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Bento Cordeiro**

**IMPLEMENTAÇÃO DE *LEAN MANUFACTURING*
NOS PROCESSOS DE ENCHIMENTO E
DISTRIBUIÇÃO NA LACTOGAL, PRODUTOS
ALIMENTARES**

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FILLING AND DISTRIBUTION PROCESS IN
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Relatório de Projeto apresentado à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Engenharia e Gestão Industrial, realizado sob a orientação científica da Prof. Doutora Ana Maria Pinto de Moura, Professora Auxiliar do Departamento de Economia, Gestão, Engenharia Industrial e Turismo da Universidade de Aveiro.

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palavras-chave

Lean, OEE, 5S, TPM

resumo

Atualmente a evolução tecnológica está a desencadear grandes mudanças no contexto das organizações, bem como no ambiente em que operam. Por sua vez, estas dinâmicas têm contribuído para que as organizações repensem a forma de trabalhar, observando-se uma necessidade contínua de melhorar os processos de maneira a ganhar eficiência e alcançar situações de vantagem competitiva.

Este relatório apresenta um estudo que foi conduzido numa empresa nacional dedicada ao fabrico de produtos lácteos, mais especificamente no departamento de produção, com foco na organização do espaço produtivo através da melhoria dos fluxos de material e na melhoria do desempenho de duas linhas produtivas semelhantes.

O principal objetivo deste projeto consistiu na melhoria de fluxos de material e de informação, bem como na redução do tempo e frequência de paragens das duas linhas produtivas selecionadas. Para tal foram usadas ferramentas de mapeamento de processos, bem como técnicas de análise de desperdícios. Enquanto que a filosofia *Lean* foi escolhida para mapear os processos e os fluxos de informação, as ferramentas, tais como os 5S's e o OEE, foram usadas para identificar as atividades de valor não acrescentado e, consequentemente, os desperdícios presentes naqueles processos. Por forma a fazer a prova de conceito foram testados diferentes cenários no chão de fábrica.

Como contributo prático deste projeto espera-se que estas propostas de melhoria, que integram pessoas, dados, fluxos e processos, venham a potenciar ganhos de eficiência nas tarefas diárias dos operadores, e na identificação e redução de paragens que em nada acrescentam valor, melhorando, assim, o desempenho global da atividade produtiva.

keywords

Lean, OEE, 5S, TPM

abstract

Nowadays, the technological evolution is unleashing big changes inside organizations, directly affecting their operational environment. Therefore, these new dynamics have been playing a role to encourage new ways to work. A continuous need to improve processes to earn efficiency and achieve competitive advantage is becoming noticeable worldwide. This report presents a study conducted in a national dairy company, more specifically in the production department, with focus on the organization of the shop floor through an improvement on material flows and a growth in the performance of two similar productive lines. The main objective of the project was to improve material and information flows, as well as a reduction on time and frequency of stops of the two selected productive lines. To do that, process mapping and waste analysis tools were used. While the *Lean* philosophy was chosen to map the process and the information flows, tools like 5S's and OEE were used to identify non-value-added activities, and consequently, the wastes in those processes. For prove the concept, different scenarios were tested on the shop floor. As a practical contribution of the project it is expected that these proposed improvements, that combine people, data, flows and processes, will enhance efficiency earnings in the daily activities of the operator, and in the identification and reduction of stops that do not add value, thus improving the global performance of the productive activity.

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List of Abbreviations

CIP – Clean-in-Place

LSS – Lean Six Sigma

OEE – Overall Equipment Efficiency

PL – Palletizer

PLMS – Product Line Monitoring Systems

SAP – ERP (Enterprise Resource Planning) Software

TPM – Total Productive Maintenance

1. Introduction

The current report aims to show the work developed at *Lactogal, Produtos Alimentares*. This production plant, where the study was performed, is located in Tocha and is one of the three plants of the group.

It is an indisputable fact that a nation's economic wealth and growth are dependent on the prosperity of its industrial sector (Andersson & Bellgran, 2015). Nowadays, there is a huge pressure on organizations to improve customer satisfaction and quality in the organization and, at the same time, to improve effectiveness and reduce the number of errors (Smętkowska & Mrugalska, 2018).

So the expression "continuous improvement" has become quite popular and the concept is associated, mainly, with the quality movement, present in models such as Six Sigma and other approaches like Lean Manufacturing (Drohomeretski, Gouvea Da Costa, Pinheiro De Lima, & Garbuio, 2014).

To succeed in such environments, companies must seek to improve their business processes to ease information flows, create value for the customers and achieve strategic results, connecting all its departments. Notwithstanding, as dynamic organisms, corporations need to be continuously adapting to new situations, aligning and shaping strategies to achieve competitive advantage (Arromba, 2019).

1.1 Motivation and Work Contextualization

The present document characterises the work completed in a dairy factory that focused on improving the performance of the production (specifically in filling and distribution) through Lean Manufacturing. In the production department, the production plans are constantly being adjusted due to problems with machines, specifically unpredicted stops. Consequently, it is necessary to study this problem and reduce it, to improve the efficiency of production and the organization of safety stock in the shop floor.

In light of this, it is necessary to monitor the processes and to understand what can be improved. Such is expected to be accomplished by combining some tools and concepts, such as OEE, Lean, 5S's and TPM.

1.2 Organization

The work developed in this project consists in the application of Lean Manufacturing methodology in the filling and distribution zones of the Lactogal factory in Tocha. Lactogal, Produtos Alimentares is a Portuguese dairy company that is in a group along with Lacticínios Vigor, Etanor Penha and Leche Celta. This company is the biggest in the dairy Portuguese field and is in the top 20 of the dairy European field. It was created to avoid the entrance of an international brand in the Portuguese market in 1996. The companies that join to constitute Lactogal – Cooperativa Agros, Cooperativa Lacticoop and Proleite/Mimosa S.A. – combined their industrial assets and their brands and are until today the biggest patrimony of Lactogal.

In their portfolio, it is possible to find the following brands: Adagio, Agros, Castelinhos, Castelões, Fresky, Matinal, Milhafre dos Açores, Mimosa, Pleno, Primor, Serra da Penha, Serra Dourada and Vigor. Figure 1 illustrate their logos.



Figure 1 - Logos of some of the Lactogal brands

The company has about 1400 workers, and their facilities are divided by manufacturing units, logistics platforms and commercial delegations located in Portugal and Spain.

The manufacturing units in continental Portugal are in Tocha, that is responsible for the production of the premium brand, Matinal, with an installed capacity of 227 ML/year for UHT milk production and flavoured milk beverages; in Oliveira de Azeméis, with an

installed capacity of 83 ML/year for pasteurized milk and yoghurts, 400 ML/year for butter production, 11,3 M Kg/year for cheese production and 210 ML/year for powder milk production; the last fabric unit is in Modivas, that has an installed capacity of 491 ML/year of UHT milk.

To help in distribution there are four logistics platforms in continental Portugal, which are in Frielas, Tocha, Oliveira de Azeméis and Modivas.

The commercial delegations are in Chaves, Modivas, Oliveira de Azeméis, Viseu, Pombal, Frielas, Beja, Algoz, Funchal and one in Spain.

Figure 2 shows the distribution of Lactogal facilities.

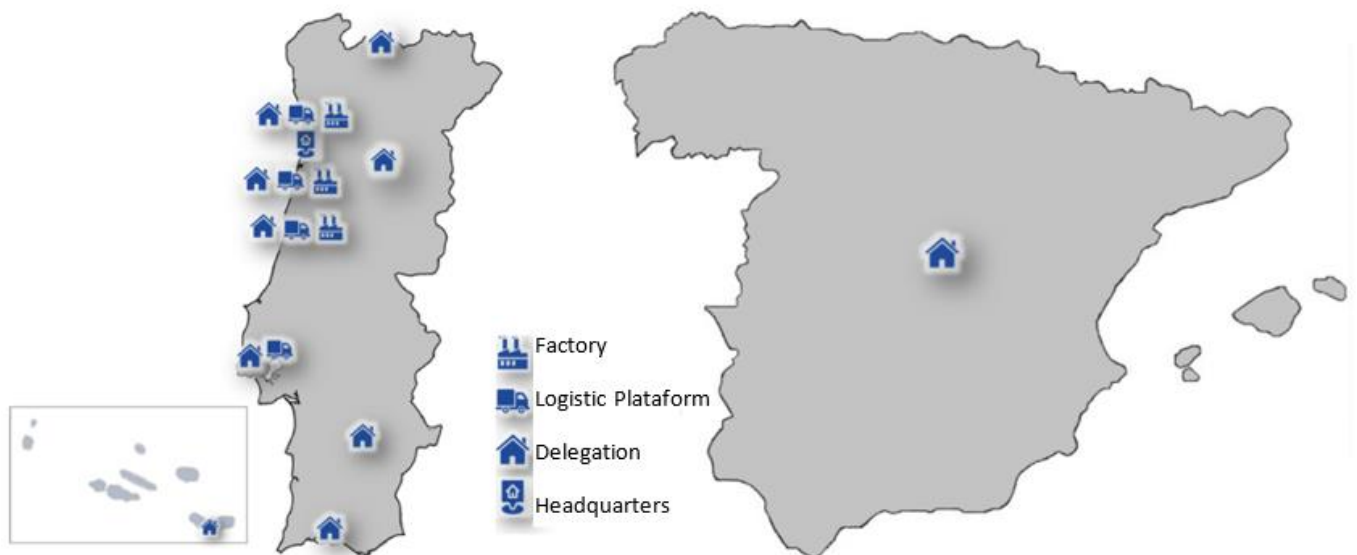


Figure 2 - Distribution of Lactogal Facilities

In terms of international market representation, the sales for external market represent 27% of the total sales and they are spread through 34 markets in the 5 continents.

In terms of certification, Lactogal has the FSC - Forest Stewardship Council, that is an international certification that guarantees the highest social and environmental norms in the forest area; the certification ISO9001:2015 and certification of a product, Matinal. Furthermore, this product holds the declaration of conformity on the preparation of

selected milk. Lactogal also holds the certification for IFS Food – International Feature Standard, which certifies the security and quality of the food products and their processes; the certification for Biological Production Mode and for HALAL, which secures that the products follow the Islamic laws for being considered a Halal product that allows the penetration in international markets.

1.3 Objectives and Methodology

The main objective of this work is to improve the production process, through the reduction of waste in the transportation of material, overstock in shop floor and time spent in stops. The material previously referred is the raw material necessary to pack the dairy products, such as the paper for each bottle, the straws, the paper for the box of packages and the plastic coil to wrap each box. These materials need to be near the machines to feed them during production. To accomplish these objectives, it is necessary to map the processes and information flow to understand where the problems are and suggest solutions for each one. The specific goals will be:

- Understand the processes and the dynamics between the departments involved in the tasks.
- Identification of workflow and posterior mapping to verify where is the waste and therefore eliminate it.

A methodology must be followed throughout the project to achieve the objectives previously mentioned. The first step is to describe the current situation of the process, and that involves the following steps:

- Gemba Walks through the factory to see the daily base of tasks, and dynamics between operators and machines, to understand the rhythm of production and to think about how the stops affect that.
- Process mapping and analysis.
- Identification of the main information flows.
- Identification of the main causes for stops and the average time to solve them.

The second step is the description of the ideal future situation, and to accomplish that the following activities will be needed:

- Gathering with the main responsible of production and maintenance to come up with solutions and to define the focus on specific problems to reduce them.
- Observation *in loco* of the maintenance repair and what can be done to speed it up and to prevent it.
- Through the DMAIC cycle check if the improvements are going in the initial and intended direction.

1.4 Structure of the Report

This report is structured in 5 chapters, defined in accordance to the methodology described previously.

In the present chapter, chapter 1, a succinct background and introduction was unveiled to better understand the motivation of the report. Additionally, the methodology and the objectives expected to be fulfilled are also exposed.

In chapter 2, a theoretical background with the most pertinent concepts is listed. This background is fundamental to clearly understand the themes that support the work developed.

In chapter 3, the focus is on the case study, including a description of the current situation in the company, the production process, and the manufactured products.

In chapter 4, a process analysis will be performed, considering two different projects, applying Lean in the shop floor and improving equipment efficiency. Finally, the proposed improvements are described, as well as a critical analysis of them, and a general overview of the work developed.

In chapter 5, the main conclusions and limitations of the project are described. At this point it will also be addressed some work perspectives and suggestions for the future.

2. State of Art

This chapter presents the state of art of the research related to the topic of this project report and allows the reader to acquire the knowledge needed to fully understand all the concepts used to answer the practical case study.

2.1 Lean

Nowadays, it has been seen a growing interest for economic, environmental and social sustainability. Following this line of thought, more dimensions were added to the complexity of designing and operating a production system in a resource-efficient way. This way is translated as “Lean and green manufacturing”, a term that was adopted to describe the goals and channels to achieve resource efficiency within manufacturing (Andersson & Bellgran, 2015).

Lean already has a few decades and some have been trying to implement it as a way to improve the work method, in a way that the factory can continue to perform and some improvements will be added through time.

Going back to the beginning, lean was born in Japan within Toyota in the 1940s. At that time, the method implemented was the Toyota Production System (TPS). It was based on a continuous production flow which did not rely on long production runs to be efficient, alternately, it was rooted in the realization that only a small fraction of the total time and effort to process a product, really added value to the end customer (Melton, 2005). So, this idea can be resumed as a philosophy focused on minimizing the waste to maximize the value for the client (Kavosi, 2019). The TPS gained adepts in the country, and years later spread around the world. Some authors tried to define this production philosophy, but it was, James P. Womack, Daniel Roos and Daniel T. Jones in the book “The machine that changed the world”, in the year of 1990, that used for the first time the term “LEAN” (Almeida, 2015). Nonetheless, Lean is grounded in two key principles: continuous improvement and respect for people. It is important to notice the people perspective at Toyota, where the idea was that the development and utilization of

workers capabilities were as relevant as waste removal (Drotz & Poksinska, 2014). To this extent, it is possible to remove waste from many processes, like the way the product is conceived and it's conformity it's guaranteed, but also the draw of operations and line layout (Melton, 2005).

The waste, also known as *Muda*, is defined by Fujio Cho from Toyota as “everything that is beyond the minimum quantity of equipment, materials, space and workforce, strictly essential do value the product” (Almeida, 2015).

There are eight types of waste in the manufacture systems, and Hicks (2007) describes them as:

- **“Overproduction** – occurs when operations continues after they should have ceased. This results in product excess, products being made too early and increased inventory.
- **Waiting** – Sometimes referred to as queuing it occurs when there are periods of inactivity in a downstream process because an upstream activity has not delivered on time. Sometimes idle downstream processes are used for activities that either do not add value or result in overproduction.
- **Transport** – Unnecessary motion or movement of materials, such as work in progress (WIP) being transported from one operation to another. In general, transport should be minimised as it adds time to the process during which no value is added and handling damage can occur.
- **Extra processing** – Extra operations such as rework, reprocessing, handling or storage that occur because of defects, overproduction or excess inventory.
- **Inventory** – All inventory that is not directly required to fulfil current customer orders. Inventory includes raw materials, work-in-progress and finished goods. Inventory requires additional handling and space and its presence can also significantly increase extra processing.
- **Motion** – Refers to the extra steps taken by employees and equipment to accommodate inefficient layout, defects, reprocessing, overproduction or

excess inventory. Motion takes time and adds no value to the product or service.

- **Defects** – Finished goods or services that do not conform to the specification or customer's expectation, thus causing customer dissatisfaction (Hicks, 2007).
- **Underutilization of employee** – “Unused employee creativity and skills to improve the processes and practices this refers to wasting the available knowledge, experience or skill of the workforce by under-employing them or not using them in the proper department” (Mostafa, Dumrak, & Soltan, 2015).

The wins of Lean can be seen in time, cost and value, and these are the three factors that contribute directly to the company strategy (Drohomeretski et al., 2014). Some of the Lean tools and techniques more used and known are: the Kanban, which helps in controlling the flow of production or transport, the kanban itself can be physic or digital; the 5S methodology, very well known for the goal of motivating and making aware the entire company through organization and discipline in the job place; Poka-Yoke it's a mistake-proof device, which helps mitigate the defects in production or incorrect utilization of tools or products; SMED is also one of the more used tools because it can help reduce the setup time (Melton, 2005). It is very important to improve equipment efficiency through the reduction of time of stops or setups.

Another very important Lean tool for visual management is the Andon. This tool can be a sign or a signal that highlights an issue, which helps to solve it immediately. As a communication tool, it is employed to reveal the status of a production line or a process. Andon systems can have many forms, from traffic light systems to complete display boards placed through the production plant. This tool is included in lean manufacturing because it can reduce waste of various resources like time taken to understand data (Ito, Abd Rahman, Mohamad, Abd Rahman, & Salleh, 2020).

2.2 Lean Six Sigma (LSS)

LSS rise from the combination of lean manufacturing production system with the efficient Six Sigma improvement methodology. It can be defined as a business strategy, and at the same time, as a technique that boost process performance, culminating in greater client satisfaction and results (Drohomeretski et al., 2014). This integration arises as Lean cannot deliver a process under statistical control and Six Sigma alone cannot completely improve process speed (Gleeson, Coughlan, Goodman, Newell, & Hargaden, 2019).

One of the tools to implement lean is value stream mapping (VSM) (Drohomeretski et al., 2014). By using VSM, the gap of not knowing where the necessity is and where improvements should be suggested, is reduced. Therefore, we need to understand our process through visual management, that is a powerful tool to highlight the stage of work in process (WIP), to fix issues with process invisibility and to help in sharpening communication. All these features lead to an improvement in problem-solving and specifying outcomes. Visual management also quantifies and audit the impact on the processes and their improvement (Gupta, Sharma, & Sunder M, 2016).

2.3 Lean Maintenance

Lean thinking can be integrated into other areas, like maintenance through the application in maintenance activities of its principles and practices. Maintenance itself is the process that includes the planned and unplanned actions to maintain a physical asset in the adequate operation condition (Mostafa et al., 2015). A successful maintenance strategy can help achieve higher productivity, better quality, fewer downtimes and improved safety (Bataineh, Al-Hawari, Alshraideh, & Dalalah, 2019).

Accordingly, to some studies, the cost of maintenance could be from 15% to 70% of the total production costs, representing a large share in the operational budget. The longer the downtime (DT) the higher the maintenance costs are. The rising of DT is a consequence of Non-Value Added (NVA) activities or wastes within the maintenance procedures.

The first stride in lean maintenance is to pinpoint types of waste in the maintenance process. In the maintenance process, there are seven types of waste and the eighth type is found in the production system. They are described by Mostafa as:

- **“Unproductive maintenance:** performing preventive maintenance (PM) and predictive maintenance (PdM) tasks at intervals more often than optimal results in the overproduction of maintenance work.
- **Waiting for maintenance resources:** the production department is waiting for maintenance personnel to perform the maintenance service. It involves waiting for tools, parts documentation and buying extra tools and store them near the job location.
- **Centralized maintenance:** centralization of the Maintenance, Repair and Overhaul (MRO) stores that are far from the job, commonly used repetitive parts that have not been kitted, documentation that must be hunted down, and work orders for machines that are not available, all cause excess transportation. Therefore, maintenance personnel spends more time in motion and transportation which does not add value to the process.
- **Poor inventory management:** the MRO inventory contains needed materials and spares. Additionally, work in process inventories may be used to ensure availability of required materials. Inventory for a maintenance operation also includes the work order backlog. Excessive inventory of maintenance work results in a slow response, unexpected breakdowns, and a high reactive labour percentage.
- **Unnecessary motion:** the wasted motion is usually concentrated around preventive maintenance tasks. Doing inspection monthly on a pump that has not changed status in three years should be extended longer to quarterly, semi-annually, or annually depending upon the criticality of that piece of equipment.
- **Poor maintenance:** performing incorrect repair is a source of poor maintenance. Incorrect maintenance requires several repeated times to complete the repair job correctly. This affects the maintenance cost and the

quality of the product. Applying proper training and detailed procedures can assist in poor maintenance elimination.

- **Ineffective data management:** collecting unnecessary data or inadequate collection of important data such as failure rate, root causes...etc.
- **Under-utilization of resources:** maintenance technicians do NVA works” (Mostafa et al., 2015).

The mindset for maintenance activities has been changing in the last years, with the arrival of industry 4.0 that introduces and develops a lot of different methods to do the maintenance. Maintenance costs are considered value in industry 4.0, opposite to previous thinking which was a cost that should be diminished because the tendency was to only repair the machine or equipment when they stopped (Poor, Basl, & Zenisek, 2019).

2.4 Total Productive Maintenance (TPM)

An acclaimed and worldwide approach to improve production performance is Total Productive Maintenance (TPM) (Andersson & Bellgran, 2015). Andersson & Bellgran say that “TPM is a production-driven improvement methodology that is designed to optimize equipment reliability and ensure efficient management of plant assets through the use of employee involvement, linking manufacturing, maintenance and engineering” (as cited in Ahuja, 2007).

Ordinarily, maintenance management activities are described as the merge of all technical and administrative actions, like supervision, which assures that a manufacturing system is in its appropriate functioning state. “Maintaining a system is usually related to maintenance actions such as repairing, replacing, overhauling, inspecting, servicing, adjusting, testing, measuring and detecting faults to avoid any failure that would lead to interruptions in production operations” (Sahoo, 2019). The basis of maintenance is to find and apply cost-effective ways to avoid or reduce machine performance degradation (Sahoo, 2019).

The introduction of TPM goes back to 1960, when Toyota tested the concept of Preventive Maintenance plant-wide, and over the last decades, a set of ideas had been used in the TPM programme, including the following ones: maintenance prevention, autonomous maintenance, corrective maintenance, preventive maintenance, predictive maintenance, early equipment design and early product design (Bataineh et al., 2019).

TPM is a result-oriented process which brings a methodology for data collection that can be analysed, solutions can be implemented with the goal of zero downtime, zero error and zero disturbances. TPM is about to surmount the traditional division between people that work on the machine and workers who repair it. To merge both groups it is necessary to train the employees, which is one of the basic pillars of TPM (Poor et al., 2019).

TPM has been entrenched as an original approach to machine maintenance that can be interconnected with TQM, JIT, continuous performance improvement, and other manufacturing practices (Sahoo, 2019).

2.5 Overall Equipment Efficiency (OEE)

Overall Equipment Effectiveness (OEE) is a measure within the concept of TPM, used to analyse and improve the effectiveness of the production process (Baghbani, Iranzadeh, & Bagherzadeh khajeh, 2019). So, the ultimate challenge is to achieve a stable and high OEE, as a signal of a good performance.

Products have three crucial attributes: quality, price, and delivery times. Every equipment has an unequivocal impact on all three, having in mind that the breakdowns, repairs, and quality defects interfere with quality, cost and delivery time (Baghbani et al., 2019).

To get the most of an equipment, OEE is used as a qualitative tool for improving equipment condition. This qualitative tool is a component of the performance evaluation methods extensively used in various industries. It consists of three components: availability (A), performance (P) and quality rate (Q) (see figure 3), which is calculated in

the form of six large losses: equipment failures, setup and readjustments, minor stopping, reduced speed, defects, and reduced efficiency (Baghbani et al., 2019).

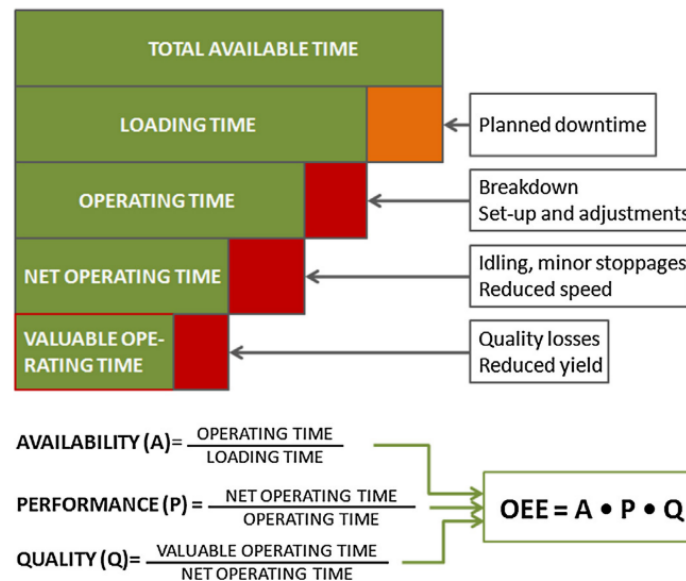


Figure 3 - Definition and computation of OEE (Andersson, 2015)

Andersson & Bellgran (2015) claim that “effectiveness describes external efficiency, that is, doing the right things, while efficiency refers to internal efficiency, or doing things right.” In reality, OEE measures internal efficiency rather than external effectiveness, hence a more precise definition would be Overall Equipment Efficiency.

OEE is a tool that functions well for the individual and isolated equipment, however controlling single machines doesn’t seem to be enough, because no machine runs isolated in a factory, instead, it depends on the environment, logistics, etc (Oechsner, Pfeffer, Pfitzner, Binder, Müller, Vonderstrass, 2002). Having this in mind, it is important to combine OEE measure with other complementary measures or key performance indicators (KPIs) to aim for a complete picture of productivity.

The material flow in a progressively convoluted production system has an impact on the equipment and vice versa. For this case, OEE control is not enough, therefore in the future, following the principles of industry 4.0 an imperative objective is to improve the performance of the whole factory instead of focusing only on single tools. A factory-wide approach for meeting this objective is Overall Factory Effectiveness (OFE). OFE includes a

combination of machines and processes and integration of information across independent systems and sub-systems (Oechsner et al., 2002).

2.6 5 S's

The 5S is the tool to create and keep up efficiency, cleanness, and a top-notch working environment. The way of thinking of 5S traces back to Japan, in the mid-1980s, where Osada proposes the term, that is a truncation of five Japanese words. Burawat explains 5S as:

- **“Seri (sort):** aim to sort, organize the workplace and eliminate the unnecessary materials (such as waste materials, non-conforming products and damaged tools). It helps to maintain the clean workplace and improves the efficiency of searching and receiving things, shortening the time of running the operation.
- **Seiton (set in order):** aims to visualize the workplace and the place for everything (for example, painting the floor distinguisher the spots of the capacity of every material or transport ways).
- **Seiso (shine):** aims to clean and remove waste or dust, once that regular cleaning permits to identify and to eliminate sources of disordering and to maintain the clear workplace. It is essential to upkeep the individual cleanliness.
- **Seiketsu (standardize):** aims to give a specific and constant place for things, consistent guidelines of association, stockpiling and keeping cleanness. Worked out and actualized norms as techniques and directions grant to maintain control on the work environments. The norms should be informative, clear and straightforward so every member in the workplace can understand them.
- **Shitsuke (sustain):** aims to be the automatic realization of the above-mentioned rules, in such way that workers do not have to think to do it, is just part of their routine” (Burawat, 2019).

3. Project

3.1 The Process

The production process has five distinctive phases: reception, concentration, UHT treatment, filling and packaging.

The reception begins when tanker trucks arrive at the factory. Then the samples are collected from each compartment, because it can have milk from different collections, which means that one truck can have milk from different farms, so each type of milk is separated and needs to be tested individually. If the milk is not in the required conditions, it must remain in the truck and the loss is allocated to the cooperative. The cooperative is the company responsible for milk extraction and transportation until the manufacturing unit. The transference of responsibility for the milk only happens when it is pumped from the insulated road tanker to the storage tanks. If it is within the control limits it will be unloaded and divided into the available silo tanks.

In the next phase, concentration, the milk is separated from the fat, according to the type of milk that it is pretended to produce (skim, fatty or half-fat milk) the cream goes to another storage tank. The cream that is not used in this factory is transported to another one where more cream is necessary to produce other types of dairy products such as cheese or butter. After this separation, the ingredientation occurs when the ingredients are joined with milk as it says in the recipe to prepare future productions. This phase can be divided into the ingredientation itself and the resting time before it continues to the next phase.

After the concentration phase, it is time to begin the UHT treatment. Figure 4 represents the conditions to achieve it. This treatment consists in increase the temperature to 140°C during 5 to 6 seconds to turn the milk commercially sterile, which means to decrease the number of living organisms in the milk. This way the product can remain in the bottle during months in the same conditions.

The EU defines the heat treatment necessary for achieving commercial sterility. “UHT treatment is achieved by a treatment: (i) involving a continuous flow of heat at a high temperature for a short time (not less than 135°C in combination with a suitable holding time) such that there are no viable microorganisms or spores capable of growing in the treated product when kept in an aseptic container at ambient temperature, and (ii) sufficient to ensure that the products remain microbiologically stable after incubating for 15 days at 30°C in closed containers or for seven days at 55°C in closed containers or after any method demonstrating that the appropriate heat treatment has been applied.” (Ref: Commission Regulation (EC) No 1662/2006 (amending Regulation (EC) No 853/2004)).

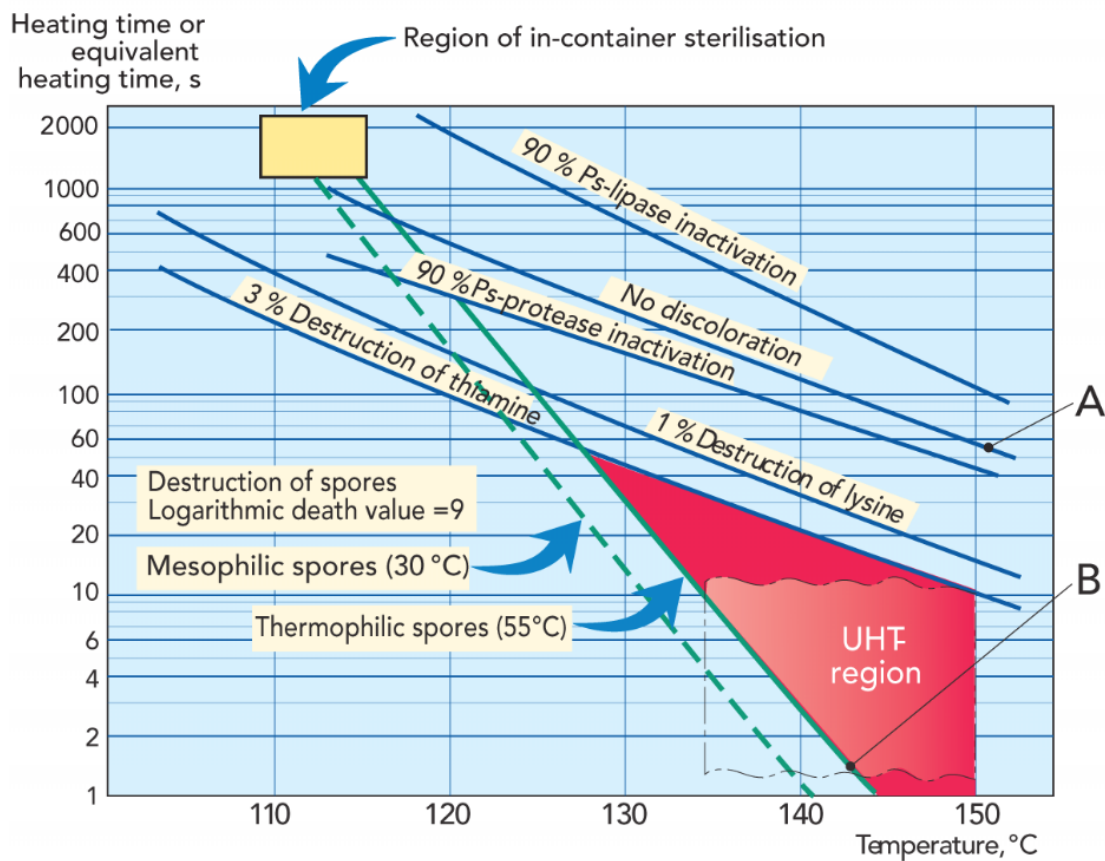


Figure 4 - Graphic with relation between temperature and time to UHT treatment (*Dairy processing handbook*, 2003)

The UHT treatment differs from the pasteurization because this process is done at a lower temperatures (72 to 75 °C) for 15 to 20 seconds, which allows a bigger number of

living organisms in the milk (excluding the unwanted microorganisms and all pathogenic bacteria), that's why the pasteurized milk has a shorter shelf life, of about 8 to 10 days at 5 to 7 °C in an unopened package.

After the UHT treatment, the milk goes to the filling machines. Here, it has two different possible destinies, Evero lines where the bottle has a component of injected plastic, and the other lines where it is only used the treated paper.

After the bottles are filled, they continue to the lines where they will be going to be grouped in packs and the packs will be plasticized. In the line, depending on the reference/product, there can be different steps, some products have a straw, some are in packs of 3, others in packs of 4 and others in packs of 6, so it depends on the specific product. Packs can go directly to form a pallet or to a box before forming a pallet.

The production phase ends, when the pallet enters the logistics warehouse, at the end of the production line.

3.2 Products

Lactogal, Produtos Alimentares offers a widespread variety of products and there are plenty of aspects that differentiate them. Products are generally known by their stock-keeping unit (SKU), which represents a specific code assigned to a product. That SKU provides all the information about a product, for example, their components/ingredients or information about their package. In addition to their brands, they also packed other brands for different commercial clients, so it is necessary to have into account the client's requirements.

Each machine can produce some specific SKUs according to the characteristics of the packaging. The solution to overcome the challenge in dealing with such a high number of SKUs per machine is a good planning method which optimizes the use of the machine and the time available for production.

- Lines 37 and 38 are responsible for the filling and packaging of SKUs with a Tetra Top package, only for 1L per bottle, as it can be seen in figure 5.



Figure 5 - Tetra Top Package

- Line 39 is responsible for the filling and packaging of SKUs with a Tetra Prisma Aseptic Dream Cap package, for 200 mL or 250 mL per bottle, as it can be seen in figure 6.



Figure 6 - Tetra Prisma Aseptic Dream Cap Package

- Lines 40 and 28 are responsible for the filling and packaging of SKUs with a Tetra Brik Slim package for 200 mL or 250 mL per bottle, as it can be seen in figure 7.



Figure 7 - Tetra Brik Slim Package

It is important to refer that Tetra Pak is the main supplier of machines and equipment and therefore, there is a close relationship between both companies to achieve the maximum performance. So, besides of the Lactogal maintenance team, there is also some employees of Tetra Pak that are full time in the factory, and others as a team do maintenance when it is needed.

3.3 Problem Contextualization

3.3.1 Applying Lean on Shop Floor and Information Flows

The first challenge proposed was an assessment of the quantity necessary to have as a security stock on the shop floor. This was an interesting project for reducing the necessary materials to keep the machines working nonstop but without obstructing the path. On the other hand, if there was only what is necessary for each production it would be easier to have better control over the material that exists in the advanced warehouse. This warehouse is also called PSA on SAP, the enterprise resource planning (ERP) system of the firm, that is a management software used across the entire firm. The advanced warehouse is a room next to the shop floor. In this way the material that is necessary to consume in the following productions is near and it allows the reduction of time spent by operators to get the required material.

Initially, the contact with the work routine as well as with the work teams was essential to understand the relation between production plans and stock reposition routine in the shop floor.

Through informal interviews with the production managers, it was possible to understand how the information flows. First, they receive the production plan for the week, only with the quantities of each product and with priorities defined. Then they need to transfer that data to an excel document, see annex 1, where the productions are distributed in the various machines. In that distribution process, it is mandatory to have in mind the times for pre-production and CIP between productions and lots. To better understand the importance of this topic in the production plan, figure 8 explains the cycle of the filling machine.

CIP is a acronym for cleaning-in-place, it appeared around 1950 and evolves rinsing water and detergent solutions circulating through tanks, pipes and process lines without the equipment having to be dismantled. CIP can be defined as circulation of cleaning liquids through machines and other equipment in a cleaning circuit.

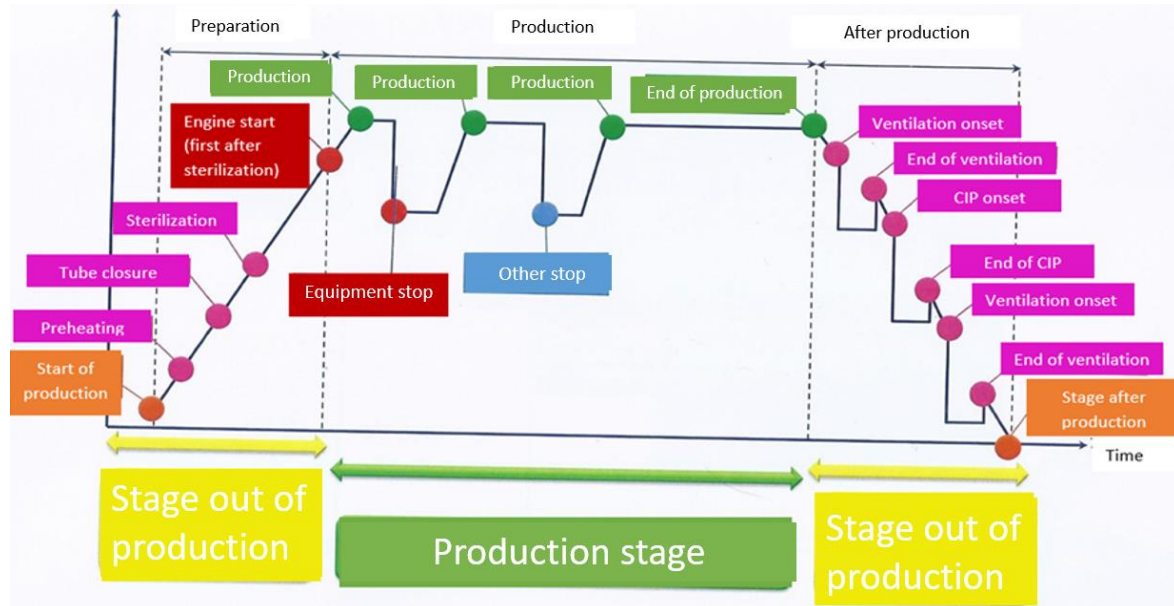


Figure 8 - Cycle of the filling machine

The arrangements for cleaning the equipment that comes in contact with products are an essential part of a food processing plant. It must be kept in mind that food manufacturers are always obliged to maintain high hygienic standards. This obligation can be considered under three headings: trade, moral and legal obligation (*Dairy processing handbook*, 2003).

In parallel, the logistic department also receives the production plan for the week, in that way it is possible to transfer the material needed for each production from the raw material warehouse to the PSA.

This system works well when the equipment stops are not significant, but when changes need to be done in production, like anticipate or delay it, it can occur stock rupture. Rupture is more susceptible to occur at weekends because Logistics only works 8h/day for 5 days, while Production works at 3 shifts/day, except on Sunday that works only 2 shifts. So, these work time differences create a stock rupture when Logistics is not able to meet the needs of production.

3.3.2 Improving Efficiency

The second challenge aimed to improve the efficiency of Evero lines through a reduction in time and/or frequency of stops.

The objective was to increase the availability, a component to calculate OEE, and since the availability is conditioned by breakdowns, cleaning, preparation time like setups, this study only focuses in one of them, more specifically breakdowns. Although it was also possible to collect the information that affects quality (another OEE component), that is waste, in units wasted per stop, it is not going to be part of this study.

As it was previously explained the availability is conditioned by different kinds of stops. Figure 9 provides a simple explanation of the difference between them.

- Equipment stops are stops caused by the machine/line in analysis.
- Other stops are stops not caused by the machine/line in analysis.
- Stops outside production, are stops to wash internally and externally the machine, to preheat before starting the production and to maintenance.

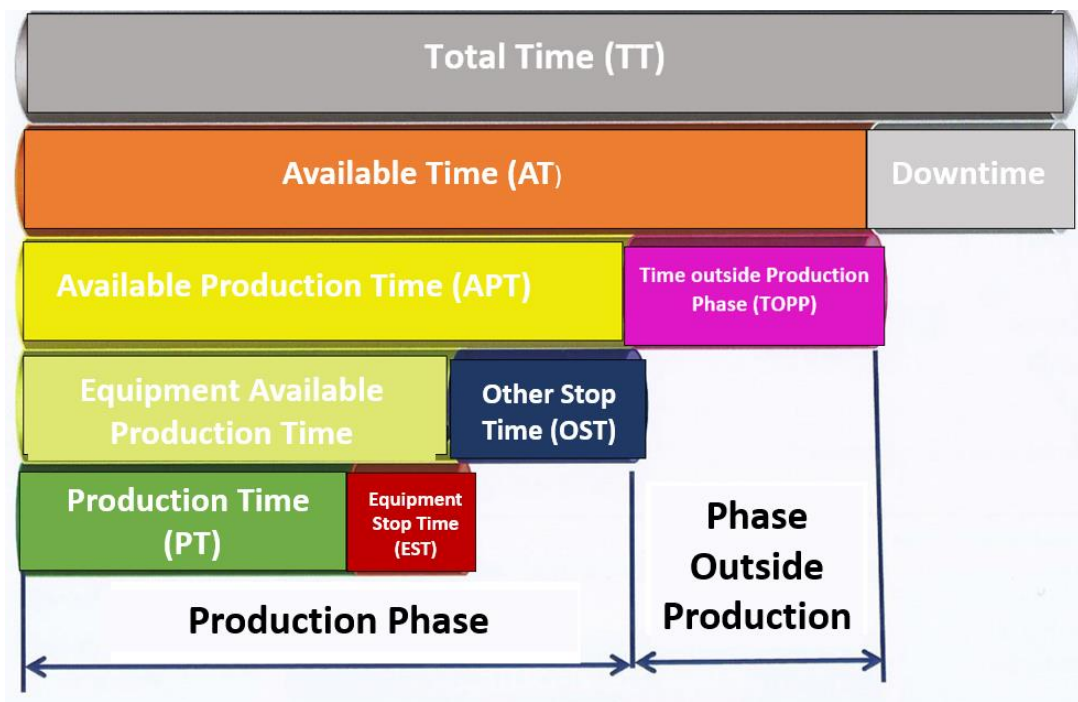


Figure 9 - Illustration of the different uses of time

In Evero lines, the equipment has a specific order of machines, as figure 10 illustrate, and stops are allocated to one of them. Although there are conveyors between all of them, it is highlighted the one between AmbaFlex (figure 11) and Palletizers because it is a long conveyor that crosses different rooms and has some sensors along the way.



Figure 10 - Machinery Sequence



Figure 11 - AmbaFlex

In the baseline situation, the effort to improve efficiency was to do preventive maintenance to the filling machine. This idea comes from the rule that at 10 times that the filling machine stops, it needs to have a CIP, which delays production. Having in mind that stops above 15 minutes in the line will also stop the filling machine because the Helix (figure 12) becomes full since it takes around 15 minutes to fill the conveyors that exist in Helix. So, the effort applied in preventive maintenance was to reduce at maximum the time that the filling machine was stopped to prevent an additional CIP.



Figure 12 - Helix

Passing over the idea to focus on just one equipment, it was necessary to assess how the rest of the line was working. By analyzing the end of the line, the palletizers, it was clear that they had not a designated operator to that workstation. The operator responsible for machine 40, that is placed in front of palletizers, is the one responsible to control both stations (PL37, PL38 and machine 40). Other times, it is the forklift operator that helps to solve problems with the Evero palletizers. And, if no one is there and a mechanic passes by the workstation and sees that the equipment stopped, he will help and set the palletizer to work.

Additionally, the transition from AmbaFlex to palletizers implies a physical separation because these machines are in different rooms. The communication done among the operators between Evero distribution room and the palletizer zone is done by phone or by going there physically. Since there is no fixed allocation at the palletizer workstation in some shifts, it can be a different operator to answer the phone without even knowing 100% how the failure occurred, because they were also responsible for other

workstations. Thus, this delays the resolution of problems and increases the duration of stops.

It is even more complicated to quickly solve a stop if the cause is neither in the machines in Evero distribution room or the palletizers. When this happens, it is mandatory to look at LC30 monitor screen (figure 13) to see which part of the path is being affected, this is necessary to check because sometimes the AmbaFlex is not working because a package is covering a photocell. Sometimes this error will take a while to verify because it is not possible to the operator to always see the whole path, so just when the machines are stopped and if there is not a problem is any of them, they will check the monitor screen to see in which section the problem occurred.

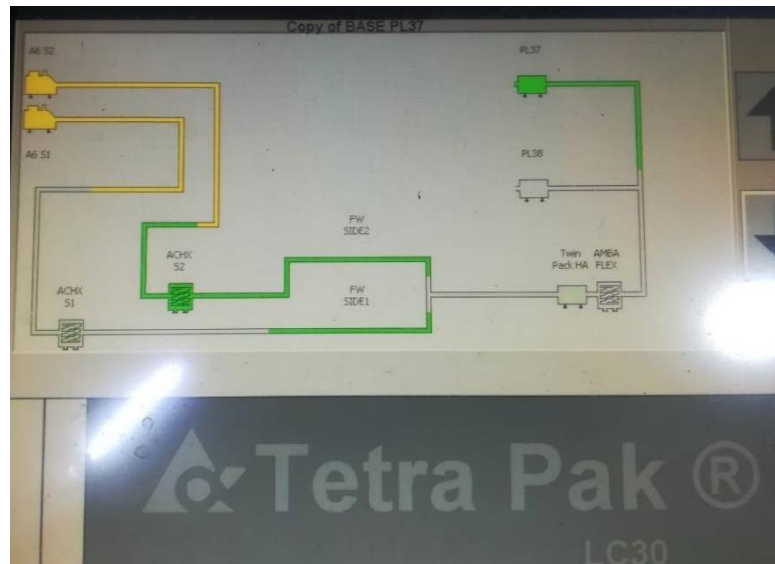


Figure 13 - LC30

It is vital to communicate between stations, because the Evero distribution room needs to know where the problem is. In this room, that are two boards, one for line 37 and another for line 38. When the line is working the letters in the board are yellow, and when something stops the letters turn red with the indication of the place where the malfunction occurs. That means if it was in the palletizer of line 37, it will appear PL37 in red, if it was in the Gampack side 1 it will appear GAP50 1, as figure 14 shows. In here the

andons are correctly placed, and the operator knows when a failure occurs by the visual sign that turns from green to orange.



Figure 14 - Line 37 screen

4. Improvement Proposals

The project was developed based on the DMAIC cycle. To simplify the explanation each improvement proposal is divided into study, proposed improvement, and results.

4.1 Applying Lean on Shop Floor and Information Flows

The project of applying 5S's at the shop floor had the objective to become familiar with the work routine in the factory as well as the teams. All this to better understand the relation between the production plans and the stock reposition routine.

Some of proposed improvements in this chapter are a way of providing knowledge and empowering operators to a *Lean Thinking* strategy, because their work would be affected by some of the proposals.

4.1.1 Change in the information flow

Study: One of the points that had the opportunity for improvement was the information flow between Logistics and Production departments. To better understand it, the methodology used was informal interviews with both sides. That was done to understand what documents were transferred and in which days did this transference of information occur. After the interviews, it was clear that Logistics relies on information from SAP so they only resort to documents from Production in the last instance. On the other hand, Production relies more on their documents that were constantly changed and unless they send them through email to Logistics, the other department would not be able to access it.

Proposed improvement: Creation of a routine of information transference each day, which would be accomplished by sending an email with the alterations highlighted to check if the delivery of materials should be changed. In this way, Logistics could prevent a stock rupture in the Production department. The material flow would be only from Logistics to Production, without any need for operators from Production come to Logistics warehouse pick materials.

Results: There were some constraints to the implementation of the proposal because a new scheduling production plan was being tested. The production plan will change from the excel in annex 1 to a Tetra Pak programme that includes more features. It should include an integrated view of the entire process since the concentration phase, different from the current situation, where planning for filling and distribution is done, and then it is done for the previous phases.

4.1.2 Supplier Function

Study: Looking at the distribution of human resources it was clear that there was a lack of staff. Shifts were with less staff than they used to be, and new operators needed training to completely be responsible for a machine. Having this in mind it was taken into consideration if it could be more profitable if the supply the entire shop floor was allocated to one of the operators. Previously, each operator was responsible for supplying the machine that was allocated to them.

Proposed improvement: Allocate an operator to the supplier function, this person would be responsible for supplying the shop floor with the necessary material and remove the remaining to PSA. Also, he would be responsible for controlling the materials in PSA. The ones that were not going to be used in the next few days should be transferred to the raw materials warehouse again.

Results: This solution was tested during a week in the afternoon shift. The improvements in the organization at the PSA and in the shop floor were notable during the experimental trial. Nevertheless, that level of organization was not made routine, because it was not always possible to have a supplier per shift, which destroyed the effectiveness of the solution.

4.1.3 Tool to help reducing to minimum the safety stock

Study: One of the topics approached to fulfil the objective of reducing material in the shop floor was to reduce the excess of safety stock. Although the production managers knew the quantity of material that was going to be consumed according to the quantity to be produced, the operator did not have access to that information, because it could only be accessed through SAP. So, to empower operators with knowledge regarding the quantity of safety stock that should exist in the shop floor, an inventory on the consumables was done. It was necessary to make a list of the quantity per pallet in each reference because they are different from reference to reference.

Proposed improvements: Creation of an Excel sheet that by inserting the quantity in liters of the product meant to be produced it returns the quantity of each material necessary. For example, if it were necessary x carton boxes, it would be necessary at least one pallet of that reference. The advantage of using this tool was for operators to understand if the material in the shop floor was only the necessary or if exceed that and, in the last case, return the remainder to PSA (intermediate storage).

Results: The tool is the one in annex 2. To use it, it was necessary some technological device, like a computer or tablet since it is not a static sheet, it is a dynamic sheet that gives outputs accordingly with the inputs. There was no real implementation of this proposal because of its feasibility. Maybe, in the future, with an investment in technological devices, this proposal would be implemented.

4.1.4 Repositioning the safety stock

Study: To apply Lean in the shop floor, it was used one of the most common tools, 5S's, because it allows an organization and cleanliness that shows that everything is in the right place where it is supposed to be. In the point "Set in Order", a recurrent method to implement this is to paint on the floor the places where the materials should be. To evaluate in which places should material exist, informal interviews were done to check if the places where previously existed materials were the most suitable. Having in mind that the safety stock should be near the machine where it would be consumed, most places

remain the same. Apart from that, materials that were on the shop floor just to avoid going to PSA were removed from where they were. Leaving only the necessary places with material to avoid interruption of machines.

Proposed improvement: Drawing in the blueprint of the factory the places to be painted, with the right measures and with enough space to have a safety stock.

Results: The proposal was saved so, in the future, it can be included in the budget the investment required to implement it.

4.1.5 Applying 5S's to PSA

Study: To organize the materials in the shop floor it was also necessary to organize the materials in PSA. The organization in this space would pass through an identification system for the shelves along with a sheet with information about what exists there. In this way, with a notion of materials turnover, it would be possible, in the future, to establish fixed places for materials that are constantly consumed.

Proposed improvement: An identification system for the shelves, like the one in figure 15.



Figure 15 - Identification system in PSA

This identification system is meant to be used along with a sheet (annex 3) created to know what is currently in PSA. These measures could potentially help to have a better organization in this space through the instant notion of existent material just by reading a sheet.

Results: The proposal was presented to managers who accepted the idea. Due to the time limit of the internship, it was not possible to implement it.

4.2 Improving Efficiency

4.2.1 Analysis of Data

Study: To assess the current situation of Evero lines, it was first done an analysis of the times recorded by line 37 in the year 2019. The data was downloaded from PLMS (Product Line Monitoring Systems), a software from Tetra Pak for collection and data analysis, with the objective of measuring and improving performance. The data analysis follows the next steps:

Step one: Analysis of October 2019, in every stop, including other stops, equipment stops, stops outside production and all the stops together. This analysis was done only for side 1, then for side 2, and finally for both sides together. The filling machine has two sides, as it can be seen in figure 16, this allows the consumption of two coils of treated paper for packages. For this reason it was done individual and joint analysis of the sides.



Figure 16 - Filling Machine A6

With the information from October, it was possible to see that between sides the results were very similar. In this step, it was also analyzed Accept data (another data source which has input from operators). But the two sources did not match 100%, and the extraction of data from Accept was not automatic. So, for posterior steps, it was decided to only focus on both sides at the same time, without the distinction, and analyze only data from PLMS.

Step two: Analysis of six months (June to November 2019) only focusing on the equipment stops of the line. With this analysis, it was possible to understand that the main cause of stops was in the line (part of the distribution) and not in the filling machine. Table 1 and figure 17 represent the data of this step.

Table 1 - Top 10 Stops - June to November 2019

Line Label - 37 TC TEA A6 1000	Total Time	Frequency
1. PL: Full feed conveyor	127:22:38	361
2. FW GAP50: Failed film retractile	77:53:26	185
3. Line Controler LC 30: AmbaFlex Stop	71:11:29	201
4. FW GAP50: Mechanical film sealing	60:54:51	160
5. HA-MDEL: Missing Handle 1	38:34:13	155
6. HA-MDEL: Not ready without alarm	37:36:16	142
7. PL: Production time support cylinder	36:16:47	121
8. Others	32:19:36	34
9. FW GAP50: Not ready without alarm,S2	31:01:09	100
10. PL:Production Time of the empty pallet feeder	28:56:15	101
Total:	542:06:40	1560

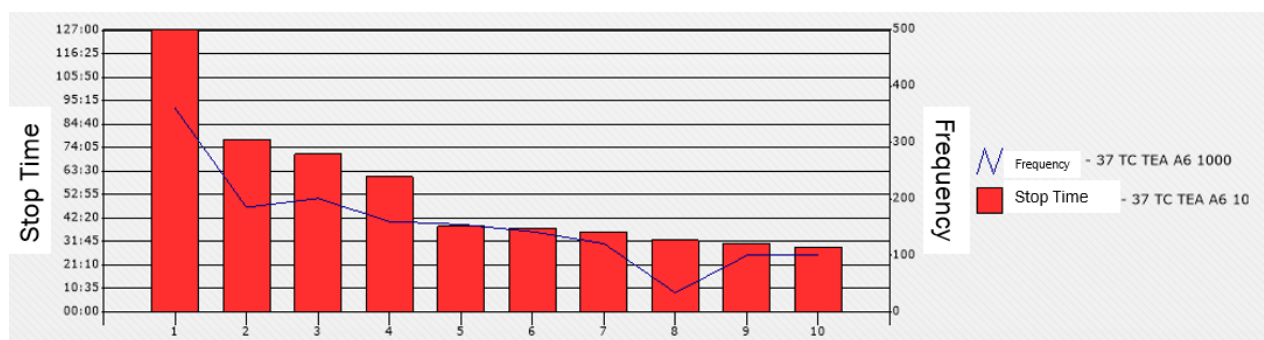


Figure 17 - Graphic with the stops from June to November 2019

Step three: Analysis of the equipment stops of the year 2019. A podium of the top 5 frequencies was done, by taking the top 5 each month and then sum those frequencies to have the top 5 of the year in term of frequencies. Table 2 represents the podium of the top 5 frequencies. Although the frequency was not the only measure to be discussed it was extremely important to see that some types of equipment are responsible for the biggest shares of downtime. The other measures used were the total time per stop, the average time per stop and the median of the time. The results are shown in the next table.

Table 2 - Top 5 frequency on line 37

Line Labels	Frequency	Average Time	Total Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PL: Full Feed Conveyor	893	00:19:13	274:43:31	x	x	x	x	x	X	x	x	x	x	x	x
FW GAP50: Fim Retractable Failure	322	00:18:37	116:10:05					x	x		x		x	X	X
HA-MDEL: Missing Handle 1	352	00:14:20	84:45:48	X	x	x			x	x					
Line Controler LC 30: Amba Flex Stop	234	00:24:38	84:29:25								x	x	x		
PL: Production Time of Support Cylinder	179	00:15:50	54:21:18									x	x	x	x
TOTAL	1980		614:30:07												

The types of equipment that pop up in the data as the main contributors were the palletizer (PL) and the Gampack (FW GAP50), both in the line, so for these two machines gathering with all their stops was done.

The x in the months represent the ones where that specific stop cause was in the top 5, meaning that it could also occur in months that do not have the x but was not in the top 5 frequencies of that month.

This method of analysis was done to more machines/ lines specifically, the 38 (also Evero) – see table 3, the 39 (DreamCap) – see annex 4, and the 28 and 40 (Slim) – see annexes 5 and 6, respectively.

Table 3 - Top 5 frequency on line 38

Line Labels	Frequency	Average Time	Total Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Line Controller LC 30: Amba Flex Stop	291	0:25:22	122:55:29										X	X	
HA-MDEL: Missing Handle 1	292	0:21:13	103:56:14	X		X	X	X	X	X		X	X	X	X
Conveyors S1, acumulation on the conveyor belt	162	0:09:42	30:44:04								X	X	X	X	X
FW GAP50: Mechanical Film Sealing	162	0:22:31	53:42:49	X	X	X								X	
PL: Production Time of the empty pallet feeder	156	0:18:46	46:37:37			X	X	X		X					
TOTAL	1063		357:56:13												

Since the top 5 is similar in lines 37 and 38, and these are similar lines as well, it was decided that any improvements suggested would be implemented in both lines.

After presenting the report to the team, it was clear that the most frequent stops were in the line, not in the filling machine. Therefore, maybe all the preventive maintenance schedule that is currently implemented on the filling machine should not be the focus. It was very clear with this data, that there were at least two machines which take a big share of responsibility on stops at both lines.

To come up with improvements, it was necessary to meet with all the workers involved, such as operators in these specific workstations, maintenance workers and maintenance workers from Tetra Pak. These three parts were necessary because when a stop occurs it can be solved by one of the three, depending on the error that causes the stop.

To do what was mentioned above a meeting was organized, with the two Tetra Pak workers that are responsible for the Evero lines in the company, the production managers, the responsibility for the process, the maintenance responsible, the factory

director and a senior employee that is the worker responsible for their team in their shift. The outcomes of that meeting were:

1. Palletizers are not the same brand of the line (palletizers are InterSystem and the line is TetraPak) which causes communication problems, such as:
 - a. The alarms are not sufficient to help the workers, which means that with different causes the same alarm it showed.
 - b. Although an effort had been done in the past to have specialized workers re-doing the programs in the palletizer, the problems tend to return to the norm (that is a weak communication with the line) after some time.
2. The big share of Gampack stops was caused by the fact that this machine does not stop at a point zero, which causes a lot of stops to restart the system.
3. Skim milk makes the packages more unstable which causes more failures due to overturning of packages.

Proposed Improvements: To rectify these flaws, an action plan was formed. This plan includes:

1. Improvement of programs between the InterSystem Palletizer and the Tetra Pak line/machine, which was allocated to the responsibility of Maintenance and Tetra Pak.
2. Always have an employee at the workstation of the palletizer, at least for a week to see if the data would improve, in a further notice include training to other workers, which was allocated to the responsibility of the production managers.
3. Talk with Intersystem to improve the alarms, to help the workers understand the problem and quickly solve it, which was allocated to the process engineer.

4. Stand out one of the Tetra Pak workers to do with the Evero lines the same that was currently being done with DramCap (line 39)¹, which was allocated to Saúl, one of the Tetra Pak workers responsible for Evero lines.

Results: In here it is presented the results for each proposed improvement at the stage they were when the internship ended.

1. One of the maintenance responsible who knows automatic programming was trying to improve the communication between the systems.
2. Due to staff allocations constraints, it was not possible to have during an entire week, an operator allocated in the palletizer workstation. So it was not possible to check if the continuous presence would change the data, and therefore the efficiency of the line.
3. Although this meeting between InterSystem and the process engineer had not occurred yet, the next subchapter, analysis *in loco*, could potentially provide the kick-off to come up with better alarms since some examples of problematic alarms had been discovered.
4. This proposed improvement had also not been implemented so far. Nonetheless, it could be implemented in the future along with the other proposed improvements.

4.2.2 Analysis *in Loco*

Study: To evaluate what could be done on the shop floor to solve or attenuate this problem, it was collected data from observation *in loco*. Since it was not possible to be present 24h, it was necessary to establish a collaboration with the employees from each shift. So, one of the things that helped was to leave a sheet which workers would fill with the time of the stop and with the alarm that was given by InterSystem. The sheet is in annex 7. The sheet was placed in the workstation for the operators to describe the stops

¹ Due to the low efficiency of this line, a Tetra Pak worker followed during a few months the production, helping the mechanics and the operators to solve the problems that occurred.

and the corresponding alarms. In the next day with this information, it was checked if the time and frequency pointed out by operators was the same as the one pointed by the machine. Through a combination with notes taken through observation, it was possible to understand that the frequency and duration of stops that appear in PLMS program were not translated. Some explanations to this situation were the fact that the same alarm corresponds to different types of problems and the fact that some alarms that appear in the palletizer monitor do not appear as a cause in the PLMS program. With this misinformation, it was impossible to cross data between the two sources. Neither of them was completely true since a 24h observation was not possible, and not all operators wrote the stops that occur and their time to solve.

Data collected *in loco* also shows that when a stop occurs, the equipment in line does not start working at the same time, there is a 10 seconds delay between the restart of Amba Flex (figure 11) and the Twinpack, and a delay of 30 seconds between the Twinpack and the Gampack. This increases the amount of time imputed to machines at the beginning of the line, which could explain why initially the effort to reduce stops were being focused in the filling machine and not in the distribution line.

The following images elucidate the situation where the same alarm appears because of completely different problems.

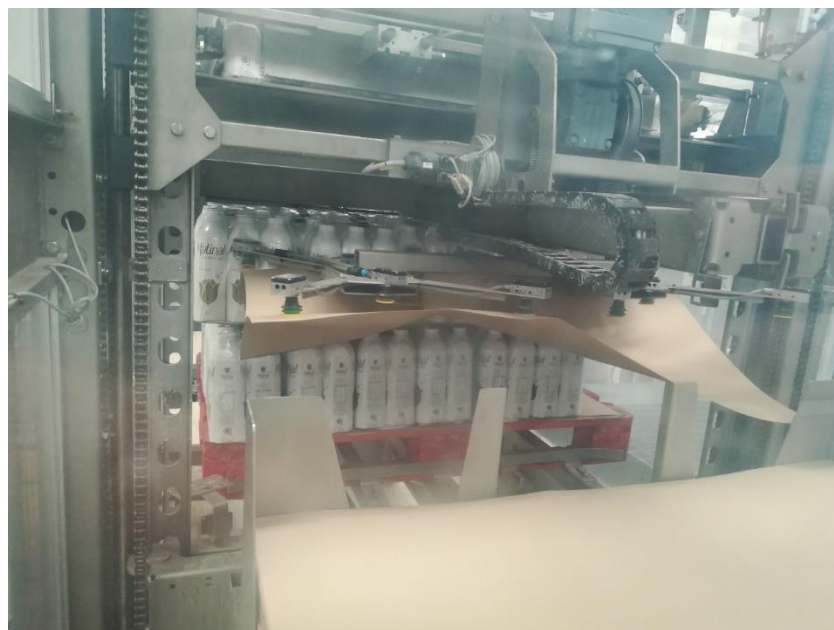


Figure 18 - Split conveyor blocked alarm 1



Figure 19 - Split conveyor blocked alarm 2

Looking at both figures, it is obvious that the problem is in completely different spaces of the machine. Nonetheless each time the palletizer stops for a malfunction caused by itself, as in these cases, it gives a visual and an audio alarm.

In addition to the monitor, each palletizer has its *andon*, but they are not instinctively visible to be allocated as the visual sign of each machine since they are distant from them and close to one another.

They are only distinguishable because their colors are different (see figure 20), the PL37 *andon* is green, orange and red, while the PL38 *andon* is green, blue and white. However, when it was questioned to the operators when each color would light up, they were not able to be sure about it.



Figure 20 - Andon PL37 and PL38

In figure 18, the elevator did not come down and the chain with the suckers that transport the paper between layers crashed against the packs.

In figure 19, a pack got stuck in the middle of both conveyors. To build a layer the packs go to the right or left, this movement is done by the blue conveyor that appears in the image. In this case, the pack did not go completely to one of the sides, preventing the continuity of the blue conveyor movements.

Undoubtedly, these two situations in different spaces and with different root causes should have a different alert.

Proposed Improvements:

Move the andons near to their respective palletizer, with clear information of the meaning of each light.

Redesign the physical separation between sides where the package got stuck (figure 17), which causes the blocking of the split conveyor.

Results: The proposed improvements were not implemented during the internship, nonetheless they are feasible solutions which, in the future, if implemented would alert more quickly operators to solve problems and prevent one recurrent error.

5. Conclusion, Limitations and Future Work

In this final chapter, the major intention is the outline of conclusions. It is fundamental to synopsise the project and understand the main contributions, not only for the success of the improvements proposed but also for the company.

The work developed at *Lactogal, Produtos Alimentares* and described throughout this document intends not only to improve the efficiency in Evero lines but also to reduce waste in the information and material flows during the distribution process. To support this project, an integration of different areas was performed, focusing on Lean Thinking concepts like 5S and OEE. It is important to recall that, by reducing waste in information and material flows, it is possible to make processes more agile.

Considering that the main goals of this work were to improve the production process, through the reduction of waste in the transportation of material, overstock and stops reduction. It can be said that in general, this work fulfilled the defined goals. However, there will always be opportunities for improvement, so it is important to understand the limitations of what was developed and suggestions for future work.

Throughout this work, several inefficiencies and problems were exposed. The problems identified in the first project, applying Lean in the shop floor, were mainly due to the information flow between the departments of logistics and production. Although it was made an effort to map the flows, it was not possible to achieve a blueprint of them. However, that was not a hindrance to propose improvements in other factors that were also contributing to inefficiencies. The main contribution of the proposed improvements for this first project was the introduction of a new way of thinking (Lean), that could potentially help increase the performance of the team.

In the second project, improving efficiency in Evero lines, the biggest limitation was that this report only presents data regarding the baseline situation. The proposed improvements were not fully implemented during my length of stay. This situation precludes a final comparison of data to assess if the improvements proposed would bring results. Therefore, testing the feasibility of the solutions proposed would be something to do in the future to give continuity to this study. For what was done in this project, it is still

possible to highlight its main contribution. In this case it shed light on the importance of data analysis to verify where the investments should be done to increase performance.

To conclude, improving a process in a company is not easy. When the improvements change the behavior of doing things, people will see it as something to avoid, making it hard to implement. It is recommended that the solution developed should be simple and practical. Also, everyone must be involved in the significant changes right from the start, to avoid the resistance to break the routine way of performing. If these new solutions are seen and showed as a way of improving and having better results, changes like the ones proposed in this exploratory study can be successful.

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ANNEXES

Annex 1 – Excel with a weekly plan

37									
Equip.	21/10/19 02:30	Qt	Q	Lav	Início	Fim	seg, 21/10/2019	ter, 22/10/2019	dom, 27/10/2019
Stork+AI52	LEITE CALÇAO MG 1L EIERO	31.000	7,5		21/10 02:30	21/10 06:38			
Stork+AI52	LEITE CALÇAO MG 1L EIERO	208.000	7,5	17:00	21/10 23:38	23/10 03:22			
Stork+AI52	LEITE UHT MATINAL MG 1L	240.000	7,5	6:00	23/10 09:22	24/10 17:22			
Stork+AI52	LEITE UHT MATINAL MG 1L	260.000	7,5	6:00	24/10 23:22	26/10 10:02			
38									
Equip.	21/10/19 03:30	Qt	Q	Lav	Início	Fim	seg, 21/10/2019	ter, 22/10/2019	dom, 27/10/2019
AI6+AI54	LEITE 0% LACTOSE MAGRO 1L	240.000	6,5		21/10 03:30	22/10 16:25			
AI6+AI54	LEITE UHT MATINAL LEITE 1L	120.000	7,5	6:00	22/10 22:25	23/10 14:25			
AI6+AI54	LEITE CRESQ +3AN 1L	30.000	7,5	6:00	23/10 20:25	24/10 00:25			
AI6+AI54	BEB LAC CRESQ +3AN 1L	48.000	7,5	1:00	24/10 01:25	24/10 07:49			
AI6+AI54	LEITE EQUILIB AMENDOIA 1L	18.000	7,5	6:00	24/10 13:49	24/10 16:13			
AI6+AI54	LEITE 0% LACTOSE MG 1L	240.000	7,5	6:00	24/10 22:13	26/10 06:13			
39									
Equip.	21/10/19 17:00	Qt	Q	Lav	Início	Fim	seg, 21/10/2019	ter, 22/10/2019	dom, 27/10/2019
A4+TA6	LEITE 0% LACTOSE MG 15L TPRM	19.000	1,05		21/10 17:00	22/10 11:05			
A4+TA6	LEITE 0% LACTO CH MG 15L TPRM	19.000	1,5	4:30	22/10 15:35	23/10 04:15			
A4+TA6	LEITE UHT MATINAL LEITE 15	9.000	1,5	4:30	23/10 08:45	23/10 14:45			
A4+TA6	LEITE PROTEINA CACAU (TAB 24)	15.000	1,5	4:30	23/10 19:15	24/10 05:15			
40									
Equip.	21/10/19 05:40	Qt	Q	Lav	Início	Fim	seg, 21/10/2019	ter, 22/10/2019	dom, 27/10/2019
ANS2+AI51	LEITE CIPOLÉ BANN 36X0,2L	7.500	1,75		21/10 05:40	21/10 09:57			
STRK+TA2	SUMOS REFRIG MACA 15L	22.320	1,7	3:00	21/10 12:57	22/10 02:04			
STRK+TA2	SUMOS REFRIG LARANJA 15L	20.800	1,6	5:00	22/10 07:04	22/10 20:04			
A4+TA6	BEB LAC CRESQ +3AN 15L	8.300	1,6	14:00	24/10 10:04	24/10 15:16			
A4+TA6	LEITE CICHOC AJUST 36X15,LM	19.000	1,6	4:30	24/10 19:46	25/10 07:38			
A4+TA6	LEITE CICHOC AJUST 36X15,LM	19.000	1,6	4:30	25/10 12:08	26/10 00:01			
A4+TA6	LEITE CICHOC AJUST 36X15,LM	19.000	1,6	4:30	26/10 04:31	26/10 16:23			

Annex 2 – Excel with stock per SKU

			Tampas					Painhinhas			Pegás			Etiquetas		Botões por				
	Qtd a produzir (l)	Qtd por pacote (l)	Nº pacotes por embalagem	Qtd por paleta	Qtd por caixa	Un tampa/L	Precisamos de x caixas	Qtd por paleta	Qtd por caixa	Un painhinha/L	Precisamos de x caixas	Qtd por paleta	Qtd por caixa	Un pegaj/L	Precisam os de x caixas	Qtd por caixa	Qtd/L	Precisam os de x caixas	Qtd (kg) por paleta	Qtd (kg) botão
MATIN.MG	40000	1	6	19 200	1 200	40 000	34					210 000	15 000	6666,667	1				538	29,8889
MATIN.MAGRO	20 000	1	6	19 200	1 200	20 000	17					210 000	15 000	3333,333	1				538	29,8889
0%LACT.MG EVE		1	6	19 200	1 200	0	0					810 000	22 500	0	0				538	29,8889
BEB.LACT.CRESC.1.3 IL		1	6	19 200	1 200	0	0					810 000	22 500	0	0				538	29,8889
CRANÇAS +3 EVE		1	6	19 200	1 200	0	0					810 000	22 500	0	0				538	29,8889
EQUILIB.AVEIA 1L EVE MI		1	6	19 200	1 200	0	0					810 000	22 500	0	0				538	29,8889
EQUILIB.AMENDOA 1L EVE MI		1	6	19 200	1 200	0	0					810 000	22 500	0	0				538	29,8889
CALCIO MAGRO		1	6	19 200	1 200	0	0					810 000	22 500	0	0				538	29,8889
CALCIO M/G		1	6	19 200	1 200	0	0					810 000	22 500	0	0				538	29,8889
BIOLOGICO MG PV Helicap		1	6	105 000	4 375	0	0					312 000		0	0	0			754	31
CONTINENTE M/G Helicap		1	6	105 000	4 375	0	0					312 000		0	0	0			754	31
CONTINENTE Magro Helicap		1	6	105 000	4 375	0	0					312 000		0	0	0			754	31
CONTINENTE Gordo Helicap		1	6	105 000	4 375	0	0					312 000		0	0	0			754	31
NATAS CHEF Helicap		1	6	105 000	4 375	0	0					312 000		0	0	0			754	31
MAÇÁ Helicap 1000cc		1	6	105 000	4 375	0	0					312 000		0	0	0			754	31
ANANÁS Helicap 1000cc		1	6	105 000	4 375	0	0					312 000		0	0	0			754	31
TROPICAL Helicap 1000cc		1	6	105 000	4 375	0	0					312 000		0	0	0			754	31
LARANJA Helicap 1000cc		1	6	105 000	4 375	0	0					312 000		0	0	0			754	31
MILSANI MAGRO		1	6									312 000		0	0	0			630,4	19,7
CONTINENTE MAGRO		1	6									312 000		0	0	0			630,4	19,7
MILSANI M/G		1	6									312 000		0	0	0			630,4	19,7
CONTINENTE M/G		1	6									312 000		0	0	0			630,4	19,7
GRESSO M/GORRO		1	6									312 000		0	0	0			630,4	19,7
CRANÇAS 3+ 1/5L		0,2	36									192 000	32 000	0	0				536,29	22,3
MORANGO 1/5L		0,2	36									192 000	32 000	0	0				536,29	22,3
BANANA 1/5L		0,2	36									192 000	32 000	0	0				536,29	22,3
CEREAS 1/5L		0,2	36									192 000	32 000	0	0				536,29	22,3
LEITE C/CHOC.AJUST		0,2	36									192 000	32 000	0	0				536,29	22,3
NATAS UHT S/LACTOSE		0,2	36									192 000	32 000	0	0				536,29	22,3

Annex 3 – Stock Identification System in PSA

Material	Quantity	Place	Reception Day	Check out Day	Operator
Yellow Straws	4 Boxes	B3	4/3/2020	6/3/2020	

Annex 4 – Top 5 of stops frequency in Line 39

Line Labels	Frequency	Average Time	Total Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Conveyor/Distribution Equipment	339	00:29:50	171:17:22	x	x	x					x	x	x	x	x
Engine Start	284	00:00:24	1:53:55	x	x	x	x	x	x	x	x	x	x	X	X
The line is not ready	202	00:22:07	82:47:04	X		x					x	x	x	x	
Indexing unit, failure of the servomechanism	151	00:07:58	19:52:00		x	x	x	x							
Exit unit, failure of the servomechanism	134	00:14:25	25:12:50		x		x	x	x		x				x
TOTAL	1110		301:03:11												

Annex 5 – Top 5 of stops frequency in Line 28

Line Labels	Frequency	Average Time	Total Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Engine Start	473	00:00:26	3:29:07	x	x	x	x	x	x	x	x	x	x	x	x
Exit, failure of the servomechanism	399	00:10:45	73:10:22	x	x	x	x	x	x	x		x	x	X	X
FW32: Crash Guard	308	00:22:16	114:39:49	X	x	x	x	x	X	x	x	x	x	x	x
Exit, obstruction in the packaging conveyor	127	00:11:02	25:37:55	x	x	x			x	x					
CBP32: Open door	111	00:25:08	40:57:50				x	x			x	x	x		
TOTAL	1418		257:55:03												

Annex 6 – Top 5 of stops frequency in Line 40

Line Labels	Frequency	Average Time	Total Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Conveyor Obstruction	1024	00:30:56	526:59:23	x	x	x	x	x	x	x	x	x	x	x	x
Engine Start	386	00:00:25	2:40:23	x	x	x	x	x	x	x	x	x	x	X	X
Exit, failure of the servomechanism	196	00:09:36	28:55:49			x		x					x	x	x
Conveyor/Distribution Equipment	158	00:33:56	92:34:11	x	x	x	x	x		x	x	x	x	x	
Exit, obstruction in the packaging conveyor	161	00:19:22	26:01:17		x	x	x		x				x		x
TOTAL	1925		677:11:03												

Annex 7 – Palletizer sheet to describe stops

[illegible]