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# Integrating Ergonomics with Lean Six Sigma on a meal solutions industrial kitchen

Dissertação para obtenção do Grau de Mestre em
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# ABSTRACT

The integration of Ergonomics with Lean and Six Sigma are the foundations of this dissertation. Lean Six Sigma (LSS) philosophy has already proven its worth through several successful implementations in the most varied kind of industry. Several researchers are complementing Lean Six Sigma values and prepositions with other disciplines, so that improvement doesn't concern only the processes flow, but also the entire ecosystem with it. Therefore, Ergonomics integrates perfectly with LSS, not only in a sense of concerning about employees while LSS concerns about processes, but also helping to improve efficiency. It should be integrated on the core of every company's management team.

This dissertation focuses on studying the production system of an Industrial Kitchen which produces ready-to-eat (RTE) meals for Pingo Doce retailer. The aim was to apply Ergonomics, Lean and Six Sigma's principles in an integrated form, in order to improve the Kitchen's productivity and efficiency. The HACCP standards are crucial in a food industry of this kind so were, therefore, considered at all times. The methodology utilized was a holistic approach of the DMAIC cycle, including Ergonomics in all stages and HACCP especially in the Improve phase.

This case study brought added value to the company by achieving the initially proposed goals, regarding elimination of waste and productivity increase by 16% in 2015 vs 2014 results, always focusing on the well-being of employees. The operational costs decreased 18%, overcoming the initially set goal of 6%.

Developing this project has made it possible to understand the applicability of the utilized methodology and the impact it may have in all kinds of industries, as well as its limitations. The DMAIC cycle, together with all the other LSS implemented tools, proved their worth when it comes to planning and implementing a project of this kind. They are simple to apply and highly effective.

The approached theme – and the integration of other disciplines with LSS – should be applied in different industries, so that broader conclusions can be made while continuously improving the implementation strategy and proving its value.

**Keywords:** Ergonomics, Lean, Six Sigma, DMAIC, industrial kitchen, HACCP, ready-to-eat meals, meal solutions, food industry

# SUMÁRIO


Esta dissertação tem como fundamento a integração da Ergonomia com o *Lean* Seis Sigma. A filosofia *Lean* Seis Sigma (LSS) tem vindo a provar o seu valor através de várias implementações bem-sucedidas nos mais variados tipos de indústria. Adicionalmente, vários autores complementam os valores e princípios inerentes ao *Lean* Seis Sigma com outras disciplinas e filosofias, para que as suas melhorias não se cinjam ao fluxo produtivo, mas se estendam também a todo o ecossistema envolvente. É desta forma que a Ergonomia se envolve perfeitamente com o LSS. Não apenas por se preocupar com as pessoas enquanto o LSS se ocupa dos processos produtivos, mas também para ajudar a melhorar a eficiência do sistema como um todo. Deveria ser parte integrante de qualquer equipa de gestão de uma empresa.

O estudo desta dissertação baseou-se no sistema produtivo de uma Cozinha Industrial que produz refeições prontas para a companhia de retalho portuguesa Pingo Doce. O objetivo é a aplicação dos princípios e valores da Ergonomia, *Lean* e Seis Sigma de uma forma integrada para melhorar a eficiência e produtividade desta companhia. As normas de segurança alimentar são cruciais nesta indústria, portanto as regras de HACCP foram consideradas como imperativas durante todo o projeto. A metodologia utilizada foi uma abordagem holística do ciclo DMAIC, que inclui a Ergonomia em todas as fases deste ciclo e as restrições impostas pelo HACCP em especial na fase *Improve*.

Este caso de estudo trouxe valor acrescentado para esta empresa, na medida em que atingiu os objetivos inicialmente propostos, relativamente à eliminação de desperdícios e aumento da produtividade em 16% em 2015 face aos resultados de 2014, simultaneamente com o foco no bem-estar de todos os operadores. Os custos operacionais decresceram 18%, ultrapassando o objetivo inicialmente proposto de 6%.

Com este projeto foi possível perceber a aplicabilidade da metodologia utilizada e o impacto que poderá ter em qualquer tipo de indústria, bem como as suas possíveis limitações. O ciclo DMAIC e as ferramentas de LSS implementadas provaram ter grande valor no planeamento e implementação de um projeto deste tipo, além de serem de simples aplicação e elevada eficácia.

O tema desenvolvido - bem como a integração de outras disciplinas com o LSS - deveria ser aplicado em mais indústrias para que se possam tirar conclusões mais alargadas, melhorar continuamente as estratégias de implementação e provar o valor do mesmo.



**Palavras-chave:** Ergonomia, Lean, Seis Sigma, DMAIC, cozinha industrial, HACCP, refeições prontas, indústria alimentar

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CCP – Critical Control Points

CTD – Cumulative Trauma Disorder

CTQ – Critical to Quality

DFSS – Design for Six Sigma

DMADV – Define-Measure-Analyse-Design-Verify

DMAIC – Define-Measure-Analyse-Improve-Control

DPMO - Defects Per Million Opportunities

DPO – Defects Per Opportunity

DPU – Defects Per Unit

DOE – Design of Experiments

FMEA - Failure Modes and Effects Analysis

FTE – Full Time Employee

HACCP – Hazard Analysis and critical control points

HFE – Human Factors Ergonomics

IEA – International Ergonomics Association

IDOV – Identify-Design-Optimize-Validate

JIT – Just in Time

JM – Jerónimo Martins

KPI – Key Process Indicator

KRI – Key Result Indicator

LESS – Lean Ergonomics and Six Sigma

LSS – Lean Six Sigma

MRP – Material Requirement Planning

NNVA – Necessary but non-value adding

NVA – Non-value adding

OSH – Occupational Safety and Health

PD – Pingo Doce

PDCA – Plan-Do-Check-Act

PI – Performance Indicator

PPE – Personal Protective Equipment

RI – Result Indicator

ROI – Return on Investment

RTE Meals – Ready to Eat Meals

SIPOC – Supplier-Input-Process-Output-Customer

SMED – Single Minute Exchange Die

SOP – Standard Operating Procedures

SPC – Statistical Process Control

SQC – Statistical Quality Control

TPM – Total Productive Maintenance

TQM – Total Quality Management

TPS – Toyota Production System

VA – Value-adding

VOC – Voice of Customer

VOE – Voice of Employee

VSM – Value Stream Mapping

WIP – Work in Progress

WRMSDs – Work Related Musculoskeletal Disorders

# 1 INTRODUCTION

In the present chapter an introduction to the work developed is made. Starting with the subject-matter overview, a brief explanation about the outlined objectives and methodology used is given, finishing with an overview of the structure of this dissertation.

## 1.1 OVERVIEW

Nowadays focus on new management strategies for detaching a company or a project from the rest of the market is what everyone looks for. The competitiveness is everyday increasing with new easier ways to build a start-up from scratch and make it grow into a considerably fearless competitor, along with new exciting developments in the scientific area and third world countries gaining economic power. Well, as the laws of nature dictate, either adapt or die, so companies must do their best to keep up to a faster and more dynamic world. Fulfilling their mission in a more effective and efficient way, with fewer resources than its competitors, is what makes an organization better or even the best.

Also, we live in the age of information and the population is better educated than it was a decade ago, so human resources are starting to be seen as a gold mine rather than cannon fodder. A lot of companies already understood that in spite of all the technology implemented and all the strategies adopted, what actually matters is people. So, to achieve a good performance, the companies need to go along with technological developments but also to allow and provide good environmental work conditions (Maia, Alves, Leão, 2012).

Regardless the market or the type of job, the work force must be motivated, inspired and with the best conditions possible in order to lead the company to success. A lot of studies have already shown that a person's motivation and personal well-being is directly linked to its reference.

Therefore, improving all the parameters in a company's structure and throughout all the supply chain where it belongs is a goal every manager should look for achieving. The quest for perfection is utopic but it is what leads to continuous improving – always trying to do best.

Just as "mass production" is viewed as the production system of the 20th century, "lean manufacturing" is becoming the production system of the 21st century (Nunes & Machado, 2007).

The implementation of the Lean paradigm on production allows the company to meet the pre-set goals, improving competitiveness. When engaging the methodologies of the Lean approach, the organization can rationalize and reduce waste, focusing on the activities that add value to its customers. Consequently, the production flexibility rises, so does product quality. Citing Womack and Jones (2003), the [lean] value equation is very simple: to get from where we are to where we want to be safely with the least hassle at a reasonable price.

On the other hand, according to Montgomery & Woodall (2008), Six Sigma is a disciplined, project-oriented, statistically based approach for reducing variability, removing defects, and eliminating waste from products, processes, and transactions. The Six Sigma initiative is a major force in today's business world for quality and business improvement. Therefore, using Lean Six Sigma allows a company to better solution, in a competitive way, the needs of each client, reducing mainly the production costs. Since the two philosophies have a common objective for production capacity and waste elimination, they shape as complementary instead of antagonist (Nunes, Gouveia, Figueira & Cruz-Machado, 2012).

Linking this management strategy with Ergonomics it's what can take a company a step ahead. Both Lean and Six Sigma philosophies are very important to reach a good productive performance. However the impacts may be very demanding from a human physiological perspective, because the intended goal is to ensure maximum production with minimum resources. Considering this fact, Ergonomics has a great relevance during the implementation of these paradigms, in order to preserve good health, well-being and safety of workers (Freitas & Nunes, 2015). Hence, the implementation of the Lean Six Sigma management paradigm together with the Ergonomics principles have the ability to empower the workers, motivating them with more conditions, smarter processes and the tools to make a difference.

## 1.2 OBJECTIVES

The present work intends to increase both productivity and the work and ergonomic conditions in Pingo Doce's Industrial Kitchen. Since it's a food industry dealing with final products, the rules and restrictions imposed by the HACCP control were also taken into consideration. Hence, this project is based on a holistic approach combining synergies between Lean, Six Sigma, Ergonomics, HACCP and Sustainability disciplines. Sustainability comes in place due to the importance of sustaining the gains achieved and ensuring the company's success in long term.

Through a detailed background research it is possible to better understand the Lean Six Sigma management paradigm and the Ergonomics fundamentals, by studying the main concepts and looking at recent case studies that approach these themes, even if individually opposed to the actual integration here proposed. After the theoretical background is covered, a practical study of the environment of the industrial kitchen is done in order to apply the previously considered concepts. With this case study methodology, three main goals are set:

1) Identification and characterization of the company's production system, specifying several improvement opportunities;
2) Use of the synergies amongst the previously referred disciplines to study how to increase productivity while improving work and ergonomic conditions in the Kitchen;
3) Definition of improvement proposals that match the global objectives of the company.

The outlined objectives for this project therefore reside on the improvement of productivity and enhancement of the production capacity of this Industrial Kitchen, while preserving and cultivating the health, well-being and safety of all employees, thus ensuring a motivational work environment.

The reason for choosing the presented theme was the author's interest in further exploring the Lean Six Sigma paradigm together with Ergonomics, because it is a "new" field with much to explore, and the belief that a lot of good results can come from a wider inclusion of Ergonomics in the companies' management strategies.

## 1.3 METHODOLOGY

The research methodology used was a literature review focused on the Ergonomic tools and Lean Six Sigma methodologies, preferentially on a food industry environment. The keywords used in the search were mainly: "Ergonomic tools", "Ergonomics and Lean", "Ergonomics", "Lean Production", "Lean Six Sigma", "DMAIC", "Catering", "HoReCa", "Industrial Kitchen", "Ready-to-Eat meals", "HACCP", "Ergonomics and Sustainability". The data bases used were essentially RUN, Science Direct, Taylor&Francis Online, Scielo, Researchgate.net, Intech, Elsevier and the FCT-UNL library.

The case study methodology applied throughout this dissertation was developed in several phases and adapted along the way, so as to enfold as many improvement opportunities as possible, in a sequential and organized manner.

Firstly, the production process is observed and studied step by step with the intent of unfolding the extant opportunities for improvement. This stage is developed by accompanying the daily work routine for over a month, observing each area separately and fulfilling some of the tasks so to fully understand the hidden problems within each process.

With this first approach then follows the theoretical background research aiming to disclosure the most suited tools and methodologies. Also, decisions had to be made concerning the scope of this study, since there are many operations within the kitchen process and a large number of products are made there, some of them seasonally.

At this stage, a profounder knowledge of the Lean Six Sigma paradigm, of the Ergonomics science and how they combine together to achieve greater efficiency was acquired, allowing for a better understanding, evaluation and implementation of the possible improvements in this process. The HACCP procedures, standards and rules were considered at all times, requiring a superficial background research so to better understand the restrictions on the production flow.

After studying all the operations in detail and deciding how to narrow the scope, a specific methodology was designed, based on the Six Sigma’s DMAIC approach. In each phase, the adequate tools were applied to improve the process both from a productivity and an ergonomic point of view. Taking into account the DMAIC cycle, firstly the production structure and problems are identified – Define phase; in the Measure phase, the process was measured concerning operations’ length and sequence and process capability. Also the KPIs – Key Performance Indicators - were defined; then comes the Analyse phase, where the causes for the observed problems were explored; the Improve phase covered specific suggestions of how to tackle identified problems; finally, the Control phase aimed at discovering how to sustain the improvements made.

The applied methodology is therefore the “case study” one, mentioned by Robert Yin (2013) in his book. From the three existing types of study case referred by (Yin, 2013) – descriptive, exploratory and explanatory – the present work focuses on the descriptive and exploratory ones. Firstly, the processes and projects developed in the kitchen are analysed and described. After that, a new project is explored and proposed to the company, aiming to improve the kitchen process.

Table 1-1 illustrates the dissertation work plan and timings defined by the author. This plan was a useful guide for the work developed during this six months.

*Table 1-1: Dissertation plan and timings*

| | January | February | March | April | May | June | July |
|---|---|---|---|---|---|---|---|
| **Integration in the company** | ■ | | | | | | |
| **Study of the kitchen's process** | ■ | ■ | ■ | ■ | ■ | ■ | |
| **Waste identification** | ■ | ■ | ■ | ■ | | | |
| **Improvement opportunities identification** | ■ | ■ | ■ | ■ | | | |
| **Background research** | | ■ | ■ | ■ | ■ | | |
| **Current situation analysis** | | | ■ | ■ | ■ | | |
| **Improvements implementation** | | | | | ■ | | |
| **Improvements analysis** | | | | | | ■ | |
| **Conclusions and future work** | | | | | | ■ | ■ |
| **Dissertation writting** | | | ■ | ■ | ■ | ■ | ■ |

## 1.4 DISSERTATION'S STRUCTURE

This dissertation unfolds in five chapters, including the present one - Introduction, where a general explanation about the work developed, overview of the subjects discussed, objectives and methodologies used are presented. The dissertation's structure is presented on Figure 1-1.

On the second chapter the theoretical background is presented, aiming to frame this study, founding the usage of certain tools and methodologies on the case study. The concepts explored are, therefore, Lean (and Kaizen), Six Sigma, Ergonomics and HACCP, as well as all the connections between these.

On the third chapter the applied methodology of the case study is scrutinized, explaining the steps taken and why and how the project was developed, giving the motto to the fourth chapter where the case study is described. The organization's overview is presented here, providing context to the practical case study application.

Accordingly to the theoretical fundamentals stated on the second chapter, the company's characterization and the approach presented on the third, the areas and operations amenable for improvement are exposed for analysis, studied and improvement actions concretized. The results from the projects development are also represented on the results chapter.

Finally, the last section presents the conclusions of this study as well as future work considerations. The following are also covered: an evaluation of the work developed in order to assess its success, a collection of the restrictions and difficulties found, the objectives accomplished and future ways to further develop the issue that cannot be pursued in this dissertation.

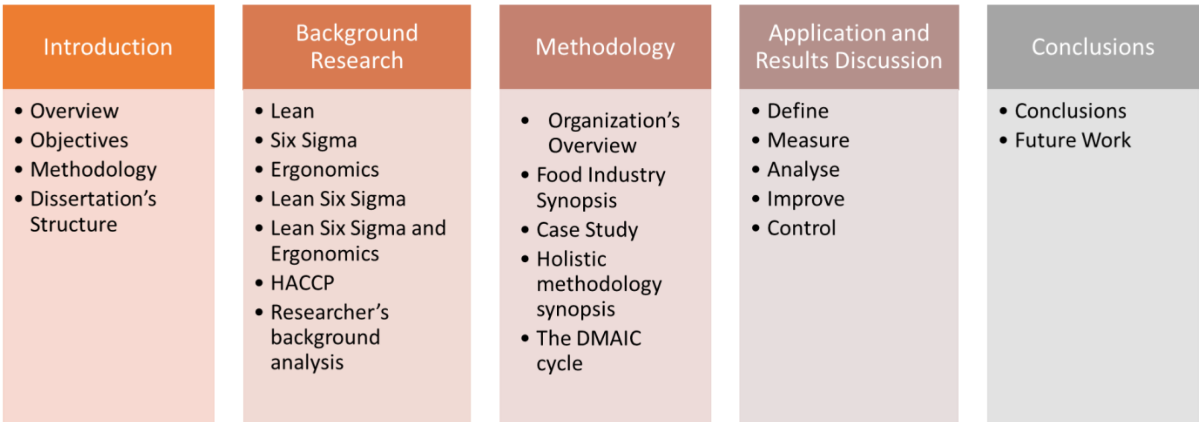


*Figure 1-1: Dissertation's Structure*

# 2 BACKGROUND

This chapter intends to give a theoretical overview of the matters discussed and used as basis for this study. Being that, it is here presented a detailed background research on the Lean Six Sigma management philosophy and the Ergonomics role on organizations. Its tools and methodologies are also revealed so to further understand the work developed.

The revised information is organized into seven main sections. First the role of Lean paradigm is explored. Secondly the same happens with the Six Sigma philosophy and respective tools and its application on industry. Then the integration of these two is discovered through the Lean Six Sigma management paradigm, so to understand how they combine and complement each other. Next comes Ergonomics – what is it and how does it fit on an industry management concept. Following comes the consideration of how Ergonomics integrates with Lean and Six Sigma in an organizational viewpoint. This is the crucial point of this background study, giving understanding for the following project. Additionally, a background overview on HACCP is needed to contextualize the food industry and the restrictions dealt with during the application of this study's methodology. Finally, it is here presented the researcher's background analysis giving a synopsis and the researcher understanding on all this background information.

This literature review involved consulting several specialty magazines, articles, master's thesis, books and the internet. For academic articles and master's thesis a time horizon of 10 years was demarcated, so to use up-to-date and relevant information. Exception made to some specific studies and authors whose work is a timeless reference.

## 2.1 LEAN PARADIGM

The concepts and history of the Lean paradigm are presented here in a structured manner through subchapters. Firstly, the origins and definition of the concept, including the concepts that constitute the pillars of this paradigm, are presented. Following comes the benefits and constraints of implementing such paradigm, presented through examples and case studies. Finally, the tools and methodologies inherent to the Lean paradigm are exposed.

### 2.1.1 CONCEPTS AND EVOLUTION

The Lean philosophy had its origins in Japan, on the Toyota Production System (TPS), by the end of World War II (Yasuhiro Monden, 1993). Toyota has worked since the late 1940s to develop and hone an operations philosophy which cuts costs and lead time within their factories without sacrificing quality or customer service (Womack, Jones and Roos, 2007). This philosophy totally opposed to the production systems practiced at that time. The occidental companies produced massively, focusing on big volumes and minimal system flexibility (Womack & Jones, 2003). Hence, Eiji Toyoda - founder of the Toyota Motor Company - and its production director, Taiichi Ohno, concluded that mass production would never thrive in Japan (Womack, et al., 2007). So, they created Toyota Production System (TPS), taking into account some restrictions like the big variety of products acquired by the market; workers' manifestations demanding better work conditions and more responsibility within the companies; the impossibility of mass importation of occidental technology; and the high competition existent in the automobile industry. This system in essence shifted the focus of the manufacturing engineer from individual machines and their utilization, to the flow of the product through the total process (www.lean.org). Its main objectives are waste elimination and client satisfaction (Ohno, 1997).

According to the TPS philosophy, quality improvement would be obtained essentially through the reduction of flaws and rework on the production processes. This production system also had the ambition of reducing investment costs, opposed to costs due to non-quality, services, equipment maintenance, raw materials and extra man-hours. The objectives of reducing lead time, production time, stocks and increasing equipment availability were also set (Womack, et al., 2007).

As cited in us.kaizen.com, the Toyota Production System is constantly evolving, based on the fundamental principles of respect for people and *kaizen* (continuous improvement) and towards the ideal condition which can:

- Make what the customer needs, at the right time and in the right amount
- Minimize inventories of all types
- Build quality into the process and prevent errors from happening
- Separate machine work from human work and fully utilize both
- Reduce change over times and lead-times
- Respond flexibly to customer demands and schedule changes
- Produce a high mix of low volume products efficiently

The time when investing in high performance machines or top technology meant competitive advantage has passed. Machines don't replace workers when it comes to the ability of thinking, analysing, creating, developing or the flexibility of doing any task necessary (Takeuchi, et al., 2008).

The *Lean Production* term was firstly utilized by the investigator John Krafcik, from the Massachusetts Institute of Technology, to designate the TPS system because it used less of everything compared with the mass production system. Meaning, less human effort, less fabric floor, less storage space, less investment in tools, less hours developing new models, less defects and less stock (Womack, et al., 2007).

Over the time, a lot of characterizations were made to the Lean Production system, by various authors. Womack, et al. (2007) define it as a "*System that requires half the human effort, half the fabric floor, half the investment and half the time to develop a new product*"; Bhasin & Burcher (2006) say "*It intends to continually reduce the time between the client's order and its delivery, eliminating everything that adds time and cost"*; while Cruz-Machado (2007) talks about the primary meaning - "*the word Lean has a vague translation to thin or skinny, meaning that if something is lean, it doesn't have anything more than the absolute necessary. Lean production focus essentially on process optimization, aiming to reduce or eliminate activities that don't have added value*"; Shah & Ward (2007) say it is "*a technical and social system which main objective is waste elimination, reducing or minimizing suppliers, clients and internal variability*"; finally, Hopp & Spearman (2004) characterize lean production as "*a system that minimizes costs associated with high lead time and stock or capacity excess*".

Lean Production has then evolved to a school of thought, Lean Thinking. The primary goal of lean thinking is to increase profit by reducing cost and increasing productivity. This is achieved through the elimination of all the waste in the system (Monden, 2011). The lean philosophy principles were initially applied to motor's production in the 50s. On the following decade extended to assembly lines and by the 70s were covering the entire supply chain (Hines, Holweg & Rich, 2004). From 2000 and onwards, the lean concept has involved a greater degree of contingency and the scope has been enlarged to include the organizational learning perspective (Nordin, et al., 2012). Hence, currently the Lean concept is applicable to either production or services and also to every link in a supply chain. Any type of production system is susceptible of producing waste and not adding value to its client. In short, lean thinking is "lean" because it provides a way to do more and more with less and less, while coming closer and closer to providing customers with exactly what they want (Womack & Jones; Daniel T., 2003).

There is a big variety of tools and methodologies that support the principles of the Lean paradigm. All these are used aiming to insure that all productive processes add value to the client and that activities that don't add value are eliminated and a continuous production flow is established without any waste (Melton, 2005). *Waste* is defined as something for which the client is not willing to pay. On Table 2-1 the different practices from the Lean philosophy and their characteristics are presented, according to a literature revision by Pettersen (2009).

*Table 2-1: Lean practices and their characteristics (adapted from Pettersen, 2009)*

| Lean Practices | Characteristics |
|---|---|
| JIT (just-in-time) | • Production levelling (Heijunka)<br>• Pull system (Kanban)<br>• Production according to Takt Time<br>• Process synchronization |
| Resources reduction | • Producing in small batches<br>• Waste elimination<br>• Reduction of setup time (SMED)<br>• Reduction of lead time<br>• Reduction of stock |
| Human relations management | • Teams' organization<br>• Multidisciplinary training<br>• Workers' involvement |
| Improvement Strategies | • Improvement circles<br>• Continuous improvement (Kaizen)<br>• 5 Whys analysis |
| Defects control | • Automation (Jidoka)<br>• Failure prevention (Poka-Yoke)<br>• 100% inspection<br>• Lines stoppage (Andon) |
| Supply chain management | • Mapping the value flow (Value Stream Mapping, VSM and flow charts)<br>• Workers' involvement |
| Standardization | • 5S<br>• Standard Work<br>• Visual management and control |
| Scientific management | • Policy deployment (Hoshin Kanri)<br>• Study of the work/time<br>• Multi manning<br>• Reduction of the work force<br>• Layout adjustments<br>• Cellular manufacturing |
| Group techniques | • Statistical quality control (SQC)<br>• Total productive maintenance (TPM) |

Carvalho (2010) sets a time frame for Lean evolution from 1850 to 1990, represented on Figure 2-1, where it is possible to see the origin and progress of some of the tools and methodologies previously exposed.

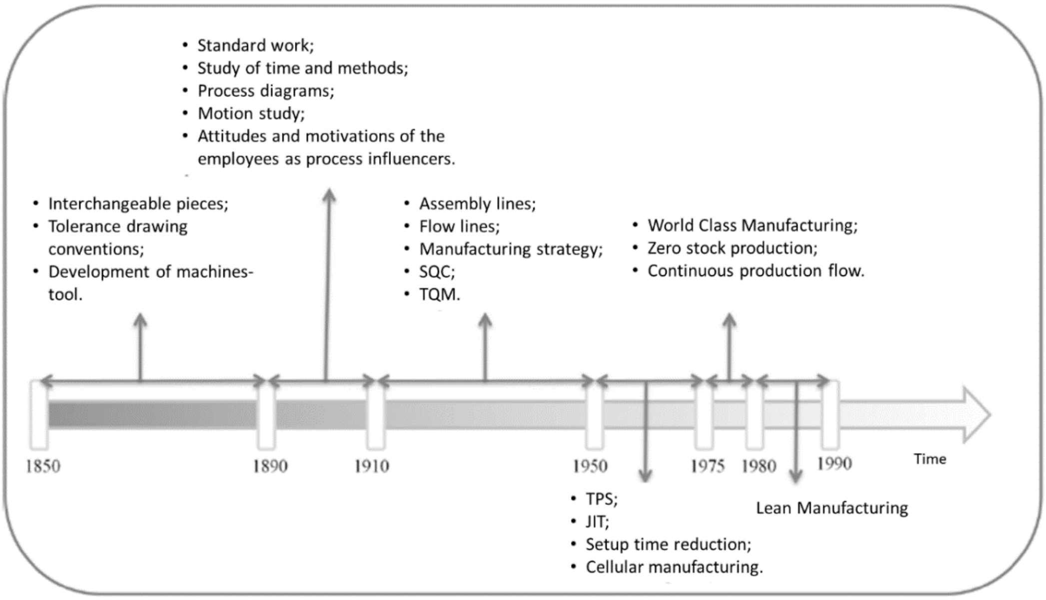


*Figure 2-1: Evolution of the Lean paradigm (adapted from Carvalho, 2010)*

The lean production concept was to a large extent inspired by the *Kaizen*, a Japanese strategy of continuous improvement (Nunes & Machado, 2007). The word *kaizen* comes from the Japanese language, meaning change (*kai*) for better (*zen*). The Kaizen philosophy consist on the improvement of an organization as an whole, including management, production, human labour, resources and existent materials (Ohno, 1997). The expected interaction and outcome of a kaizen implementation are represented on Figure 2-2, adapted from Freitas (2014).

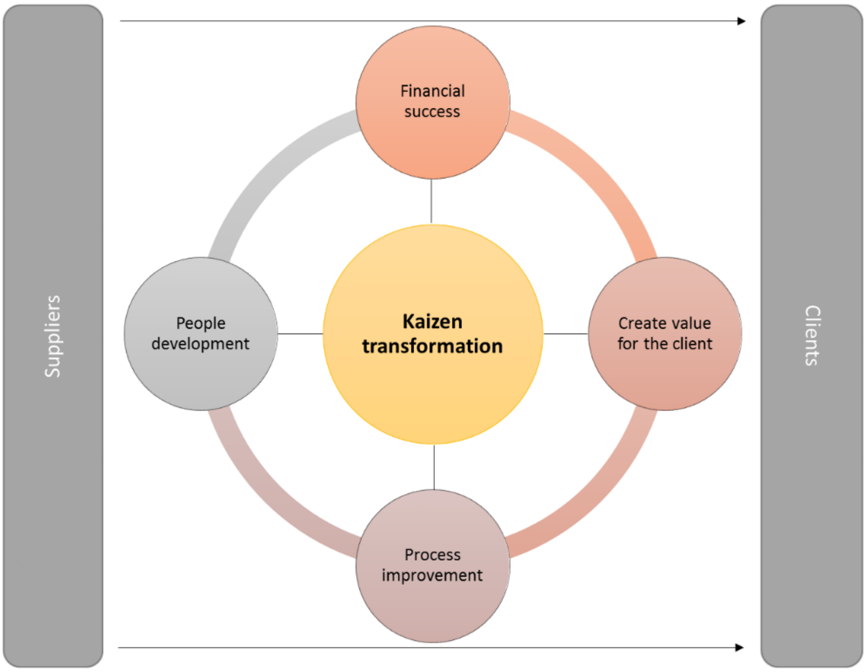


*Figure 2-2: Expected interaction on a kaizen implementation (adapted from Freitas, 2014)*

Disruptive innovation goes forward through big steps and creates great technological leaps. On a company where the continuous improvement culture doesn't exist, innovation can conduct massive improvement. The risk is that this improvement is not sustained and therefore excellence cannot be achieved (Almeida, 2012). On Table 2-2, Almeida (2012) makes the comparison between innovation and continuous improvement.

*Table 2-2: Continuous Improvement vs Innovation (adapted from Almeida, 2012)*

| | Continuous Improvement | Innovation |
|---|---|---|
| **Principle** | Good knowledge of the work, with the possibility of improving carrying little costs | Improvement is based on using the most recent techniques on the market |
| **Habits** | Little change executed in small steps | Big modifications |
| **Workers** | Participate in the changes | Are confronted with facts |
| **Reliability** | Equal or better | Training and more frequent malfunction |
| **Investment** | Low | High |
| **Maintenance** | Equal or less | Unknown, sometimes very high |
| **Amortization** | Amortized or very low cost | High |
| **Efficiency** | Small improvement in a short period of time | Great improvement in a long-term perspective |

The five pillars that are the basis for Lean manufacturing evolved from the basic concepts of the Toyota Production System Model of Excellence, represented on Figure 2-3 from the us.kaizen.com source.

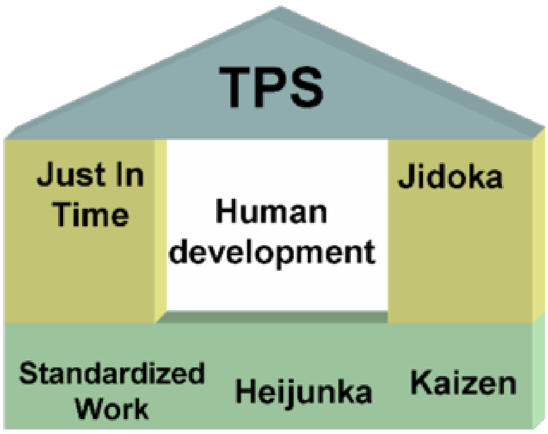


*Figure 2-3: TPS Model of Excellence (from us.kaizen.com)*

In order to satisfy the inherent concepts of JIT (left pillar) it is necessary to implement a production system that allows a continuous manufacturing flow. Based on this need, "pull" is born. The idea is that the client pulls the production, meaning the product is only manufactured from the moment the client orders it on. This way producing exactly what is needed, when is needed (Womack & Jones; Daniel T., 2003). According to Liker & Morgan (2006), the JIT practice differentiates from the traditional approach with the following goals: zero defects, zero setup time, zero stocks, zero movements, one-piece batch.

Besides JIT, *Jidoka* – Japanese term meaning automation – constitutes the other pillar for TPS. According to Silveira & Coutinho (2008), this concept consists in machine automation allowing more efficiency and control over the processes. Also, *Jidoka* enables the operator autonomy in a way that he can stop the production when some abnormality occurs. This can improve quality control, once the problem is solved once it is spotted, and avoid rework at the end of the process. Quality rates and product reliability increase. *Jidoka* frees the worker from constantly supervising one machine, allowing him to either supervise a group of machines or perform other tasks (Liker & Morgan, 2006). Without this concept, the machine can work *for* the operator but not *instead of* the operator.

At the centre is human development. In past decades, the TPS concept has progressed from a technical oriented aspect to human oriented aspect. The human elements in lean manufacturing share the company's vision and team-work, which include labour flexibility, multi-skilled aspect, and greater responsibility in maintenance, quality improvement, and personnel issues (Nordin et al., 2012).

The thought process of Lean was thoroughly described in the book *The Machine That Changed the World* (1990) by James P. Womack, Daniel Roos, and Daniel T. Jones. In a subsequent volume, *Lean Thinking* (1996), James P. Womack and Daniel T. Jones distilled these lean principles even further to five. These principles are schemed on Figure 2-4, from www.lean.org.

1. **Value** - Products should be designed for and with customers, should suit the purpose, and be set at the right price.
2. **Value stream** - Each step in production must produce value for the customer, eliminating all sources of waste. The concept of waste (*muda*) is far-reaching and may include waiting, travel, mistakes, or inappropriate processing.
3. **Flow** - The system must flow efficiently, ideally without intermediate storage. Among other things, flow depends on materials being delivered, as and when they are needed, to the quality required.
4. **Pull** - The process must be flexible and geared to individual demands – producing what customers need when they need it.
5. **Perfection** - The aim is perfection. Lean thinking creates an environment of constant review, emphasizing suggestions from the "floor" and learning from previous mistakes.


*Figure 2-4: Lean principles (from www.lean.org)*

According to Almeida (2012), the assumptions attached to these principles are that:

- Flow becomes easily managed visually;
- Waste is the main profit restrictor;
- The quick implementation of a series for small improvements can make the system more efficient than an analytical study about it;
- The interdependence effect between the system actions, that create constraints, can be overcome through the continuous improvement of the value chain.

Lean thinking must start with a conscious attempt to precisely define value in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers. Specifying value accurately is the critical first step in lean thinking. Providing the wrong good or service the right way is *muda* (Womack & Jones; Daniel T., 2003). Hence, the main objective of the Lean management paradigm is to increase the value creation through waste reduction, meaning, create more value with fewer resources.

## I. VALUE AND WASTE (*MUDA*)

Very often, more than 95% of the time a worker spends on the factory is not being used to add value to the product. Regarding the WIP materials, more than 95% of its time is spent on a warehouse waiting to be transported, processed or inspected. On the other hand, a machine can be producing unnecessary of abnormal products, be broken or in need for maintenance (Suzaki, 1993). According to Liker & Morgan (2006), on any generic process, waste can represent up to 95% of its total time. Simultaneously, companies traditionally guide their effort to increase productivity on the areas that already add value to products, instead of eliminating the activities that don't.

To identify “value”, from the costumers’ perspective, is important to answer the questions: What do clients want? When and how do they want it? What combination of resources, abilities, availability and price is the ideal one for the client? This way, the clear definition of value on a product or service, leads us so that the activities that don’t add value to the process are studied and, posteriorly, eliminated (Hines et al., 2004).

*Muda* is the Japanese word for “waste”, specifically any human activity which absorbs resources but creates no value: mistakes which require rectification, production of items no one wants so that inventories and remaindered goods pile up, processing steps which aren’t actually needed, movement of employees and transport of goods from one place to another without any purpose, groups of people in a downstream activity standing around waiting because an upstream activity has not delivered on time, and goods and services which don’t meet the needs of the costumer (Womack & Jones; Daniel T., 2003).

The seven types of waste identified by Taiichi Ohno (1912-1990), are represented on Figure 2-5 from (Hines, et al., 2011). Its individual description is explicated on Table 2-3 adapted from (Walder, Karlin & Kerk, 2007).

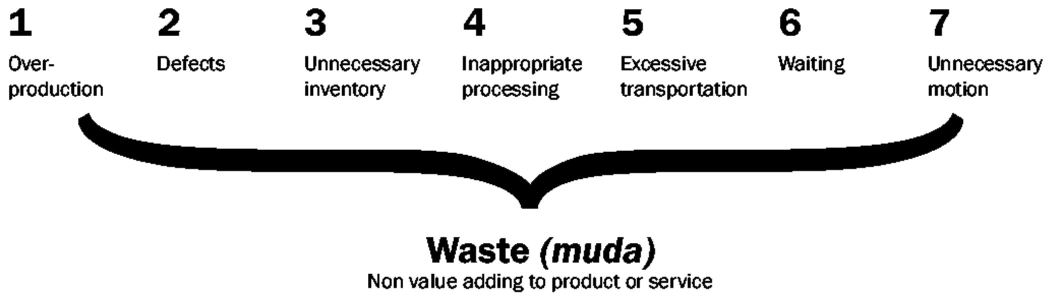


*Figure 2-5: The seven types of waste (from Hines, et al., 2011)*

Many practitioners and teachers of lean thinking add an eighth type of waste: the underutilization of the workers. The authors of the renowned *The Machine that Changed the World* book were the first to do it (Walder et al., 2007). Liker & Morgan (2006) in their analysis on Toyota, identified that the lean concept operates on two main principles: ‘continuous improvement’ and ‘respect for people’.

*Table 2-3: The eight types of waste description (from Walder et al., 2007)*

| Waste | Definition |
|---|---|
| **Over-production** | Produce only the amount of goods necessary – not faster, sooner, or more. |
| **Defects** | Perform each operation without error. Build quality into every process. |
| **Unnecessary inventory** | Provide material when needed by the customer and only in the quantity required. |
| **Inappropriate processing** | Provide only the required amount of processing and effort for each operation. |
| **Excessive transportation** | Minimize the distance between processes, and avoid temporary material locations. |
| **Waiting** | Assure machine availability. Perform preventative maintenance. Use man/machine charting to ensure optimization of operator's time. |
| **Unnecessary motion** | Simplify standardized work sequence to eliminate unnecessary movements. |
| **Underutilization of the workers** | Eliminating this waste in the system means encouraging and making constructive use of the creativity and ingenuity of the people actually doing the work as well as assuring that the workers are adding value to the product rather than doing "make-work" activities |

Regarding the elimination of these types of waste, several authors express their appreciations: Womack & Jones (2003) tell us that Lean Thinking provides a way to make work more satisfying by providing immediate feedback on efforts to convert *muda* into value; Wilson (2005) states that by eliminating waste, quality improves, while time and production costs reduce; Like Y. Monden (1993) that had already said "*cost reduction and productivity improvement are attained through the elimination of various wastes such as excessive inventory and excessive workforce*".

Often, work activities are placed into two categories: value added and everything else, where "everything else" is waste. There is a third category that should also be considered: incidental work. *Incidental work* regards all activities that are transparent to the customer, but necessary to complete the value added tasks. For example, payroll and accounts receivable are incidental work for most organizations. While, like value added work, incidental work may have waste within it, the task itself is likely necessary to the overall operations of the organization (Walder et al., 2007). Just as activities that can't be measured can't be properly managed, the activities necessary to create, order and produce a specific product which can't be precisely identified, analysed and linked together cannot be challenged, improved (or eliminated altogether) and, eventually, perfected (Womack & Jones; Daniel T., 2003).

## II. VALUE STREAM

According to Womack & Jones (2003), the value stream is "*the set of all the specific actions required to bring a specific product through the three critical management tasks of any business: the problem-solving task, the information management task and the physical transformation task*".

A value stream is the group set of all the actions (both value added and non-value added) currently required to bring a good through the main flows essential to every product: the production flow from raw material into the arms of the customer, and the design flow from concept to launch. Within the production flow, the movement of material through the factory is the flow that usually comes to mind. But there is another one - of information - that tells each process what to make or do next. Taking a value stream perspective means working on the big picture, not just individual processes, and improving the whole, not just optimizing the parts (us.kaizen.com).

On Womack & Jones (2003) book *Lean thinking: banish waste and create wealth in your corporation*, the authors say that value stream analysis will almost always show that three types of actions are occurring along the value stream: (1) many steps will be found to unambiguously create value; (2) Many other steps will be found to create no value but to be unavoidable [due to specific laws or technology and equipment requirements, for example] (we'll term these Type One *Muda*); and (3) many additional steps will be found to create no value and to be immediately avoidable (Type Two *Muda*).

## III. FLOW

Henry Ford and his associates were the first people to fully realize the potential of flow. Ford reduced the amount of effort required to assemble a Model T Ford by 90% by switching to continuous flow in final assembly. After World War II, Taiichi Ohno and his technical collaborators, including Shigeo Shingo, concluded that the real challenge was to create continuous flow in small-lot production when dozens or hundreds of copies of a product were needed, not millions (Womack & Jones; Daniel T., 2003).

The most basic problem is that *flow thinking* is counterintuitive; it seems obvious to most people that work should be organized by departments in batches (Womack & Jones; Daniel T., 2003). According to Melton (2005), the lack of a continuous value flow is the main responsible for huge piles of stock either on storage houses as throughout the production line, constantly consuming human capital.

### IV. PULL

Ohno (1997) had the objective of providing Toyota with an organism that could respond rapidly to demand, without high stocks, while guarantying a continuous flow production system, avoiding production disruptions and stoppages.

The MRP (Material Requirement Planning) approach implicates a sales forecast based on statistical methods, meaning that production is *pushed* to the client - push system (Carvalho, 2010). The *pull* system, on the other hand, is the ability to design, schedule and make exactly what the customer wants just when the customer wants. It means you can throw away the sales forecast and simply make what customers actually tell you they need. That is, you can let the customer *pull* the product from you as needed rather than pushing products, often unwanted, onto the customer (Womack & Jones; Daniel T., 2003).

### V. PERFECTION

These principles imply the dedication of all people, being the last one - pursuit perfection - the principle that implies the strongest and continuously commitment of people in order to improve all the processes and activities in companies. This improvement has to do not only with the process and operations improvement as referred, but also, and more important, with the worker conditions and behaviours improvement. This is implicit on the key idea of Lean Production: "*doing more with less*" and less means less space occupied, less transports, less inventories, and most important, less human effort (Laura C. Maia et al., 2012).

The four initial principles interact with each other in a virtuous cycle. It dawns on those involved that there is no end to the process of reducing effort, time, space, cost, and mistakes while offering a product which is ever more nearly what the customer actually wants. Suddenly perfection, the fifth and final principle of lean thinking, doesn't seem such a crazy idea (Womack & Jones; Daniel T., 2003).

Summing up, Lean thinking is indeed an agile and effective way to think management, but it presumes a total abandonment of all management models where a crosswise administration and valuing all workers aren't imperative (Carvalho, 2010).

## 2.1.2 LEAN'S BENEFITS AND RESTRICTIONS

Countless studies have been showing the benefits of implementing the Lean paradigm on company's productive systems. A research by Alves, et al. (1990) synthesized the benefits obtained through the implementation of 41 different projects in 18 Portuguese companies:

- Reduction of the machines' setup time (27 to 90%);
- Simplification of the material flow, making it simpler to identify and control the process;
- Biggest production flexibility;
- Reduction of the necessary work space;
- Elimination of working shifts and reduction of the number of employees;
- Reduction of waste regarding transportation and motion;
- Reduction of the batches size;
- Increase of the machines performance;
- Reduction of WIP (18 to 84%)
- Increase in productivity (20 to 30%)
- Reduction of stocks (both finished goods and WIP products);
- Reduction of cycle time and delivery time;
- Reduction of human effort;
- Production levelling;
- Costs' reduction;
- Reduction of the need for rework and increase in product quality.

Besides the benefits referred through the implementation of these projects, Womack & Jones (2003) further stand out:

- Biggest precision on material ordering forecasts;
- Reduction of the response time to engineering changes and market variations;
- Biggest involvement, participation and motivation of the employees;
- Capacity of identifying and solving problems faster and more effectively.

On a summarily way, Melton (2005) highlights the six more important benefits of a Lean implementation:

- Less waste within the process;
- Shorter product lead time;
- Less production failures and less need for rework;
- Financial benefits;
- Better understanding of the processes (clearer vision);
- Less stock.

Walder et al. (2007) refers that removing waste from systems and processes has many benefits, including:

- Decreasing lead-time – removing waste shortens the supply chain as well as shortening the internal value added processes;

- Increasing quality – removing waste also removes excess steps and inventory waiting that may hide quality problems or hide the quality problem until it is too late to fix easily;
- Decreasing costs – removing waste decreases the inventory that must be held and may decrease costs of equipment, facilities, and people as well;
- Increasing productivity – removing waste removes unnecessary movement, inventory, and double handling, leaving the people and machines available to be more productive.

On the other hand, Melton (2005) also pointed out that change review is important to control and sustain a lean manufacturing system. The elements that are usually analysed are performance, communication system, business and physical processes, and continuous improvement or improvement records.

Although there is a generalised disclosure about the Lean implementation and its benefits, there are a lot of companies that don't do it (Maia, et al., 2010). According to a study developed by Silva, et al. (2010), the main reasons for not implementing the Lean paradigm are:

- Lack of knowledge about the organizational model and how to implement it;
- Lack of knowledge and understanding of the Lean principles;
- Lack of support from top management;
- Ignorance about the benefits of the model or about the way to quantify them;
- Consideration of the existence of investment costs.

According to Melton (2004), the two biggest obstacles to the Lean implementation are the perception of the lack of tangible benefits and the idea that most processes are already efficient enough. Melton (2005) suggests that the main resistive force to the implementation, that should be contradicted and overcome, is the resistance to change.

The process of moving the organization from A to B cannot go well without changing the people processes. That's because the lean management system falls apart without appropriate people systems (Bartholomew, 2015). Hence, many researchers had argued that the transition from the traditional to lean environment is more of a cultural change within the organisation issue rather than a manufacturing or technical issue (Nordin et al., 2012).

Regarding this matter, Bartholomew (2015) refers some competences that need to be developed to ensure a successful lean transformation. These often include:

- A quality first orientation;
- An emphasis on customer service;
- A team orientation;
- More effective communications.

There are many reported problems and issues regarding the failure of lean manufacturing implementation (Nordin et al., 2012).

Table 2-4, from Nordin et al. (2012), illustrates some of the barriers that are probable causes of delay that prevent the success of lean manufacturing system implementation. While

Table 2-5, from the same authors, illustrate the critical success factors for a Lean manufacturing implementation.

*Table 2-4: Barriers for Lean implementation (from Nordin et al., 2012)*

| *Lean barriers* | *Authors* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Bamber and Dale (2000)* | *Stewart (2001)* | *Crute et al. (2003)* | *Melton (2005)* | *Bonavia and Marin (2006)* | *Worley and Doolen (2006)* | *Real et al. (2007)* | *Lee-Mortimer (2008)* | *Scherrer-Rathje et al. (2009)* | *Wong et al. (2009)* | *Bhasin (2011)* |
| Misunderstanding the concept and purpose of lean | × | | × | | × | | | × | | × | × |
| Lack of resource availability (time, expertise, financial) | | | × | × | × | | × | | | × | × |
| Cultural differences | | | | × | | × | | | | | |
| Lack of clear communication | × | | | | | × | | | × | | |
| Lack of top management support for change | × | × | | | | | | × | × | | × |
| Lack of interest and commitment in lean | | × | | | | | | | × | × | × |
| Company culture | | | | | | | | | | × | |
| Lack of continual evaluation on lean | | | | | | | | | × | | |

Table 2-5: Critical success factors for a Lean implementation (from Nordin et al., 2012)

| *Critical success factors* | *Worley and Doolen (2006)* | *Real et al. (2007)* | *Motwani (2003)* | *Scherrer-Rathje et al. (2009)* | *Stewart (2001)* | *Bamber and Dale (2000)* | *Achanga et al. (2006)* | *Papadopoulou and Ozbayrak (2005)* | *Boyer (1996)* | *Sim and Rogers (2009)* | *Losonci et al. (2011)* | *Puvanesvaran et al. (2009)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Effective leadership | × | | × | × | × | | × | × | × | × | × | × |
| Comprehensive change plan | | | | × | × | | | | | | | |
| Team development | | × | × | | | × | | | × | | | × |
| Communication | × | | × | × | | × | | × | | × | × | |
| Education/ training | | | × | | | | | | × | × | | |
| Change agent | | | | × | | | | | | | | |
| Culture readiness | | | × | | | | × | × | | | × | × |
| Employee autonomy | | | | × | | × | | × | | | | |
| Lean change evaluation | | | | | × | × | | | | | | |
| Worker empowerment | | | | | | | × | × | × | × | | × |
| Rewarding system | | | | | | | | | | | | × |

Organisational collaboration factors cannot simply be duplicated to achieve the same result. The result also proved that national culture has significant impact during the lean implementation process (Nordin et al., 2012).

On Figure 2-6, Hines et al. (2011) explicates the importance of a Lean culture change on the long-term: "*Using lean tools will improve performance. However, behaviours focused on continuous improvement/pursuit of perfection will provide sustainable long term improvement*".

On the same publication, Hines et al. (2011) illustrates the sustainability of Lean through an iceberg – shown on Figure 2-7 – where we can see that tools, methodologies and management processes are the tangible part of the paradigm, while strategy and alignment, leadership, conduct and engagement are the enabling factors, hidden below the surface.

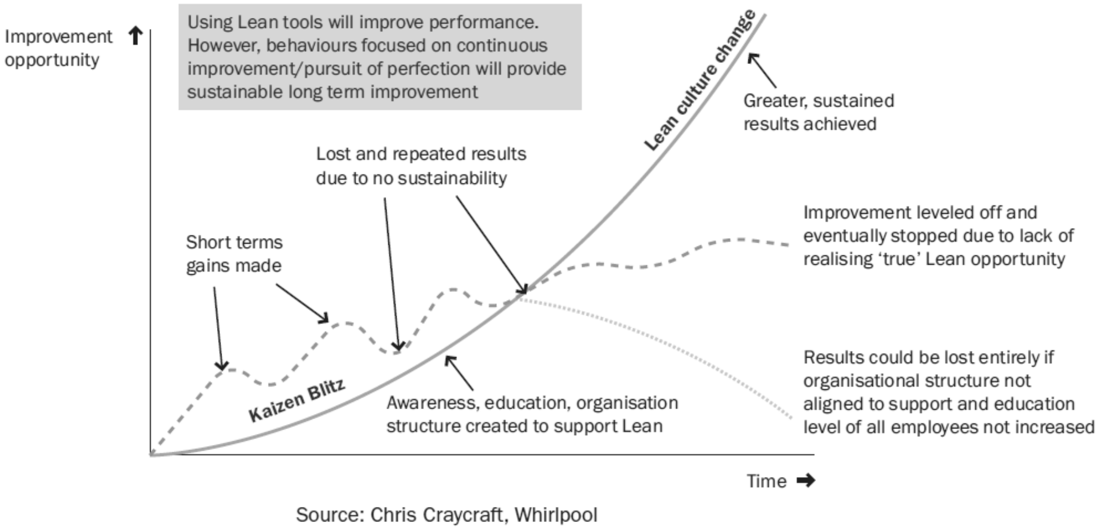


*Figure 2-6: Improvement opportunities in a Lean context (from Hines et al., 2011)*

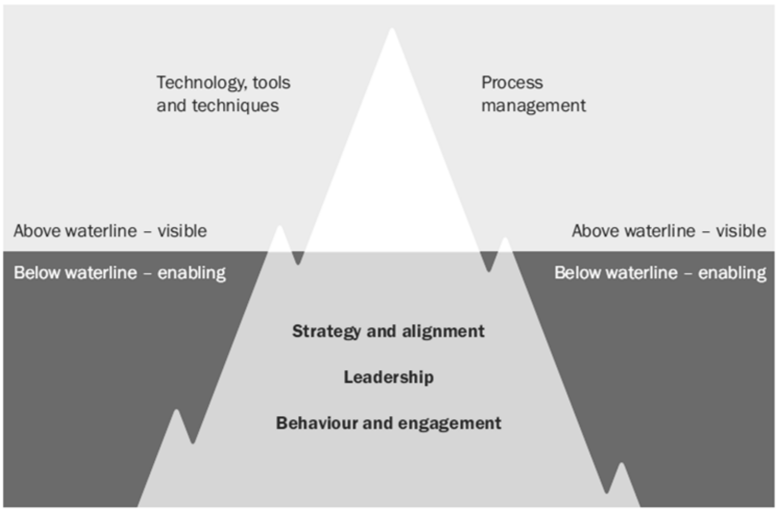


*Figure 2-7: The Lean sustainability iceberg (from Hines et al., 2011)*

Summarizing, the change from a traditional manufacturing system to lean manufacturing is not an easy task. The change requires attention focusing on the impact on both the process and people (Nordin et al., 2012).

The majority of the books on lean thinking are about manufacturing situations. While these examples are important, lean thinking is not restrained to production operations. Fortunately, lean thinking is really a philosophy – a way of operating – rather than a discrete set of tools or techniques. Just as a company can create new tools to implement lean thinking on the shop floor, tools and techniques can be tweaked or created new to infuse lean thinking in the office and other service sector situations (Walder et al., 2007).

### 2.1.3 Tools and Methodologies

The implementation of the Lean management paradigm could be based on several techniques and methodologies, but it has to be done in a coordinated and structured way (Hunter, 2004). The fundamental principles of the paradigm must be respected at all times. All the methodologies and tools used to support the Lean paradigm are unique, meaning that all of them have their own method and approach to fulfil a specific goal. This way, each methodology or tool aims to improve processes from different points of view, through problem resolutions of different nature. The tools and methodologies that contribute to the implementation of Lean are represented on Table 2-6, all aiming to make companies more efficient and competitive.

*Table 2-6: Lean tools and methodologies*

| Methodologies | Tools |
|---|---|
| **Kaizen** | • Standard Work |
| **Just-in-Time (JIT)** | • Value Stream Mapping (VSM) |
| **Jidoka** | • Poka-Yoke |
| **5S** | • Brainstorming |
| **PDCA Cycle** | • Spaghetti diagram |
| **SMED** | • Continuous flow |
| **Visual control** | • Ishikawa diagram |
| **Total Productive Maintenance (TPM)** | • Overall Equipment Effectiveness (OEE) |
| **Total Quality Management (TQM)** | • Kanban |
| | • Heijunka |
| | • One-piece production |
| | • Takt Time |
| | • Single Minute Exchange of Die (SMED) |
| | • Layout Configuration |
| | • 5 Why's technique |
| | • A3 |

According to Feld (2000), the methodologies can be grouped in these categories: production flow; organization and culture; process control; KPIs and logistics.

On an improvement planned action there are diverse Lean tools and methodologies available, as the ones mentioned above. But every case is different and determining which tools and methodologies to apply is a job for the top management, depending on the set goals and the existing problems. Being so, this dissertation will focus on the tools and methodologies studied and applied during the practical development of the case study.

## I. Kaizen

The Lean production system follows an organizational and behavioural philosophy in order to create value and reduce waste – the Kaizen philosophy. This is a continuous improvement approach that had its origin in Japan, driven by Masaaki Imai. In the Kaizen way of thinking, no process can be perfect because there is always room for improvement.

According to Ohno (1997), when this “mentality” is applied in the work place, a methodology - based on the daily search for improvement measures on the work methods, from all employees within every company and its immediate analysis and execution - is implemented. This methodology involves all productive and administrative types of processes. An organizational culture that implicates the study and continuous personal search for improvement opportunities is an excellent way to promote learning enthusiasm and development of the skills within the company’s human resources, as well as process improvement.

Brunet & New (2003) stated the Kaizen’s most referenced characteristics in the literature:

- It’s continuous – unceasing search for quality and efficiency;
- It’s gradual – opposes to big reorganizations or technologic advances;
- It’s participatory – implicates the involvement and intelligence of the workers, which is beneficial for them either to their psychological well-being as for their quality of life at work.

Summarizing, Kaizen consists on the support mentality for the whole Lean paradigm. It’s about continuous improvement efforts, executed by everyone, looking for a constant waste elimination. Its application is based on the execution of “Kaizen events”. These are defined by the identification of improvement opportunities and the implementation of these improvements, whenever possible, using methods and tools from Lean production on a particular area (Araujo & Rentes, 2006).

Farris, Van Aken, Doolen & Worley (2009), on the other hand, define “Kaizen events” as focused and structured continuous improvement projects, with a multifunctional team dedicated to improve a specific work area, with well-defined goals, on a short period of time. Besides the possible direct improvement achieved, the Kaizen events serve the goal of training mechanism for the workers involved, helping them develop problem’s resolution skills and be more motivated to participate in future improvement activities.

## II. 5S

According to Chapman (2005), in manufacturing, employees are searching for misplaced tooling and components, obsolete parts litter the production floor, supervisors spend hours looking for WIP amid a sea of incomplete orders scattered throughout the shop, and nonconforming products are mixed with good parts and are inadvertently sent to customers. Most companies approach workplace organization in the same way many homeowners do - they clean up and organize only when they have guests coming or during their annual spring cleaning. Figure 2-8 shows the causes of an unorganised shop floor, according to (Gupta & Jain, 2015).

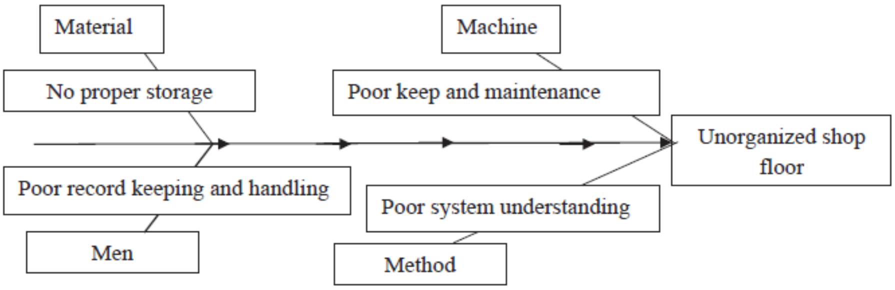


*Figure 2-8: Cause-and-effect diagram for an unorganised shop floor* (adapted from Gupta & Jain, 2015)

Chapman (2005) indicates that these day-to-day workplace organization issues manifest into bigger problems such as:

- Longer lead times;
- Low productivity;
- Higher operating costs;
- Late deliveries;
- Ergonomic challenges;
- Space constraints;
- Frequent equipment breakdowns;
- Hidden safety hazards.

5S is systematic and organic to lean production, a business system for organizing and managing manufacturing operations that requires less human effort, space, capital and time to make products with fewer defects. It creates a work environment that is disciplined, clean and well ordered (Chapman, 2005).

The 5S acronym comes from the Japanese terms *Seiri*, *Seiton*, *Seiso*, *Seiketsu* and *Shitsuke*. In English, the acronym was translated to Sort, Straighten or Set-in-order, Shine, Standardize and Sustain as explicated in Figure 2-9 from (Hines et al., 2011).

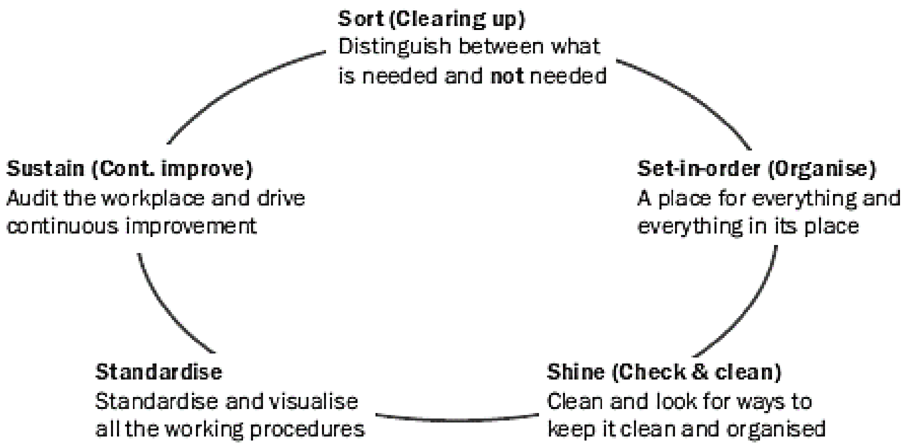


*Figure 2-9: 5S (from Hines et al., 2011)*

5S is directly correlated and integrated in the Kaizen culture, as they share the same goal – continuous improvement (Imai, 1985). According to Gupta & Jain (2015), implementing 5S in the organization is one of the important steps toward continuous improvement. Implementing 5S ensures continuous improvement in housekeeping and results in better safety standards and environment.

According to the Kaizen Institute (Imai, 1985), 5S relates to workplace organisation and forms a solid foundation upon which many organisations base their drive for continuous improvement. It is equally applicable and successful in all sectors helping to achieve high impact results. It is a systematic and methodical approach allowing teams to organise their workplace in the safest and most efficient manner. Summarizing, the benefits are:

- Improved safety;
- 5S becomes a fundamental business measure and key driver for Kaizen;
- Forms a solid foundation upon which to build continuous improvement;
- Employees gain a sense of ownership, involvement and responsibility;
- Reduction in waste – as defined by Ohno's seven forms of waste;
- Improved performance in productivity, quality and morale leads to increased profitability.

Hines et al. (2011) consider that 5S is a powerful system of workplace organisation: "*We are more productive when we are not spending time looking for items, only to discover that when we find them they are not fit for the purpose. Even so 5S does more than simply ensure that a workplace is tidy and well organised. 5S is a management tool that involves and empowers people*". At its basic level it is good housekeeping. At another level it is the first step to improving productivity. 5S is a part of a visual workplace management.

This "*there is a place for everything and everything is in its place*" type of organization, characteristic of companies such as Toyota, the pioneer of lean production, exposes inefficiencies and disruptions in workflow so these problems are no longer hidden and can be solved. The day-to-day benefits of 5S are: less searching, decreased walking and motion, reduced downtime, fewer safety hazards and accidents, improved flow, fewer mistakes and better utilization of space. These daily benefits add up to yearly improvements in productivity, quality, cost, delivery, safety and morale (Chapman, 2005).

According to a case study provided by Gupta & Jain (2015), the three main obstacles observed were not enough time, lack of top management support and resistance to change. Many companies will embark on implementing 5S only to do the first three S's: sort, set in order and shine. Some rationalize that after cleaning up and organizing, employees will simply fall in line and sustain the visual factory on their own. Successful implementation of the last two S's of 5S will determine whether you are able to transform your operations from a hidden factory of waste — affecting transportation, inventory and motion and resulting in waiting, over processing, overproduction and defects — to a visual factory where the environment is self-explaining, self-ordering and self-improving (Chapman, 2005).

Finally, it should be reinforced that 5S is an on-going journey. Workers should be encouraged to continue to make improvements to their workplace on a regular basis. The same work area might even be scheduled for a follow-up 5S event six months or a year later. Continuous improvement must become part of the routine expectations and activities of the work day. When improvement stops, the likelihood is that workplace organization will not just stagnate, but will actually deteriorate. To avoid that, keep everyone continually looking for ways to improve their work conditions (Gupta & Jain, 2015).

## 2.2 Six Sigma Philosophy

This section describes the Six Sigma fundamentals in three subsections. First, the information relating how it arises, its evolution and definition is explored, referring its importance in today's management strategies. Secondly, implementation issues, benefits and constraints are explained, giving the motto to the third subchapter. This is about the tools and methodologies inherent to this philosophy.

### 2.2.1 Concept and Evolution

The continuous improvement process with Six Sigma's theory was developed by Mikel Harry's team in *Motorola Company* by 1987, in response to an increase of the international market competitiveness created by Japanese companies. To cope with this situation, Motorola felt the need to improve the process quality, due to an excessive amount of defective production parts

(Arnheiter & Maleyeff , 2005). Hence, Motorola found in Six Sigma the way to express their goal of reducing the number of defects in their production. So, in its origin, the concept was merely statistical and it was grounded by the principles enunciated in 1809 by the German mathematician Carl Gauss, published on *Theoria Motus Corporum Arithmeticae*. The posterior development of this theory, held by Motorola University, and disclosure, undertaken by *General Electric* (GE) - through its former CEO Jack Welch -, consolidated the concept as a methodology of continuous improvement focused on reducing the variability of the value of variables and/or the attributes of a statistically controlled product or process. The improvement is achieved by reducing the variability of multiple elements involved in the problem analysis (Almeida, 2012).

### Statistical Viewpoint

The original goal, implicit within Six Sigma's definition, is the reduction of scrap to a maximum of 3.4 Defects per One Million Opportunities (DPOMO), meaning virtually zero defects as shown in Figure 2-10. Is important to define that a *defect* is *"any failure to meet a customer satisfaction requirement"* (Bonacorsi). Motorola as defined this objective so that a process's variability was ± 6 standard deviations i.e. 6 sigma away from the average. Some studies reached the conclusion that every process is vulnerable to disturbs that may move the average to a maximum 1,5 sigma from the target, justifying the 3.4 DPOMO value as shown in Figure 2-11 (Schroeder, Linderman, Liedtke, & Choo, 2008).

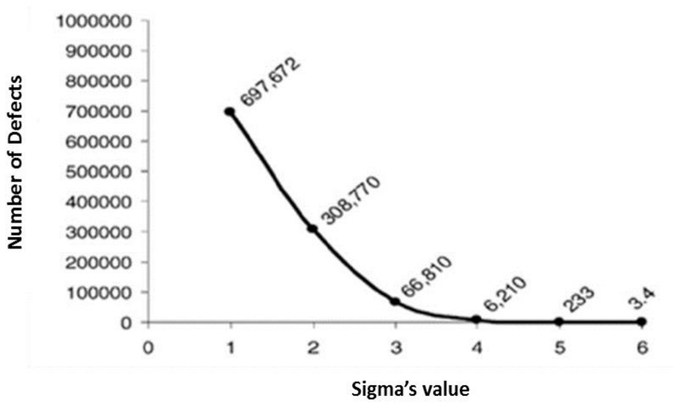


*Figure 2-10: DPOMO and standard deviation (adapted from Lindermanet al., 2003)*

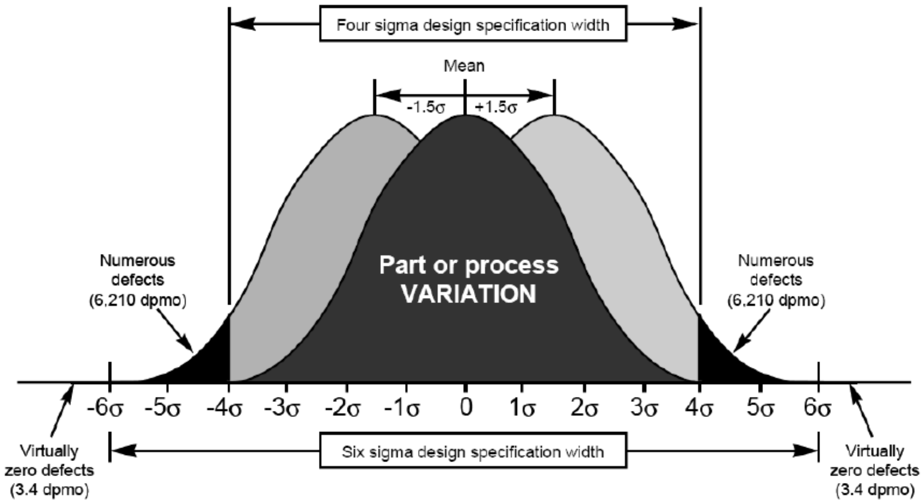


*Figure 2-11: Six Sigma statistical concept (Source:* Bonacorsi, n.d.*)*

By early 90's *Allied Signal Corporation* gave a step forward in the Six Sigma concept, by certifying their collaborators according to their level of knowledge about the Six Sigma philosophy, recently implemented in their productive system. Hence, a hierarchy was created: Green Belt, Black Belt, Master Black Belt, Champion, Leader and Sponsor, being Sponsor the higher level.

In 1996, GE contributed with another breakthrough by implementing Six Sigma on a broader sense, focusing all the business processes, customer satisfaction and cost reduction. Hence, the concept of Six Sigma started evolving from a statistical quality improvement methodology to a business philosophy as is regarded today. Kwak & Anbari (2006) tell us that the six sigma method is a project-driven management approach to improve the organization's products, services, and processes by continually reducing defects in the organization.

### Business Viewpoint

In the business world, six sigma is defined as a "*business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceed customer's needs and expectations*" (Antony and Banuelas, 2001 cited by Kwak & Anbari, 2006). The six sigma approach was first applied in manufacturing operations and rapidly expanded to different functional areas such as marketing, engineering, purchasing, servicing, and administrative support, once organizations realized the benefits. Particularly, the widespread applications of six sigma were possible due to the fact that organizations were able to articulate the benefits of six sigma presented in financial returns by linking process improvement with cost savings (Kwak & Anbari, 2006).

Lin et al. (2012) define Six Sigma as a management strategy that uses statistical methods to reduce the process's variability and defects occurrence. Its objective is to increase efficiency in organizations, by improving the product's and process's quality. As for Montgomery & Woodall (2008), this philosophy deploys into a series of tools and methodologies that aim to improve the process's outputs through the detection and elimination of errors and its causes. Reducing variability is yet another focus of Six Sigma, creating a larger productive standardization, bringing benefits in terms of production control and planning.

It was the *DuPont Company* who brought together Six Sigma and Lean philosophy, further explored on Chapter 2.3.

Summarizing, Werkema (2004) presents seven characteristics inherent to Six Sigma, that define it and allow a broader comprehension of this philosophy:

1. The six sigma scale is used to quantify the quality level of a process. The quality level is directly proportional to the value reached in the sigma scale;
2. The goal is to reach zero defects or get as close as possible;
3. Benchmarking is used to compare the quality level of two different products, operations or processes;
4. Statistics methods are used to evaluate the performance of the critical-to-quality characteristics regarding the product specifications;
5. The philosophy is based on the continuous improvement and variability reduction of processes;
6. The strategy is based on the link between the project, the production process, the final quality of the product, the delivery and the client satisfaction;
7. The vision is to make each company the best at what they do.

### The role of Six Sigma in Management

In the 20's, *quality* referred to the product's characteristics and focused on checking 100% of the outputs without analysing the causes for non-compliance. This led to the infinite reproduction of the same errors (Quality Control). In the 50's there is an understanding that quality can be manufactured, besides controlled, when a systematic, uniform and regular production is possible (Quality Guaranty). Nowadays, quality is not an option for companies. Every day is seen more and more as mandatory and crucial for keeping market share (Loureiro, 2012).

Six Sigma's philosophy, based on statistical theories, assumes that every factor of a process can be characterized and represented by a statistical distribution curve. As previously referred, the goal is to virtually eliminate every defect in every process and every product. For that, a set of tools has to be applied in a methodical and organized way (Taghizadegan, 2006). Hence, six sigma's projects guide their efforts towards three key areas: improve costumer's satisfaction; reduce cycle time; and reduce defects (Loureiro, 2012).

Following the same line of thought, Almeida (2012) tells us that the assumptions underlying the theory of Six Sigma can be stated as follows: (a) a process's characteristics can be translated, in a suitable way, by numbers. The further knowledge one has about those numbers, the more qualified one is to evaluate the process from different perspectives and implement some improvement in it; (b) reducing variability in each operation throughout the process leads to the improvement of the system's performance as one.

According to Devane (2004), process improvement, statistical methods, consumer focus, process focus and a management system centred around improvement projects with high return on investment (ROI) constitute six sigma's principles to reach continuous improvement and significant financial gains. But most companies work with a four sigma quality system, meaning they expect 6210 defects per million. The discrepancy is very high, as seen in Table 2-7 with some service comparisons between four sigma and six sigma quality.

*Table 2-7: Comparison between Four Sigma Quality service and Six Sigma Quality service (adapted from "Grupo Werkema", 2008)*

| Four Sigma (99,38% OK) | Six Sigma (99,99966% OK) |
|---|---|
| **7 hours of power outages per month** | 1 hour of power outages every 34 years |
| **5.000 incorrect surgical operations per week** | 1,7 incorrect surgical operations per week |
| **3.000 misplaced letters for each 300.000 sent** | One misplaced letter for each 300.000 sent |
| **15 minutes providing non-potable water per day** | 1 minute providing non-potable water every 7 months |

## 2.2.2 Six Sigma's Benefits and Restrictions

According to Loureiro (2012), in the 80's TQM (Total Quality Management) was very popular, but it went through a wear phase. So it was necessary to create a method that motivates leadership for quality. This occurred due to Six Sigma's three main characteristics:

1. Client focus
2. Six Sigma's projects deliver big return on investment
3. Six Sigma's philosophy turns the company's course around. It implicates a statistical model as well as a management philosophy.

Carvalho (2010) tells us that the success of Six Sigma is based on:

- The continuous improvement of processes and procedures;
- The expansion of the methodology aiming to involve every area of the company, suppliers and clients;
- Suit the methodology to the company's reality, regarding its tangible goals (it's important to set ambitious but doable objectives);

- Constant broadcast of the results obtain throughout the process, both to stakeholders and every employee of the organization;
- Specific and dedicated training for the program specialists.

Also, the Six Sigma methodology should be considered an innovation regarding the previous. Meaning that it won't be necessary to fold any existing quality management program in the company in order to apply Six Sigma (Carvalho, 2010).

Table 2-8 shows us some benefits and savings resulting of Six Sigma's implementations in the manufacturing sector, gathered by Kwak & Anbari (2006).

*Table 2-8: Reported benefits and savings from six sigma (Kwak & Anbari, 2006)*

| Company/project | Metric/measures | Benefit/savings |
|---|---|---|
| Motorola (1992) | In-process defect levels | 150 times reduction |
| Raytheon/aircraft integration systems | Depot maintenance inspection time | Reduced 88% as measured in days |
| GE/Railcar leasing business | Turnaround time at repair shops | 62% reduction |
| Allied signal (Honeywell)/laminates plant in South Carolina | Capacity Cycle time Inventory On-time delivery | Up 50% Down 50% Down 50% Increased to near 100% |
| Allied signal (Honeywell)/bendix IQ brake pads | Concept-to-shipment cycle time | Reduced from 18 months to 8 months |
| Hughes aircraft's missiles systems group/wave soldering operations | Quality/productivity | Improved 1,000%/improved 500% |
| General electric | Financial | $2 billion in 1999 |
| Motorola (1999) | Financial | $15 billion over 11 years |
| Dow chemical/rail delivery project | Financial | Savings of $2.45 million in capital expenditures |
| DuPont/Yerkes plant in New York (2000) | Financial | Savings of more than $25 million |
| Telefonica de espana (2001) | Financial | Savings and increases in revenue 30 million euro in the first 10 months |
| Texas instruments | Financial | $ 600 million |
| Johnson and Johnson | Financial | $ 500 million |
| Honeywell | Financial | $1.2 billion |

(Sources: Weiner, 2004; de Feo and Bar-El, 2002; Antony and Banuelas, 2002; Buss and Ivey, 2001; McClusky, 2000).

According to Werkema (2002) Six Sigma might fail if there's a lack of strong leadership from the top management and if there's a low level of compromise from the middle management. Also, the lack of commitment from the black belt candidates can also be an issue. Some companies don't choose their projects wisely – a Six Sigma project should be complex enough for it to be meaningful for the company, but not so complex that it might be concluded on a four to six months' time frame (mid-term) or from eight to twelve months (long-term).

Organizations must realize that six sigma is not the universal answer to all business issues, and it may not be the most important management strategy that an organizations feels a sense of urgency to understand and implement six sigma. To ensure the long-term sustainability of the six sigma method, organizations need to analyse and accept its strengths and weaknesses and properly utilize six sigma principles, concepts, and tools (Kwak & Anbari, 2006).

Kwak & Anbari (2006) also further explore the topic by saying that "*the more important issue is the change in organizational culture that puts quality into planning. Addressing the problems and issues that are easy to correct and claiming that the six sigma method is a big success is simply deceiving. Organizations without a complete understanding of real obstacles of six sigma projects or a comprehensive change management plan are likely to fail*". They reinforce, "*if the* *commitment and support of utilizing various resources do not exist, organization should probably not consider adopting Six Sigma*".

Summing up, Kwak & Anbari (2006), based on various literature reviews and discussions with six sigma leaders in organizations that adopted the six sigma method, identified four key elements of successful six sigma applications: Management involvement and organizational commitment; Project selection, management, and control skills; Encouraging and accepting cultural change; Continuous education and training.

Motorola was the first organization to use the term six sigma in the 1980s as part of its quality performance measurement and improvement program. Six sigma has since been successfully applied in other manufacturing organizations such as General Electric, Boeing, DuPont, Toshiba, Seagate, Allied Signal, Kodak, Honeywell, Texas Instruments, Sony, etc. (Kwak & Anbari, 2006). Although, Linderman et al. (2003) mentions that not every process should operate on a six sigma quality level. The appropriate level of sigma should depend on the strategic importance of the process and the balance between its improvement cost and benefit.

Juran & Godfrey (1979) refer a study that was conducted of over 1000 improvement teams at 35 financial institutions. The most successful teams, measured in terms of saving and revenue enhancement, defect reduction, customer satisfaction improvement, and increase in employee satisfaction, shared some important characteristics:

- **Team makeup:** Mix of 75 percent officer/manager level, 25 percent non-exempt; average team size - 7; "ideal" team size - 4 or 5.
- **Team member selection:** By management.
- **Training:** Two days minimum.
- **Project selection:** By management or the quality council.
- **Projection Duration:** Three to four months, meeting weekly for 90 minutes.
- **Improvement tools used:** Brainstorming, Pareto analysis, surveys, cause and effect diagram, data collection, flowcharting, work simplification, and cost/benefit analysis.

The Six Sigma's philosophy uses a structured methodology, represented on Figure 2-12, either the objective is improving an already existing process or creating a new one. For this last option, the adopted methodology is DFSS (Design for Six Sigma). This usually follows a cyclic way-of-thinking called DMADV (Define, Measure, Analyse, Design, Verify) - when the goal is incremental innovation – or the cycle IDOV (Identify, Design, Optimise, Validate) – when radical innovation of a process is required. If we want to improve an existing process, there's a structured and organized approach to manage the activities required for this project, represented through the DMAIC cycle - Define, Measure, Analyse, Improve, Control (Domingues, 2013). The organization inherent to this method centres on the existence of different tools and techniques associated with each stage of the cycle (Marques, Requeijo, Saraiva, & Frazão-Guerreiro, 2013).

DMAIC is an acronym for five interconnected phases: define, measure, analyse, improve and control, as shown in Figure 2-13. Simply stated by El-Haik & Roy (2005), the steps are (1) Define the scope of the project, the improvement opportunities and the costumer's requirements; (2) Measure the key process characteristics and parameters, guaranteeing the adequate metrics, stability and capability of the process; (3) Analyse the inputs and the root causes for the problems found; (4) Improve the processes in order to optimize performance and (5) Control to sustain the gains. Citing Sokovic (2010) "*DMAIC is an integral part of Six Sigma. It is systematic and fact based and provides a rigorous framework of results-oriented project management*".

This DMAIC cycle approach will be further explored in the Methodology chapter of this dissertation.

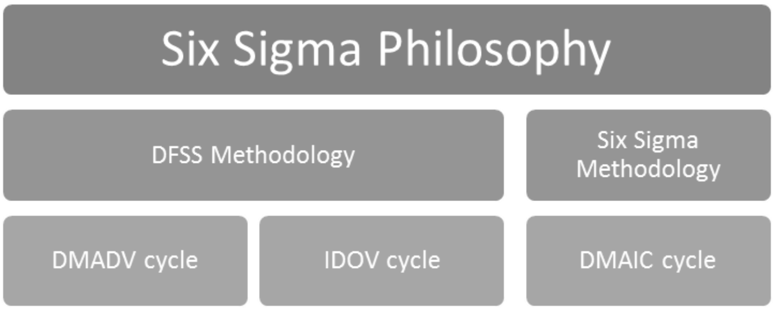


*Figure 2-12: Six Sigma's most common implementation methods (adapted from Domingues, 2013)*


*Figure 2-13: The DMAIC cycle*

## 2.2.3 Tools and Methodologies

To develop each stage of the Six Sigma methodology, following the DMAIC cycle (method used in this case study), there's an essential toolset for a well-succeeded improvement implementation, shown on Figure 2-14 (adapted from Werkema, 2006) and another approach shown on

Figure 2-15 (from Knowleset al., 2005).

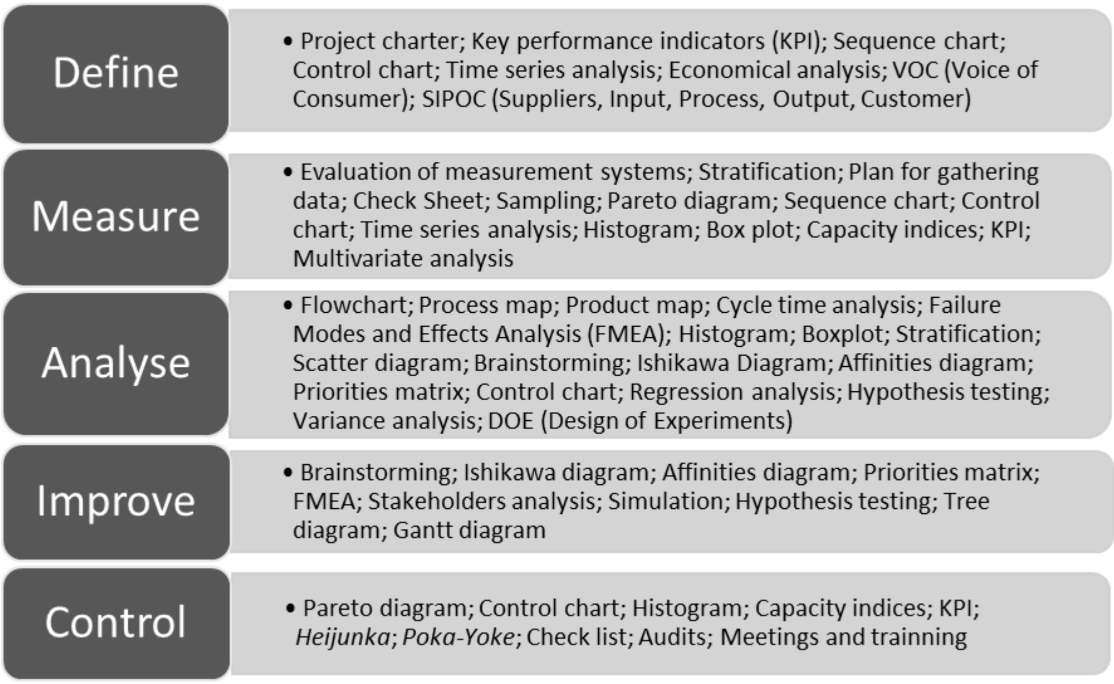


*Figure 2-14: Tools and techniques utilized throughout the DMAIC cycle (adapted from Werkema, 2006)*

| | D | M | A | I | C | | D | M | A | I | C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Affinity diagram | ♦ | | ♦ | | | Pareto chart | | ♦ | ♦ | ♦ | |
| Brainstorming | ♦ | | ♦ | ♦ | | Planning tools (Gantt charts) | | | | ♦ | |
| Business case | ♦ | | | | | Prioritisation matrix | | ♦ | | ♦ | |
| Cause-and-effect diagram | | | ♦ | | | Process capability | | ♦ | | ♦ | |
| Charter | ♦ | | | | | Process Sigma | | ♦ | | ♦ | |
| Consensus | | | | ♦ | | Quality control process chart | | | | | ♦ |
| Control charts | | ♦ | ♦ | ♦ | ♦ | Regression | | | ♦ | | |
| CTQ (critical-to-quality) tree | ♦ | | | | | Rolled throughout yield | ♦ | | | | |
| Data collection formats | | ♦ | ♦ | ♦ | ♦ | Sampling | | ♦ | ♦ | ♦ | ♦ |
| Data collection plans | | ♦ | ♦ | ♦ | ♦ | Scatter plots | | | ♦ | | |
| DOE (design of experiments) | | | ♦ | ♦ | | SIPOC diagram | ♦ | | | | |
| Flow diagrams | ♦ | ♦ | ♦ | ♦ | ♦ | Stakeholder analysis | ♦ | | | ♦ | |
| Histogram/frequency plots | | ♦ | ♦ | ♦ | ♦ | Standardisation | | | | | ♦ |
| FMEA | | ♦ | | ♦ | | Stratification | | ♦ | ♦ | ♦ | ♦ |
| Gage repeatability & reproduceability | | ♦ | | | | Stratified frequency plots | | | ♦ | | |
| Hypothesis test | | | ♦ | | | Time series plots (run charts) | | ♦ | | | |
| Kano model | | ♦ | | | | VOC (voice of the customer) | ♦ | | | | |

*Figure 2-15: DMAIC tools used in each stage (from Knowles, Whicker, Femat, & Canales, 2005)*

In this subchapter, like in the previous one where the Lean tools were pointed out, some Six Sigma tools will be explained, according to its importance to this case study.

## I. SIPOC

SIPOC stands for Suppliers, Input, Process, Output and Clients/Customers. Defining the integrating factors of this diagram according to George (2003):

- Suppliers are the entities (person, process, company) that provides whatever is worked on in the process (information, forms, material). The supplier may be an outside vendor or another division or a co-worker (as an internal supplier)
- Input is the information or material provided
- Process is defined by the steps used to transfer (both those that add value and those that do not add value)
- Output is the product, service or information being sent to the customer
- Clients are the next step in the process, or the final (external) customers.

SIPOC Diagrams are very useful at the beginning of a project to supply information to the project team before the actual work starts. According to Simon (2010), this tool is especially useful when it is not clear (a) who supplies raw materials; (b) what are the specifications required for the inputs; (c) who the clients are and (d) what are the clients' requirements. Miles (2006) refers that the extensive comprehension of a process, its parts and how they relate, is crucial for its improvement. It also insures that every member of the team understands the process in the same way. A SIPOC diagram usually takes shape during the Define stage of DMAIC, but its impact is felt throughout the rest of the improvement project as well (George, 2003b).

## II. VOICE OF CUSTOMER (VOC)

Griffin & Hauser (1993) tell us that, in order to address both strategic and operational decisions, industry practice has evolved a form of customer input that has become known as *Voice of Customer*. Werkema (2004) also discusses this important tool that consists in a group of data that represent clients' expectations and needs, as well as their perception about the company's products. This data can come from complaints, commentaries, meetings, surveys or target researches. They are essential for identifying the Critical to Quality characteristics of the products and its specifics.

Although, in the Six Sigma philosophy there are three very important voices that should be heard: the voice of process, the voice of customer and the voice of employee. The **voice of process** is listened to during the all project, through the tools here presented like SIPOC. The **voice of customer** is used in order to achieve the required quality for the process, as expressed in the CTQ Tree tool. The **voice of employee** can be searched for but it is, most commonly, spontaneously presented. It constitutes an important tool to both gain solutions, new ideas and involve, commit employees. Walumbwa & Schaubroeck (2009) say "it concerns the bottom-up process of rank-and-file employees making innovative suggestions for change and recommending modifications to standard procedures". Like helping behaviour, constructive voice behaviour should be valued by leaders because it can reveal problems and solutions to problems as well as point to other ideas that may help work unit functioning.

## III. Critical-To-Quality Tree

Six Sigma's implementation distinguishes from other methodologies because is based on goals and deadlines defined according to the clients' needs instead of internal assumptions or considerations on the business performance (Linderman et al., 2003). An essential task for any Six Sigma improvement project is, therefore, determining exactly what the Customer needs and, subsequently, explaining the parameters inherent to the characteristics that need improvement in each process.

The critical to quality (CTQ) tree is used for identifying critical customer requirements. This simple tool helps to move from general needs of the customers to more specific requirements (Ditahardiyani, Angwar, & Ratnayani, 2008). According to Carvalho (2010), the CTQ tree tool permits transforming the clients' needs, identified with the VOC tool, into metrics that represent important impacts on clients' requirements, processes' performance and quality. These metrics are called quality characteristics and are pivotal to the project development, once that they're where the improvement actions should focus. A successful implementation depends on the comparison between these quality characteristics at the beginning and end of the project.

## IV. Project Charter

Werkema (2004) tells us that the Project Charter is a document that represents an agreement between the team responsible for the development and the company's management team. Its main goals are the clear definition of what is expected from the development team; the alignment between the company's priorities and the team's work; formalizing the delivery of the project from the Champion to the team; and keeping the team's work within the project's scope.

Looking at some Project Charter examples, like the one presented in Werkema (2004), is possible to infer that this tool should include the problem addressed and opportunity presented in order to develop this project, the problem's historical and contemporary context, purpose, objectives, restrictions, predicted finish date, project members (team structure) and a preliminary schedule.

## V. Focus Groups

According to Kitzinger (1995), Focus Groups are a form of group interview that capitalizes on communication between research participants in order to generate data. Although group interviews are often used simply as a quick and convenient way to collect data from several people simultaneously, focus groups explicitly use group interaction as part of the method. The idea behind the focus group method is that group processes can help people to explore and clarify their views in ways that would be less easily accessible in a one to one interview. Everyday forms of communication may tell us as much, if not more, about what people know or experience. In this sense focus groups reach the parts that other methods cannot reach, revealing dimensions of understanding that often remain untapped by more conventional data collection techniques.

The downside of such group dynamics is that the articulation of group norms may silence individual voices of dissent. The presence of other research participants also compromises the confidentiality of the research session. The groups can be "naturally occurring" (for example, people who work together) or may be drawn together specifically for the research.

## VI. Brainstorming

Juran & Godfrey (1979) tell us that Brainstorming is “a group technique for generating constructive and creative ideas from all participants. The use of this tool should provide new ideas, or new applications and novel use of existing ideas”. The technique is outlined here:

- Good ideas are not praised or endorsed. All judgment is suspended initially in preference to generating ideas.
- Thinking must be unconventional, imaginative, or even outrageous. Self-criticism and self-judgment are suspended.
- To discourage analytical or critical thinking, team members are instructed to aim for a large number of new ideas in the shortest possible time.
- Team members should “hitchhike” on other ideas, by expanding them, modifying them, or producing new ones by association.

## VII. Key Performance Indicators

Key Performance Indicators (KPIs) measure the business health of the enterprise and ensure that all individuals at all levels are "marching in step" to the same goals and strategies. They also provide the focal point for enterprise-wide standardization, collaboration and coordination. KPIs are quantifiable metrics which reflect the performance of an organization in achieving its goals and objectives. KPIs reflect strategic value drivers rather than just measuring non-critical business activities and processes. KPIs align all levels of an organization (business units, departments and individuals) with clearly defined and cascaded targets and benchmarks (Bauer, 2004).

According to Parmenter (2010), there are four types of performance measures, as shown on Figure 2-16:

1. Key result indicators (**KRIs**) tell you how you have done in a perspective or critical success factor.
2. Result indicators (**RIs**) tell you what you have done.
3. Performance indicators (**PIs**) tell you what to do.
4. **KPIs** tell you what to do to increase performance dramatically.

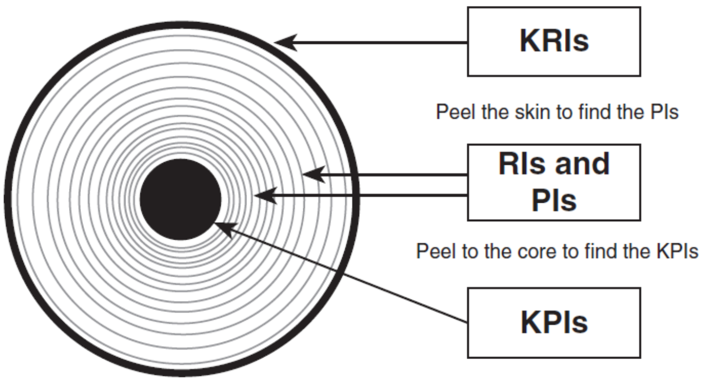


*Figure 2-16: Four types of performance measure (from Parmenter, 2010)*

So, according to this indicators' definition presented by Parmenter (2010), there are the seven characteristics of KPIs:

1. Are nonfinancial measures (e.g., not expressed in dollars, yen, pounds, euros, etc.)
2. Are measured frequently (e.g., 24/7, daily, or weekly)
3. Are acted on by the CEO and senior management team
4. Clearly indicate what action is required by staff (e.g., staff can understand the measures and know what to fix)
5. Are measures that tie responsibility down to a team (e.g., CEO can call a team leader who can take the necessary action)
6. Have a significant impact (e.g., affect one or more of the critical success factors [CSFs])
7. They encourage appropriate action (e.g., have been tested to ensure they have a positive impact on performance, whereas poorly thought-through measures can lead to dysfunctional behaviour).

KPIs are current- or future oriented measures as opposed to past measures (Parmenter, 2010). Companies have to choose wisely the variety of KPIs used and balance them so that one KPI won't measure overlapped information from another KPI. This choice depends on the goals defined for each organization/project.

Within Six Sigma projects, the most commonly used metrics revolve around the sigma level, quality characteristics and number of defects. Therefore, Werkema (2004) refers the four main metrics based on the measurement of defects:

1. Defects per Unit (DPU) – mean number of defects per each product unit
2. Defects per Opportunity (DPO) – mean number of defects per each product unit, considering the number of defect opportunities
3. Defects per Million Opportunities (DPMO) – represents the same as DPO, but for one million defect opportunities
4. Sigma scale – is where the limits of the specifications of each process are, in standard deviation units. This can be converted from the DPMO value.

## VIII. Pareto Diagram

The Italian economist Vilfredo Pareto (1848-1923) observed, in 19th century Italy, that 20% of the population owned 80% of the usable land. Pareto found the same distribution in other economical and natural processes. Since the 80/20 phenomena seems to be so ubiquitous the question is, whether there might be "law of nature" behind this observation (Ultsch, 2002). This [Pareto] principle states that in any population that contributes to a common effect, a relative few of the contributors—the vital few—account for the bulk of the effect. The principle applies widely in human affairs (Juran & Godfrey, 1979).

According to Loureiro (2012), the Pareto Diagram objective is to draw, amongst the factors that contribute to a certain effect, the vital ones and the trivial ones, through a quantitative and ordered comparison. Is possible to verify that a small group of causes leads to a substantial part of the defects. By applying this tool, one can distinct the few really pivotal problems from the mass of small non-important ones.

Under the Pareto principle, the vital few projects provide the bulk of the improvement, so they receive top priority. Beyond the vital few are the useful many projects. Collectively they contribute only a minority of the improvement, but they provide most of the opportunity for employee participation. Choice of these projects is made through the nomination selection process (Juran & Godfrey, 1979).

Ultsch (2002) also tells us that Pareto's 80/20-law is used in the so called ABC analysis, utilized for the optimization of businesses and projects. ABC-analysis means to classify subprojects into three classes A, B, and C. Subprojects are ordered in decreasing order of yield. Class A should contain projects of high yield, class B projects of medium yield and C projects of low yield. Typical proposals for the limits of yield in class A range from 5% to 33%. Proposals for class B range from 15% to 33%, for class C from 25% to 50%.

Juran & Godfrey (1979) complement saying that, in addition to facilitating analysis, presenting the data in the form of a Pareto diagram greatly enhances communication of the information, most notably in convincing upper management of the source of a problem and gaining support for a proposed course of action to remedy the problem.

## IX. Ishikawa Diagram

Developed by Kaoru Ishikawa, this tool is frequently called the Ishikawa diagram in his honour. Its purpose is to organize and display the interrelationships of various theories of root causes of a problem. By focusing attention on the possible causes of a specific problem in a structured, systematic way, the diagram enables a problem-solving team to clarify its thinking about those potential causes, and enables the team to work more productively toward discovering the true root cause or causes (Juran & Godfrey, 1979).

Hagemeyer, et al. (2006) tell us that the Ishikawa diagram, also known as cause-effect diagram, is a schematic tool which resembles a fishbone, where the causes and sub-causes of a determined problem are listed.

As said by Carvalho (2010), this tool allows a simple and effective vision of a significant number of causes of a certain effect. These are structured in 3 core categories: main causes (bones), sub-causes (bones' ramifications) and the effect.

Werkema (2006) mentions six common causes that lead to the effect: material, method, measurement, milieu, man and machine. Taghizadegan (2010) remarks that this tools can be very useful when investigating root-causes of a certain problem, as well as when identifying areas where problems may arise.

## X. Flowchart

A Flow Chart is defined as a formalised graphic representation of a program logic sequence, work or manufacturing process, organisation chart, or similar formalised structure. It is a graphical representation in which symbols are used to represent such things as operations, data, flow direction, and equipment, for the definition, analysis, or solution of a problem. It has frequently been used over many years although there is no exact date for its origin (Aguilar-Savén, 2004).

The main characteristic of Flow Chart is their flexibility. A process can be described in a wide variety of ways. The standard just gives the notation, but how the different building blocks are put together is up to the designer of the chart. When we look at a flowchart representation, it is easy to recognise the processes it describes.

Aguilar-Savén (2004) also mentions that the real strength of the standard is the communication ability. The Flow Chart model is very easy to use. It does not take a very long time to draw a sketch of a process. The weakness of the standard is that it is too flexible. The boundary of the process may not be clear. Visualising the process with a flowchart can quickly help identify bottlenecks or inefficiencies where the process can be streamlined or improved.

## XI. PRIORITIES MATRIX

The priorities matrix allows one to restrict some previously formulated options to the ones with a higher priority level. This priority must be defined according to pre-established criteria. This tool should be used when facing a set of concurrent solutions to a problem, and a pivotal decision have to be make regarding the prioritization of future actions (Domingues, 2013).

In line with Pereira & Requeijo (2012), to construct a priorities matrix, the following steps should be taken:

1. Identify the alternatives for evaluation.
2. Define evaluation criteria and correspondent weighing. This should be done by the project owners, according to the identified needs. The weighing is provided by the evaluation grid shown on Table 2-9.
3. Calculate each alternative according to the pre-established criteria. Matrixes should be designed combining the weight of each alternative consistent with each one of the criteria. As so, the number of matrixes at this stage should be the same as the number of defined criteria.
4. Evaluate each alternative in line with each one of the criteria, through the previously constructed matrixes.
5. Assess the results obtained and select the alternatives that show higher relevance percentages.

*Table 2-9: Evaluation grid for the criteria assessment on the Priorities Matrix method*

| |
|---|
| 1.0 = Equally important or equally preferred when judged against the other |
| 2.0 = Significantly more important or more preferred |

| |
|---|
| 5.0 = Extremely more important or more preferred |
| 0.2 = Significantly less important or preferred |
| 0.1 = Extremely less important or preferred |

## 2.3 Lean Six Sigma Management Paradigm

Bringing together the information exposed on the two previous subchapters, the Lean Six Sigma Management Paradigm will here be discussed as a complementary methodology. First, the definition and concepts concerning this philosophy are presented, regarding the concepts from both Lean and Six Sigma's approaches. Then, a brief overview on the application of this methodology is given, with reference to the advantages of integrating these two schools of though.

### 2.3.1 Definition and concepts

Lean Six Sigma (LSS) is a result of the approach through the perspectives of Lean and Six Sigma, in a way that the company responds with the highest efficiency possible to its client while taking into account the increase in profitability through continuous improvement (Loureiro, 2012).

Companies feel the need to continuously improve their performance in all areas, such as in operations, organization or even in the adopted management strategy. This necessity leads many companies to implement Lean Manufacturing and Six Sigma principles, in order to optimize performance and keep up with competitors, or even overtake them (Melton, 2005). Focusing on different strategies, the convergence between Lean and Six Sigma leads to an approach that allows the systematization of the intervention on a company's processes, always considering the criticality of the activities and the priority of the improvement actions (Taghizadegan, 2006). The Six Sigma methodology emphasises on controlling the processes variation. Though, this doesn't mean the processes will rapidly increase efficiency. In order to improve processes efficiency one can adopt the Lean methodology (Carvalho, 2010).

Although their distinction, the two concepts are alike in the sense that both are management systems that require cultural significant changes, new approaches to production and client service and a high level of formation at all levels of the organizational structure of a company (Arnheiter & Maleyeff, 2005). Lean philosophy prizes the elimination of all the activities that do not add value and a continuous flow of production, promoting a quicker stream of the product to the client. Then again, the Six Sigma philosophy focuses on eliminating the errors that produce defects and reducing variability on processes. Applying these two philosophies translates in a truly important conjugation of principles steering towards the success and growth of the company (Werkema, 2006).

In this sense, both Lean and Six Sigma's philosophies partake as their main goal the improvement of the processes' outputs, reducing waste and variability (Devane, 2004). On Figure 2-17, Loureiro (2012) illustrates the blend between Lean and Six Sigma's methodologies into the Lean Six Sigma management paradigm, displaying its main goals and pillars.

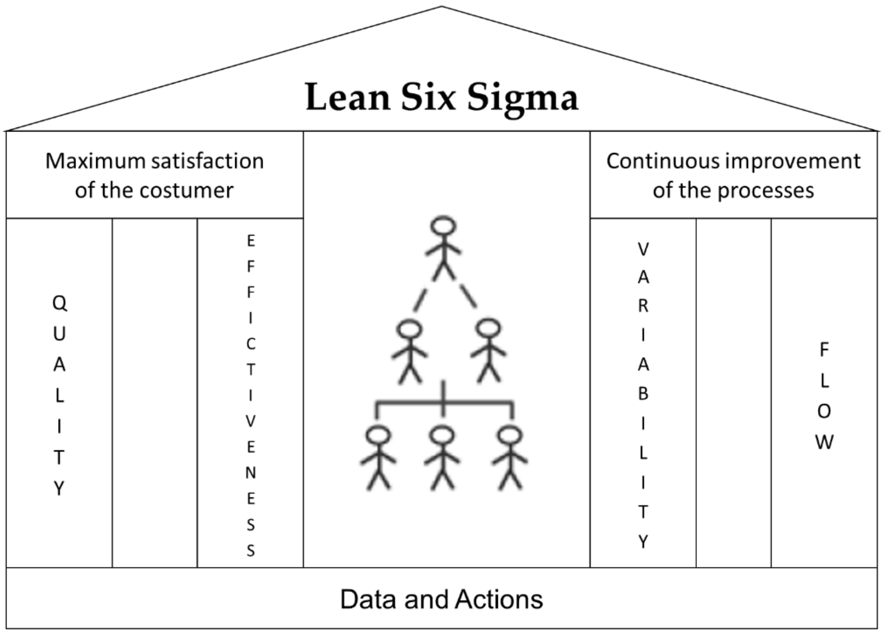


*Figure 2-17: Illustrative scheme of the Lean Six Sigma paradigm (adapted from Loureiro, 2012)*

On the words of Carvalho (2010) the LSS methodology can be considered the state of the art strategy, aiming to develop the entire structure of an organization and, mainly, guarantee the preservation of the gains obtained. If the implementation of each (Lean and Six Sigma) results in an improvement, is naturally witnessed that their merger will allow an even more positive result, given their complementarity.

### 2.3.2 Applications and Benefits

As stated by Werkema (2006), the Lean paradigm doesn't have a structured profound method for problem solving armed with the proper statistical tools to deal with the variability of processes. This problem can be bridged by Six Sigma. On the other hand, Six Sigma doesn't emphasize the improvement of the process flow or the reduction of lead time – features that constitute the very core of the Lean paradigm. El-Haik & Roy (2005) also refer that, as both philosophies have the common goal of continuous improvement, the DMAIC methodology presents as a crucial support tool so as to achieve it - once that this cycle aims to improve processes without the need for reengineering.

The greater implications of the application of the LSS method are: i) the involvement of the all organization, ii) the appreciation of the collaborators and iii) the capacity to accept change (Carvalho, 2010). On Table 2-10, Taghizadegan (2010) provides an useful comparison between the application of the traditional management methods and the LSS management paradigm method.

Arnheiter & Maleyeff (2005) denote the advantages of each paradigm separately: Six Sigma, on one hand, allows the attainment of a lower cost of production through the reduction of variability. Lean, on the other, has a bigger impact on the client's perspective, by specifying what means value for the costumer. Therefore, by putting the two procedures together is possible to obtain advantages from either sides, benefiting both the producer and the client. This theory is illustrated ahead, on Figure 2-18. The same authors also mention more gains regarding the integration of Lean with Six Sigma. These concern the global optimization of the production system, the incorporation of a decision making process based on the impact on the client and the implementation of a highly structured regime of training omnibus to the entire company.

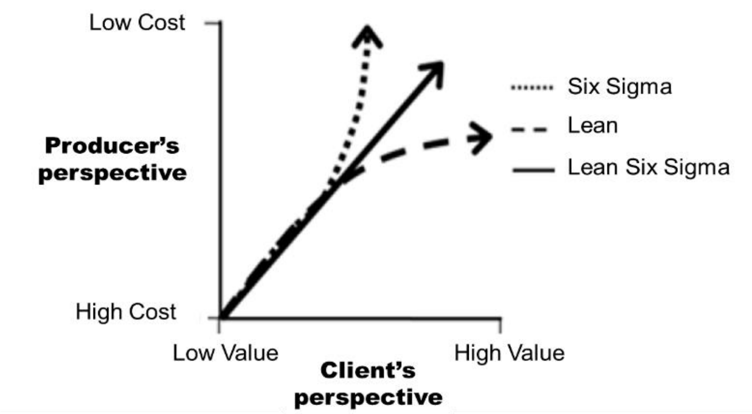


*Figure 2-18: Advantages of putting Lean and Six Sigma together on both the producer's and client's perspective (adapted from* Arnheiter & Maleyeff, 2005)

On a highly competitive environment, the previous authors have verified a decrease of the stated benefits when each philosophy was implemented independently.

Devane (2004) sum it up affirming that the strengths of one paradigm correspond to the weaknesses of the other. Thus the author presents a resume of the LSS advantages by topics:

- Provide waste reduction and increase production flow rapidness
- Conduct to significant financial gains that derivate from the reduction of stock and other production materials
- Reduce the level of defects and variability, through the statistical process control (SPC)
- Allow establishing system performance metrics, facilitating the process control.

*Table 2-10: Comparison between traditional methods and Lean Six Sigma approach (adapted from Taghizadegan, 2010)*

| Problem | Traditional methods | Lean Six Sigma |
|---|---|---|
| Problem | Resolve | Prevent |
| Stock level | Produce in big quantities | Produce only when necessary |
| People | Cost to the company | Company's assets |
| Management | Cost & Time | Quality & Time |
| Worker's goal | Company | Client |
| Product engineering | Few intervention from the client | Much intervention from the client |
| Quality focus | Product | Process |
| Conformity | Evaluation by experience | Evaluation based on statistics |
| Company's prospection | Short-term plan | Long-term plan |
| Clients' satisfaction | Acceptable quality index | Near zero defects |
| Layout | Functional | Cells/by product |
| Production schedule | Forecasts | Client's orders |
| Production costs | Continuously increasing | Stable and decreasing |

All the tools used in the LSS paradigm come from either Lean or Six Sigma's methodologies, having therefore been mentioned above.

## 2.4 ERGONOMICS

The definition of Ergonomics is here presented together with some context about its origins. Then, a few characterizations and related principles are discussed. Furthermore, some relevant concepts to this case study are brought to light, namely ergonomic risk factors, work-related musculoskeletal disorders and absenteeism. The most commonly utilized tools and methodologies are overviewed so to conclude the chapter on Ergonomics.

### 2.4.1 DEFINITION AND CONCEPTS

The word "Ergonomics" comes from the Greek *ergon* meaning work and *nomos* that means the laws of nature. Ergonomics is a science which objective is to adapt the work station, equipment or tasks to the person working, so to improve its security, health, comfort and performance without compelling the person to adapt to the task (Dul & Weerdmeester, 2008). In fact, Tavares (2012) tell us that in ancient Greece, work had double meaning: slave work, painful and without any creativity (*ponos*) and the work of creation, satisfaction and motivation (*ergon*). Therefore, Ergonomics goal is to transform *ponos* into *ergon*. The word Ergonomics is becoming everyday more familiar and utilized. Yet, it was created due to the need of expressing the scientific study of men and the relation with their work.

The International Ergonomics Association (IEA Council, 2000) defines Ergonomics (or human factors) as "*the scientific discipline concerned with the understanding of interactions among humans and other elements of a system. It is also the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. Practitioners of ergonomics and ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people*".

As said by Dul & Neumann (2009), besides the social objective of the workers' well-being, Ergonomics also has an economic objective, aligned with the global company's performance. Yet, Nunes, et al. (2012) adds that managers still associate Ergonomics with occupational safety and health (OSH) and its legislation, instead of linking it to the organizational performance. Thus, Dul & Neumann (2009) confirm that for Ergonomics to be valued in companies, a switch-over has to occur from the Ergonomics/health paradigm to Organizational Ergonomics paradigm, though never loosing from sight the OSH goals and rules. Tavares (2012) mentions that Ergonomics has been a reason for increasing productivity and improving product quality in companies, if not to talk about the gain of quality of life for the workers.

Ergonomics is a science that can be applied at any productive system, so to expand the workers performance with a consequent improvement in the processes quality, work environment and workers health. Thus it should be incorporated from the beginning of the plan and conception of a productive system, so to integrate the worker as a piece of the engine from scratch. The work conditions created should contemplate workers health, individual and collective performance and the maximum utilization of their capacities so to reach the organization's goals (Diogo Freitas, 2014).

The impact of Ergonomics in a company can have a social nature, regarding the increased motivation of workers due to the improvement of work conditions, and an economical nature where financial gains can be obtained due to this increase in workers' motivation (Dul, 2003). Ergonomics intent is to maximize human resources efficiency without risking their safety; minimize their exposure to risk factors due to lack of ergonomic adequacy; and proactively obtain a continuous improvement program at the initial stage of any conception activity or when changes in the production flow or processes have to be made (Smith, 2003 cited by Nunes et al., 2012).

This science is not only constituted by anthropometry and biomechanics, but searches fundamentally to adapt the work to the worker, so to provide satisfaction and incentive. This adaption doesn't concern only the environmental, but also physiological conditions (Tavares, 2012). The IEA Council (2000) also affirms that "*there are domains of specialization within the* *discipline, which represent deeper competencies in the specific human attributes or characteristics of human interaction*". These are broadly the following: physical ergonomics, cognitive ergonomics and organizational ergonomics – and are summarily presented next.

### Physical ergonomics

Physical ergonomics is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity. Relevant topics include working postures, materials handling, repetitive movements, work related musculoskeletal disorders, workplace layout, safety and health (IEA Council, 2000).

### Cognitive ergonomics

Cognitive ergonomics concerns mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. Relevant topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system design. (IEA Council, 2000).

### Organizational ergonomics

Organizational ergonomics regards the optimization of sociotechnical systems, including their organizational structures, policies, and processes. Relevant topics include communication, crew resource management, work design, design of working times, teamwork, participatory design, community ergonomics, cooperative work, new work paradigms, virtual organizations, telework, and quality management. (IEA Council, 2000)

Tavares (2012) provides other types of classifications for the science of Ergonomics. It can be classified according to its coverage, contribution and interdisciplinary. Regarding Ergonomics **coverage**, the categorisations are:

- <u>Work station ergonomics</u>: micro-ergonomics approach.
- <u>Production systems ergonomics</u>: macro-ergonomics approach.

As for its **contribution**, the groupings are:

- <u>Conception ergonomics</u>: applying norms and ergonomic specifications when projecting tools or work stations, before their implementation.
- <u>Correction ergonomics</u>: is the modification of existent work situations. The ergonomic study is performed after the implementation of the productive system.
- <u>Physical arrangement ergonomics</u>: improvement of the processes sequence and production flows, by changing the plant layout for example.

- Awareness ergonomics: revolves around the capacitation of people about the methods and technics of ergonomic analysis at work.

Concerning the **interdisciplinary**, the subjects are:

- Engineering: project and production according to ergonomic standards, guaranteeing the safety, health and efficiency of people at work.
- Design: application of the ergonomics norms and principles to the project and design of products.
- Psychology: recruitment, training and staff motivation.
- Medicine and Nursing at work: preventing accidents and work related illnesses.
- Administration: human resources management, projects and organisational changes.

Ergonomics principles and guidelines are useful in the prevention of operator fatigue and stress leading to potential work-related musculoskeletal and neurovascular disorders (Walder et al., 2007). Nunes & Machado (2007) confirm that the consequences of not applying ergonomic principles to the work system are both to the worker and to the company. The emergence of muscular discomfort, fatigue, work stress, and/or musculoskeletal disorders is the most common consequence for workers. For the companies the results may be the increase of errors, workers' absenteeism, or the diminishment of productivity and employees' morale.

Some of the key ergonomics principles for a sound workplace design, provided by Walder et al. (2007), include:

- Avoiding prolonged, static postures
- Promoting use of neutral joint postures
- Locating work, parts, tools, and controls at optimal anthropometric locations
- Providing adjustable workstations and a variety of tool sizes
- When appropriate, providing adjustable seating, arm rests, back rests, and foot rests
- Utilizing feet and legs, in addition to hands and arms
- Using gravity
- Conserving momentum in body motions
- Providing strategic location (in the *power zone*, see Figure 2-19) for lifting, lowering, and releasing loads
- Accommodating for a broad variety of workers with respect to size, strength, and cognitive abilities.

Many of these principles can be met by using techniques such as redesigning work, standardizing work, and reducing or eliminating risk factors for potential development of WRMSDs, especially the physical risk factors (NIOSH, 2007 cited by Walder et al., 2007).

The *power zone*, shown on Figure 2-19, is the lifting region that is considered optimal by ergonomists. The power zone optimizes worker strength and durability with the most comfort by providing the arms and back with maximum leverage. Often, workplace lifting and lowering occurs in locations that are out of the power zone. The advantage of material handling assist devices is to bring objects into the power zone at critical points during the work task. By bringing material, especially heavy loads, into the power zone, material handling assist devices improve ergonomics and decrease the risk of WRMSDs (Walder et al., 2007).

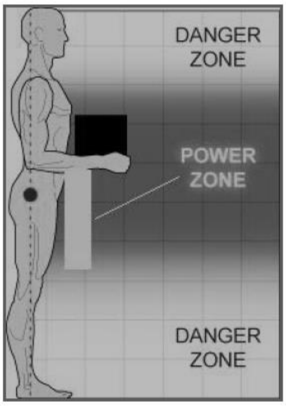


*Figure 2-19: Power zone representation (from Walder et al., 2007)*

The three fundamental characteristics of Human Factors/Ergonomics (HFE), according to Dul et al. (2012), are:

1. Requires a systematic approach: HFE is based on systems that were conceived to integrate the human part with their work environment. This environment can be an artefact made by men (product, tool, task, e.g.) or constituted by other humans. For this, HFE has to consider different aspects of the person/individual (physical, physiological, psychological and social) and of the setting (physical, social, etc.). It's possible to approach the study from different levels: micro (human interaction with a tool or a simple task), mesial (human interaction in an organization or technical process) and macro (human interaction on a network of organizations, regions, countries or the world). Even though, the context surrounding the man in its environment is always taken into account and this is what is called a systematic or holistic approach.
2. Has the goal to conceive: Ergonomics strives to improve the performance and well-being through the systems' conception. The HFE can be involved in every stage of the planning, design, implementation, evaluation, maintenance and continuous improvement of systems. These phases might not be sequential (they are dynamic), but the design has to be attendant in every single one of them.
3. Focuses on two results that relate to each other – performance and well-being: Performance and well-being interact – performance can be influenced by the well-being and vice-versa, either in short as long term. Performance deteriorates when the setting

doesn’t suit the human capacities and limitations (when there are system’s parts that become an obstacle instead of a support).

Ergonomic interventions improve significantly the efficiency, productivity, safety and health of workers. Actions occur in every front of any situation at work or leisure, from physical stress to ambience factors that affect hearing, vision or comfort (IEA Council, 2000).

## I. RISK FACTORS

An ergonomic risk factor is a condition or practice that can act as an obstacle to productivity, a challenge to consistent quality, or a threat to worker comfort, safety and long-term well-being (Burke, 1998).

A wide number of factors influence the ergonomics performance. They are posture (sitting, standing, change of posture, hand and arm postures) and movement (lifting, carrying, pulling and pushing), information and operation (visual information, hearing, other senses, controls for operation, dialogues, website design, mobile interaction, virtual reality), environment factors (noise, vibration, illumination, climate and chemical substances) and work organization jobs and tasks. These factors also influence the health, safety, comfort and worker efficiency (Dul & Weerdmeester, 2008).

The three major risk factors for potential development of work-related WRMSDs are high force, awkward posture, and excessive repetition. Other potential risk factors can include vibration, cold stress, lack of rest, non-occupational factors (e.g., hobbies, sports, home chores, driving, and sleep issues), personal risk factors (e.g., gender, age, health history, and fitness level), and even psychosocial factors (e.g., organizational climate and culture, job attitude and satisfaction, personality traits, and personal problems [e.g., loss of a loved one, financial difficulties, etc.]) (Walder et al., 2007).

Burke (1998) affirms that most risk factors fall into the following categories:

- Awkward range positions: An awkward range position occurs when a person moves a body part as far as it will go or close to this position.
- Unsupported postures: An unsupported position occurs when an individual holds a body part without moving it or resting it on anything for a period.
- Forceful exertions: A forceful exertion occurs when an individual moves a body part against resistance or maintains a body part in a static position against resistance.
- Environmental conditions: An environmental condition is an element of the physical surroundings that may result in discomfort or interrupted productivity.

- <u>Excessive physiological demands</u>: Excessive energy demand is a requirement for physical exertion that by nature of its excess can lead to discomfort or interrupted productivity.

The adopted work posture is determined by the interaction of several factors such as the system layout, work organization, ambience and psychosocial factors (Tavares, 2012).

According to the European Agency for Health and Safety at Work, "*the work related stress is one of the major challenges towards health and safety in Europe. Near one in every four employees is affected by stress. There are studies indicating that stress is responsible for approximately 50 to 60% of the lost work days*". Another research, led by A. Vania Apkarian at a Northwestern University, found that chronic back pain shrinks the brain by as much as 11%, equivalent to the amount of grey matter lost in 10 to 20 years of normal aging.

Hence, contemporary work design seeks to utilize an optimal balance of human and machine capabilities. When humans become overtaxed, either physically or mentally, they experience fatigue (physical or mental) and experience subsequent decreases in output, productivity, and quality. Therefore, for the human side, it is key to understand and fully utilize both physical and mental capabilities in an optimal manner, sometimes described as **"***working smarter, not harder***"** (Walder et al., 2007).

## II. WORK-RELATED MUSCULOSKELETAL DISORDERS (WRMSDS)

The designation adopted for this type of perturbations is not consensual among the international literature. Some of the terms used include Cumulative Trauma Disorder, Occupational Overuse Syndrome, and Repetitive Strain Injury. The designation adopted in this document is work-related musculoskeletal disorders (WRMSDs).

Work-related musculoskeletal disorders are described by Nunes (2006) as pathological states of the musculoskeletal system, that arise as a consequence of the cumulative effect of the lack of balance between the mechanical repetitive solicitations at work and the capacity of the hit part of the body to adapt, for a long period of time while recovery time isn't enough. Any body part can be affected, although upper limbs, neck and the lumbar area stand the majority of incidence parts.

The WRMSDs present a common health problem in the industrialized world of today and are one of the main causes for work incapacity. They can affect nerves, tendons or muscles, causing localized fatigue, discomfort, pain, swelling or tingle. These injuries develop due to the exposure to adverse conditions throughout the time (months or years), such as highly repetitive activities, protracted or repetitive effort, sustaining the joints in extreme positions for large periods of time, external pressure or exposure to vibration. Additionally, the personal characteristics, ambience and socio-cultural factors are also recognized as risk factors to the development of these illnesses (Nunes, 2006).

The knowledge that labour can adversely affect health is not recent. Since 1717 - almost 300 years ago – the relationship between work and certain injuries in the musculoskeletal system was recognized. This was the doing of an Italian doctor - Bernardini Ramazzini, father of Occupational Medicine. These type of problems didn't fade away but instead it was admitted as an inevitable consequence of certain practices. The technological development brought more lack of individual initiative in managing the working/resting time. The more modern versions of the symbolic assembly line are e.g. offices with computers or food processing centres [as the one in the case study here presented] (Nunes, 2006).

Nunes (2006) also refers that, because of the prevalence of these disorders, they create one of the biggest occupational problems that workers meet, generating enormous human and economic costs. The economic impact of the WRMSDs can be analysed considering direct and indirect costs. The *direct costs* regard claims and medical costs payed to injured workers. These can represent from 30 to 50% of the total amount of costs. The *indirect costs* concern the value of the work loss that results from loss of productivity and quality, turnover and training of new employees, when these individuals are absent from work or experience diminished productivity at work while recovering from the illness (Pauly et al., 2002; Nunes, 2006). These are very often slighted because their accurate quantification is impossible. Walder et al. (2007) affirms that WRMSDs typically account for about one-third of workplace reports of injury, but more importantly they often account for about three-fourths of costs. WRMSD claims requiring surgery can, in total, cost approximately $15K for a wrist disorder, $20K for a shoulder injury, and $40K for a back injury. The cost of lost workdays of WRMSDs, based on lost earnings and workers' compensation, has been estimated at $13-20 billion annually and as high as $50 billion annually if indirect costs are included (MacLeod, 2006).

## III. ABSENTEEISM

The *European Foundation for the Improvement of Living and Working Conditions* - EUROFUND (1975) defines absenteeism as the "*temporary, continued or permanent inability to work, resulting from disease or illness*". It's stressed that the temporary incapacity to work refers to, in most countries, the first absent period (first 52 weeks of the incapacity state). Plus, it was further divided into: (1) short-term absenteeism – 1 to 7 days; (2) mid-term absenteeism – 8 to 42 days; and (3) long-term absenteeism – more than 42 days.

Fritzsche, et al. (2014) show us that theory and empirical evidence suggest that work conditions with high-physical task demands lead to more absenteeism and reduced job performance in manufacturing jobs. Supported by Kumar (2001), who states that work conditions with high-physical task demands are likely to cause WRMSDs and prolonged sickness absenteeism. The *National Institute for Occupational Safety and Health* sustains that the term *work conditions* is related with several variables that determine the action of performing a task, so as the place where this occurs. This definition covers health and safety conditions, physical work environment, schedule distribution, physical and mental work load, work organization, supervision and management style and employers involvement and participation (Rodrigues, 2011).

According to Mallada (1996), on his study about absenteeism management on Spanish companies, absence is a sociological phenomenon directly linked to individual's and society's attitude towards work. Everything plausible of providing a positive and adequate attitude, such as integration, satisfaction and motivation, results in a lower absenteeism rate; otherwise, all that deteriorates the employee relationship with the organization, namely career stagnation, monotonous and repetitive tasks, low wage, lack of acknowledgement, as others, conveys a higher absence rate. There are several studies that mention that work satisfaction has a pivotal role on the absenteeism subject (Brayfield & Crockett, 1955; Herzberg et. al., 1957; Ilgen & Hollenbeck, 1972; Porter & Steers, 1973; Vroom, 1964). Lack of satisfaction at work can translate into a high absence rate, bringing other problems related with morale, discipline, stress, productivity and administrative costs (Tylczak, 1993).

Effectively, Locke (1976) has verified a strong negative link between satisfaction and absenteeism at work. The same author shows that there are determinant elements for instigating satisfaction/dissatisfaction at work. These relate to factors like the possibility of promotion, work environment and conditions, relationships with co-workers, acknowledgement, supervision and management characteristics, competences and company's policies. As for motivation, Neves (2002) cited by Rodrigues (2011), affirms it is a psychological concept that relates with the behaviour's strength and direction, because people are motivated by feelings of continuous development. The factors like the work's content, recognition, autonomy and responsibility are the ones that really motivate professionals.

Recognition is one of the most referred events in the literature as a generator of satisfaction (Locke, 1973). This condition represents an explicit desire for acknowledgement from peers and superiors and it's related with positive self-esteem and self-concept necessities (Locke, 1976). A study reported by Tylczak (1993), conducted at *Maid Bess Corporation*, showed that amongst rewards like an assiduity prize, feedback, a possible prize drawn among the assiduous employees and recognition for the work done, the one that presented the most significant results at lowering the company's absence rate was the last one – recognition. The rate lowered from 7,56 to 6,04 which translates into a 36,9% improvement. Just due to the direct cost, the company saved 58.000 dollars.

Rodrigues (2011) quotes Quick & Lapertosa (1982) that classify the absenteeism concept according to its main motives:

- Voluntary absence – what motivates the employer are particular issues, not justifiable by illness;
- Absence by illness – includes all absences due to illness or medical procedures, except for professional incidents;
- Absence by professional pathology – covers work-related diseases and work accidents;
- Legal absence – legally prevised absence like military service, pregnancy, blood donations and the death of relatives.
- Compulsory absence – if the employee has an impediment to show up for work due to a suspension from the employer, arrest or other justifiable reason that prevents it.

As cited by Nunes (2006), absenteeism linked to work-related health problems affects 22% of the Portuguese workers annually (23% of the European workers), according to a study conducted by the *European Foundation for the Improvement of Living and Working Conditions* - EUROFUND based on three surveys inquiring the European workforce (1990, 1995 and 2000). The average of lost workdays, by European worker, is four days per year (representing 1.600.000.000 days of work lost in the European Union).

Once that the fight against work absence has to be on prevention, it's indispensable to have a deep knowledge of its causes and relations. Literature on behavioural reactions to adverse organizational conditions considers essentially two types of answer from the employees to dissatisfaction: turnover and absenteeism (Agapito & Sousa, 2010).

It is considerably difficult to quantify absenteeism costs. Companies have to consider the costs from hiring a replacement or extra staff (Tylczak, 1993). Besides these, Rodrigues (2011) also mentions other type of costs resultant of absenteeism and that are even harder to evaluate: disciplinary problems – that bring administrative costs -, morale, stress, dissatisfaction towards work, team spirit, production quality, profitability, productivity, amongst other general additional costs. "*Not only is absenteeism expensive, but it places a heavy burden on employees who attend work regularly*" (Lockhart, 2001).

HR Magazine (1997), cited by Lockhart (2001), states that: "*Left unchecked, absenteeism won't improve. It'll only get worse*". According to the study conducted by Pauly et al. (2002), the productivity gains from programs or medical interventions that reduce absenteeism due to illness are very likely to be larger than the wage per day or per hour.

Summing up, the absenteeism problem is also a profitability problem (Tylczak, 1993). It's crucial to understand the relevance of the social phenomenon that bears the absence behaviour, looking for the implementation of management measures that correct the problem (Rodrigues, 2011).

### 2.4.2 Tools and Methodologies

Ergonomic tools allow diagnose and evaluate worker conditions, providing the information to take decisions in order to improve them. The improvements will reduce the risk of diseases and work-related accidents (Maia et al., 2012). Walder et al. (2007) confirm that the proper use of ergonomic assist devices can eliminate or reduce fatigue-related risk factors and thus allow the worker to stay both physically and mentally capable throughout the work shift.

As stated by Nunes (2006), when defining the strategy for an ergonomic intervention that aims to prevent the manifestation of WRMSDs, one has to identify and evaluate the existent or potential risk factors, either in a new or already existing work station. This evaluation is done based on the available scientific knowledge, practical experience, labour laws and norms and using ergonomic analysis tools and methodologies. Among the vast amount of available methodologies, Nunes (2006) talks about the following - OWAS, RULA, STRAIN INDEX and QEC:

1. **OWAS** – Ovako Working Posture Analysing System: a swift way to analyse and control inadequate postures in an industrial environment. The practiced postures are compared with previously defined positions and consequently classified. Additionally, this method also allows the evaluation of another risk factor – force.
2. **RULA** – Rapid Upper Limb Assessment: intends to evaluate the worker's exposure to wrong postures, excessive force and non-healthy muscular activities. This method also scores postures by comparison, as the previous. Furthermore, it scores strength and load, as well as muscle usage. All these risk factors' assessments are registered in a proper document, which provides a final evaluation together with the some recommendations regarding the level of action needed.
3. **STRAIN INDEX**: it a semi-quantitative method that evaluates intensive manual activities concerning hands, wrists and elbows exposure to the risk factors. It provides a final score named the SI score, which is related with the risk level of developing WRMSDs on that specific body part. This methodology is based on the six risk factors existent in each task: effort, wrist posture, work rapidness, percentage of the duration of the effort for every work cycle, effort per minute and the duration of the task (per day). The first three factors are evaluated based on an estimate and the last three through measurements. To apply the Strain Index method, one has to utilize the "User Guide".
4. **QEC** – Quick Exposure Check: this method analyses the body exposure to the most relevant risk factors, in the most endangered body areas: back, shoulders, arms, hands/wrists and neck. It was conceived with the objective of having a quick, easy and training-free implementation. It's based on two forms – one with questions, both directed to the analyst and the operative; the other is for registering and calculating the scores. The final score corresponding to each body part results from the interactions between the exposure levels of the risk factors. Besides analysing the exposure level, is best to watch for the interactions that most contribute to this final score.

## 2.5 Lean Ergonomics and Six Sigma (LESS)

The previous chapters detailing Lean, Six Sigma, LSS and Ergonomics characteristics and key principles all merge here to explain the theoretical idea behind this case study. LESS is the way to strive for excellence in any organization. Hereafter it is possible to understand why these paradigms belong together and how does it can be put into practice.

Wilson (2005) put it this way: "*Since lean and ergonomics share the goals of eliminating waste and adding value, there are natural integration points in most lean processes. Ergonomics is simply another tool that can be used to make lean processes more successful*".

### 2.5.1 Why?

"*People are at the centre of the Toyota Production System. Developing people is both a result and an essential input for a world class operating system such as TPS. Another name for TPS is the Thinking People System because that is what is required to sustain it*" (us.kaizen.com).

As said by Dul & Neumann (2009), managers usually associate ergonomics with occupational health and safety and related legislation, not with business performance. But the value of ergonomics extends beyond health and safety. While maintaining health and safety of consumers and workers, ergonomics can support a company's business strategy to stay competitive. The same authors refer an essay in the Administrative Science Quarterly, by Perrow (1983) that argued that the problem of ergonomics is that too few ergonomists work in companies; that they have no control over budgets and people; and that they are seen solely as protectors of workers, rather than builders of systems – for example by not blaming human errors on workers but on designers and managers.

It's impossible to dissociate Ergonomics from Lean Six Sigma, once that if Lean Six Sigma presents itself as a methodology searching for process and product excellence, it cannot leave aside the tools to improve the most fundamental factor – human (Carvalho, 2010). As previously referred on the Lean Paradigm chapter, it is implicit on the key idea of Lean Production: "*doing more with less*" and less means less space occupied, less transports, less inventories, and most important, less human effort (Laura C. Maia et al., 2012). It's a given fact that Lean transformations emphasize worker participation, but too often the role of the human resources organization is overlooked (Bartholomew, 2015). Having good working conditions presents one strategy for attracting and retaining high-quality employees (Dul & Neumann, 2009).

Maia et al. (2012) show us that the synergy between Lean and Ergonomics have been recognized by others authors, namely Gilkinson (2007) demonstrating that when combined, they successfully conduce a company to reduce risk and improve the system; and Heston (2006) that considers

Ergonomics as the first step to Lean implementation, being the resistance to the change reduced when workers are involved in their work space improvement. As Lean Thinking align with Ergonomics principles, the Ergonomics principle of "*working smarter, not harder*" becomes possible (Walder et al., 2007).

The implementation of new production paradigms that reduce the work cycle times and task variety, such as Lean manufacturing, tend to increase the physical and psychological strain on workers. Such approaches demand particular care with the issues related with human factors, in order to avoid health and safety problems to workers and losses to companies, due to productivity lost, absenteeism, compensations and law suits. Ergonomics plays an important role on the elimination or at least the diminishing of the problems on the Man-Machine-Environment system and on the improvement of the safety and health conditions (Nunes & Machado, 2007). Hence, ergonomics may help companies to control the negative human effects of the downsizing, lean production and business process re-engineering approach in order to obtain the real benefits from this strategy (Dul & Neumann, 2009).

When looking at the principles of Ergonomics and Lean, it becomes clear how the two interlink. The combination of Lean thinking and Ergonomics results in a system where the worker is as efficient, safe, and comfortable as possible while trying to produce the best product possible. Material handling plays a significant role in Lean by keeping the worker at the centre and ameliorating many of the ergonomic problems that would otherwise remove the person from the process. Transportation and unnecessary motion are two of the seven types of wastes that can be significantly reduced with the implementation of ergonomic assist systems and equipment. With the correct ergonomic assist product in place, waste can be removed from the system creating an increase in production, decreased costs, and an upsurge in quality (Walder et al., 2007). Also, employee creativity can be enhanced by stimulating organizational and physical work environments (Dul & Neumann, 2009). Wilson (2005) exemplifies: "in Japan, companies implement two ideas per employee per month on average. In the United States, employers implement less than one idea per employee per year. Some of the best ideas will be generated by hourly employees".

On an ideal scenario, the Six Sigma philosophy, the DMAIC cycle and Lean tools should be implemented simultaneously so that the organization reaches high performance levels on processes and significant improvement on the production system (Montgomery & Woodall, 2008). Besides, Lean thinking, when implemented correctly, requires effective ergonomics. Effective ergonomics is a necessary part of any sustainable organization. The successful implementation of lean thinking and ergonomics includes the redesign of processes, standardizing work, and reduction or elimination of WRMSDs risk factors. Successful implementation often includes utilization of material handling assist devices also (Walder et al., 2007). Hence, by planning a complete intervention including all these methodologies is the way to assure the best possible results.

### 2.5.2 How?

Dul et al. (2012) highlighted the importance for the Ergonomics discipline to demonstrate its value to main stakeholders influencing system design. Therefore, more studies are needed that illustrate economic impacts of ergonomics combining objective measures of wellbeing and performance to make ergonomics design a top priority for managers in manufacturing industries. Edwards and Jensen (2014) cited by Fritzsche, et al. (2014) further emphasise that key performance indicators such as absenteeism and quality should be used to demonstrate positive effects of ergonomics.

Unfortunately, lean processes can make jobs highly repetitive while eliminating critical rest time for employees. When ergonomics is not integrated into the process, the repetitive jobs take their toll on employees as stressful postures and high forces are repeated continuously throughout the day. In the long run, the financial savings from the productivity gains and quality improvements may have to be used to fund the higher costs of cumulative trauma disorder (CTD) claims (Wilson, 2005). Nunes & Machado (2007) support by telling that the benefits and advantages of lean manufacturing systems to cope with customer requirements, having in mind optimal use of the resources involved are well recognized. However, the use of just-in-time environments can produce high levels of stress in some time, and adequate ergonomic principles can be missed, eventually. This situation suggests the implementation of an ergonomic monitoring system based in specific tools. The reduction of the number of defects and process variance are the pillars of the Six Sigma philosophy, and Ergonomics can also help achieving these goals. Fritzsche, et al. (2014) mentions a study where Eklund (1995) found that quality deficiencies in car assembly lines were three times more likely for jobs with ergonomics issues because employees put less effort in correctly performing the work in order to reduce discomfort and fatigue. Similarly, the study of Lin, Drury and Kim (2001) is mentioned because it showed that time pressure and awkward postures predicted over 50% of the quality variance (i.e. error rates) on cycled assembly lines.

Dul & Neumann (2009) denote that *strategy* may be a useful connection point through which organizations might begin to internalize ergonomics because strategy: (a) has top management priority; and (b) is normally broadly communicated and implemented in the organization. Connecting Ergonomics to the company's strategy may provide managers with a more 'positive' motivation to apply this discipline. The authors refer "*We do not see ergonomics, in and of itself, as a strategy. However, since attention to ergonomics can contribute to many different strategies and business outcomes, we see ergonomics as an important feature of the strategy formulation and implementation process*". In these terms, ergonomics becomes a tool, or a means, rather than an 'end' in and of itself. This model is illustrated on Figure 2-20, from the authors' work *Ergonomic contributions to company strategies*.

According to Porter (1985) cited by Dul & Neumann (2009), another way to compete is to have a *cost strategy*: the company competes on the basis of the cost of the product or service. By ergonomic design of the production system and the elimination of unhealthy or hazardous tasks, the costs per unit can be reduced and labour productivity increased. Hence, ergonomics could be linked to a company's cost strategy by increasing labour productivity and reducing labour costs. As a complement, Nunes & Machado (2007) tell us that the integration of an Ergonomic approach in Lean Manufacturing design and implementation is vital; the use of ergonomic computer-based simulation and ergonomic risk assessment, as decision support tools, can provide important contributes to the design of lean production systems concurrently with the application of safety design principles.

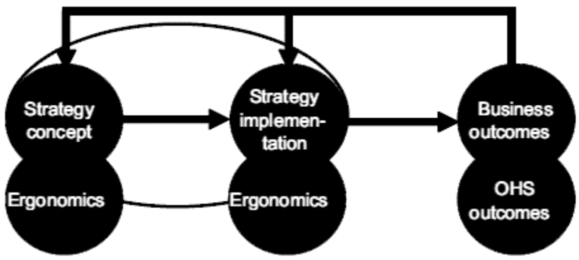


*Figure 2-20: Dul & Neumann's final model of linking Ergonomics to strategy and business outcomes (2009)*

Some tools like 5S, Standardized work, SMED, Kaizen includes safety and ergonomics aspects and benefits for the worker, for example, less accidents due to adequate equipment and instructions about how to use; less confusion in the workstation; less effort, exhaustion, stress and frustration; more responsibility and moral (Bittencourt et al., 2011 cited by Maia et al., 2012). Nowadays, it is common to designate the 5S tool by **6S,** being the sixth S the sense of Safety (Leff, 2011 cited by Maia et al., 2012). This author explains how company safety officials can use Lean initiatives to reinforce their safety programs, through the elimination of the 7 wastes. All these forms of waste make the system more complex and confuse with more WIP, more idle time, more transport of materials, more motion from the operators, more shadow and dark areas, after all, more opportunities for accidents and injuries to happen. Applying the 5S tool, all space will be cleaner, organized, classified and normalized (without unpredictable negative "surprises" such as a cut on a hand because of a sharp tool in the wrong spot) having as a result more safety at work (Maia et al., 2012).

The implementation of restructuring processes in production systems must be done with human factor orientation. Otherwise, it can result in a careless reduction of work cycle times and task variety, awkward working postures, increased pace, excessive repetitive motion (Nunes & Machado, 2007). As an example, an automobile manufacturer experienced 100% increase in CTD cases and received *California Division of Occupational Safety and Health* citation for insufficient attention to Ergonomics after implementing Lean during a changeover of one assembly line in 1993. The same automaker implemented Lean on a second assembly line model changeover in 1995 and this time integrated Ergonomics into the process. The changeover was completed in 38% less time, achieved similar productivity gains and quality improvements, and reduced the number of injuries on the line by 30% (Wilson, 2005).

Wilson (2005) enunciates the factors that should be considered to integrate ergonomics effectively into Lean processes:

- **Lean prioritization:** Incorporating ergonomics risks assessments and quality metrics into the VSM process will provide a structured method for prioritizing lean opportunities.
- **Ergonomics training:** basic ergonomic concepts and ergonomics design factors should be included in this training to enable team members to apply these factors as they develop conceptual designs.
- **Ergonomic design:** Applying ergonomic design concepts will reduce costly errors, improve productivity and reduce CTD risk factors that lead higher workers' compensation costs.
- **CTD risk assessment:** Quantifying the CTD risk factors enables lean teams to confirm and quantify the positive impact on the level of risk or identify unintended consequences of new designs.
- **Stakeholder involvement:** Some of the best ideas will be generated by hourly employees. Stakeholder involvement also is crucial to the acceptance and effective implementation of the lean design modification.
- **Quantifying the impact**: Measuring the financial impact of lean ergonomics solutions is essential to attaining continued support and involvement of senior management and keep the process a management priority.
- **Creating a culture for success:** Establishing a culture of employee involvement and empowerment in the lean ergonomics process helps produce a positive work environment in which workplace changes are expected and accepted. Sharing the mission and goals, and recognizing employees who make meaningful contributions to achieving cost savings will help to make the process successful and effective.

Also, *Monitoring Ergonomics* can be an important approach to get better benefits from the lean manufacturing system, without compromising health and safety of workers The importance of this monitoring derives from the following fact: the need to attain the *takt* time (i.e., the available production time divided by customer demand) requires to levelling the type and quantity of production over a fixed and limited period of time; it enables production to efficiently meet customer demands while avoiding batching and results in minimum inventories, capital costs, manpower, and production lead time through the whole value stream. Nevertheless, this situation promotes frequent changes in production, namely in the number of workstations to perform the tasks, and layout. In addition, the strategy of reducing lot sizes requires frequent changes in the workstations; even considering that the workload can be less repetitive, there is still a high probability of difficult adaptation in the man-machine system (Nunes & Machado, 2007).

## 2.6 Hazard Analysis and Critical Control Points (HACCP)

Food safety, and more particularly the HACCP system, assume some relevance in this case study due to the nature of studied industry. Therefore, the definition of HACCP and some important concepts regarding the food industry are deliberated in this chapter so to contextualize the upcoming methodology and practical application of the theoretical conceptions.

### 2.6.1 Definition and concepts

According to the *Codex alimentarius* (Rev. 4 – 2003), HACCP consists on a systematic and structured approach to identify dangers and their probability of occurring at any stage of food production, so as defining control measures (Sarmento, 2011).

On the food industry, Food Safety must be assured through the HACCP principles (requirements of Reg. (CE) nr. 852/2004 and nr. 853/2004). The HACCP system constitutes the basis for the current implementations of alimentary security systems, looking to control the activities based on precautionary concepts and principles. With the HACCP structure the aim is to apply procedures to effectively control systems, through the identification of steps or conditions where dangers could be find. These dangers can have a biological, chemical or physical nature (Baptista, 2007).

Pedroso (2003) cited by Sarmento (2011) says it's essential that every employee in the company comply with the plan's guidelines and promote the HACCP spirit, constantly reinforcing the Food Safety awareness. Competes to each one of the managers, supervisors or any headship individuals to be responsible for the means and development of the HACCP system throughout the entire company.

#### Food Safety

The real incidence rate of food transmitted diseases is not known. The *World Health Organization* (WHO) have adopted the resolution of recognizing Food Safety as an essential function to Public Health and developing a global strategy to reduce the impact of food transmitted diseases.

Food safety is defined in the *Codex Alimentarius* – Rev. 4 – 2003, cited by Sarmento (2011), as the set of procedures that guarantee that food products don't cause harm to the consumer, when cooked or ingested according to the predefined consumption way.

One of the biggest problems of food safety control is cross contamination. *Cross contamination* is the process through which microorganisms from one area are transported to another which was not previously contaminated (Sarmento, 2011). Food poison can be one of the results of an adulteration like this. It is defined as an illness due to the ingestion of contaminated food (Sarmento, 2011).

## Food Hygiene

Sarmento (2011) introduces a brief definition on food hygiene: group of adopted measures to ensure the safety, quality and wholesome of food products at any stage of production, transformation, packaging, storage, distribution, maintenance and sale or delivery to the final costumer (*Codex Alimentarius* – Rev. 4 – 2003).

On the food industry, the word *dirtiness* usually refers to the sediment of alimentary products that were chemically and biologically modified, to the combings of food constituents (sugar, fat, protein,…) or to the presence of bacteria from water characteristics (Dias, 2009).

*Sanitation* can be an example of one of the adopted measures. Sanitation is a paradox in food processing. Food safety cannot be assured without robust cleaning[1] practices, but sanitation itself adds no value to the product. Dealing with these potentially conflicting objectives is a paramount responsibility for management. The key premise of Lean is that 80-90 percent of activity is waste. Sanitation is no exception. Applying the tools of Lean manufacturing to reduce the complexity and time to complete clean-up is a tried and succeeded approach. We call this Lean Sanitation (Tessman, 2006).

## Food Quality

Food quality differentiates from the previous, being defined as the group of processes that ensure that food products are acceptable for human consumption according to the predefined consumption way (Sarmento, 2011).

## The Seven Principles

Dias (2009) stated the seven principles of the HACCP system, defined by the *National Advisory Committee on Microbiological Criteria for Foods* (NACMF) and established according to the Codex Alimentarius Commission's "Hazard Analysis and Critical Control Point (HACCP) System and Guidelines for its Application" document, appendix CAC/RCP-1 (1969) Rev. 4 (2003):

---

[1] Cleaning – removing solids, waste, lard and other unwanted materials (*Codex Alimentarius* – Rev. 4 – 2003).

1. Identification of dangers and its preventive measures
2. Identification of the Critical Control Points (CCP)
3. Establish the critical bounderies for each CCP (e.g. time, temperature, pH)
4. Create a monitoring system for each CCP
5. Define corrective actions (in case a CCP is out of control i.e. out of its critical limits). A corrective action should not me mistaken for a correction, which is a measure to deal with an already contaminated product.
6. Verify the system (define rotine check procedures)
7. Establish registration and documentation practices (e.g. temperatures, analysis, audits).

### 2.6.2 Rules and Best Practices

The cleaning principles for equipment that touches food products e.g. is a crucial factor for a food processing unit. These should be present at all times, once that producers have to maintain high standards regarding hygiene and the fulfilling of norms and rules applicable to equipment and, of course, people that handle the products. Dias (2009) asserts that these norms can be differentiated according to three types of obligations:

1. **Commercial Obligation**

Any product that has health, quality, hygiene and is free of dangers to public health is, obviously, good for business. It has commercial value. Otherwise, if the product is contaminated, lacks quality or can cause any type of harm to the consumer, the consequences of selling it can be very prejudicial to any of the companies in that supply chain.

2. **Moral Obligation**

Most consumers never get to see the production site or the way products are conceived. Clients buy the products based on confidence. Confidence on society, the company's or brand's good name or on someone that recommended that product. So, for any customer is an acquired fact that operations are the most clean and safe ever. Nowadays everyone knows its rights, is demanding and aware of these factors.

3. **Legal Obligation**

The law tries to protect the client and consumer towards health and safety of the food products. If one does not oblige with national or local legal rules, the result can be very severe punishments. A law suit can be more harmful to a company's reputation than any other market player.

Because of all this, companies feel the need to build and maintain very high quality standards in their products, very often stricter than the legal obligations per se. In order to assure more visibility and transparency throughout the all process, the main internal practices can be evaluated and certificated from an external entity. Companies often strive to obtain certifications such as the food safety management system ISO 22000:2005. ISO stands for *International Organization for Standardization* and it's an international network of standardization institutes, constituted by 156 country-members. Its headquarters are in Genève, Switzerland (www.iso.org).

## 2.7 Food Industry Synopsis

The food processing industry is the largest manufacturing sector in Europe with a turnover of €965 billion, 4.4 million people directly employed, and constantly serving over 500 million consumers (CIAA, 2010). Moreover, other industries such as agriculture, chemical and packaging are closely linked to the food processing industry (Dora, Kumar, & Goubergen, 2013). According to the *European Commission*, the European food sector lacks competitiveness in comparison to the North American and Australian food processing sector. Nonetheless, the food market has also transformed itself, adapting both to new lifestyles, tastes refinement and also to the families' financial availability. Every year an infinity of new products appears to meet the needs of an ever more demanding consumer, often with a shorter life cycle (Chiochetta & Casagrande, 2007). "Ready-made meals" are the number 2 on the European ranking of the most innovative food sectors with 65% in 2012 and 75% in 2013 of the total percentage of food innovation in Europe (FoodDrink Europe, 2014).

The definition of ready meals (meals ready to eat, MRE or ready-to-eat meals, RTE) is inconsistent, but the food industry sometimes defines it as a pre-prepared main course that can be reheated in its container, requires no further ingredients and needs only minimal preparation before consumption. Technomic defines meal solutions as "*prepared (or partially prepared) foods that are found in sections of the store where consumers can pick up ready-to-eat or ready-to-heat items from service counters or self-service/grab-and-go areas. These are products that do not require extensive preparation beyond reheating (if applicable)*" (technomic.com).

Over the last years the food industry has been searching to improve its processes' efficiency, aiming to meet the market necessities and contribute for its development. New methodologies have been implemented, namely concerning quality management and food safety through the HACCP methodology, but it is not enough. The Lean Six Sigma philosophy is now starting to gain recognition in this industry segment (Loureiro, 2012). By implementing the lean concept, food companies can increase customer value through cost reduction or through provision of additional value-enhanced services such as shorter lead times (Lehtinen & Torkko, 2005). There are limited empirical studies on lean manufacturing practices in food processing SMEs. Moreover, the sample size of these studies is relatively small due to a low response rate (Dora et al., 2013).

Dora et al. (2013) refer a study by Luning, Marcelis, & Jongen (2002) that attributed low impact of lean manufacturing to the unique characteristics of the food sector including short shelf-life, heterogeneous raw materials, seasonality, and varied harvesting conditions. Furthermore, the authors talk about a complex production chain and complicated network of many suppliers and buyers hugely affect storage, conditioning, processing, packaging and quality control. All these factors might be attributing to the difficulty level of lean initiative in the food processing SMEs.

## 2.8 Researcher's Background Analysis

After researching and putting together the information about Lean, Six Sigma, Lean Six Sigma, Ergonomics, LESS (Lean Ergonomics and Six Sigma) and HACCP, the researcher took the liberty of sharing some considerations on the exposed matters.

Hence, starting with the Lean paradigm, it was possible to understand that its origins go back to the Toyota Production System (TPS), but gradually the word became bigger than just an adjective, starting to name an actual model – Lean Manufacturing. Then it evolved to Lean Thinking, allowing its concepts, values and principles to be applied further than industry. Nowadays, Lean is an ever evolving culture and state of mind that can embrace any type of business. But it uncovers more dangers than it initially showed. The trigger is to involve the entire company and everyone in it, from top to bottom, reaching for the rest of the supply chain if doable. The goal now is more focused on sustainability rather than the tools' implementation.

Sustainability can be thought of in the sense that for something to be sustainable, it is able to be maintained, that it is ongoing (Martin, Legg, & Brown, 2013). Sustainability is the key to success and the glue that brings all these disciplines together as one. Continuous improvement is based on sustaining the small gains achieved and keep on improving undeterminably. The fifth in the Lean Thinking pillars is *perfection*. Endless search for perfection is what guarantees continuous improvement rather than big innovation jumps, which translates into the sustainability of the implementations made. To ensure the long-term sustainability of the Six Sigma method, organizations need to analyse and accept its strengths and weaknesses and properly utilize six sigma principles, concepts, and tools (Kwak & Anbari, 2006). The DMAIC cycle, e.g. is a very important tool to assure Six Sigma's sustainability, once that it provides a structured cyclic approach that never ends, thus never stops making things better.

*Kaizen* is continuous improvement. However, *kaizen* events have to be dealt with a lot of precaution, once that can have the same effect as innovation – they fix a problem, but then no monitoring is done and the gains are lost short after, and a new intervention is needed. Frequently managers try to apply kaizen events in an isolated manner, because it’s a faster, less expensive, smaller measure that can show some improvement when needed. The way to correctly apply this method, so to assure sustainability, is by including kaizen events in a bigger project (Lean implementation), so to deal with specific problems within the continuous improvement culture that is being built.

In order to be successful, people must be at the core of the occurrence. “Human development” is at the centre of the TPS model for some reason. Several Lean and Six Sigma implementations failed due to lack of commitment from top management or a fierce resistance to change from the employees. This opposition to change can be diminished through Ergonomics. As referred before, people are more willing to accept change if they’re involved in improving their own working space and can see more direct benefits from their effort. 5S tool and ergonomics are crucial at this point. The last S stands for Sustain, although a lot of companies only go in for the first three S’s. The 5S method allows employees to see and feel improvement in a simple and fast way. Consequently, increases safety and environmental work conditions, which are pivotal factors in Ergonomic evaluations.

Ergonomics is critical to sustain Lean Six Sigma implementations, once the human factor is valorised and cherished. It mainly acts in two fronts: physical improvements in the work space, together with the employment of few lean tools, can reduce risk factors willing to cause WRMSDs and eliminate health dangers from the work site; psychological work-related problems like stress and motivation, e.g., can be improved through the involvement of the employees, the enhancement of work conditions and a healthier management culture, cultivating better relationships among all workers. Several authors include the “underutilization of the workers” as a type of waste [from the 7 types of waste in Lean]. The maximization of both human and machine’s productivity is very beneficial both to employers and employees, if done the right way. Increase satisfaction at work and the company’s results will rise over the roof.

But sustainability also has to be though off in the sense of environmental sustainability. The concepts of Green Lean and Green supply chain were already developed, but in a summarized way, by striving for less waste, defects and human effort, all these disciplines think sustainable.

That’s why *LESS is more.* Lean Ergonomics and Six Sigma brought together guarantee more value, more productivity, more efficiency, more quality, more flexibility, more motivated employees with less variance, less waste, less human effort, less stock and less risks – always searching for perfection while safeguarding sustainability.

# 3 METHODOLOGY

This chapter revolves around the conceptual methodology of the case study. Firstly, the company's overview is presented to contextualize the following work method. Then, a rundown on the Food Industry is done. Finally, a theoretical synopsis about the methods used is shown next, justifying the choices made.

## 3.1 ORGANIZATION'S OVERVIEW

### 3.1.1 JERÓNIMO MARTINS GROUP

The Jerónimo Martins Company was founded in 1792 by a Galician young man, by the name of Jerónimo Martins, who found in Lisbon an opportunity to thrive with his modest little shop selling everything from bushels of wheat and corn to tallow candles and brooms. This grocery store became very prestigious due to its high quality products and variety. Going through several economic crisis, two World Wars and almost bankrupting, it survived and thrived with the acquisition by Francisco Manuel dos Santos and his partners at "Grandes Armazéns Reunidos", being now a multinational, operating in industry, services and the core business – distribution.

The Jerónimo Martins Group nowadays is a food specialist that operates in three distinct areas: Distribution, Industry and Services. Industry and Services are only developed in Portugal, its country of origin, being that Industry is characterized by the Unilever joint-venture and Gallo, and Services by JMD, JMRS and Hussel. Distribution is the core business of this group, operating under the insignias Pingo Doce and Recheio in Portugal, Biedronka and Hebe in Poland and Ara in Colombia.

### 3.1.2 ODIVELAS CENTRAL KITCHEN

Within this huge Group stands Odivelas Central Kitchen, producing RTE (ready-to-eat) meals for the company's restaurants, as shown on Figure 3-1. Gaia Kitchen produces only deserts and side dishes, partnering with Aveiro Kitchen (that produces main dishes) to supply stores on the north of the country.


*Figure 3-1: Industrial Kitchen's Position in the Company*

### Pingo Doce:

The company Pingo Doce was founded in 1978. By 1993 Pingo Doce conquered leadership in Food Distribution, in the supermarkets segment. Since then it has been ever innovating in the retail market, having conquered a very strong position amongst its competitors. In the first quarter of 2015 it also increased sales in 4%, contributing with 24% of the sales of the Company.

### Meal Solutions:

Pingo Doce, assuming ever more a role of a food solutions supplier at all levels, develops the Meal Solutions operation in 2010 (Take away and Restaurants), which has been proving a differentiation vector, bringing customer loyalty and sales promotion in all categories. Take away is already functional in 214 out of the 349 Company stores and there are currently 33 operational Restaurants.

Odivelas Central Kitchen was inaugurated in 2011 to provide Meal Solutions with more food solutions, creating a differentiating factor for Pingo Doce. Jerónimo Martins is the only Distributor in Portugal that cooks its own food products. It was congratulated in 2014 with an Excellency Award in Retail Innovation and Sustainability, by APED[2]. This came from initiatives like utilizing fruit and vegetables that can’t be commercialized on stores, because its shape, size or looks; and because of production techniques that help reduce water and energy consumption.

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[2] APED – Associação Portuguesa de Empresas de Distribuição (N.A.: Portuguese Association for Distribution Companies)

## Odivelas Central Kitchen in Figures:

- **Production:** around 20 tons per day (80% of all meals nationally), producing a total of 5 766 692 kg of food in 2014
- **Products:** Main dishes, deserts, soups, side dishes, salads and pies summing a total of 330 different recipes (always changing)
- **Schedule:** 12 months per year, 6 days per week, 24 hours per day
- **Team:** around 165 people
- **Client:** provides soup for 376 Pingo Doce stores and all products for 220 of them.

To help give a better picture of the Kitchen's layout and production flow, on Appendix B this is represented. The total Kitchen working area is around 5 000 square metres and the Cooking area is around 1 000 square metres.

## Process description:

This industrial kitchen is an intern supplier of Pingo Doce and Caterplus Food & Services (HoReCa channel supplier of Jerónimo Martins). The supply chains are represented in Figure 3-2. The goal of this company, as an internal supplier of the Group, is not to have profit, but to hit a balance of zero, meaning profits equal to costs – neither surplus nor deficit. The clients (Pingo Doce and Caterplus) pay the food products at cost price.

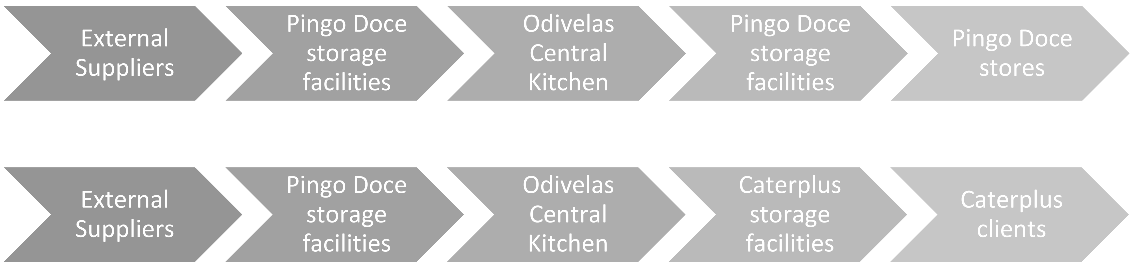


*Figure 3-2: Odivelas Kitchen's position in the supply chain*

The menus are set every three months and the daily demand comes every day until 9 a.m. via an internal communication system belonging to the ERP implemented, SAP. According to historical records and the menu set, forecasts are made to help manage the suppliers. Orders for raw material are made in different timings, depending on the supplier and the type of product. For example, some fruits and vegetables are ordered every day, opposing to the meat that, sometimes, has to be ordered one month in advance. Besides that, the In & Out Team makes some adjustments after receiving the client's orders, thus raw materials are requested to the suppliers every day. In case of urgency, the nearby Pingo Doce store works as a flexible partner, receiving some products when they are near their expiration dates and providing some others in case of need.

Subsequently the daily demand is assembled in a production map that serves as a guide for the whole kitchen that day, establishing the priorities and work sequence. Operators pick the necessary products, then preparation operators take all the packages out, prep the raw materials and gather them by orders (type of dish). The prepared raw materials are left in a compartment organized in the same way and, after that, the cooking can start. All the products and materials needed are available in that room and the recipes are available in the touch screens spread around the labour area. The cooking operations are usually guided by the priorities established on the production map and by the time needed for operations that don't require operator's intervention (like cooking in the hoven).

When the product's cooking is finalised, it goes to a "tunnel" where it cools at a rapid pace to maintain its properties without having to freeze or apply non-natural additives. The time spent there depends on the type of food, but it cannot exceed a specific number of hours, required by the HACCP Direction. When it is at the desired temperature – below four degrees Celsius – it is taken to the packaging machine and then piled into a batch and stored until later that day, when it is shipped for the company's central warehouse, in Azambuja, where the batches are divided by store, according to what they have previously ordered.

So, from the moment that the client orders until the moment it receives the products, 3 days are required. But, inside the kitchen, an order only takes 2 days to be ready between the order and the shipping moment. The production flow chart is here shown on Figure 3-3, matching the description above.

### Current situation:

This industrial kitchen is a new business within a centenary Group. In the beginning of this project, a new director had just taken over. It was a good start, once that new people usually come thrilled to make some changes and this was the case.

The company has never made any kaizen or lean implementation of any sort, but it is easy to see that some people already have a continuous improvement culture inherent. The infrastructure was not designed for an industrial kitchen with the amount of production that it now has, becoming an obstacle with the current business growth. Besides all the difficulties, new changes are made every day in order to improve product quality, processes, worker's health and well-being, team work and overall conditions.

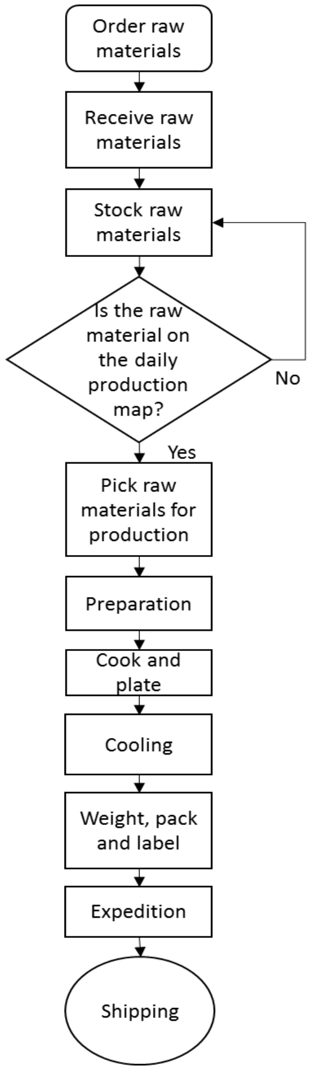


*Figure 3-3: Odivelas Central Kitchen Flow chart*

## 3.2 CASE STUDY

The case study approach is a research strategy commonly used in Social Sciences. Robert Yin (2013) defines the case study as the most utilized strategy when the intent is to know the "how" and "why" of a certain situation, when the researcher as little control over the real events and when the research field focuses on a natural phenomenon within a real context. The case study is, therefore, a methodological investigation approach that allows comprehending, exploring or describing certain complex events and contexts. The same author refers that the case study might be defined based on the phenomenon characteristics and the means to collect and analyse the data.

Yin (2013) formalizes three types of case studies: descriptive, exploratory and explanatory. Regarding the present case study, it follows an exploratory slope. An exploratory case covers the issue or problem being explored, the methods of exploration, the findings from the exploration and the conclusions for further research.

With this concept in mind, an implementation model was designed, as shown in Figure 3-4.

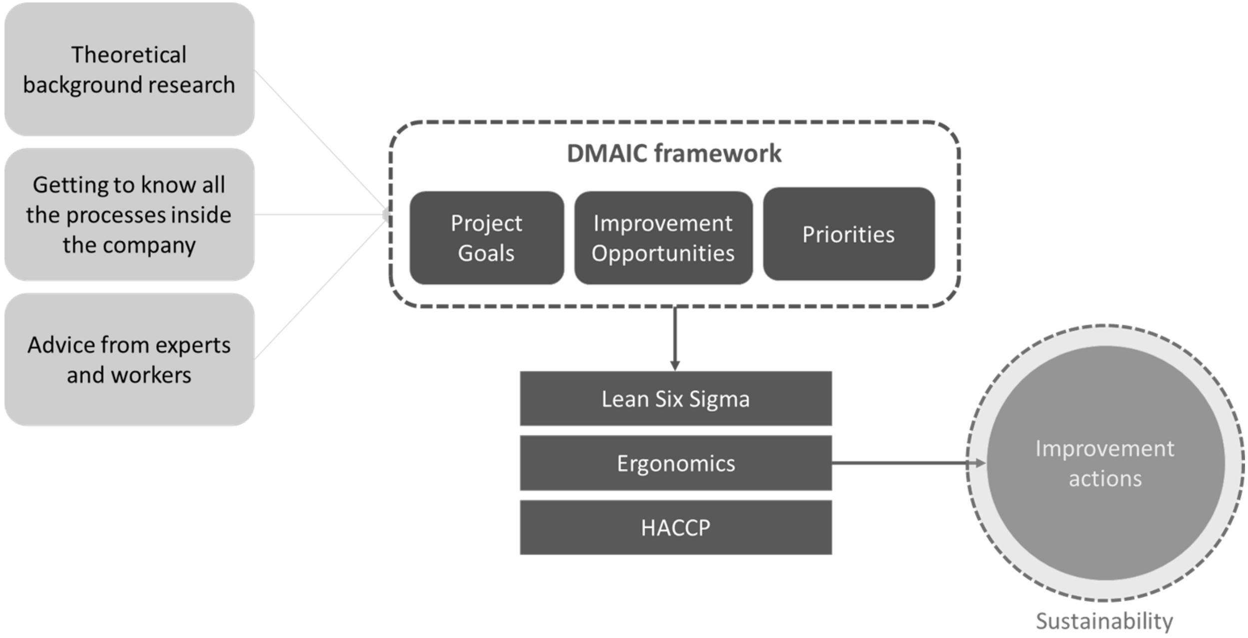


*Figure 3-4: Implemented methodology*

The data collection and analysis methodology leads to the project goals, improvement proposals and implementation priorities, guided by the DMAIC framework – giving the researcher a systematic way of approaching the problem. With the multidisciplinary set of tools and concepts, the researcher reaches some conclusions regarding the improvement measures that should be considered and generates results by either simulation or actual implementation.

## Data collection:

Multiple sources of evidence were used to validate data. Yin (2013) identifies six major sources of evidence. Five were used in this study. First, qualitative data were collected through documentation obtained in the form of letters, memoranda, progress reports, strategic planning reports, etc. Second, quantitative data were collected in the form of archival records of financial data, ordering processing, quality reports, purchase orders, operational data, performance measurements (such as annual sales and responsiveness). Third, additional qualitative data were collected through extensive interviews with participants and stakeholders such as managers and employees, as well as through a survey made to the workers. Fourth, qualitative data were collected in an observation mode involving many decisions during the implementation. Fifth, since the researcher was involved with decision making during the implementation it was possible to collect data in a participant-observation mode. During the study the researcher kept a research log that documented each problem encountered during the implementation, in addition to the thoughts and insights gained during the process.

## Data Analysis:

In order to analyse the data, firstly the researcher spent a month going through every section of the kitchen, performing the daily operations together with the workers and learning how to do almost every activity, as well as speaking to the operators in order to learn more about the environment. This helped understand the current situation of the company and facilitated the analyse process, once that the researcher was familiar with all the processes and problems that occur, being able to judge the data and better understand the improvements needed.

Subsequently, measures were taken regarding the length of each operation, waiting times and movements needed to perform a task. To understand the activities that add value and the ones that don't, the researcher personal experience was also very important. Regarding ergonomic conditions, it was better to actually feel the physical effort that some activities require than just earing it from the operators. Hence, a practical analysis of the work conditions and improvement opportunities was done *in loco*. A statistical and empirical analysis was made regarding the survey made to the workers.

Then, theoretical data was experienced within the company and theoretical concepts and tools explored so as to systematically evaluate the problems found and elaborate solutions.

Is important to mention that the data presented in this case study regarding Odivelas Kitchen's production refers to the timeframe from January 2015 to June 2015, together with some data from 2014 full year history.

## Holistic methodology synopsis

The adopted methodology exploited the synergies between Lean (continuous improvement), Six Sigma and Ergonomics values, practices and tools in order to pursue the objective of improving the work conditions and productivity in the Industrial Kitchen, always having the sustainability issue in mind. HACCP contributes to this holistic view in a sense of awareness to the food industry restrictions.

Having in mind the data collected and analysed, the problems found within the company environment, the market position, the working method of the company and the restrictions presented, the researcher decided to adopt a multidisciplinary approach to the DMAIC metaroutine, putting together several tools from the previously mentioned disciplines, having in mind the experience described on Freitas et al. (2015) and Zeferino (2014).

As previously explicated, the Lean Six Sigma management paradigm has proven to be most beneficial to the majority of the companies that implemented and adopted it as a new way of thinking, but most people will find their jobs more challenging as Lean spreads. And they will certainly become more productive. At the same time, they may find their work more stressful, because a key objective of Lean production is to push responsibility far down the organizational ladder (Womack, J.P., Jones, T. and Roos, 2007).

Therefore, Ergonomics has an important role preventing this repercussion to happen. Although, HACCP rules and best practices cannot be forgotten, so that zero defects (Six Sigma's goal) walks along zero complaints regarding food safety and the best possible work environment (Ergonomics' goal), also guarantying the environment sustainability to build a better future. Thus, tirelessly seeking for perfection through continuous improvement (Lean's goal), a surety of productivity. A better illustration of the synergies shared between this disciplines is on Figure 3-5.

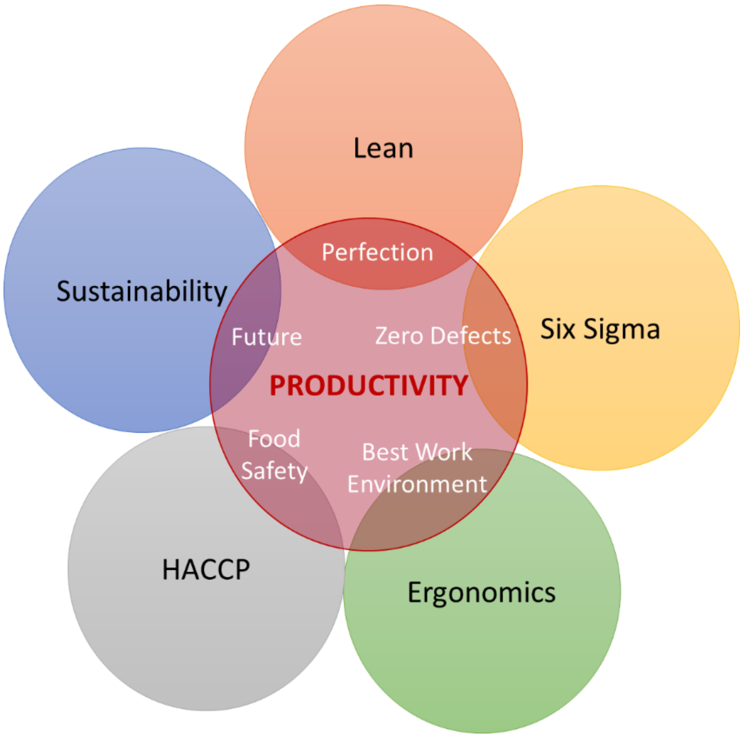


*Figure 3-5: Synergies shared in this project*

The utilized DMAIC methodology is described next, presenting the work frame for each phase as well as their respective tools.

## 3.3 THE DMAIC CYCLE

The DMAIC cycle provides a metaroutine - a routine for changing established routines or for designing new routines - which organizational members follow to solve problems and improve processes. Following a structured method helps avoid jumping to conclusions and helps ensure an adequate search for alternative solutions to a problem. Through frequent revisions in each step of the cycle, organizational leaders can control and guarantee the proper execution of each phase of a project (Schroeder et al., 2008). As said by Carvalho (2010) "*There's not a methodology that can improve the sum, without gradually improving the parts or operations*".

Accordingly to De Mast & Lokkerbol (2012), Six Sigma's DMAIC method is a rather general method. Originally described as a method for variation reduction, DMAIC is applied in practice as a generic problem solving and improvement approach. As for Schroeder et al. (2008) the DMAIC method is consistent with the problem-solving steps of the PDCA [Plan-Do-Check-Act] model and places more emphasis on integrating specific tools into each step of the method.

The DMAIC cycle was chosen as the right technique for approaching this project because it is an organized, systematic method that allows the identification of problems and their posterior resolution, always aiming for continuous improvement. Six Sigma's DMAIC method is applicable for a wide range of well- to semi- structured problems (De Mast & Lokkerbol, 2012).

Kwak & Anbari (2006) also tell us that DMAIC is a closed-loop process that eliminates unproductive steps, often focuses on new measurements, and applies technology for continuous improvement. On this case, a new influence had to be taken in account when applying this method, as shown in Figure 3-6. In the food industry, quality has acquired relevance since the consumer became increasingly aware of quality and governments were compelled to take more responsibility for public health and safety as affected by food products. So, especially when entering the Improve phase of the cycle, the HACCP rules and restrictions have to be given special attention so not to be bent.

Quoting Taghizadegan (2010), ergonomics has evolved throughout the last few years. Now is not just about WRMSDs developed on the workstation, but also about pursuing a continuous project about improving the workstation, work environment and social behaviours, regarding these as performance constraints for the worker. Once that this project aims to integrate ergonomics on the Lean Six Sigma systems improvement approach, ergonomics has a core role when applying the DMAIC tools, contributing to every phase of the process. Hence, a different kind of DMAIC cycle is presented on Figure 3-6, bonding several considerations in one methodology only.

A more detailed explanation of each one of the steps in the cycle is given by Kwak & Anbari (2006) on Table 3-1 below, adapted from McClusky (2000).

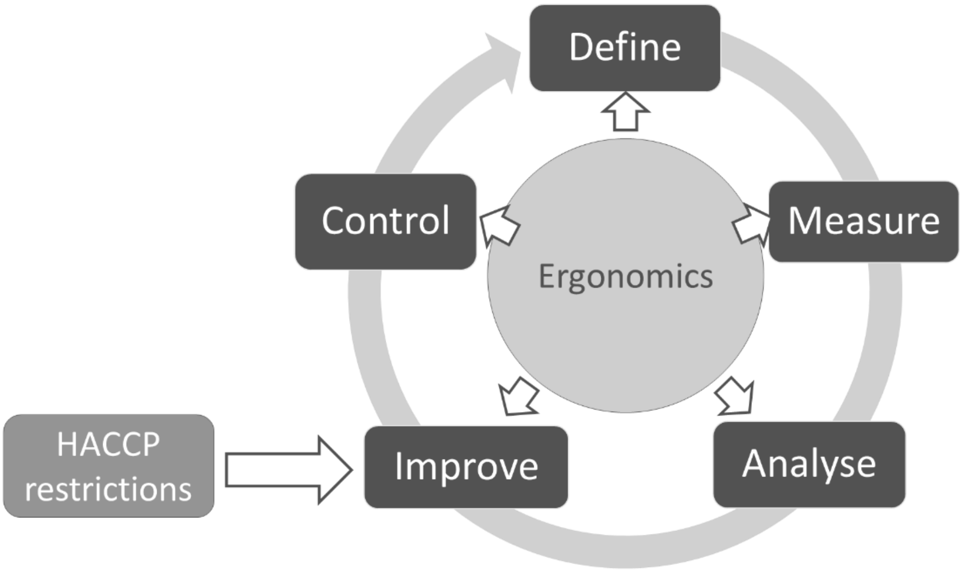


*Figure 3-6: Adapted DMAIC cycle*

*Table 3-1: Key steps of six sigma using DMAIC process (from Kwak & Anbari, 2006)*

| Six sigma steps | Key processes |
|---|---|
| Define | Define the requirements and expectations of the customer<br>Define the project boundaries<br>Define the process by mapping the business flow |
| Measure | Measure the process to satisfy customer's needs<br>Develop a data collection plan<br>Collect and compare data to determine issues and shortfalls |
| Analyze | Analyze the causes of defects and sources of variation<br>Determine the variations in the process<br>Prioritize opportunities for future improvement |
| Improve | Improve the process to eliminate variations<br>Develop creative alternatives and implement enhanced plan |
| Control | Control process variations to meet customer requirements<br>Develop a strategy to monitor and control the improved process<br>Implement the improvements of systems and structures |

On the Define phase the objectives, scope of the project and current situation of the company are defined, so as the improvement opportunities. The production, ergonomics, HACCP and even OSH requirements, internal or external to the company process, are determined.

Regarding the holistic concept previously exposed - aiming to gather of knowledge from different areas - the tools necessary for the development of this stage were the CTQ (Critical To Quality) Tree, outlining the CTQ characteristics, through the VOC (Voice of Customer) and VOE (Voice of Employee); the Project Charter, that frameworks the project to be developed; and the SIPOC

(Supplier Input Process Output Customer) tool, that summarizes the business, as the name shows.

On the Measure phase, productivity and ergonomics metrics are defined in order to quantify the given outputs. This way, the previously observed *muda* is quantified. Also, the production flow is explored and described, considering the HACCP procedures and restrictions as part of it. For this, flow chart is a useful tool, helping to understand and characterize the Kitchen's work stream. To formalize the ideas collected from observation and reunion with workers on the previous phase – VOE – a survey was distributed to all the employees.

The data analysis allows the researcher to find the causes of the problems regarding productivity issues as well as health and safety matters, revealed on the Define stage. To do that, several quality tools are required. These should determine where we are instead of justifying mistakes (Knowles et al., 2005). If the unfolded causes regard HACCP restrictions, they must be complied at all times. The Pareto diagram is crucial to prioritize the information collected from the survey. But according to Knowles et al. (2005), the Pareto diagram gives priority to the most important factors on the failures and errors creation, but that does not mean that one shouldn't consider the remaining causes. So, for that, the 5 Why's technique is much useful, so as the Ishikawa diagram. Brainstorming is pivotal in this stage of the study.

On the Improve stage is essential to have the participation of all the people involved in the process, as well as creativity. This phase implies conception and implementation (Knowles et al., 2005). On this particular project, the researcher proposed several improvement measures, focusing on the productivity and ergonomic problems found before. Then meetings were held with the team in order to understand the possibility to implement the projects, priorities, restrictions, risks, the HACCP boundaries, actions needed to pursue the implementation, schedule, costs and people responsible for each task required. This meetings lead to the realization of a project plan for each proposal, as well as a priority matrix resuming the decisions made.

The last step – Control – was taken into account on the development of the project plans previously referred. The intent of this stage is to document and control the implementations done - while guaranteeing the sustainability of the HACCP standards - as well as develop contingency plans for these projects.

Every time the Control phase is terminated, a new project has to begin by the Define stage of the DMAIC cycle, and not any other stage (Carvalho, 2010).

A schedule was determined for the development of each phase in this project, as shown on Table 3-2. Improve and Control phases were developed almost simultaneously and continued after the researcher left the project. The Kitchen's management team gave it continuity, regarding the designated project plans.

Table 3-2: DMAIC implementation schedule

| | January | February | March | April | May | June |
|---|---|---|---|---|---|---|
| **Define** | | | | | | |
| **Measure** | | | | | | |
| **Analyse** | | | | | | |
| **Improve** | | | | | | |
| **Control** | | | | | | |

Table 3-3 helps to understand the case study development, explicating which tools were used in each phase in a more systematic way. Brainstorming with the management team was something done almost in every phase and extremely useful.

Table 3-3: Tools utilized in each DMAIC phase

| Tools | Define | Measure | Analyse | Improve | Control |
|---|---|---|---|---|---|
| 5S | | | | X | |
| 5 Whys technique | | | X | | X |
| Brainstorming | X | | X | X | X |
| CTQ Tree | X | | | | |
| Flowchart | | X | | | |
| Focus Groups | X | | | | |
| Ishikawa Diagram | | | X | | |
| Kaizen | | | | X | |
| Pareto Diagram | | X | | | |
| Priorities Matrix | | | X | X | |
| Project Charter | X | | | X | X |
| SIPOC | X | | | | |
| Standard Work | | | | X | X |
| Working Conditions Survey | | X | | | X |
| Visual Control | | | | | X |
| VOC | X | | | | |
| VOE | X | | | | |

### 3.3.1 DEFINE

This is the first stage of the cycle. It's pivotal to identify and clearly define the problem. Then, it is necessary to establish goals and objectives. For these to be as accurate as possible, it's essential to know the reality where the improvement might take place. Being that way, usually a process mapping is done, with a *gemba* walkthrough. In fact, only the profound knowledge of each process and the relations between each one of their activities will allow to develop meaningful improvement in the company. After knowing the process and identifying the problems, it is possible to maximize the efforts in the direction of the problems that have a bigger impact and return on the investment (Pyzdek & Keller, 2009).

Citing Miles (2006), it is necessary to plan the project in a way that every intervenient is align and tuned with the defined strategy. The collection of historical data from the problems to be studied is relevant for the team's awareness, so that the problems aren't underestimated.

The first steps towards understanding the company's process and difficulties are naturally a part of the Define phase. In order to define the stakeholders, their needs, their difficulties and the process flow, one has to get to know the business dynamics inside-out. Accordingly to Loureiro (2012), the problem definition is essential for the following steps of the process. In fact, it was estimated that correctly defining a problem influences about 50% of its resolution. A poorly defined problem leads to solving false problems.

An overview of the work developed within this first stage of the project is represented on Figure 3-7, providing a guiding map for the application and results chapter, where the results of each step of the flow chart are presented.

According to (George, 2003b), a core principle of Lean Six Sigma is that defects can relate to anything that makes a customer unhappy. To address any of these problems, the first step is to take a process view of how your company goes about satisfying a particular customer requirement. This was why this stage began with the SIPOC tool. This and the subsequent resorted tools are presented next.

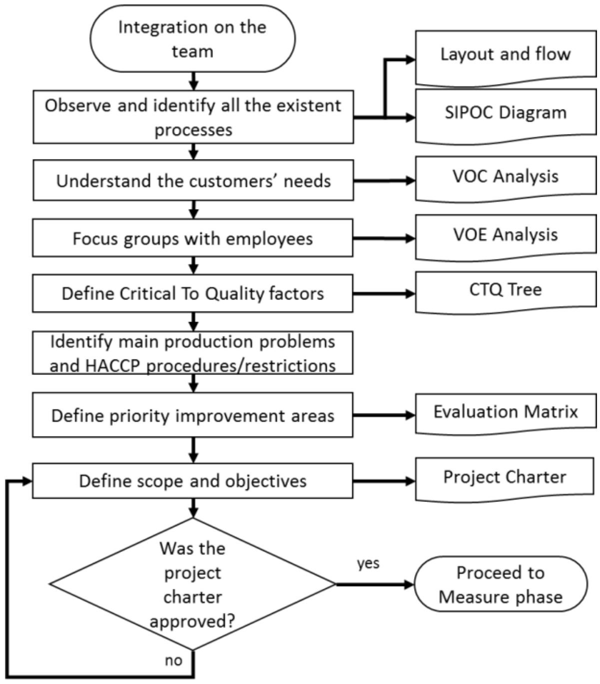


*Figure 3-7: Define phase flow chart*

**SIPOC Diagram:** This model states that suppliers provide inputs that through the steps in the process add value, which produces an output for the customer. SIPOC moves left to right. The final product reflects this movement (Eckes, 2003). It intends to provide a macro perception of an organization or department's behaviour, allowing anyone to rapidly understand the organization's drivers. It is essential to understand all the parts of the process and how they fit together and to ensure that all team members and sponsors view the process in the same way (Miles, 2006).

**VOC Tool:** This tool is the bridge between client and company and should be every business driver. It can be obtained through various ways, like surveys or market researches for example. In this case, the management team already had knowledge about the clients' needs and expectations, especially because as an intern supplier in the same Group, it is easier and less expansive to have access to this information.

**VOE Tool:** The goal of this tool is to report the needs, suggestions and complaints of the employees directly to the management team. This is an important resource, because it informs the ones that might implement corrective measures and even run other improvement actions. Regarding the scope of this project, it is essential to take into account the employees' opinion, once that ergonomics and work conditions are two of the pillars of the methodology's development, and there is no one better to evaluate these than the people that experience it every day – the operators.

**CTQ Tree:** This study's success is directly connected with the successful utilization of this tool, because it helps to identify the improvement opportunities. Subsequently the key process indicators are defined due to the previous, implicating in the improvement actions proposed. The key process indicators (KPIs) are determined and calculated concerning the information retrieved from the VOC and VOE tools, so as the Critical-to-Quality (CTQ) factors that will compose the CTQ tree diagram.

**Project Charter:** This document formalizes the commencement of the project. It summarizes and presents the essential information about the study in place – title, scope, limitations and goals, issues in focus, schedules and people responsible, amongst others. It serves as a guideline and as a business card for this study.

**Brainstorming:** This is a group dynamic widely used in the business world to solve specific problems, develop new ideas or concepts and put several pieces of information together stimulating creative thinking. Even though, there is also the "individual brainstorming" concept. Putting both of them in practice throughout this Definition phase, the researcher can better scope the project, define the goals, identify the improvement opportunities and understand the company's needs.

**Focus Groups:** Focus groups are useful for examining work place culture. The method is particularly useful for exploring people's knowledge and experiences and can be used to examine not only what people think but how they think and why they think that way (Kitzinger, 1995). This tool was especially helpful to fully understand the voice of employee. According to the same author, the groups can be "naturally occurring" (for example, people who work together) or may be drawn together specifically for the research. In this case, all the groups took the "naturally occurring" form due to the nature of the research.

### 3.3.2 MEASURE

The Six Sigma methodology offers analytical orientation but needs data to sustain the implementation. On the other hand, the Lean methodology tends to improve processes without complete data, so that the root cause of the problem is disclosure. This leads to projects with a short success rate and disappointing results. Uniting data with knowledge and experience is what differentiates a true improvement process from a simple momentary "fixing" the process. Therefore, on the second stage of the cycle it is crucial to obtain the process's metrics, aiming to build a factual knowledge of it. This knowledge helps narrowing the range of possible causes for the identified problem, that will be investigated in the Analyse phase (Pyzdek & Keller, 2009).

De Mast & Lokkerbol (2012) say that this stage aims to evaluate and understand the current state of the process. This should be done by identifying metrics that quantify the performance of the productive system.

On the words of Loureiro (2012), the Measure phase purposes to develop actions that allow to:

1. Identify the KPIs of the process
2. Collect data
3. Validate the metric system
4. Comprehend the process behaviour
5. Measure the current process capacity.

This phase of the cycle is crucial to readjust the approach defined to tackle the problems, if needed, once that productivity is here quantified in a more detailed manner (Carreira, 2005). The work developed was organized as represented on Figure 3-8 by a flow chart.

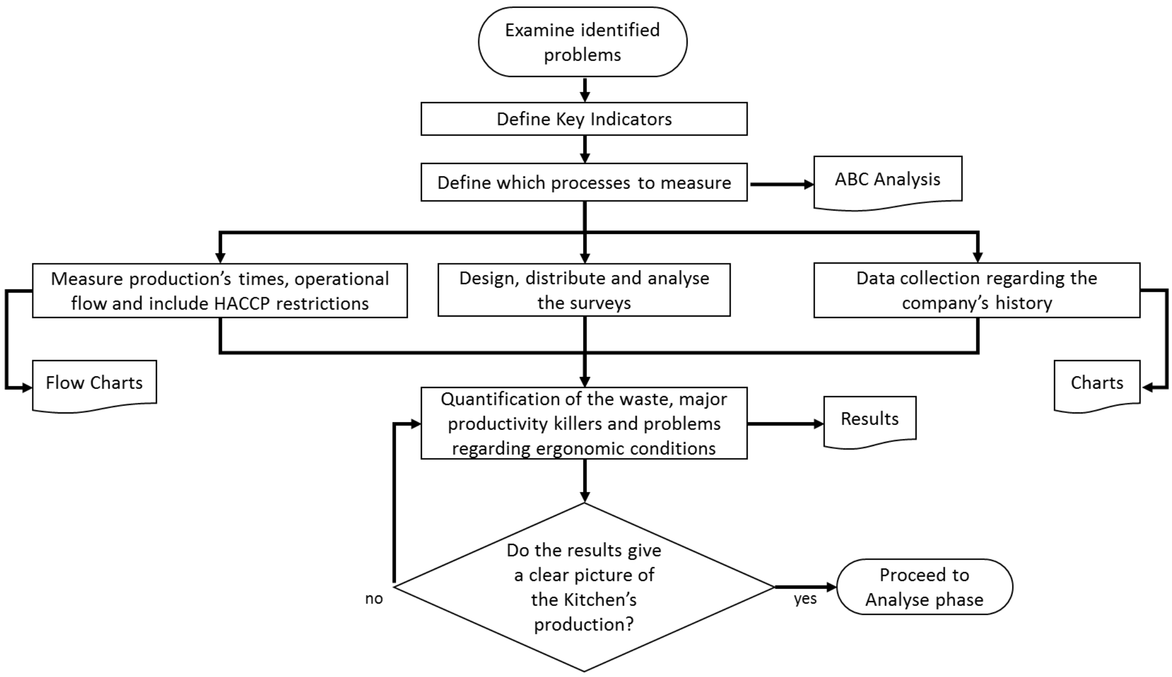


*Figure 3-8: Measure phase flow chart*

After understanding <u>what</u> to measure amongst the Kitchen's processes, it is important to understand <u>how</u> to measure it and keep track of the improvements that will be made, so to recognise the gaps and keep on improving or correct if necessary.

**Key Performance Indicators (KPIs):** KPIs represent a set of measures focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization. KPIs are rarely new to the organization. Either they have not been recognized or they were gathering dust somewhere unknown to the current management team (Parmenter, 2010).

Having this definition in mind and crossing the information with the project's goals, two sets of KPIs are combined. These will help measure the Kitchen's performance, understand <u>why</u> some problems or inefficiencies occur and if they can be improved: KPIs regarding the Kitchen's productivity; and KPIs regarding the work and ergonomic conditions. **Productivity** will be measured regarding the previous definition of waste and looking at production costs and capacity.

- Waste: these were identified, observed and registered by the researcher during the time comprehended in the internship. According to the Lean management paradigm, there are seven types of waste to be considered and eliminated: *overproduction, waiting time, transportation, over-processing, inventory, motion and defects* (Nunes & Machado, 2007).

  *Overproduction* is defined by Shigeo Shingo as "producing too much or too soon, resulting in poor flow of information or goods and excess inventory" (in Peter & Taylor, 2000). This was not considered a relevant waste, once that production is planned daily according to the clients' orders – pull system.

  *Inventory* is defined by the same source as "excessive storage and delay of information or products, resulting in excessive cost and poor customer service". This is one of the most worrying problems referred to in Lean application projects literature (for example in the novel The Gold Mine, by Freddy Ballé & Michael Ballé). In the food industry it's harder to build up such worrying piles of stock. Foodstuff products deteriorate much quicker than any other and can no longer be used. HACCP rules regarding this matter are very strict and inventory is constantly examined (more than once a day).

  *Defects* were hereby defined as producing more or less than the quantity ordered by the customer. Once that producing more is scrap, because HACCP rules do not allow stocking final products, and producing less means low service levels and customers unsatisfied. Also, production defects are corrected in loco and do not flow downstream, and there is no record keeping of these within the company.

- Production cost: the costs for producing each one of the products are divided in two groups – costs of activity and costs of raw materials. On the first group are included all the expenses generated by the work done, as for personnel, water, lights, electricity, machinery, etc. On the second group are included all expenses with foodstuff needed for production.

  Due to the fact that Odivelas' Kitchen works as an internal supplier for Pingo Doce's stores, the production cost only considers the costs of activity for business analysis. The costs of raw materials are aggregated in the PD commercial department.
- Quantity produced: this information was retrieved from the company's ERP system, where an automatic registration of the daily production is made on real time by the packing equipment on the Expedition section.
- Productivity $= \frac{Production\ [kg]}{number\ of\ worked\ hours\ per\ day\ [H]}$

**Work and ergonomic conditions** KPIs regard accidents, absenteeism, staff turnover, safety risks and work conditions.

- Accidents: the data was collected from the company's intranet, where the "safety deputies" in the Kitchen (nominated by the OSH Responsible) upload the information about each accident that occurs, following certain parameters defined by the portal.

- Absence: the data was collected from the company's intranet, where digital information about presences and absences is automatically registered as the workers sign in on an electronic device. This confers reliability to the data.
- Turnover: information about employees' admission and lay off was searched and registered informatically by the researcher, resorting to the company's archives.
- Employees' perception of the work conditions: the chosen data collection tool was the self-conducted survey. This may be read and filled-in with no interference from the researcher. The main advantages of the application of this tool are: low cost, time saving, data uniformisation, wide coverage and respondents' confidentiality.

**Work Conditions Survey:** The term *survey* is used in a variation of ways, but generally refers to the selection of a relatively large sample of people from a pre-determined population (the 'population of interest'; this is the wider group of people in whom the researcher is interested in a particular study), followed by the collection of a relatively small amount of data from those individuals to make some inference about the wider population. Data are collected in a standardized form. This is usually, but not necessarily, done by means of a questionnaire or interview (Kelley, Clark, Brown & Sitzia, 2003). Here, a questionnaire was designed to suit the research. The research question proposed to be answered by this survey tool was "How are the work and ergonomic conditions at Odivelas Kitchen perceived by the employees?" – The questionnaire is presented on Appendix A. To distribute and advertise the questionnaire, the investigator posted a communication on the information boards existent in the work area, explaining the survey's purpose and fostering responses. Additionally, every day personal reminders were made to all the employees, by the researcher and some managers.

Within the priority areas, choices had to be made regarding which type of products' path to measure, once that a lot of the foodstuffs produced share the same processes even though they don't have the same sequence. For this matter, the Pareto diagram tool was used in order to understand the most important products in the value chain, so that they would serve as examples for the measuring of all processes.

**Pareto Chart (ABC Analysis):** This is a tool used to establish priorities, dividing contributing effects into the "vital few" and "useful many." A Pareto diagram includes three basic elements: (1) the contributors to the total effect, ranked by the magnitude of contribution; (2) the magnitude of the contribution of each expressed numerically; and (3) the cumulative-percent-of-total effect of the ranked contributors (Juran & Godfrey, 1979).

This analysis focused on the January sales historic because it represents the current state of the Industrial Kitchen better than the historic from previous years. Also, it was the data available at the start of the measuring phase. In the following months some alterations occurred, even due to the seasonality of the products.

In order to understand the work stream in detail, the bottlenecks and the inefficiencies, all processes had to be measured and comprehended. As doing this in loco, the researcher resort to the flow chart tool as a way to represent the process in a simple way.

**Flow Chart:** A Flow Chart is defined as a formalised graphic representation of a program logic sequence, work or manufacturing process, organisation chart, or similar formalised structure (Lakin et al., 1996 in Aguilar-Savén, 2004). It is a graphical representation in which symbols are used to represent such things as operations, data, flow direction, and equipment, for the definition, analysis, or solution of a problem (Aguilar-Savén, 2004).

The quantification of the waste, as defined by the Lean paradigm, was done when measuring process timings. The researcher described every activity observed in terms of: objective, final product, timings, department where it occurred, number of workers involved, total quantity of product to be handled (in weight units), the quantity handled while observing, etc. Some notes regarding problems that arose, moments dedicated to other type of activities, along with other relevant remarks were also annotated. Hence, it was possible to differentiate value-adding (VA) from non-value adding (NVA) and even from necessary but non-value adding (NNVA) activities. Amongst the NVA and the NNVA tasks, the investigator could analyse what type of waste was there and its relevancy in the process.

### 3.3.3 Analyse

At this stage, it is common to try to comprehend why the problems occur and, formerly, divide it into multiple reasons that are identified as possible causes. Meaning, one tries to understand which inputs are affecting the process outputs. Once the principal factors are known – the ones that highly contribute for the output variation – and these justify the problem found, the Improve stage is called upon (Pyzdek & Keller, 2009). Dias (2009) also refers that the analysis made to the retrieved data from the previous phase is of the outmost importance for the process improvement, for that it is in this stage that one discovers and identifies the reason for the problem to exist.

According to Eckes (2003), teams frequently start out with a preconceived notion of the reason behind the identified problem. This makes them fly through the Analysis phase superficially, providing hasty improvement measures. But, so as Knowles, et al. (2005) mention, analysing the problem allows one to discover the root cause. For that, several quality management tools are used. There are seven classic statistical tools and seven advanced tools. The analysis tools should be used to determine where we are instead of justifying the errors found.

After gathering all the information and measurements necessary, the researcher has to be capable of drawing valuable conclusions at this phase. Then, improvement opportunities will be clear and the Improvement phase can culminate all the work previously done. The Analyse work flow is presented on Figure 3-9.

More than assembly and understand the information about the company's production, is essential to understand the underlying causes that trigger the identified problems. The Fishbone or Ishikawa or Cause-and-Effect diagram is used with that intend.

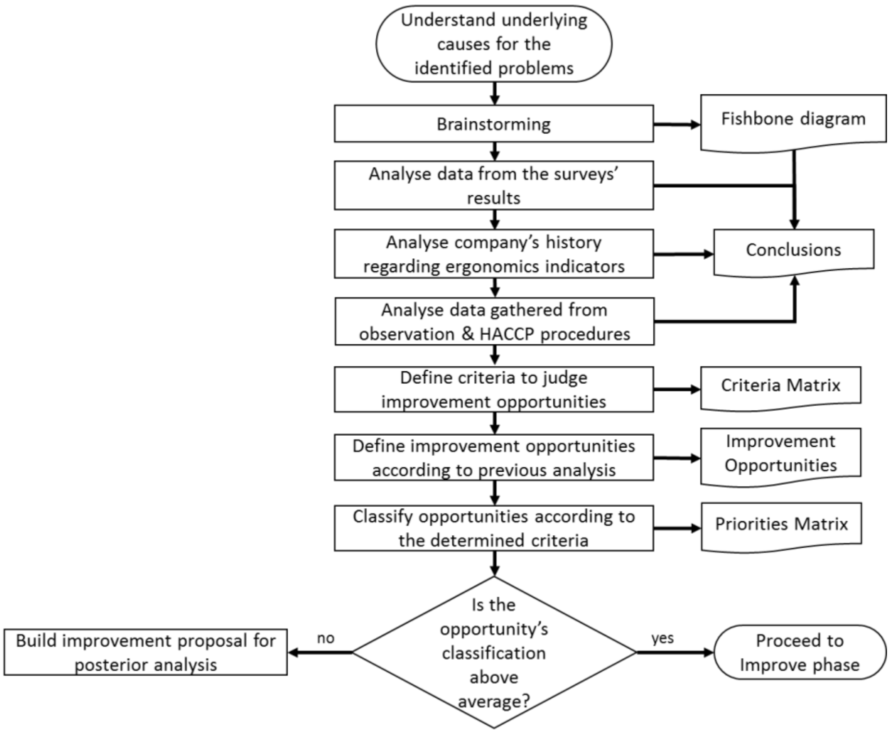


*Figure 3-9: Analyse phase flow chart*

**Fishbone or Ishikawa or Cause-and-Effect diagram:** The fishbone diagram identifies many possible causes for an effect or problem. It can be used to structure a brainstorming session. It immediately sorts ideas into useful categories. It should be used when identifying possible causes for a problem and especially when a team's thinking tends to fall into ruts (Tague, 2005).

A thorough analysis on the results from the Measurement stage is done, to the previously referred indicators, one by one. Conclusions are drawn and then have to be studied in order to prioritize. For this matter, the Priorities Matrix is a very useful tool.

**Priorities Matrix:** According to Bonacorsi (2011) "The discipline of a prioritization matrix allows you to avoid setting arbitrary priorities that have less likelihood of helping you reach your desired objectives". One should consider creating a prioritization matrix if one: cannot do everything at once; is uncertain about the best use of resources or energy; or is looking toward specific improvement goals. This tool can also help to make a decision in situations where the criteria for a good solution are known or accepted, but their relative importance is either unknown or disputed. For example, a prioritization matrix might be used to help decide the purchase of a major piece of equipment or the selection of a single-source supplier.

Rendering to the evaluation done using this tool, the improvement opportunities chosen set the tone for the start of the Improvement stage of the DMAIC cycle.

### 3.3.4 IMPROVE

In the words of Pyzdek & Keller (2009), at this phase, improvement is brainstormed, developed and implemented after carefully studying all the suggestions presented in response to the causes identified on the Analyse stage. This improvement should translate into changes that eliminate the problem and even its root-causes. The project team should guarantee, through the tool set provided by the applied methodology, the reduction or elimination of all the defects, waste and unnecessary costs regarding the client's needs previously identified in the Define stage.

At the Improve stage of the cycle, all the work done previously comes together to provide concrete actions of improvement. These are proposed, approved, developed and concretized according to the scheme presented on the flow chart in Figure 3-10.

Starting with the improvement opportunities identified in the previous stage of the DMAIC cycle, there's a need to understand which NVA activities can be eliminated or reduced first. Then comes the need to reduce non-ergonomic tasks, together with the previous. This will improve working conditions and, on the other hand, by improving working conditions the cognitive ergonomics concern is comprised. All the improvement actions proposed arise from the previous analysis and have now to be evaluated. The Priorities Matrix proves to be a very useful tool in this case also. Using the same method, is possible to understand what actions are possible and priority to implement, according to the researcher together with the Kitchen's management team. Is important to refer that large investment possibilities are very scarce due to the Group's policy at the moment.

Hence, with the results drawn from the final matrix, one gets to know the improvement actions accepted and the project plans for its implementation are render. Suggestions for future improvement actions are also presented, when the choices made didn't allow their implementation in a near future.

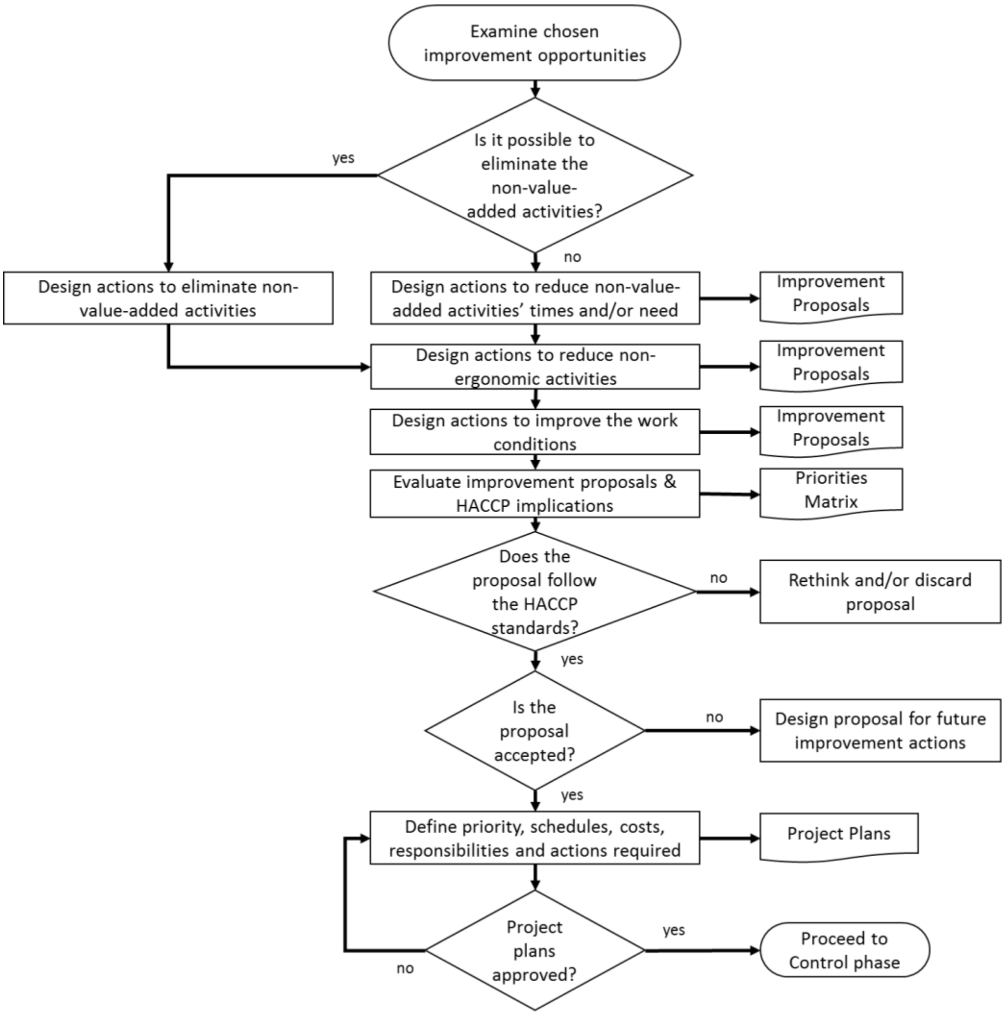


*Figure 3-10: Improve phase flow chart*

Finally comes the final iteration of the DMAIC cycle – the Control stage.

### 3.3.5 CONTROL

The improvement implementation from the previous phase solves the problem in a short-term manner. Nevertheless one has to guarantee not only that the problem won't occur again, but also that the redesigned processes can continue to be upgraded in the future. For this, it is indispensable to control the processes through documentation, accompaniment and monitoring, utilizing the adequate metrics and tools, therefore guaranteeing the abidance of the implemented development (Pyzdek & Keller, 2009). Normalizing procedures and using productivity indicators are two ways of registering and controlling the improvement impacts, together with other failure detection systems, so to assure that implementations are put into practice from then onwards. The metrics from the Measure stage are equally useful in the Control stage, so to have a reference from the previous performance. This will reassure the productive levels obtained with the implemented improvement (Freitas, 2014).

This final stage closes the cycle, allowing all the work done up to here to have continuity. On Figure 3-11, the approach followed at this phase is represented.

The project plans are only complete with the guarantee of success. The control procedures give that. Therefore, each improvement action was debated with the Kitchen's management team so to understand the needs for their abidance. When a consensus was reached, the control procedures were documented and this cycle could be closed.

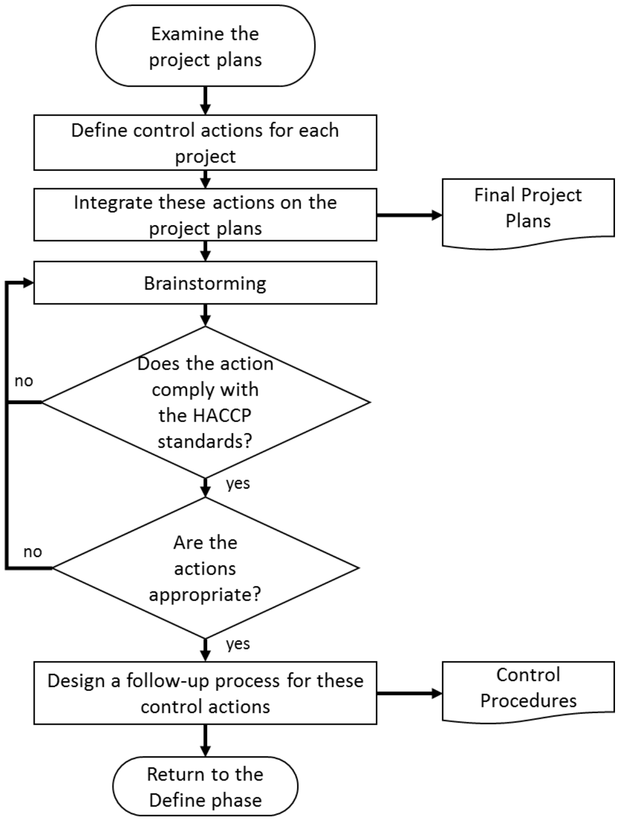


*Figure 3-11: Control phase flow chart*

# 4 APPLICATION AND RESULTS

This chapter explains the application of the previously proposed methodology and provides the results obtained. A thorough discussion of the results was not possible because there are no similar case studies in the literature, regarding Industrial Kitchens.

## 4.1 DEFINE

As seen in the Methodology chapter, the Define phase began by gathering knowledge about the company and the production process. The SIPOC tool was the mean used to synthetize the Kitchen's process from one end to the other. This analysis was made together with the management team and is represented on Table 4-1. The information was gathered by observation and by inquiring the management members.

*Table 4-1: SIPOC analysis tool*

| **SIPOC Analysis** | | | | |
|---|---|---|---|---|
| SUPPLIER | INPUT | PROCESS | OUTPUT | CUSTOMER |
| Pingo Doce storage facilities | meat | Preparing and cooking ready-to-eat meals for the final consumer, either for take-away or restaurant services | Main dishes | Pingo Doce Stores |
| | fish | | Side dishes | Caterplus |
| Campotec | fresh cut | | Soups | Special Orders |
| Caterplus | vegetables | | Deserts | Social Institutions |
| ELS | vegetables | | Salads | |
| Montalva | frozen goods | | Pies | |
| Domingos e Ferreira | packages | | | |
| Prodout | fruits | | | |
| | dairy | | | |
| | dry goods | | | |

With the aid of this tool, an overall analysis of the studied process was performed. As an internal player at Jerónimo Martins' supply chain, Odivelas' Kitchen has some companies as suppliers and customers at the same time (like PD stores and Caterplus, both companies of Jerónimo Martins Group). Only the main suppliers were characterised on this table, once that other possible providers are merely backups. There is an enormous range of inputs, but they all fit in one of the categories represented. The outputs do not include pastry, barbecues, fresh pasta and some other items that are sold on PD stores, because they are produced by other companies of the Group. The Kitchen's main customer is Pingo Doce, where a new project started this year, allowing stores' customers to order special take-away food and receive it two days later, produced by Odivelas' Kitchen (Special Orders customers).

It is important to notice that this Kitchen's clients buy the products at price cost, so the main objective of the management team is to lower the production costs, while maintaining the quality, at all times. This can be represented by the VOC Tool. VOC (Voice of Consumer) intents to translate the market necessity and VOE (Voice of Employee) shows the concerns and problems acknowledged by the workers. For the VOC Tool, data was collected within the company to present it as shown in Figure 4-1. Management members and the marketing department shared the costumers' insights with the researcher. The tool allowed the definition of the main objective of this study, regarding the company's intentions.


*Figure 4-1: VOC Tool*

It is essential to bear in mind, when looking at this scheme, that Odivelas' Industrial Kitchen's clients are Pingo Doce stores. The increasing demand of Meal Solutions products generates the need for producing more every day. But, as an internal supplier in the PD's supply chain, there is also the necessity of lowering the operational costs (since the clients buy the products at cost price). So the bottom line is to produce more and spend less money, meaning: produce better.

For the VOE Tool presented in Figure 4-2, Focus Groups with the workers were the design basis. As explicated in the Methodology chapter, the researcher used "naturally occurred" groups during the work time to inquire employees and understand their experience. Six groups were listened to, with an average of four employees per group. Each group belonged to a specific work area (Reception, Picking, Preparations, Cooking, Scullery and Expedition).

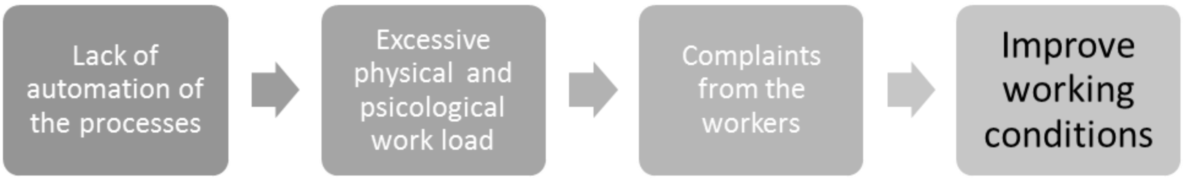


*Figure 4-2: VOE Tool*

From the employees view point, this productivity increase only exacerbates the already existing problems of lack of automation and excessive work load that translate into fatigue complaints. The inconsistency of the type of production held in this Industrial Kitchen makes it very hard to automatize processes. Also, it is very expensive to buy new top-of-the-art equipment and the company cannot afford it at this point. Despite that, this study aims to rethink some of the processes and deliver some low budget improvement suggestions to enhance working conditions.

Putting together the results from VOC and VOE Tools, a CTQ Tree was designed by the researcher as shown in Figure 4-3. This tool helps to define a clear strategy in order to better approach the improvement opportunities revealed.

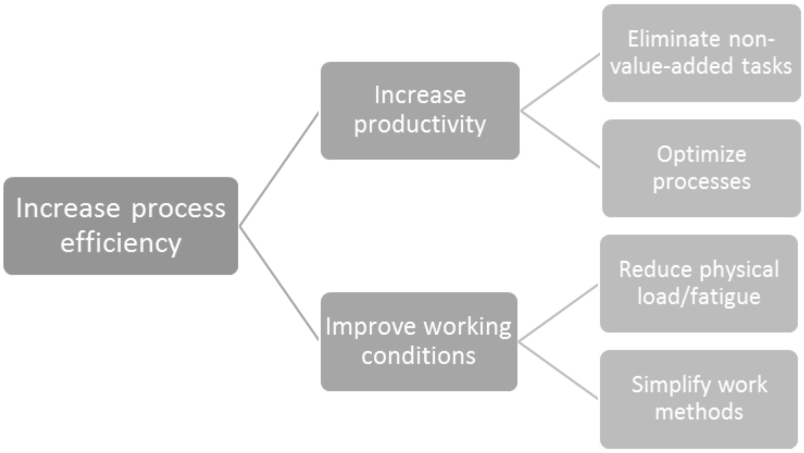


*Figure 4-3: CTQ Tree*

Through this tool it is possible to understand the basic principles of this project – increase productivity, while emphasizing the role of ergonomic conditions. In detail, the production increase can be translated into the elimination or redesign of non-value-added operations and the reduction of any of the seven types of waste define in the Lean paradigm. The working conditions concern arrays in the reduce of the workers physical and psychological fatigue, by reducing the repetitive tasks, uncomfortable static positions and heavy load handling, as well as improving the hygiene and safety conditions on the work areas. By applying the CTQ Tree tool presented above, the scope of the waste is classified, allowing its connection with the Kitchen’s main problems, identified next.

Through direct observation and focus groups, the crucial problems were identified. Firstly, the Preparation and Cooking sections were acknowledged as the ones with highest physical requirements and where processes redesign were most needed. The administration considers this to be the core processes of the company. The Scullery is understood as a part of the Cooking section, although it will be evaluated separately throughout this study because it was acknowledged as neglected and a possible bottle neck to the Kitchen’s production.

With the information obtained from the focus groups, the researcher understood that the Preparation and Cooking areas were where workers offered more complaints regarding fatigue and lack of work conditions. These high physical requirements affect the operators’ performance and the entire sections’ productivity. Thus, a thorough revision on the tasks performed in these sections is necessary, so to reduce or even eliminate the ones that compromise the production performance.

Regarding the evidence presented above, an evaluation matrix was built by the researcher together with the managing team, representing the problems found and their level of priority in each one of the Kitchen sections, as shown on Table 4-2. The red colour shows high priority, the yellow stands for medium priority and the green one means low priority levels. It is also important to understand that this classification was given by comparison between work areas and their current state, according to the previously gathered insights.

*Table 4-2: Improvement Opportunities Identification Matrix*

| | | Reception | Picking | Preparation | Cooking | Scullery | Cooling | Packing | Expedition |
|---|---|---|---|---|---|---|---|---|---|
| Improvement Opportunities | High physical requirements | Low | Medium | High | High | Medium | Low | Medium | Medium |
| | Lack of Standardization | Low | Low | Medium | Medium | Medium | Medium | Low | Low |
| | Pour equipment maintenance | Low | Low | High | High | Low | Medium | Medium | Medium |
| | Wet and dirty space | Low | Low | Medium | Medium | High | Low | Low | Low |
| | Lack of organization | Low | Low | High | High | High | Low | Low | Low |
| | Excessive number of movements | Low | Low | High | Medium | Medium | Low | Low | Low |
| | Communication problems | Low | Low | High | High | High | Low | Low | Low |
| | Lack of material to work | Low | Low | High | Medium | Medium | Low | Low | Low |

***Caption:*** *Priority level = High Medium Low*

Looking at this matrix is easy to understand the priority sections for analysis. The Preparation sector is the one with the highest priority also because it is the most important one. If this section makes a mistake, all the following sub products and final products are compromised. The Cooking division is also high priority, even if it is very dependent on the Preparation one. The Scullery, as a part of the Cooking department, does have almost the same level of priority. This is schematized on Figure 4-4, where the problems selected for further study are summarized.

1. **Preparation**

The Preparation section is the one with the highest priority in this study, regarding production and ergonomic factors. This is due to the fact that it is where some of the most important activities occur, but is simultaneously over looked because of the Cooking section, that is seen as the most important. What happens is that the Cooking section cannot do anything unless the Preparation work is flawless.

These processes involve opening all the packages from the raw materials, cutting, cleaning, mixing, seasoning and everything else necessary for the ingredients to be ready to cook. These are all put into specific containers, so that the “clean” part of the Kitchen is not contaminated by microorganisms and bacteria.

So, from the productive point of view, this section doesn't have a standardized work procedure. This causes variation on the work done, decreases work organization, makes it harder to integrate new operators and creates bigger possibility for errors or quality flaws.

From an ergonomics point of view, this section requires very repetitive tasks together with the lift of weights until 35 kg on a cold environment (between 8 and 12 degrees Celsius), causing fatigue and promoting the development of WRMSDs. Additionally, the common knife handling and the lack of organization (there is no specific secure support to put the knifes while they are being used), the usually wet and dirty floor and the lack of organization of the work space, promote accidents and an insecure work environment.

**2. Cooking**

From a productive viewpoint, there is a standard set for the daily work, but is very often over looked due to stress, variation and the need of rework. The lack of organization of the work space and prepared products origins a lot of unproductive times during the process.

Ergonomically speaking, there is a lot of tasks that need static efforts on uncomfortable positions (like cutting pre-cooked products and reeling codfish and duck, for example), sometimes on a cold room (around 5 degrees Celsius). Plating is also a hard task when performed in the cold room, requiring standing positions for a long period of time. Additionally, mixing or lifting products is often very hard due to the quantities and weight involved.

**3. Scullery**

The particularity about the scullery is that is a very small piece of the engine, thus seen as secondary and sometimes neglected. But it is an extremely important piece, because it can, and actually does, compromise the productivity of the entire Kitchen. The "lack of material to work" identified problem in the matrix refers exactly to this. Very often, the production has to stop because not sufficient material has been sanitized yet.

Ergonomically, it requires less physical exertion, although the work conditions are worse. The floor is always wet and dirty, the operators have to deal with very hot objects, unpleasant smells and do a lot of repetitive tasks when in uncomfortable positions.

**4. Packing and Expedition**

This section is more organized and standardized than the previous, but also requires high physical effort due to the handling of heavy materials and the high repetition of movements. It is also a more repetitive and monotonous type of work. The main problem is the frequent stoppage of the equipment, need for maintenance and lack of more automatized processes. This leads to rework, wasted product and production breaks.

The project is therefore formally defined through the Project Charter, presented on Table 4-3. This tool explicates the project scope, underlined objectives and responsibilities.

To sum up, at this stage the project was defined and formalized, constituting objectives and the identified problems. These should comprise Preparation, Cooking, Scullery and Packing & Expedition areas, impacting on productivity, organization and ergonomic conditions.

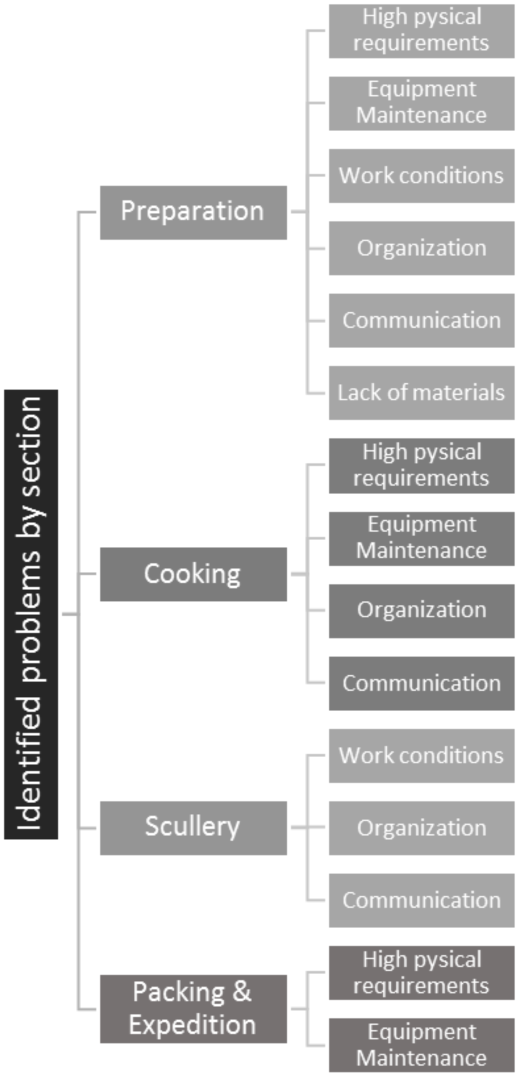


*Figure 4-4: Summary of the priority identified problems*

Table 4-3: Project Charter

| | |
|---|---|
| **Title** | Increasing productivity together with working and ergonomic conditions on the Preparation and Production of Ready-to-Eat (RTE) meals |
| **Opportunity** | With the economic recession that has been haunting Portugal in the last few years, families have restricted their budgets to the essential and began to be more careful with their shopping. This resulted on the increase of consumers on Pingo Doce Restaurants, due to a strong value for money offer. Also, Take-Away meals (especially Soups) are every day more in vogue because of the life style shift that has been noticed. Is therefore imperative to enlarge the production capacity of the Odivelas' Kitchen, by increasing its efficiency, while considering the ergonomic and work conditions of the workers. This will build a motivational work environment, valuing efficiency as much as safety, which benefits the client at the end of the line. |
| **Project Purpose** | ◦ Increase productivity |
| | ◦ Improve work and ergonomic conditions |
| **Addressed Problems** | ◦ Loss of productivity due to the workers' fatigue and dissatisfaction |
| | ◦ Non-value-added activities (waste) |
| **Objectives** | ◦ Productivity increase in 20% - Decrease of waste in 25%<br>◦ Reduction of the workers' fatigue and dissatisfaction, increasing work and ergonomic conditions<br>◦ Utilization of ergonomic principles to help increase productivity |
| **Restrictions** | ◦ Budget |
| | ◦ Time |
| | ◦ Team |
| | ◦ Food safety (HACCP) procedures and rules |
| **Finish Date** | 1st of July 2015 |
| **Project Members** | Meal Solutions Director |
| | Production Director (Tutor) |
| | Researcher |
| **Schedule** | *Define:* March 13th |
| | *Measure:* April 30th |
| | Analyse: May 22nd |
| | Improve: June 24th |
| | *Control:* June 30th |

# 4.2 MEASURE

According to the Methodology chapter, the Measure phase started by defining the key indicators that would help standardize measurements and compare results. As referred before, these will evaluate both ergonomic conditions and productivity parameters.

## I. PRODUCTIVITY INDICATORS

Starting with the productivity indicators, the following information was considered: waste, production costs and quantity, and productivity. The productivity KPI was measured considering kg per hour per employee. According to Walder et al. (2007), to increase productivity one must remove waste because removing waste removes unnecessary movement, inventory, and double handling, leaving the people and machines available to be more productive.

## Waste

After observing the Kitchen's processes, the researcher understood that the priority problems regarding the previous *waste* definition would be waiting time, transportation, over-processing, motion and defects. Overproduction and Inventory were not considered, as explicated in the Measure chapter.

Hence, the researcher focused on measuring the time workers wait for something during their production time, as work materials, work in progress (WIP), tools or information, amongst others; the problems encountered regarding failures and re-processing; and the time spent moving around people and materials around the Kitchen's floor. Inference had to be used when possible and necessary.

Classification was based on the concept of value to the customer. Hence, tasks that change the food products or add something towards the final product conception were considered VA activities. Tasks that change food products and contribute to the final production but were not absolutely necessary (happened due to previous errors on the work flow e.g.) were classified as NNVA activities. And finally, all the activities that have a support role but don't add anything to the final product were categorised as NVA. Then, amongst the NVA activities, a posterior analysis to the causes was realized in order to understand the support tasks which consumed more productive time.

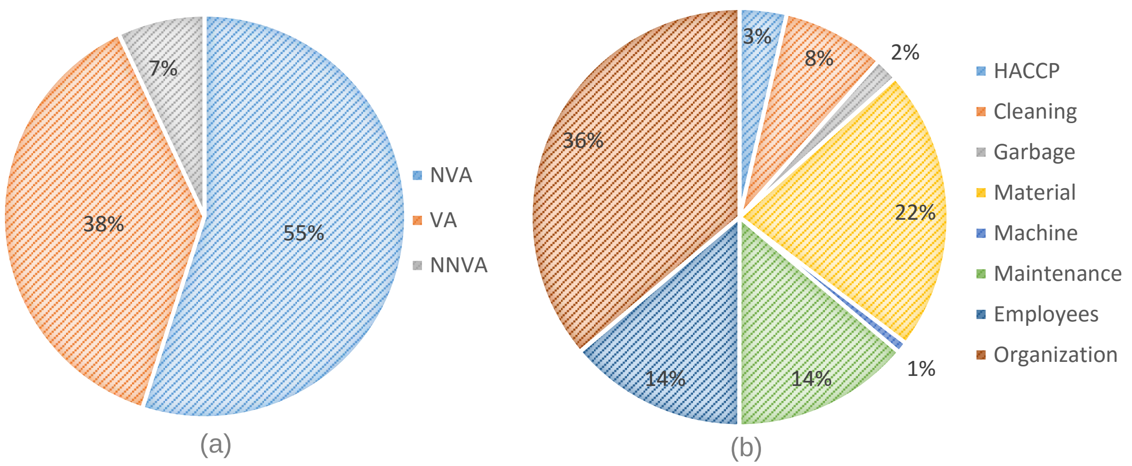


*Figure 4-5: (a) Classification of the observed waiting time (VA – value added; NVA – non value added; and NNVA – necessary but not value added activities); (b) NVA activities classification*

From Figure 4-5 (a) shown above is possible to understand that the majority of the activities are NVA (55%), like searching for tools, moving products around, picking food products, cleaning the work stations, fixing problems in the equipment, waiting for materials and information, etc.

Looking in a little bit deeper, to side (b), there is a great majority of *organization* unproductive time (36%). In this category fit activities like identifying the containers, preparing the work station, organizing the work space, taking processed products to the next station, etc.; next, with 22% of the NVA activities, is *material* related unproductive time. Meaning, stop producing to get work material, tools, equipment, raw materials, WIP products and PPEs (personal protection equipment). These often involve movement of people and material; with equal weight (14%) there are *machine* and *maintenance* NVA activities. *Machine* is the category were fit actions like feeding an equipment for it to perform a task. *Maintenance* refers to problems with equipment and tools requiring production stoppage for a short period of time; C*leanliness*, with 8% weight, remits to brief clean-ups of the work stations and equipment; Then *HACCP* (3%) is the class for activities imposed by the Health and Quality management. Washing hands is the most common; lastly there is *garbage* representing 2% of the total time. *Garbage* stands for all the actions involving production stoppage, and usually movement, in order to empty the bin and change the trash bag; *Employees* covers the daily stipulated breaks of each worker and represents only 1%.

For a better understanding of the problems in the Kitchen's process, the measured activities were divided according to the *waste* definition explained above and the results are shown on Figure 4-6. Each one of the identified waste is analysed next.

1. **Waiting Time**

*Waiting* is a waste defined by Shigeo Shingo as "long periods of inactivity for people, information or goods, resulting in poor flow and long lead times" in Peter & Taylor (2000). In this case, waiting time was measured as the amount of time a worker was waiting for work materials, products, work from upstream, a co-worker, information or work load. It is impossible to accurately measure the time product is waiting to be handled due to the complexity of the process (there are several types of products produced at the same time with a semi-random frequency; Different streams intersect and share the same work station simultaneously).

2. **Transportation**

"Excessive movement of people, information or goods resulting in wasted time, effort and cost", defined by Shigeo Shingo in Peter & Taylor (2000). Transportation and unnecessary motion are two of the seven types of wastes that can be significantly reduced with the implementation of ergonomic assist systems and equipment. For example, moving machines closer together to remove walking and material transportation between them removes waste (Walder et al., 2007). This type of waste is crucial to this case study development, once that eliminating time and effort can simultaneously improve productivity, as well as working and ergonomic conditions.

### 3. Over-Processing

According to Shingo, over or inappropriate processing means “going about work processes using the wrong set of tools, procedures or systems, often when a simpler approach may be more effective” in Peter & Taylor (2000). It is a common occurrence at Odivelas’ Kitchen, but sometimes justified by the management team as a way of preserving the peculiarity of the “home flavours” in the food. This happens to match the clients’ needs and expectations.

### 4. Motion

Motion is defined as “poor workplace organisation, resulting in poor ergonomics, e.g. excessive bending or stretching and frequently lost items” by Shigeo Shingo in Peter & Taylor (2000). This is the most important type of waste to be analysed in this project, once that converges the two issues to be put together with the work presented – ergonomics and lean management. As Walder et al. (2007) say, the waste of unnecessary motion is particularly related to ergonomics. Excess motion consists of bending, twisting, lifting, reaching and walking. These often become health and safety issues. It is also the most priority problem in the Kitchen’s process, according to the researcher’s observations. Equipment poor maintenance and infrastructure conditions contribute a lot for the difficulty of solving this problem.

### 5. Defects

Once more Shingo defines defects as “frequent errors in paperwork, product quality problems, or poor delivery performance” in Peter & Taylor (2000). The total quantity produced daily, being that deficiency or benefit, is measured and analysed every day. The researcher collected the daily report from January to June 13$^{th}$ from the company’s ERP system.

Defects caught during the production are immediately corrected so to not flow downstream. Consequently they are not recorded, making it impossible to accurately measure and analyse the quantity wasted during the production time. Thus, during this observation, defects were defined as irregularities in the Kitchen’s production, resulting in surplus or deficiency on the final product.

The peculiarity about an industrial kitchen is that food products are not constant, neither is their handling. Everything depends on nature, market, daily setbacks and especially on the people preparing and cooking the ingredients. So it is not possible no quantify the causes for the surplus and lack of product detected.

Comparing the quantity ordered with the quantity produced every day, we can see the result in percentage on Figure 4-7. Overall, the result was always benefit but that doesn’t mean the production wasn’t faulty. It only means that its defects are majorly surplus on final products. The best month was June, with zero defects.

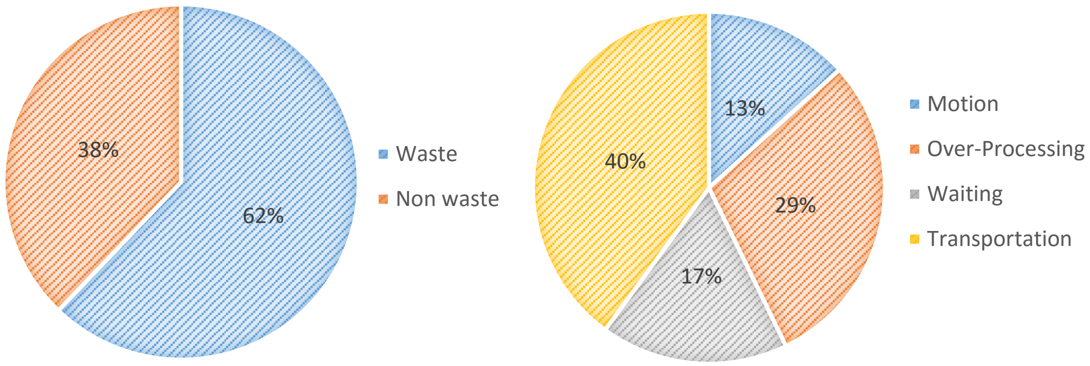


*Figure 4-6: (a) Percentage of waste from the observed activities (b) Weight of each identified type of waste*

From the observations made, a waste classification was made by the researcher according to the four types defined above. It allowed understanding how much time was considered waste and not. Hence, from Figure 4-6 (a) it is possible to understand that 62% of the measured activities were considered some type of waste. From (b) is easier to comprehend the importance of the mentioned above - 40% of the waste is *transportation*. *Over-processing* is also alarming, with 29% of the waste weight, followed by *waiting* (17%) and finally *motion* (13%). Waiting here covers essentially "material" from the first categorization; Over-processing corresponds almost directly to "work organization"; Transportation covers a larger spectrum, going from "garbage", "cleanliness" or "material"; and Motion is most related to "machine", but occurs mostly during VA activities. It is also important to mention that the *defects* can be considered as "work organization" regarding the part of the definition where Shingo talks about "poor delivery performance", hence contributing to the Over-processing classification.

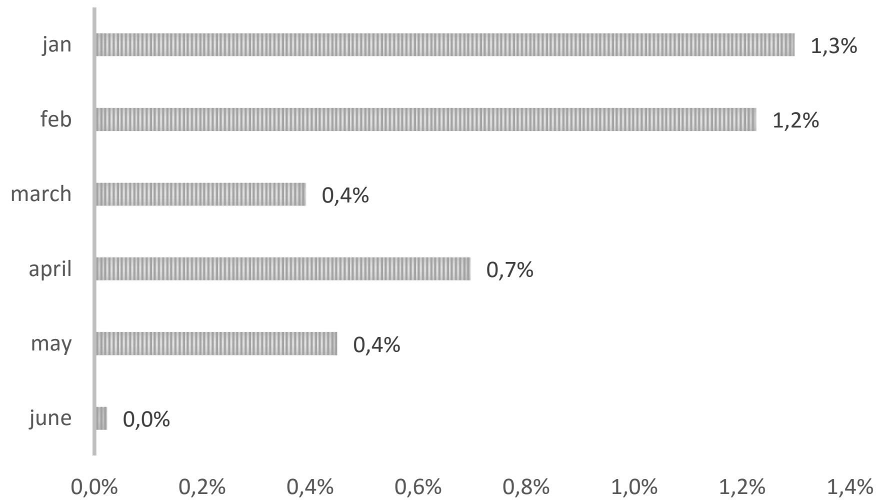


*Figure 4-7: Production variation from January to June*

A standardization of the production should help the decrease in variation, since most of the variation occurs due to human interaction. For example, the production of soup can vary depending on the amount of water added to the vegetables. This creates a different output every time.

## Production Costs and Quantity

Regarding the quantity produced and the production costs, it's possible to observe on Table 4-4 the production indicators at the full year of 2014.

*Table 4-4: Production indicators from 2014*

| | | |
|---|---|---|
| **Total Production** | 5 766 692 | Kg |
| **Average Production / FTE**[3] | 3 144 | Kg |
| **Average Personnel Cost per Kg** | 0,39 | € |
| **Total Operating Costs per Kg** | 1,06 | € |

The Odivelas Kitchen's total operating cost was 1,06 €/kg. The goal for 2015 was **1 €/kg**. The cost of raw materials is assumed as operational costs for Pingo Doce, therefore its management and reduction is not on Odivelas Kitchen's team hands. So, the only impact one can have is on the operational costs.

Also, a choice of products to analyse amongst the huge variety within the Kitchen's production had to be made before measuring the chosen KPIs. Therefore, an ABC analysis to the company's sales in January 2015 was made so to prioritize the existent products, as shown on Figure 4-8. It's possible to see that only 23% (75 out of 324, in January 2015) of the group of possible outputs contribute to 80% of the Kitchen's sales. And also that "Arroz de Pato" accounts for almost 9% of January's sales by itself. As 75 products it's still a huge sample for analysis, and we can see from the Pareto chart that there is a small group that sums almost 40% of the total sales, the researcher decided to focus on the Top 5 sellers. These are represented on Table 4-5. The symbol * on this Table is an internal rule to distinguish if the same product is going for the Pingo Doce restaurants, to be served in plates, or for the Take-Away (besides the difference among the internal codes). Therefore, if it is a plate for the restaurant it will have the * symbol next to the product name. This is necessary because, operationally, products for the restaurant have different transportation trays. By this logic, BACALHAU ESPIRITUAL * and BACALHAU ESPIRITUAL are the same product (the process just differs when plating the food in the trays). Hence, the Top 5 sellers includes one more product, so not to double the information.

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[3] FTE – Full Time Employee – it serves as an equivalence measure in terms of number of employees. E.g. if there are 2 part time employees working 4 hours a day and one full time employee working 8 hours a day, the equivalence is 2 FTEs.

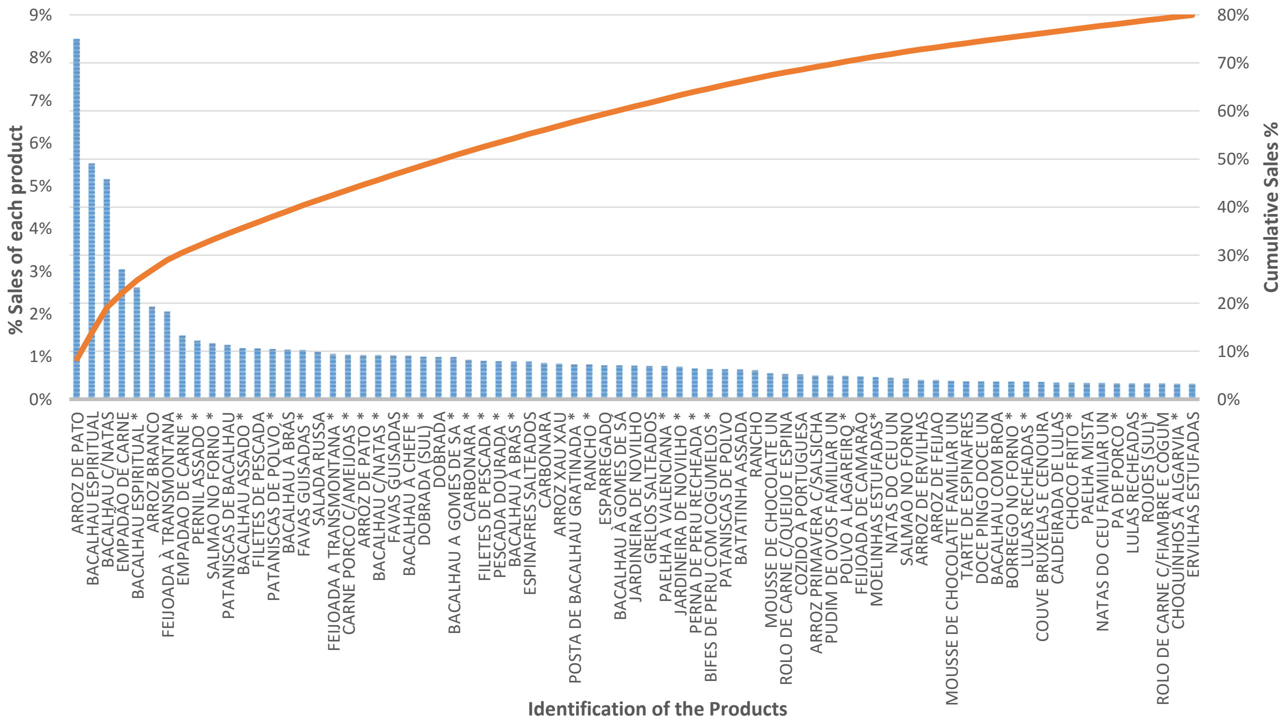



*Figure 4-8: Pareto Chart of the Sales in January 2015*

*Table 4-5: Top 5 sellers in January 2015*

| Name | Sales [EUR] | Production [kg] |
|---|---|---|
| ARROZ DE PATO | 113 773,64 | 9 605,75 |
| BACALHAU ESPIRITUAL | 74 586,83 | 8 557,15 |
| BACALHAU C/NATAS | 69 526,88 | 7 807,40 |
| EMPADÃO DE CARNE | 41 061,42 | 7 245,79 |
| BACALHAU ESPIRITUAL * | 35 336,34 | 5 390,08 |
| ARROZ BRANCO | 29 329,02 | 2 812,74 |

The choice of the KPIs mentioned on the Methodology chapter, together with the narrowing of the products' scope to the Top 5 through the ABC analysis, allowed the researcher to measure and comprehend the Kitchen's processes. Hence, a flowchart of each one of the Top 5 production processes was designed in order to better understand them. These are represented on Appendix C.

### Productivity

The productivity for each section, according to the number of worked hours, is represented on Table 4-6. All the Kitchen's areas work on three eight hour shifts per day and the average production capacity per day is 20 023 kg (in 2014). The average Kitchen's productivity in 2014 was **785 kg/hour**.

*Table 4-6: Productivity by section*

| Section | Team members [FTEs] | Worked hours per day | Productivity [kg/FTE] |
|---|---|---|---|
| **Reception** | 11 | 87 | 231 |
| **Preparations** | 27 | 213 | 94 |
| **Cooking** | 42 | 333 | 60 |
| **Soups** | 8 | 67 | 300 |
| **Deserts** | 9 | 73 | 273 |
| **Scullery** | 9 | 73 | 273 |
| **Expedition** | 28 | 220 | 91 |

## II. WORK AND ERGONOMIC CONDITIONS INDICATORS

Concerning the work conditions, there is no exact measure for it, although some statistics might be interesting. A brief overview on the number of accidents occurred in the last year, absenteeism rate and acknowledged risks might provide a shallow scenario of it.

### Accidents

Consulting the accidents history from 2014 in the company, the following data is presented: number of accidents, number of sick leave days, number of accidents by age gap, by gender, by work section and even body part where the injurie occurred, description and cause of the accident. The total number of accidents and their characterization by age and gender is on Table 4-7.

Looking at the population indicators, the bigger group of people has ages between 25 and 34 years old. Also, the bigger number of accidents is also comprised in that age group. As for gender, the same criteria applies. 63% of the Kitchen's employees are men and 63% of the accidents occurred to men. As for the location where the accidents took place, it is shown on Figure 4-9.

The Cooking section has 47% of the Kitchen's employees, so once again it is logical that a bigger number of accidents occur on that area. Despite that, 68% of the accidents happened there, which can indicate a bigger lack space organization, hygiene and safety conditions than in other sections.

*Table 4-7: Occupational accidents in 2014*

| | Number of accidents |
|---|---|
| Total in 2014 | 48 |
| **Age** | |
| < 25 years old | 10 |
| 25-34 years old | 17 |
| 35-45 years old | 9 |
| > 45 years old | 12 |
| **Gender** | |
| Men | 30 |
| Women | 18 |

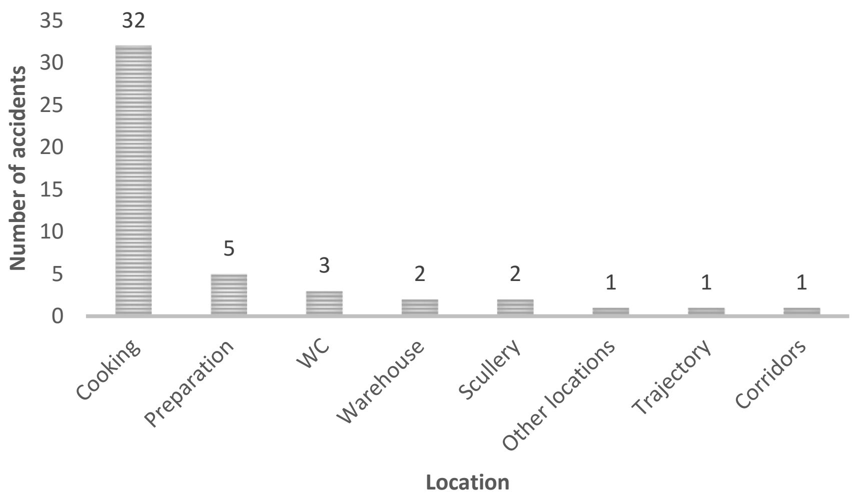



*Figure 4-9: Location of the accidents history in 2014*

The body part incidence is explicated on Figure 4-10 and the accident description on Table 4-8.

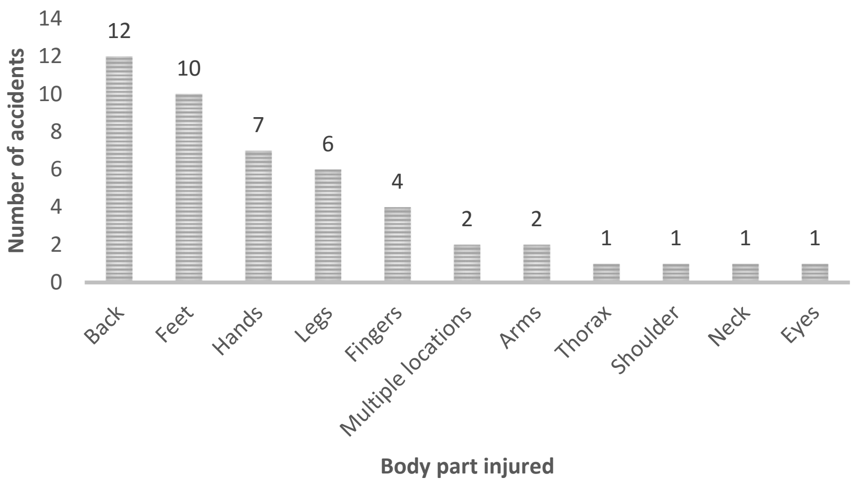



*Figure 4-10: Accidents history in 2014 distribution by body part injured*

*Table 4-8: Description of the accidents history in 2014*

| Description | Accidents |
|---|---|
| Physical effort/false movement | 13 |
| Extreme temperatures exposure | 7 |
| Cut/Laceration | 5 |
| Concussion caused by an object | 5 |
| Fall on the same height | 4 |
| Pinch on/between objects | 3 |
| Fall from higher level | 3 |
| Fall of objects | 2 |
| PPE allergies | 1 |
| Electrocution | 1 |
| Go against structure/object | 1 |
| Prick/Punch | 1 |

As shown by this historical data, the majority of the accidents are related with the back. Also, “physical effort/false movement” is the most common cause for accidents occurrence. Looking at the causes for the incidents manifestation at Table 4-9, it is possible to observe some of the issues previously considered as problematic as the heavy loads moving, pour equipment maintenance and space organization.

*Table 4-9: Causes of the accidents history in 2014*

| Causes | Accidents |
|---|---|
| Failure on the manual loads movement | 10 |
| Pour hygiene conditions | 9 |
| Faulty equipment | 9 |
| Failure to comply with the rules | 6 |
| Pour space organization | 2 |
| Pour layout conception | 2 |
| Environmental factors (Gases, fumes, dust and vapours; lightning, thermic environment, noise e radiation) | 2 |
| Failure utilizing the PPEs | 2 |
| Heavy load | 1 |
| Failure on the mechanic loads' movement | 1 |
| Inappropriate work rate | 1 |

## Absenteeism

Another indicator of the work conditions on the Odivelas Kitchen is the absence rate, because it can reflect the employees' well-being, happiness and involvement on their job.

On Figure 4-11 a distribution of the absenteeism rate by section is shown in number of days, also giving the information about the percentage of the total non-attendance time in each work area. Obviously, this is related with the number of employees by section, as seen before. But it matters to understand that the Preparation has the worse results, once that its population is about 19%

of the Kitchen's total number of employees and their absenteeism rate reaches 40%. As for all the other sections, the ratio between population and absence rate is accurate.

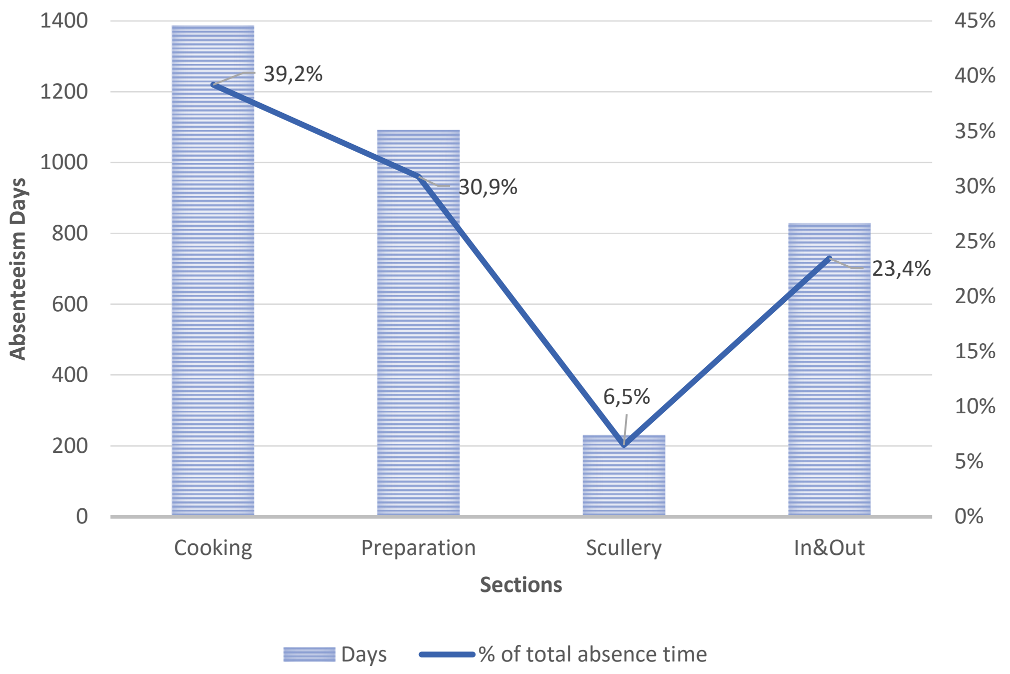



*Figure 4-11: Absence rate distribution by work sections (2014 data)*

The average absence time in the Odivelas Kitchen is 25% of the total worked time in 2014.

## Turnover

The constant depart of employees can indicate that the job does not satisfy them, as seen in the Background chapter. Poor work conditions have their role in it. The problem is that this flow of people leaving creates the necessity of finding new ones, which implies a lot of bureaucratic work, time and costs. As we can see in Figure 4-12 (data history since the opening of the Odivelas Kitchen), the big majority of reasons to hire new staff is the termination of contracts or transferences, which reflects the previous statement. Only 20% of the current staff was admitted when the Kitchen inaugurated and only 11% was admitted due to the fact that the business is growing (authorized personnel increase). Just 1% of hiring was to replace absences. This is because absences are replaced temporarily with internal staff, once that the team is quite flexible.

On Table 4-10 is possible to see the number of new employees per year. But bearing in mind that 2015 data only covers from January to April, it is easier to look at the rate of new employees per month, where we can see that 2015 has beaten the record, so far. The average turnover rate is **5,3 new employees/month**. For a better understanding, on Figure 4-13 the causes for admitting new employees are explicit on each year, from 2013 to 2015.

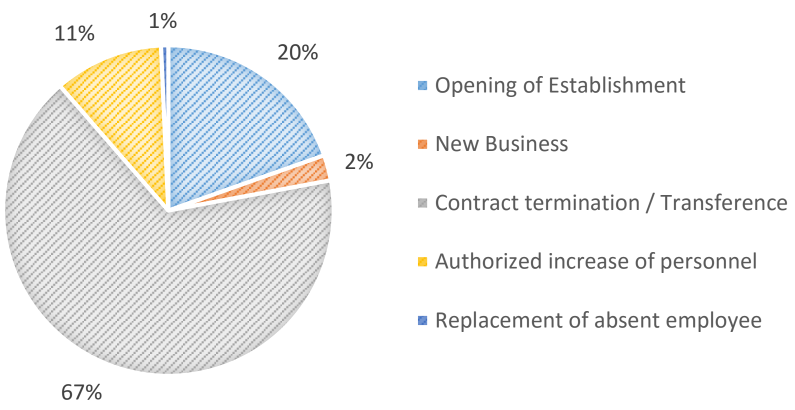



*Figure 4-12: Causes for admission of new employees*

*Table 4-10: Number of new employees per year*

| Year | Total | Rate [new employees/month] |
|---|---|---|
| **2013** | 39 | 3,3 |
| **2014** | 70 | 5,8 |
| **2015** | 27 | 6,8 |

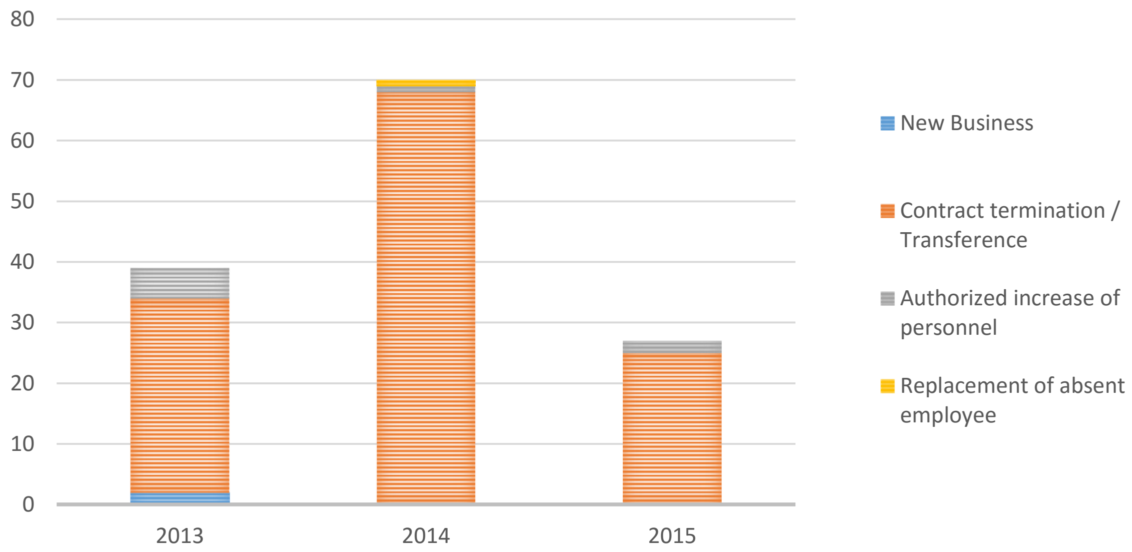



*Figure 4-13: Causes for hiring new employees (data per year)*

## Work Conditions Survey

A survey was distributed to the operators in order to inquire them about the work load, fatigue, work organization, work conditions, work environment and also ask for improvement suggestions. The survey form is shown on Appendix A. This survey helped to identify the priority areas for improvement, worse operations from an ergonomic point of view and the existing problems, from the workers' experience. Simultaneously, a positive impact was created on the work force, since they could see that someone was looking after their interests and caring about their well-being.

This survey was answered by a total of 64 employees, among a population of 164 people – around 40% of the total working force. The population is characterized by a domination of male workers (63% versus 36% of women) and the ages vary from 20 to 61 years-old, being that the majority of the population (20%) is between the ages of 26 and 35 years-old. The comparison between the characterization of the actual population and the characterization of the people that answered the survey is shown on Figure 4-14 (by gender), Figure 4-15 (by age), Figure 4-16 (by seniority in the Company) and on Figure 4-17 (by work section).

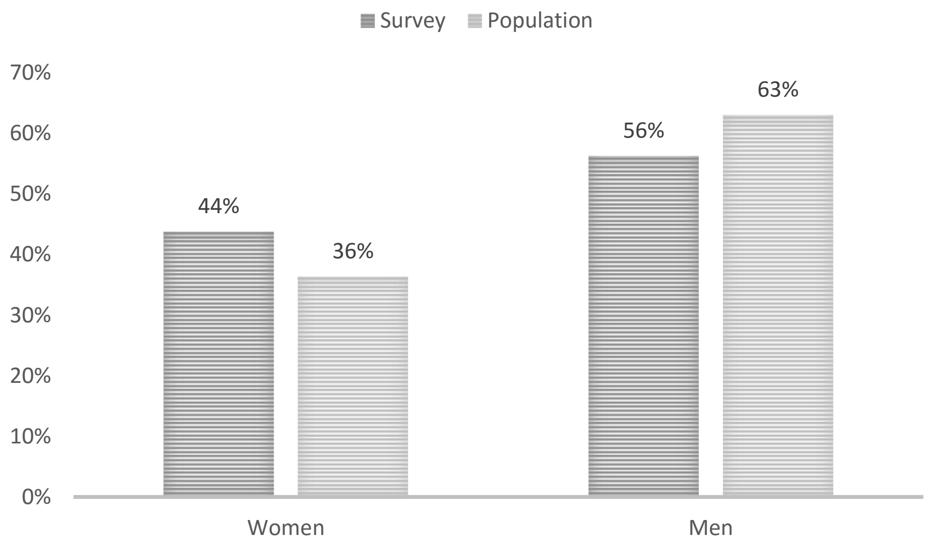



*Figure 4-14: Gender distribution (Population n=164 and survey respondents n=64)*

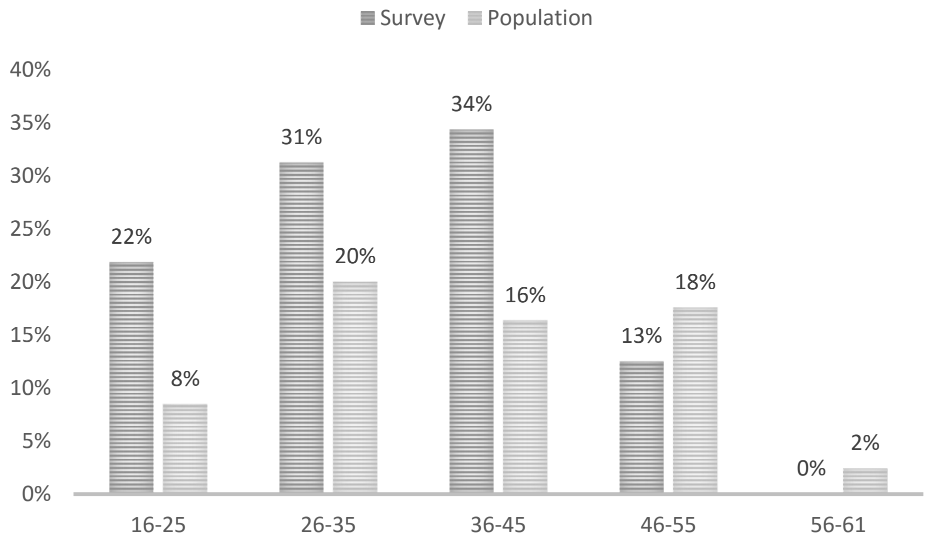



*Figure 4-15: Age distribution (Population n=164 and survey respondents n=64)*

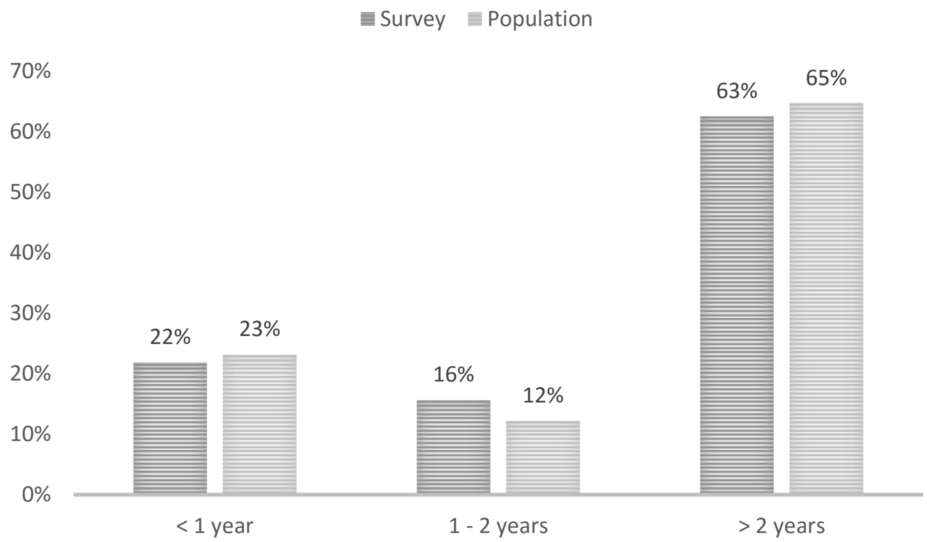



*Figure 4-16: Seniority distribution (Population n=164 and survey respondents n=64)*

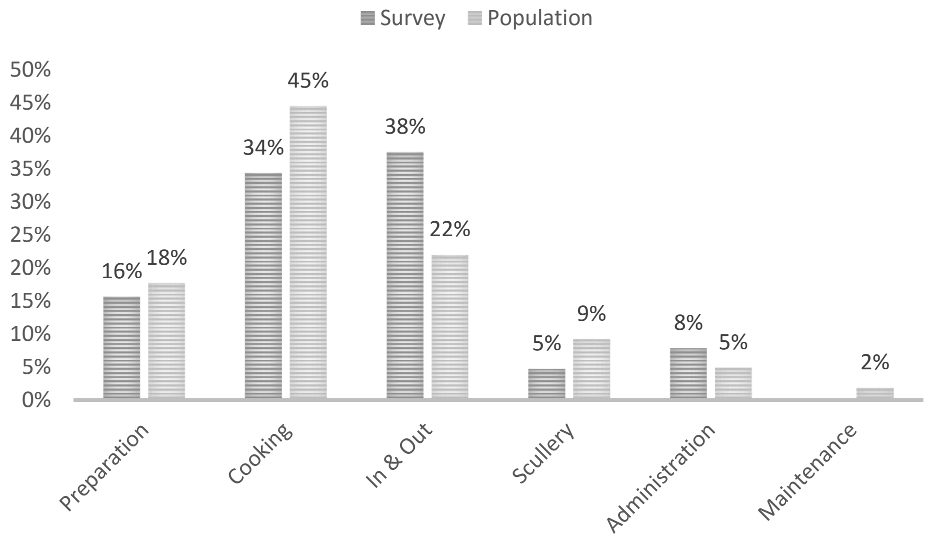



*Figure 4-17: Distribution by section (Population n=164 and survey respondents n=64)*

Is important to remember that the Odivelas' Kitchen is only three years old and, on the seniority criteria, the majority of the workers is on the company for over two years. But that only happens because the greater part of the work force came through transfer from other stores or smaller kitchens of the JM Group.

Looking at these graphs comparing populations, is possible to tell that the survey answers can represent the plurality of the Kitchen's staff. Although, women, younger people and the workers from the In & Out section were more responsive. Looking at the sections' distribution of workers and survey answers, is possible to tell the responsiveness rate by section versus the population distribution by section. The higher responsiveness rate from In & Out sections can skew the survey's answers towards these employees' opinion so, in order to get a broader perception of the information comprised in the survey's answers, a two phase's analysis was made.

First, a global interpretation of the answers and then the same examination was made by dividing the surveys by work section. Examining the global picture, regarding the work environment – temperature, cleanliness, facilities and work organization – the results are represented on Figure 4-18. Regarding cleanliness, 78% think it is "good" – this operation is performed by an external cleaning company, except for routine workstation clean-ups.

Studying this category by section, is possible to see that Cooking and Scullery areas perceived their work environments as less clean than the rest, but still with a classification of "good", as shown on Figure 4-19.

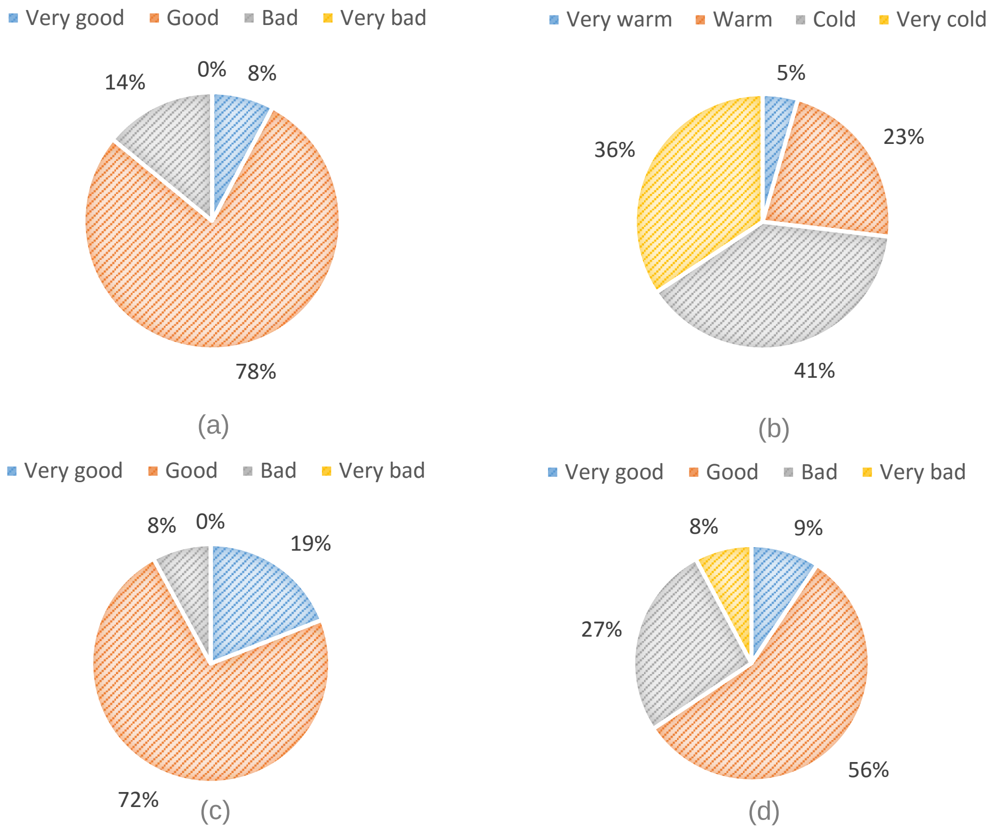



*Figure 4-18: Perceived work environment regarding cleanliness (a), temperature (b), facilities (c) and organization (d); n = 64*

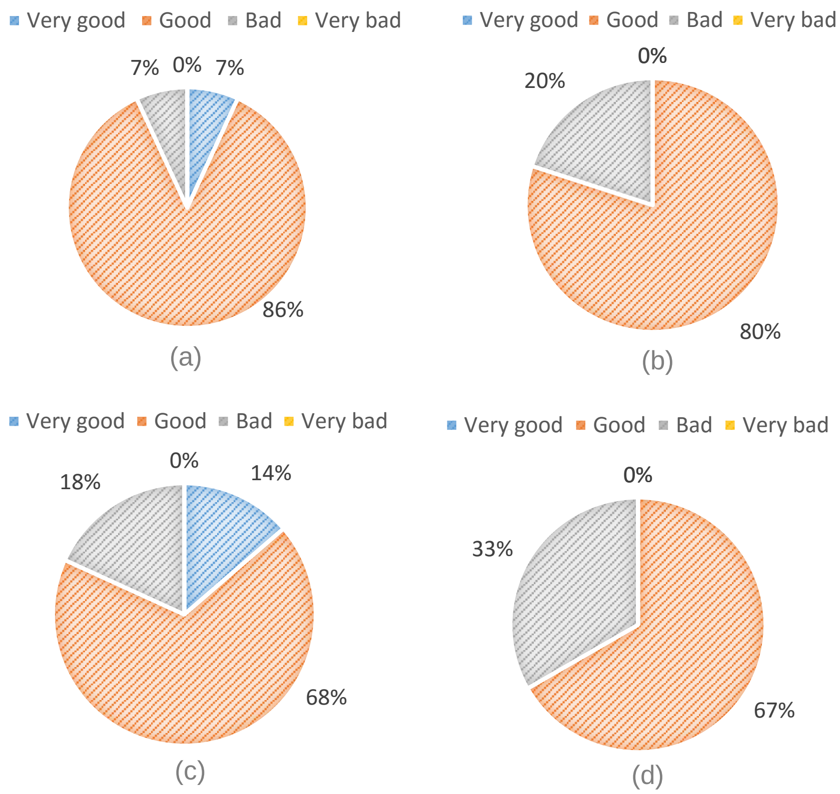


Figure 4-19: Perceived Cleanliness by work section: (a) In & Out (b) Preparations (c) Cooking (d) Scullery; n = 64

As to temperature, the majority considers it "cold" or "very cold", but this depends on the work section. The Industrial Kitchen is kept at low temperatures to preserve the quality and features of the products. The only section that is warmer is the Cooking one due to the cooking processes, although some employees (32%) consider it "very cold" because a few operations have to be performed in a room that is usually around 5 degrees Celsius. The results by section are presented on Figure 4-20.

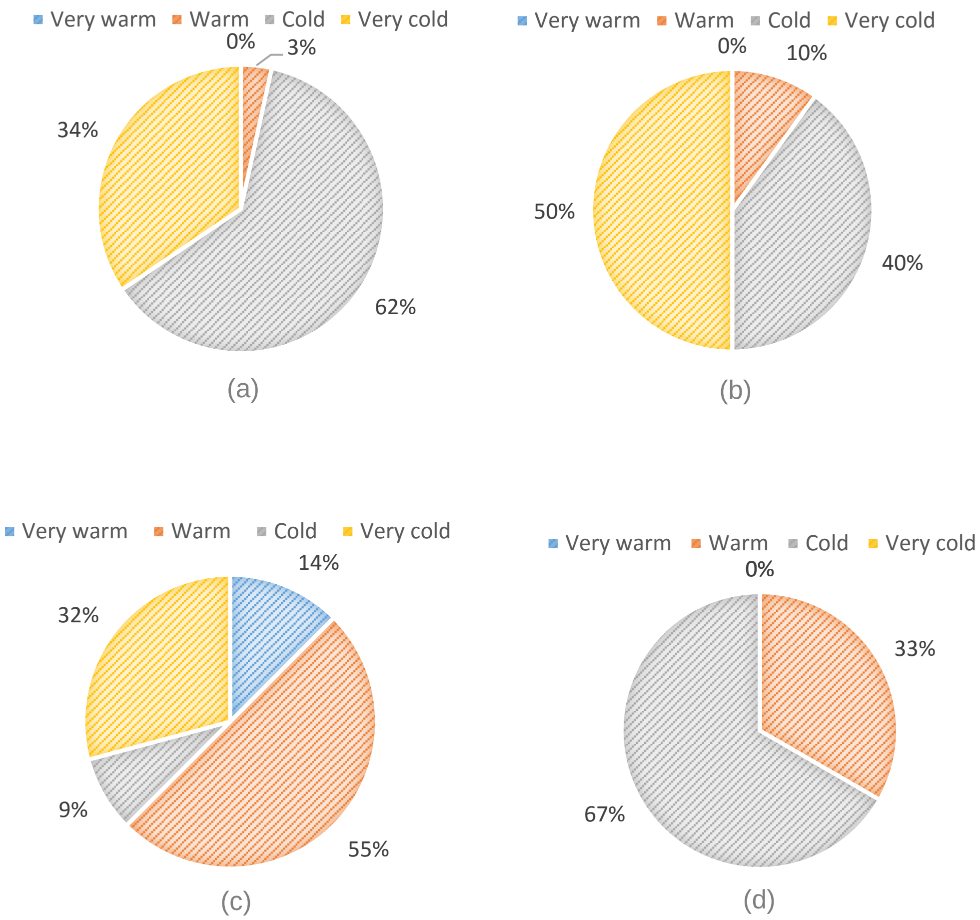



Figure 4-20: Perceived Temperature by work section: (a) In & Out (b) Preparations (c) Cooking (d) Scullery; n = 64

The work organization is seen as "good" by 56%, but the second biggest group of answers was bad (27%). There is a bigger discrepancy between sections in this category. 45% of the Cooking workers perceive the work organization as "bad" and 67% of the Scullery operators see it as "bad", while 33% as "very bad". So, it will also be evaluated separately by work area, as represented on Figure 4-21.

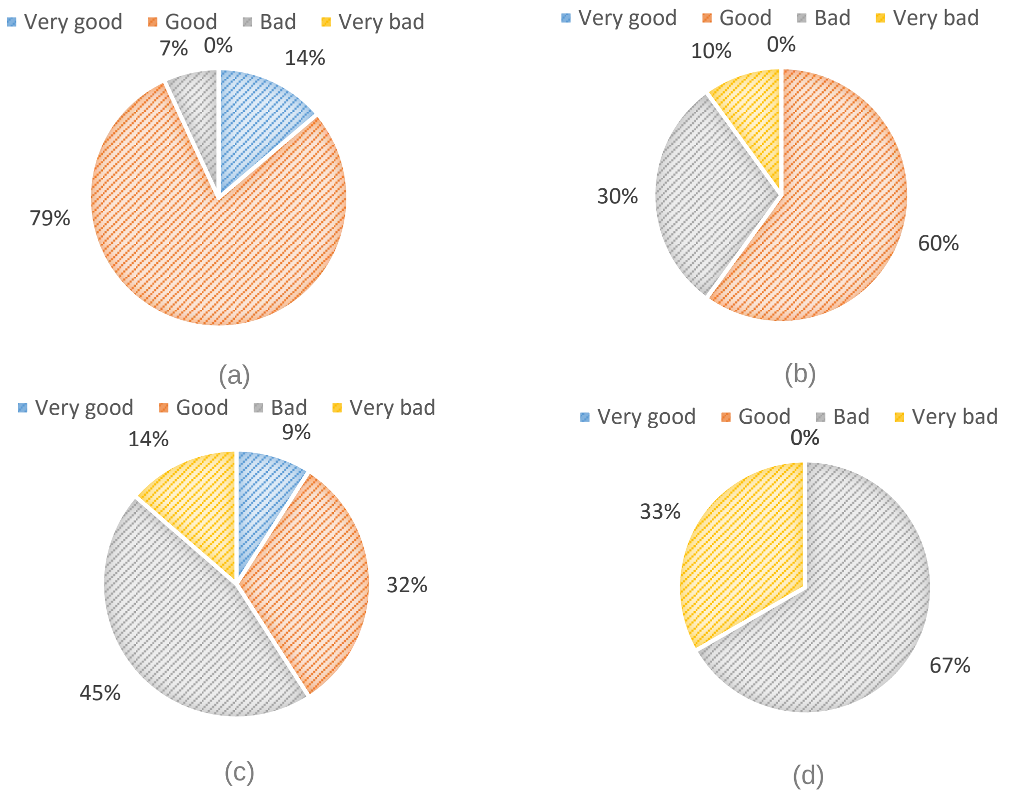



*Figure 4-21: Perceived Organization by work section: (a) In & Out (b) Preparations (c) Cooking (d) Scullery; n = 64*

So, in a general sense, employees classified their work conditions as "good", as shown in Figure 4-22, being that the Cooking section workers were the only ones that gave a worse classification to this item. The analysis by section is presented on Figure 4-23.

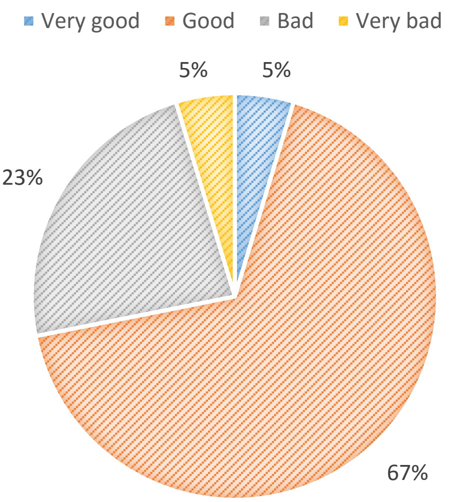



*Figure 4-22: General work conditions perceived by the workers (n = 64)*

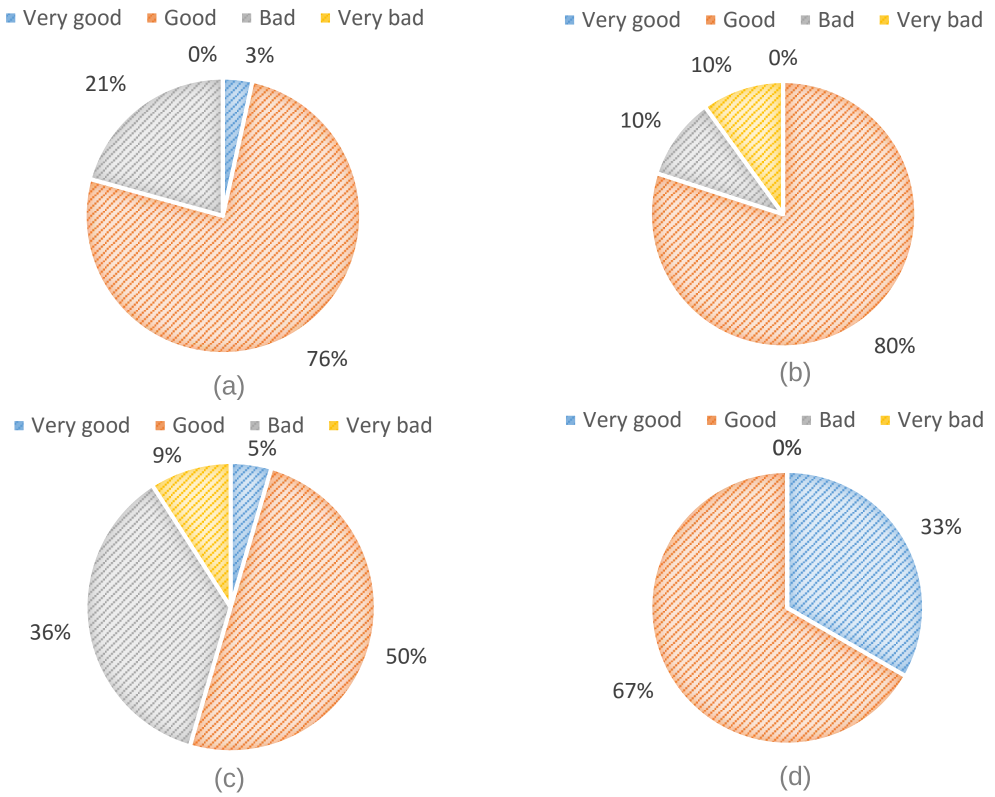



*Figure 4-23: General work conditions perceived by the workers in each section: (a) In & Out (b) Preparations (c) Cooking (d) Scullery; n = 64*

One of the most alarming issues is the physical exertion that is perceived by the Kitchen's employees as "very high", as represented on Figure 4-24. But is possible to see that Preparations is the work area with higher physical demands, as perceived by the researcher on the Define phase. Also, the In & Out section is seen as the one with less physical requirements (especially the Reception area), even by its own work force. This is represented on Figure 4-25.

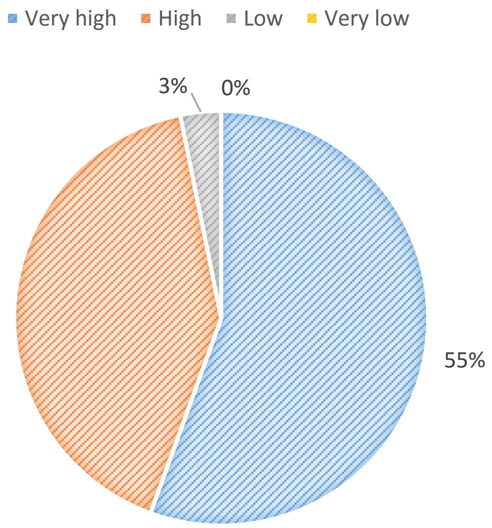



*Figure 4-24: Physical exertion perceived by the workers (n = 63)*

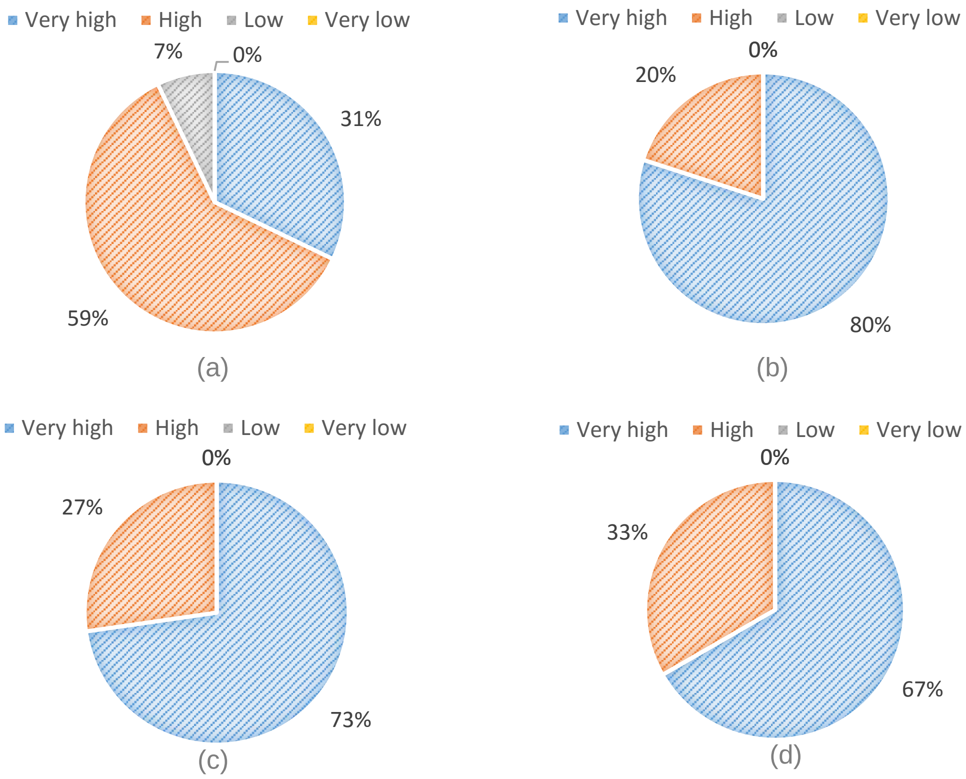



*Figure 4-25: Physical exertion perceived by the workers in each section: (a) In & Out (b) Preparations (c) Cooking (d) Scullery; n = 63*

To complement this analysis, the respondents chose which area they thought it was the most physically demanding. Some of the employees already worked in several different areas, thus having a broader opinion on the matter. The responses are shown on Figure 4-26.

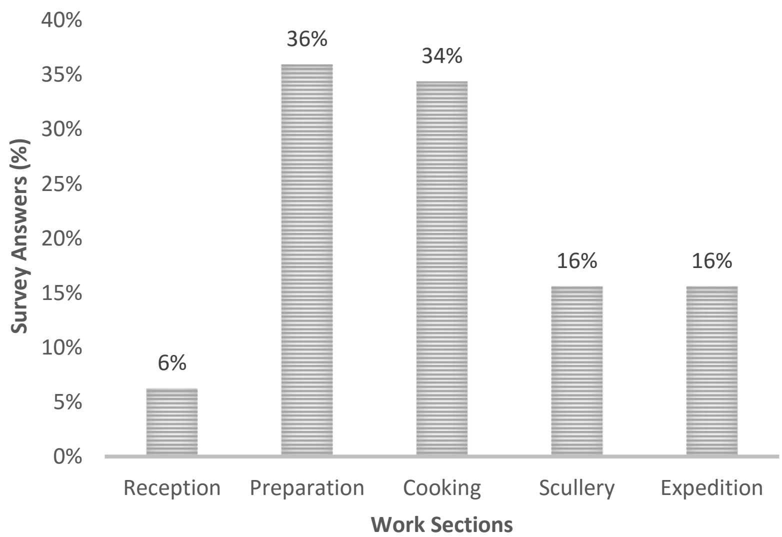



*Figure 4-26: Physical exertion distribution by sections (n = 69)*

As previously seen, the answers confirm that Preparation and Cooking are the most physically severe work areas in the Kitchen.

As for the activities that the operators conceive as most difficult and ergonomically demanding, twenty options were given, so that respondents would choose three and classify these using a Likert scale (1, 5 or 9, considering 9 as the most severe). The results are shown on Figure 4-27.

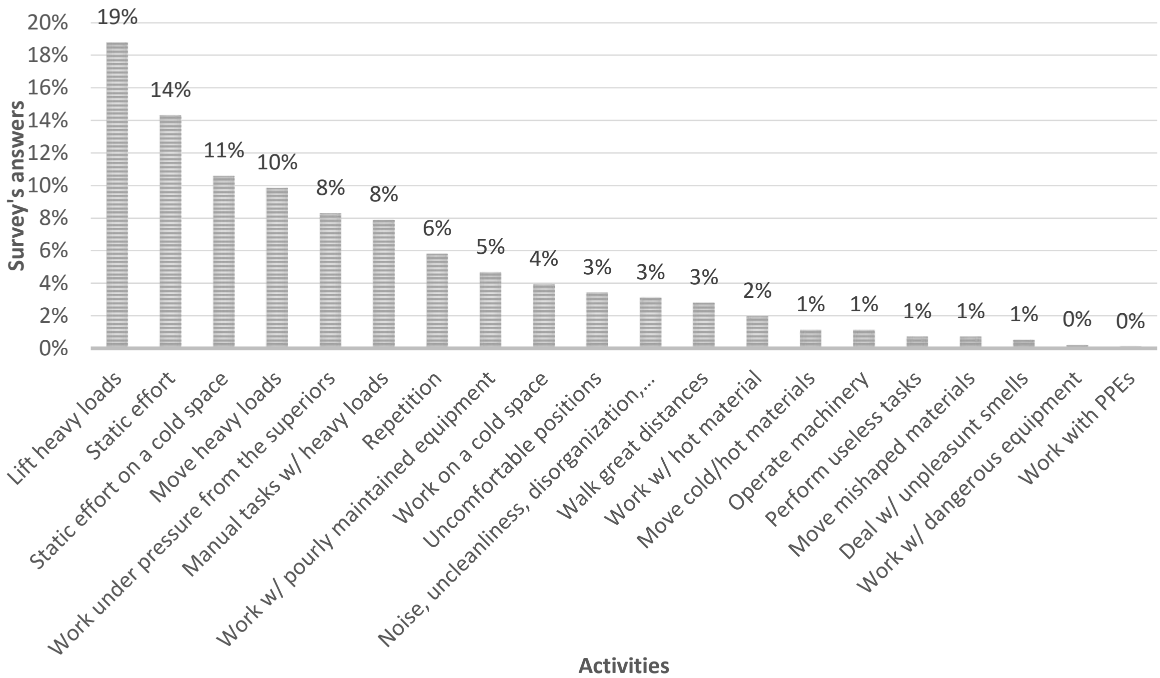
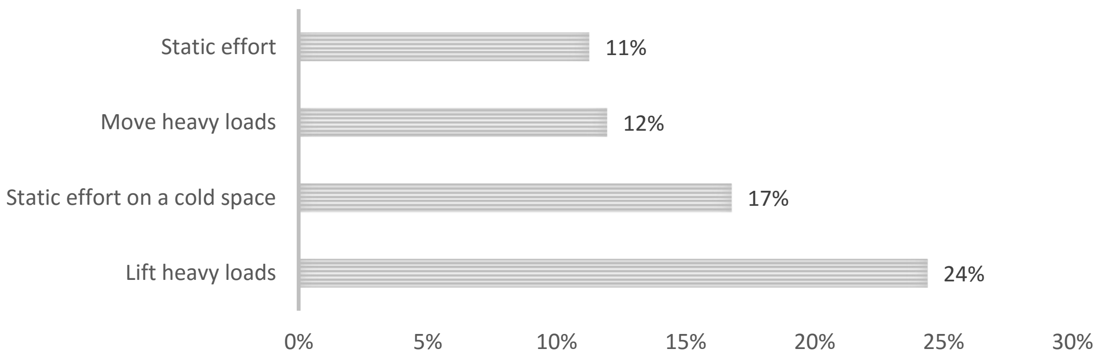
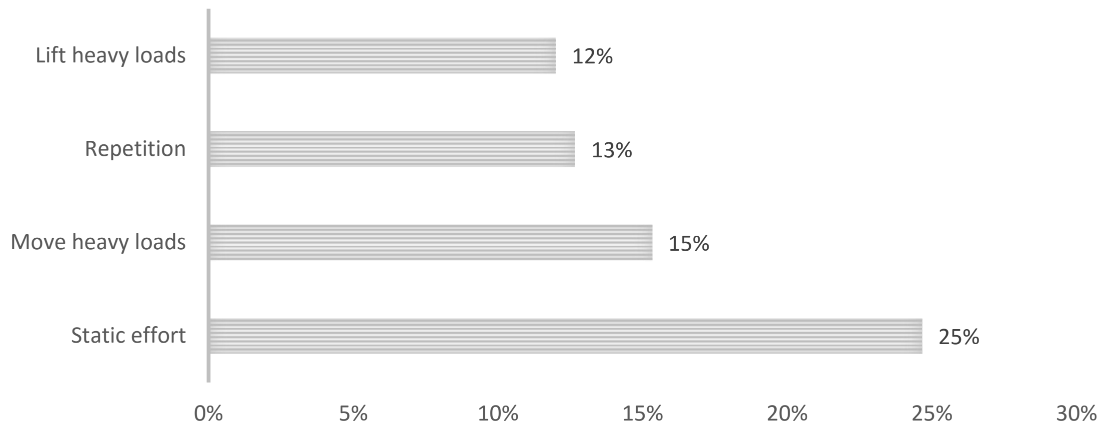



*Figure 4-27: Classification of the activities performed on the Kitchen by physical and/or physiological difficulty*

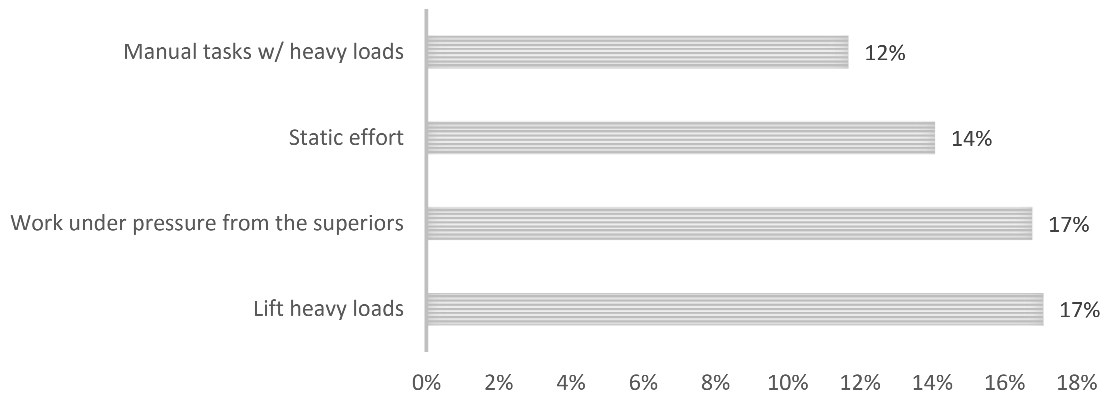
The perception of the operators is that “lifting heavy loads” is the task that requires more physical effort, followed by “static exertion” and “static exertion in cold rooms”. Is important to notice that “working under pressure from superiors” is tied in fourth place with “performing tasks with heavy loads”, meaning that the cognitive ergonomics is a very important issue to keep track during this study. Bearing this is mind, a zone-by-zone analysis is in order – this is shown on Figure 4-28 with the selection of the four most voted activities in each section.



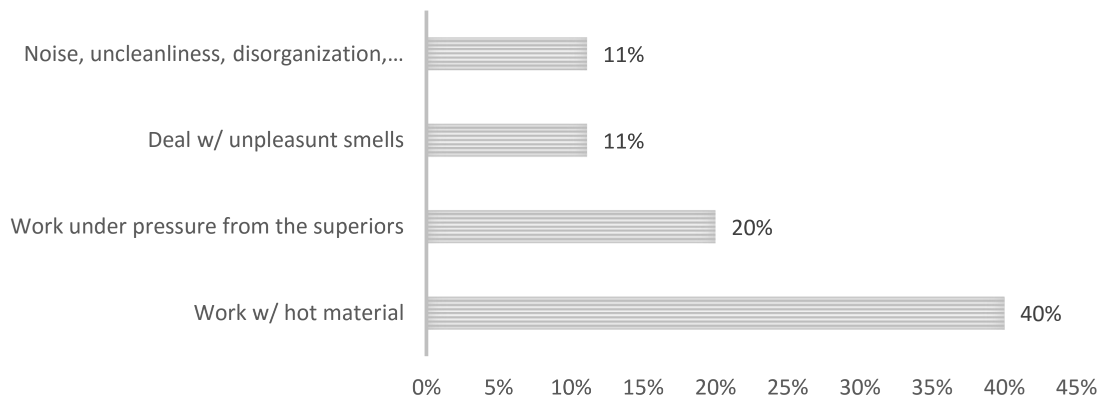

(a)




(b)




(c)




(d)

*Figure 4-28: Physical/psychological effort classification of the activities performed by section: (a) In & Out (b) Preparations (c) Cooking (d) Scullery; n = 64*

Looking at these charts is possible to understand that different tasks compromise the work in each department. On the In & Out section the weightiest tasks match the global classification. This can be due to the fact that there were more answers from this section's workers than the rest. As for the Preparation, the operations chosen as most difficult were the same observed as more dangerous ergonomically. On the Cooking section is interesting to see that working under pressure from superiors is one of the most voted causes for work stress. This helps to identify the Kitchen section where this problem is most significant. Finally, the Scullery chooses rather different options from the other areas. Working under pressure from superiors is common to the Cooking sector, because the superiors are the same (scullery is a sub-section of the Cooking). The other three options make a lot of sense to the type of work done there but are not weighty on the global classification because the scullery population is very small.

Having this data in mind, is important to look at the rest of the answers of the survey, regarding the frequency of physical discomfort at work - Figure 4-29, impediment of working due to physical pain - Figure 4-30, occurrence of pain during the last year – Figure 4-31 - and most affected body parts – Figure 4-32.

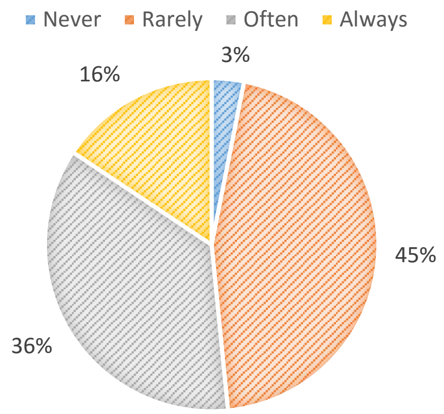



*Figure 4-29: Physical discomfort at work (n = 64)*

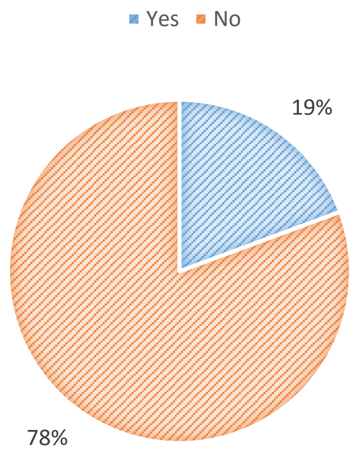



*Figure 4-30: Impediment of working due to physical pain (n = 62)*

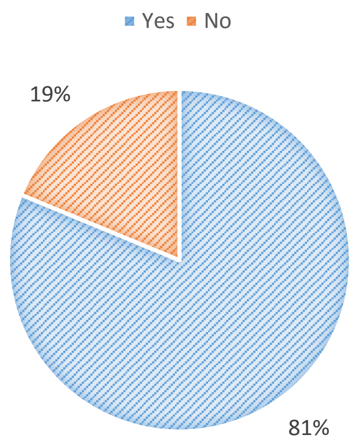



*Figure 4-31: Occurrence of physical pain in the last year (n = 64)*

Regarding physical discomfort at work, the majority answered “Rarely” but is quite alarming to see 36% of “Often” responses and even 16% say “Always”.

81% of the respondents affirm that they had physical pain during the last year, although 78% of them did not stop working while experiencing this aches. After watching this results, some verbal inquiries were made to a few employees in order to understand this discrepancy. The answer was consensual – they cannot stop working because of personal issues and because of some superiors’ pressure, so they often apply home medicines and keep on working until it becomes unbearable.

As to the body parts, the most affected ones are the lumbar and the dorsal, which makes sense regarding the most physically requiring tasks shown before.

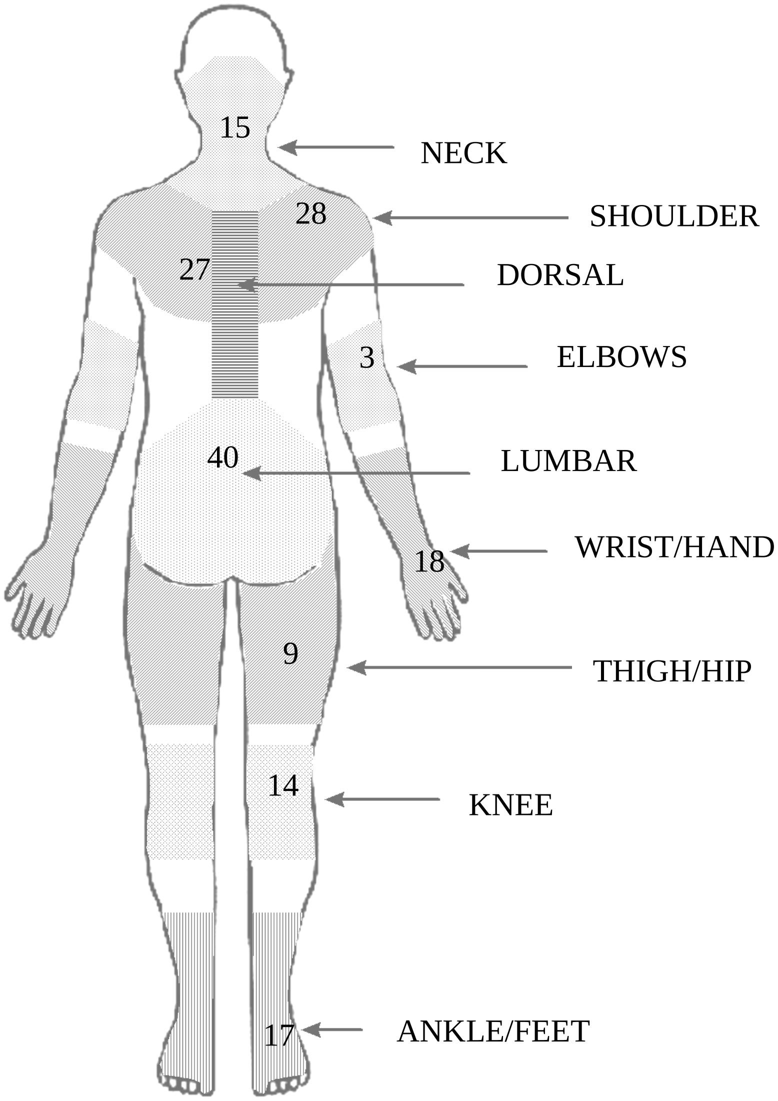



*Figure 4-32: Most affected body parts (regarding a total of 171 answers)*

Putting together all this information and results, a clearer picture of the Kitchen's production flow, productivity, work and ergonomic conditions is drawn. Hence, the Analysis phase is required at this point to start taking some conclusions from all this data.

## 4.3 ANALYSE

The Cause-and-Effect or Ishikawa diagram was used at the beginning of the Analyse stage, so to help getting to the bottom of the problems and understanding the root causes for the issues disclosure in the previous phases. It is presented on Appendix G. Then, looking at the results from the measurement phase, the researcher can have a clue about the most important issues to address in this project's improvement stage. So, analysing each KPI together with the topics from the Cause-and-Effect tool, will set the strategy for the improvement actions to be studied, as shown in the flowchart from the Analyse phase in the Methodology chapter.

The Cause-and-Effect tool show the causes that lead to low efficiency. The main problems are lack of continuous improvement and team involvement efforts, lack of motivation among the employees, too much product variety and production change factors at play, out of date equipment, lack of knowledge and interest about the business KPIs, damaged and insufficient material. These have underlying causes, exposed in the diagram and mirrored in the indicators analysed next.

## I. Productivity

### Waste:

Looking at the waste observation results, is possible to draw some conclusions.

1) **35%** of the observed activities are **NVA**. Considering the observations made as a sample of the production behaviour as a whole, 35% of the total production time is waste. The calculations made are presented on Table 4-11.

*Table 4-11: Translation of the NVA activities % into time and production (according to 2014 indicators)*

| | 2014 FY | NVA |
|---|---|---|
| **% Time** | 100 | **35** |
| **Work time [H]** | 7 344 | 2 570 |
| **Production [Ton]** | 5 767 | 2 018 |

Hence, 35% of the production time wasted corresponds to **2018 tons** more that could be produced in a year.

2) **62%** of the observation time was classified as waste, according to the Lean paradigm. 40% of the total wasted time is **Transportation (24,8%).** The most frequent Transportation classification was given to activities whenever a worker moved product around, fetched for ingredients, for disposable gloves, for garbage bags, for other working materials (usually knifes, recipients and transportation auxiliaries) or searched for a colleague to ask for information. Considering the observations made as a sample of the production behaviour as a whole, 25% of the total production time is waste. The calculations made are presented on Table 4-12.

.

*Table 4-12: Translation of the Transportation waste type % into time and production (according to 2014 indicators)*

| | 2014 FY | Transportation |
|---|---|---|
| **% Time** | 100 | **25** |
| **Work time [H]** | 7 344 | 1 836 |
| **Production [Ton]** | 5 767 | 1 442 |

Hence, 25% of the production time wasted in transportation corresponds to **1442 tons** more that could be produced in a year.

The 5 Whys technique was applied to the time waste observations, in order to search for the main cause of the Transportation topic, as presented on Figure 4-33.


*Figure 4-33: 5 Whys technique representation about the Transportation waste*

A huge amount of the time wasted in the Kitchen is *transportation*. Why? Because workers are constantly moving products around, fetching for ingredients, working materials, PPEs, information about their assigned tasks, cleaning products, etc. Also, the Kitchen's infrastructure is big and very compartmentalized, due to the HACCP requirements for food safety (temperatures, controlled atmosphere, smells and other contaminants must be confined to their own room) – which requires more moving around. But, because things are always changing place, there is not an automatic ingredients or sub-products source that goes towards the working stations. People always have to leave their place to get what they need. This happens due to the huge variety of products fabricated by the Odivelas Kitchen and the fact that the product mix is always different, which requires extreme flexibility of equipment, people and working space organization.

3) **29%** of the waste represents **Over-processing (18%)**. Over-processing links to the "Organization" classification provided by the researcher, which applies to all processes performed in a more complicated way than necessary, specifically with the wrong materials or tools, implicating more tasks than necessary, needing information that should be available, etc. i.e. producing without any value added for the costumer. **Motion (8%)** can also be linked to "Organization", in a sense of performing the tasks in a less ergonomic way due to workspace organization, as well as frequent lost items. Considering the observations made

as a sample of the production behaviour as a whole, 26% of the total production time is wasted in motion and over-processing. The calculations made are presented on Table 4-13.

*Table 4-13: Translation of the Over-processing and Motion waste types % into time and production (according to 2014 indicators)*

| | 2014 FY | Overprocessing & Motion |
|---|---|---|
| % Time | 100 | **26** |
| Work time [H] | 7 344 | 1 909 |
| Production [Ton] | 5 767 | 1 499 |

Hence, 26% of the production time wasted in over-processing and motion corresponds to **1499 tons** more that could be produced in a year.

The 5 Whys technique is here utilized in order to better understand the main causes for this to happen, in Figure 4-35.


*Figure 4-34: 5 Whys technique representation about the Over-processing waste*

Why is there so many Over-processing wasted time? Because there are a lot of processes that could be simpler. Why are they not simplified? Because most times workers cannot perform tasks the simpler way due to external restrictions imposed by the current work flow, like materials and tools don't have a determined place to be, layout is flexible, information does not have standard communication channels and procedures, materials are not available because are being used by others, the previous task which one depends on is not completed yet, etc. The reason for all these is the lack of standardized strict procedures. Work and space organization should be stricter to create a continuous more efficient work flow.

## Production indicators:

Regarding the production indicators presented on the Measure stage, the 5 Whys technique is once again utilized to better understand the lower productivity values presented, in Figure 4-35. If the quantity produced increases, without adding resources, the operational costs per kilo will decrease. This is our main goal. Hence, productivity improvement is the single most important objective.


*Figure 4-35: 5 Whys technique representation on low productivity*

The Kitchen's productivity depends on all previously referred topics, but all these linger on one main factor – the management strategy and culture. The actions taken, the way one leads a team and the rules, procedures and guidelines implemented define the type of work done and the team's involvement and satisfaction or motivation to be a part of it. This will define the team's productivity, because regardless of all equipment, material, infrastructure or conditions provided, the final output will always rely mainly on the work force.

## II. Work Conditions Indicators

### Survey's answers

Analysing the data retrieved from the answers given by the Kitchen employees, presented on the Measure subchapter above, the main getaways are presented next.

1) **Cooking** and **Scullery** are the worst sections regarding work organization. Scullery workers classify the section's organization as bad (67%) and very bad (33%).
2) The physical exertion in general is considered **very high** by 55% of the population.
   Looking further to the distribution by section:
   a) Considered "very high" by 80% of the **Preparations** work force, the most critical activities pointed out were:
      i) Static exertion (25%), as exemplified by Figure 4-36
      ii) Move heavy loads (15%)
      iii) Repetition (13%)
      iv) Lift heavy loads (12%), as exemplified by Figure 4-37 (a)
   b) Considered "very high" by 73% of the **Cooking** section employees, the most critical activities pointed out were:
      i) Lifting heavy loads (17%), as exemplified by Figure 4-37 (b)
      ii) Working under pressure from superiors (17%)
      iii) Static effort (14%)
      iv) Manual tasks with heavy loads (12%), as exemplified by Figure 4-38
3) Although 78% of the work force claims to not stop working due to physical pain or discomfort, **81%** says they have had **physical pain** during work in the last year and 52% often or always feels physical discomfort at work.
4) The body area where most pain and discomfort occurs is the **lumbar**, which reflects the fact that most workers say that lifting weights is the most demanding activity physically.

*Figure 4-36: Examples of static activities and repetition*

(a)

(b)

*Figure 4-37: Example of lifting weights' postures in the (a) Preparations and (b) Cooking sections*

*Figure 4-38: Example of manual tasks with heavy loads' postures*

The 5 Whys Technique is helpful here so to better understand why is the work at Odivelas Kitchen so physically demanding, as shown on Figure 4-39.

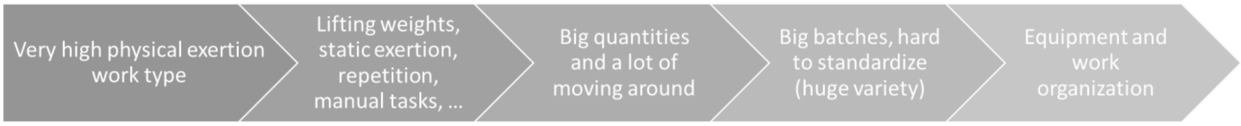



*Figure 4-39: 5 Whys technique representation concerning high physical exertion*

The work is physically demanding because there is the frequent need for lifting weights, moving heavy loads, repeating the same movements a lot of times, doing a lot of manual standing tasks, etc. And these activities require huge strength because everyday tons of product goes through the Kitchen's process and has to be moved from to and within the sections. Big quantities require huge batches and is not possible to set a production or assembly line in the Preparations and Cooking sectors because of the product variety. The products' mix is different every day and each output has a lot of tasks in common with the others, but the space and work organization has to be flexible and adapt according to the daily production plan. Therefore, the type of equipment and work/space organization are key to lighten the employees' physical effort, i.e. reduce loads movement, lifting, handling and eliminate obsolete tasks that just tire workers.

## Accidents

Regarding the accidents history data retrieved from the company's intranet, some relevant conclusions were taken.

1) 32 out of the 48 declared accidents in the Kitchen (67%) occurred on the **Cooking section**. Considering that this section has 47% of the total Kitchen's employed population, it is still an alarming fact. Therefore, the Cooking section is the **most unsafe** sector of the Kitchen.
2) The **lumbar** area is the one which most accidents are concerned.
3) Most accidents occurred due to **excessive physical effort or false move**.
4) The most frequent cause for accidents is **manual handling of loads**.

Again the 5 Whys tool is used to find the root causes for the higher frequency accidents related to the lumbar area (together with the survey's information that most workers suffer from back pain), as represented on Figure 4-40.

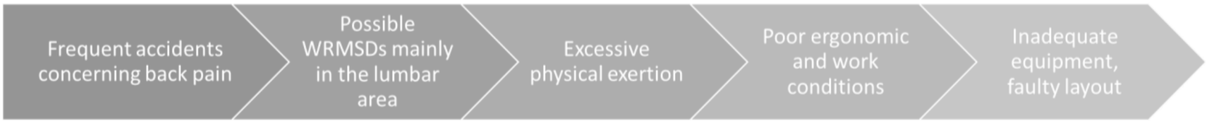



*Figure 4-40: 5 Whys technique representation concerning the accidents history*

The bigger frequency of accidents regarding the lumbar area calls for attention at the possible development of WRMSDs in the lumbar area, because of the physical effort required from the type of work practiced in the Kitchen, especially on the Preparation and Cooking sections. This can be due to poor ergonomic and work conditions, specifically concerning equipment and layout issues.

### Absenteeism and Turnover rates

About the absenteeism rate is important to notice that the **Preparations** section is the one with the highest rate (40%), besides the fact that only has 19% of the total Kitchen staff.

The fact that the great majority of the Kitchen's employees' displacements concerns the **termination of the contract** indicates one of two things – either the employees' work was not satisfactory, or the work conditions (regarding peers, superiors, infrastructure, contract conditions, etc.) not good enough. In other words, a safe, healthy, motivational work environment doesn't usually have a turnover rate like this.

The 5 Whys tool once again aids, so to analyse the information about the absenteeism and turnover rates presented - Figure 4-41.


*Figure 4-41: 5 Whys technique representation on high absence and turnover rates*

The high absence and turnover rates are indicators for employees' satisfaction and motivation at work, as explicated on the Background chapter. This can be an indicator of the Kitchen's work conditions. These conditions can be improved but, once that the business is food production, there will always be some issues regarding cleanliness, temperature and physical strain - the cleanliness problem cannot be solved because it has to be with the business type; the temperature issue is also difficult to contour once that the HACCP rules clearly define the safety temperatures for the food and food safety is the single most important concern in this business; and the physical strain has already been referred above, but will always be a little demanding, as all production work is. Regarding the infrastructure, the problem is that the plant is under the floor level, not having a single in for natural light. Hence, other motivation tactics have to be used in order to superimpose themselves to these unchanging concerns.

All the information collected from the surveys and company's files was also comfirmed by observation during the research period.

## III. IMPROVEMENT OPPORTUNITIES

With the analysis made on the measures and KPIs representing the Kitchen's production, is possible to clearly identify the improvement opportunities to tackle and utilize the Priorities Matrix to understand and select the ones to work on further. Hence, the conclusions reached lead to the improvement opportunities identified next. The conclusions are the following.

1) Focus on **Preparations** and **Cooking** sections, not forgetting that the Scullery is considered like a sub-section of the Cooking one.
2) **Organize space and work flow** within this sections – aiming to improve productivity, reduce exposure to dangerous situations, reduce possibility of failure and eliminate obsolete tasks.
3) **Lighten physical strain** within this sections, namely moving and lifting heavy loads and static efforts – the objective is to increase productivity and decrease the number of accidents and absences.
4) **Motivate and involve employees**, namely by improving work and ergonomic conditions – the goal is to decrease work pressure, improving employees' satisfaction which can increase productivity and decrease absence and turnover rates.
5) Plan for an effective **continuous improvement** program which involves every employee – aiming to keep on making small enhancements in production, while improving the employees' satisfaction and motivation, increasing productivity.
6) **Reduce NVA activities** by half, from 35% to 17%, specifically
    a) Unnecessary transportation or time wasted due to lack of organization and method, like looking for things because they are not always in the same place.
    b) Obsolete processes in the production flow, like the task or separating and organizing labels (in Preparations), the task of stowing prepared materials in the final picking chamber, the task of opening cans and draining the liquid, the task of squeezing lemons for juice, etc.

    Therefore, improving productivity to **918 kg/hour** instead of the 785 kg/hour from 2014.

In order to evaluate these improvement opportunities and the future improvement proposals, a set of criteria had to be set by the author together with the Kitchen management team. These follow the general guidelines, objectives and restrictions of the company. Therefore, the Priorities Matrix method will focus on the following criteria, presented on column one in Table 4-14. According to the evaluation grid presented previously on the Background chapter, a relative weight is provided to each of these criteria. This is presented on the second column of the table. The ranked criteria is presented on column three.

Table 4-14: Criteria for the improvement opportunities evaluation, their weight and ranking

| Criteria | Weight | Ranking |
|---|---|---|
| a. Low investment cost | 13% | 1º |
| b. Maximum use of existing resources | 5% | 11º |
| c. High potential money savings | 8% | 2º |
| d. High improvement potential for process flow | 6% | 8º |
| e. High improvement potential for increasing productivity | 7% | 3º |
| f. High improvement potential for ergonomic conditions | 7% | 4º |
| g. High improvement potential for working conditions | 6% | 6º |
| h. High customer satisfaction potential | 6% | 9º |
| i. High employee motivation potential | 5% | 12º |
| j. Minimum negative impact on other processes | 3% | 15º |
| k. Ease of implementation | 6% | 7º |
| l. High probability of quick results | 2% | 17º |
| m. Minimum number of people involved for implementation | 2% | 18º |
| n. High employee involvement potential | 4% | 13º |
| o. High improvement potential for work organization | 6% | 10º |
| p. Minimum complexity | 3% | 14º |
| q. Minimum need for employees' formation | 3% | 16º |
| r. Current availability for implementation | 8% | 5º |

The Criteria Matrix that compares each criteria amongst each other providing a weight to the final decision is presented on Appendix D.

The identified improvement opportunities, according to the conclusions presented above, were listed as shown on the first column on Table 4-15. These list of improvement opportunities was evaluated against each one of the chosen criteria, resulting in five matrices, presented on Appendix E. The evaluation grid utilized is the same as the one used in the Criteria Matrix, previously referred. The results from this matrices and the criteria matrix will combine in one final matrix, showing the most relevant improvement opportunities, according to the defined criteria and importance. This is presented on Appendix F. The results show that the improvement proposals presented in the Improvement stage of the DMAIC cycle, should focus on the opportunities that weigh more than the average (8%), as presented on Table 4-15. Some of the remaining opportunities can still be considered, with preferably cheaper and easier to implement solutions.

*Table 4-15: Improvement opportunities and their relative weight and ranking*

| | Improvement Opportunities | Weight | Ranking |
|---|---|---|---|
| 1. | Reduce number of accidents and sick leaves | 8% | 7º |
| 2. | Reduce exposure to dangerous situations | 8% | 6º |
| 3. | Improve ergonomic conditions for static activities | 6% | 11º |
| 4. | Reduce loads moving and lifting | 7% | 9º |
| 5. | Improve employees motivation and satisfaction | 10% | 3º |
| 6. | Increase employees involvement in continuous improvement | 7% | 8º |
| 7. | Reduce opportunities for defect/failure | 8% | 5º |
| 8. | Eliminate NVA activities | 13% | 1º |
| 9. | Reduce production stoppages due to faulty equipment | 7% | 10º |
| 10. | New/upgraded equipment and materials | 5% | 12º |
| 11. | Improve space and work organization | 9% | 4º |
| 12. | Eliminate unnecessary transportation | 12% | 2º |

With these improvement opportunities, it is time to concretize the proposed actions in the Improve phase of the DMAIC cycle, presented next.

## 4.4 IMPROVE

At this stage of the cycle, the proposed developments are presented, so to face the improvement opportunities exposed in the Analyse stage, as shown in the Methodology chapter flow chart.

The proposed developments were based on the following observations:

- Loss of productivity due to the fact that workers spend most of their time looking for something - either tools, ingredients, PPEs, information,…;
- Excessive fatigue due to the physical requirements and work overload;
- Frequent production stoppages/setbacks due to equipment malfunctioning;
- Frequent production stoppages/setbacks due to lack of material (scullery);
- Loss of efficiency due to lack of management skills and organization.

### Improvement Action Proposals

**Improvement Action Proposal A:** Put high-sitting benches for long-time static activities to decrease fatigue accumulation, as on Figure 4-42. This action regards both Preparation and Cooking sections. It would help decrease physical pain and the possible development of WRMSDs mainly in the lumbar area, as well as bring satisfaction to workers.

*Figure 4-42: Example of high sitting bench*

**Improvement Action Proposal B:** Work gymnastics or ergo motility - in order to relive the tension caused from the work physical and psychological load, the workers would have 10 minutes breaks to exercise during the day work. This could bring both psychological and physical better conditions to workers, decreasing pain, accidents, possible WRMSDs development, while increasing motivation and satisfaction and consequently growing productivity. This initiative was already tested in the Odivelas Kitchen with great success, according to both staff and management team. Although the company didn't move forward due to budget restrictions.

**Improvement Action Proposal C:** Garbage conduit in the Preparation section. Being that the Preparation section is where all the packages are taken off from the raw materials, due to HACCP restrictions (there are no plastic, glass, wood or any other unnatural material in the "clean" area of the Kitchen), there is a lot of transportation due to garbage. Meaning that workers have to fetch bins and garbage bags (often misplaced), and then take the full garbage bags to the "dirty" corridors. This happens with great frequency because big quantities of products imply big quantities of packages and sometimes the worker's sole task is to take the product out of the package and put it on the correct recipient. An image of the garbage bins used is presented on Figure 4-43.

Hence, a garbage conduit built under the ground with openings in every work station would decrease wasted time by 2% (of 45%), according to the observations made (in the Measure subchapter). This would reflect a 66 hours/year save and a **51 885 kg/year** increase in capacity, approximately. If the average personnel cost in 2014 was 0,39€/kg, this production capacity increase would correspond to a **20 235€/year** saving. Moreover, the investment in plastic garbage bags represent 1 403€ a month, around **16 900€/year**.

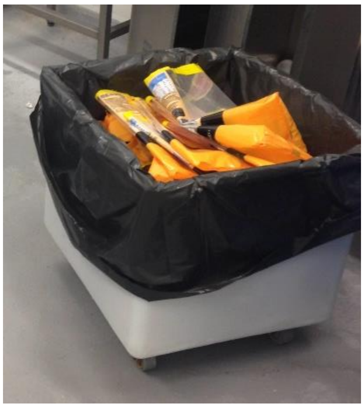
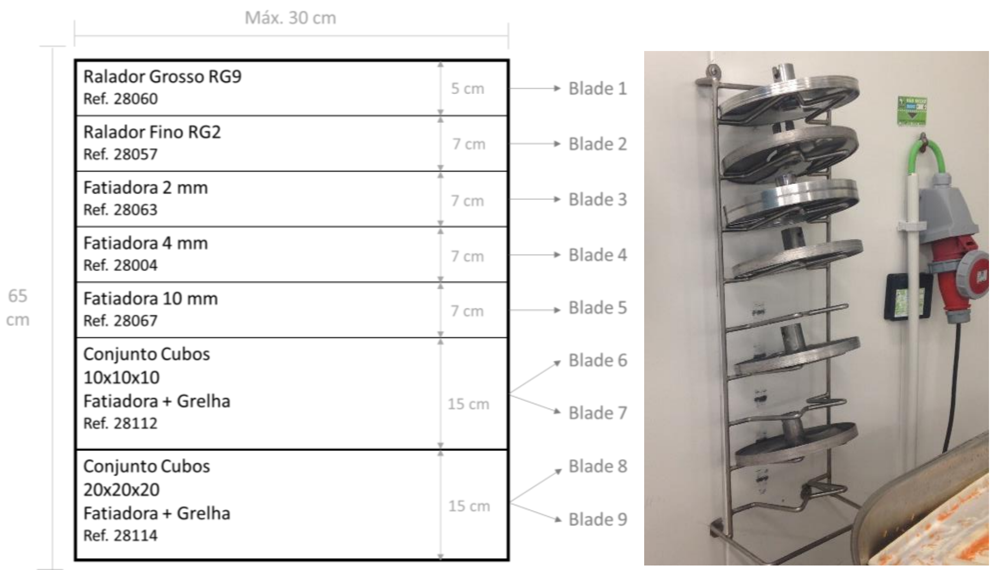


Figure 4-43: Example of garbage bin used in the Kitchen

**Improvement Action Proposal D:** Blades identification panel. In the Preparation section, identify the blades used in the kitchen robots, next to their holder - shown on Figure 4-45 (b), according to the type and dimension of the cut they do – prototype on Figure 4-45 (a). These are used by several people simultaneously and each person stows it in a different way, causing errors in the food preparation (wrong cut type) and making workers spend more time looking for the right tool. An example of a blade left out of its place (the holder) is shown on

Figure 4-44. By identifying the type of blade and the right place to put it, any person can pick one up or stow it in the right place without any doubts. Therefore, this improvement action would decrease wasted time and transportation, as well as production defects (two different types of waste).

Figure 4-44: Example of a blade misplaced




(a) (b)

*Figure 4-45: Prototype of the blades identification panel (a); Example of a blades' holder (b)*

**Improvement Action Proposal E:** Put knife holders in each working station of the Preparations section, for safety and organization matters – prototype in Figure 4-47. Knifes are safely kept after work, but during the day usually are left unattended, causing injuries and making people look for them every time they need it, as shown in the examples on Figure 4-46. By putting knife holders that are easy to use, the workers can put down the tool while performing a task, without causing arm to them or any other person and avoiding somebody to waste time looking for it later. Hence, this improvement action would decrease dangerous situations and accidents, improving work and ergonomic conditions. Additionally, it would also decrease unnecessary transportation (wasted time).

*Figure 4-46: Examples of several knifes left unattended in the Kitchen*

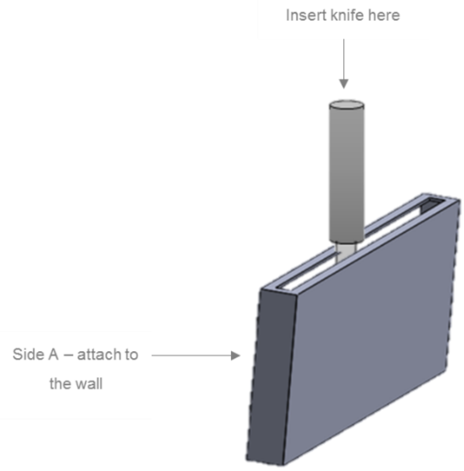



*Figure 4-47: Knife holder prototype*

**Improvement Action Proposal F:** Put disposable gloves' holders in each work station, both at Preparations and Cooking sectors – prototype in Figure 4-48. Disposable gloves are the most frequently required PPE in the Odivelas Kitchen. There are card boxes with gloves spread around the working area, but as they are not fixed, anyone can move them and the next person will spend time searching for it. Hence, this improvement action would contribute to diminishing unnecessary transportation and wasted time.

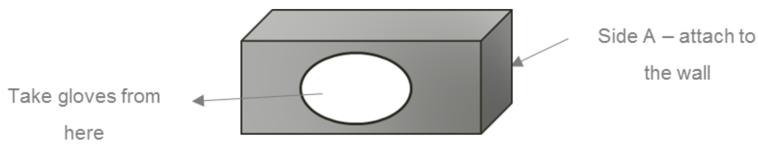



*Figure 4-48: Disposable gloves' holder prototype*

**Improvement Action Proposal G:** Self-levelling turntable, as exemplified in  performed by the Kitchen staff (a);. This equipment could be used in varied Kitchen sectors, once that lifting heavy loads is one of the biggest problems. Although it would be most helpful in the In & Out and Preparation sections. The example given on Figure 4-49 shows an activity performed on the Preparations section, where the worker as to repetitively bend to put dry codfish up on the box for soaking. The aim would be to improve ergonomic conditions in Odivelas Kitchen, obviously reducing wasted time, motion, accidents and the possible development of WRMSDs mainly in the lumbar area.

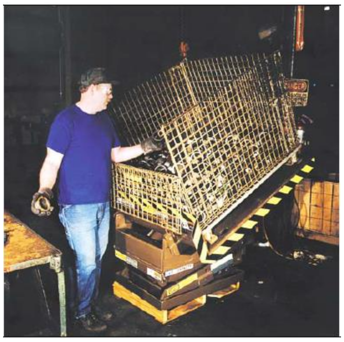
(a) (b)

*Figure 4-49: Example of wrong postures performed by the Kitchen staff (a); Self-levelling turntable example (from Wilson, 2005) (b)*

In Wilson (2005), a Motion Time Method analysis for the palletizing activity, conservatively estimated that a 14% time savings could be achieved by installing a self-levelling turntable. This simply intervention eliminates the need for the operator to bend, reach, walk and twist to palletize boxes. In this example, an annual savings of $13.104 in productivity alone was realized from this change (1.12 hours saved per shift x 3 shifts per day x 5 workdays per week x 50 workweeks per year x $16 wage benefits per hour). By including the $25.000 annual back injury that could be avoided, the total savings from this intervention exceeded $38.000 per year. The employer realized a 14.24% return on investment by spending $2.500 on a self-levelling turntable. This intervention had a payback period of 16 workdays.

**Improvement Action Proposal H*:*** Self-tilting lift, as exemplified in Figure 4-50 (b). This equipment could be used especially in the Cooking section (but also in Preparations), once that there's a lot of activities that require bending and handling heavy loads at the same time, like the example on Figure 4-50 (a). These are very dangerous tasks, ergonomically. The industrial pans already have the self-tilting option, but they are not enough. The aim would be to improve ergonomic conditions in Odivelas Kitchen, obviously reducing wasted time, accidents and the possible development of WRMSDs mainly in the lumbar area.

(a)



(b)

*Figure 4-50: Example of heavy load that requires handling in the Kitchen (a); Self-tilting lift example (from Wilson, 2005) (b)*

**Improvement Action Proposal I:** Treadmill between the Dry Goods work section and storage room (see Appendix B) – prototype in Figure 4-52. The dry goods work station is physically separated from the rest of the Preparation section, right next to the dry goods storage room. The problem is that workers have to go to the storage room very often to pick the needed materials, wasting a lot of time walking back and forward and usually making a lot of unnecessary physical effort. Depending on the quantity and weight of the materials, they either bring it with their own hands or take a mobile stand with wheels (Figure 4-51), put the products on top of it and then push it back to the work station. Therefore, this improvement action would reduce unnecessary motion, transportation and physical exertion, decreasing the number of accidents and the possible development of WRMSDs mainly in the lumbar area, while simultaneously improving productivity and simplifying processes.

*Figure 4-51: Mobile stand used in the Dry Goods area*

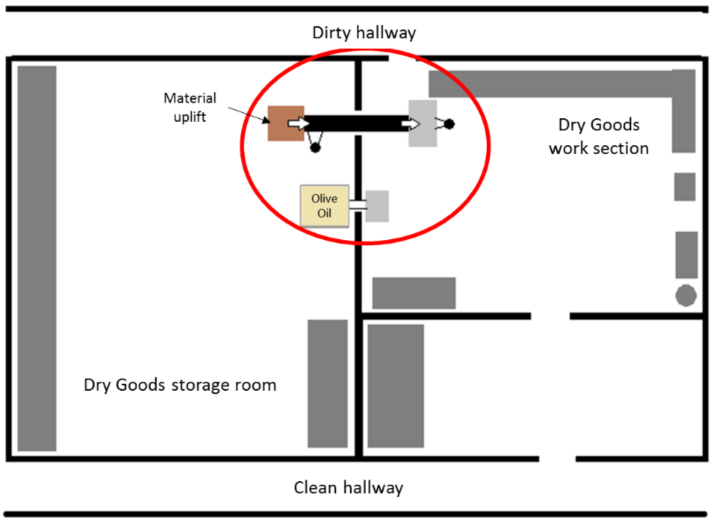



*Figure 4-52: Prototype for treadmill in the Dry Goods area*

**Improvement Action Proposal J*:*** Signs (magnets) for malfunctioning equipment, like shown on Figure 4-53. The signalling of equipment would serve the purpose of reducing the number of defects and rework. Also, it would help to improve space organization and the maintenance team work organization. Moreover, it could prevent accidents from happening, improving working conditions by reducing the occurrence of dangerous situations. The proposed procedures and signs' meaning are presented on Table 4-16.

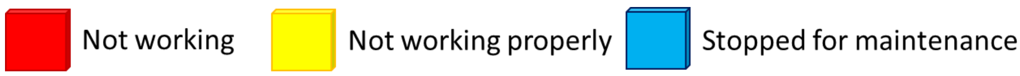



*Figure 4-53: Improvement proposal J prototype and caption*

*Table 4-16: Proposed procedures for Action J*

| | |
|---|---|
| Meaning | • Red: Equipment is totally disabled. Do not use.<br>• Yellow: Equipment needs repairing. Its usage is dangerous or very difficult.<br>• Blue: Equipment is stopped for maintenance purposes. Do not use. |
| Procedure for Kitchen's staff | 1. Worker identifies a malfunctioning equipment<br>2. Worker asks the shift leader for a red/yellow sign and explains the situation<br>3. Shift leader communicates to maintenance team or to the next leader during the shift change<br>4. Shift leaders control of the maintenance team is proceeding according to plan |

| | |
|---|---|
| Procedure for maintenance team | 1. One of the maintenance team workers goes around the Kitchen to inspect the equipment<br>2. According to the determined plan, he signals the equipment that is scheduled for maintenance on that day with the blue sign<br>3. If there is a red sign, ask the shift leader of that area about the reason and perform intervention<br>4. If there is a yellow sign, ask about the reason and take note of the problem to Schedule intervention |

**Improvement Action Proposal K:** Preventive maintenance plan to all the Kitchen's equipment and materials. This proposal would complement proposal J. Faulty equipment and materials cause defects, accidents, but it also sets back production frequently. Hence, by preventing malfunctions from happening and keeping the equipment and instruments operational at all times could improve productivity significantly.

If looking exclusively to the 14% (of 45%) observed time of "maintenance" (in the Measure subchapter) which refers to small production stoppages due to malfunctioning equipment, the wasted time would decrease around 463 hours per year which reflects a production capacity increase of **363 290 kg per year**, according to 2014 data. If looking at the average personnel cost, this production is equivalent to **141 683€ per year** in savings.

**Improvement Action Proposal L:** Dedicated team leader for the Scullery section. The Scullery is seen as part of the Cooking section, but it provides material for both the Preparation and Cooking sections, being a bottleneck for these sectors most of the time. The lack of work organization and method frequently delay production, due to deficient material provision. Figure 4-54 shows examples of lack of organization in the Scullery area. A dedicated team leader, independent from the Cooking section, could coordinate the work with both the Cooking and Preparations sections, eliminating inefficiencies and better motivating the team. This would improve productivity and eliminate or at least reduce the time spent waiting for material (eliminate production stoppages) and the unnecessary transportation to look for it.

*Figure 4-54: Examples of lack of organization in the Scullery area*

The “material” waste identified on the Measure stage of the cycle, representing 22% of wasted time observations (45%), relates almost totally to this bottleneck because it represents time spent waiting for material. Hence, by improving the scullery work organization, the wasted time could decrease up to 727 hours/year. This would improve the production capacity by **570 884 kg/year**. Regarding the personnel costs, they could be cut by **222 645€/year**.

**Improvement Action Proposal M:** Change the printing order of the tags in the Preparation section. When the work is distributed, the Preparations responsible has to print the WIP tags to identify every material that is prepared for the Cooking section. These tags are printed by production order, so then someone has to separate the tags by product, once that one product like “Arroz de Pato” has more than one production order, but the ingredients should be prepared all together. E.g. the person has to identify every tag with onion for the “Arroz de Pato” and put them together, so that the worker that is going to cut the onions can have all the information needed at once. Hence, if the tags are printed by product’s reference, this NVA activity can be eliminated.

According to the observations made, the researcher calculated an average of 4,6 seconds for each tag just to separate them by material, without including any other tasks (like cleaning the stand to put the tags on it or finding a tray to accommodate and transport them). With an average of 3600 tags a day (≈ 300 production orders a day with an average of 12 ingredients per order), this NVA activity takes about **4,6 hours a day or 1 408 hours per year**. Eliminating this activity could increase the Preparations production capacity in **1 105 562 kilos per year**. Furthermore, looking at the average personnel cost in 2014, this action could save up to **431 170€/year**.

**Improvement Action Proposal N:** Work organization board – prototype in Figure 4-55. In order to facilitate the work organization and the information flow, one could put a board in the wall indicating the work to do, the work in progress, the finished work, the person responsible, etc. As the tags are necessary to identify the containers (and so not to double work) these could be placed under the correspondent work station space on the board, to indicate “work to do”. Figure 4-56 represents an example of a task in progress that is stopped due to a shift changing, but there is no information about what is already done and what is left to do. This implicates possible defects and wasted time searching for information.

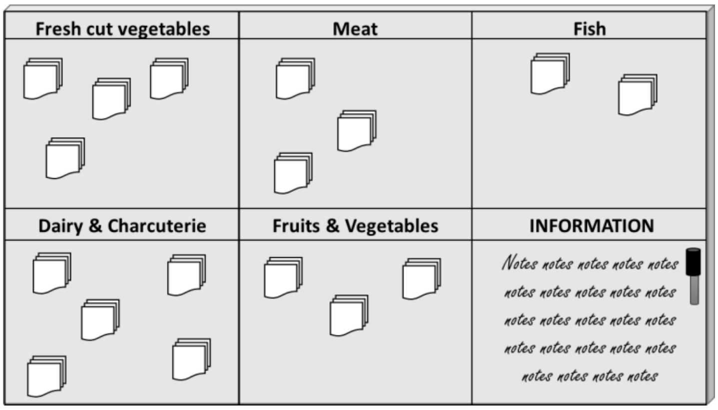
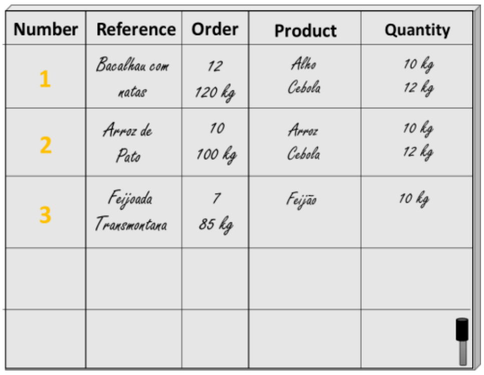



*Figure 4-55: Work organization board prototype*

*Figure 4-56: Example of a work in progress left unattended*

On the final picking room (see Appendix B), the same logic could be applied. The room could have the floor painted with numbered slots and a board on the wall would indicate which product corresponds to each slot, as exemplified in Figure 4-57. Then, all the ready materials would be stored in the correspondent product slot. This would eliminate the NVA activity of arranging the materials in the room, that consumes almost one FTE per day and usually is not effective, once that each person has its own way of arranging the space and the personnel from the Cooking section always have to look for what they need, very frequently causing mix ups (almost every product needs onions e.g.).

The employee that stows the products in this chamber belongs to the Preparations team and usually performs other support tasks during the shift, but since there are usually two people doing this job every day, the researcher assumed (with the management team's advice) that this activity consumes 8 hours/day. The elimination of this NVA translates into **2 448 hours/year**, which correspond to **1 922 170 kg per year** of production capacity increase, equivalent to **749 646€** a year in personnel costs.



| Number | Reference | Order | Product | Quantity |
|---|---|---|---|---|
| 1 | Bacalhau com natas | 12 120 kg | Alho Cebola | 10 kg 12 kg |
| 2 | Arroz de Pato | 10 100 kg | Arroz Cebola | 10 kg 12 kg |
| 3 | Feijoada Transmontana | 7 85 kg | Feijão | 10 kg |
| | | | | |
| | | | | |

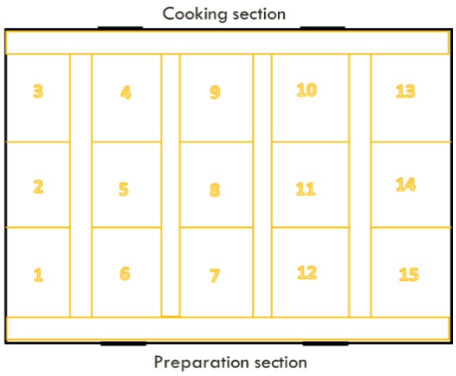



*Figure 4-57: Final picking room organization proposal*

**Improvement Action Proposal O:** Both the Cooking, Preparations and Scullery sections should have floor painted marks, so to better organize the work space. This would avoid materials mix ups or production errors, injuries due to misplaced objects and materials' quicker wear due to inappropriate utilization. Also, it would save a lot of time and unnecessary transportation because everyone knows where everything is at all times. Examples of lack of space organization in the Scullery area where already presented, so Figure 4-58 shows examples in the Cooking section and Figure 4-59 in the Preparations section.

*Figure 4-58: Examples of lack of organization in the Cooking section*

*Figure 4-59: Examples of lack of organization in the Preparations section*

**Improvement Action Proposal P:** Install a Kaizen meetings system. The teams would gather with their supervisor daily, the supervisors would meet with their area responsible weekly, the management team would meet monthly and finally the Kitchen's director would meet with his superiors to expose new ideas, problems, etc. on a trimestral basis. The improvement action Q project can be part of the team meetings discussions. Also, production KPIs would be set, measured, evaluated and discussed throughout all levels of the hierarchy. This would increase productivity, once that workers feel more motivated, satisfied and involved in the Kitchen's management, contributing with their insights for a continuous improvement strategy. The meetings plans proposal is presented on Tables Table 4-17, Table 4-18, Table 4-19, and Table 4-20.

*Table 4-17: Daily meetings plan*

| Daily Meetings | **Shift leaders and their teams** |
|---|---|
| Place | Each section defines the meetings place (always in the same place) |
| Duration | 10 minutes |
| Mediator (controls duration and topics) | Shift leader |
| Working order | 1. Record attendance (1 min)<br>2. Analyse action plan – were the actions fulfilled? (1 min)<br>3. Analyse KPIs from previous working day – was the plan fulfilled? (1 min)<br>4. Analyse problems occurred – what went wrong? (3 min)<br>5. Move to next action plan – what can be done? (1 min)<br>6. Goals for the day and work plan (3 min) |

*Table 4-18: Weekly meetings plan*

| Weekly meeting | **Team leaders and their teams** |
|---|---|
| Place | Each section defines the meetings place (always in the same place) |

| | |
|---|---|
| Duration | 30 minutes |
| Mediator (controls duration and topics) | Team leaders |
| Working order | 1. Analyse KPIs from previous week (10 min)<br>2. Analyse problems and difficulties that emerged – use the 5 whys technique (10 min)<br>3. Define priorities for next week (10 min) |

*Table 4-19: Weekly management meetings plan*

| | |
|---|---|
| Weekly management meeting | **Kitchen's Management Team** |
| Place | Kitchen's plant meetings room |
| Duration | 1 hour |
| Mediator (controls duration and topics) | Production director |
| Working order | 1. Communicate the received feedback from previous meetings (15 min)<br>2. Analyse the action plan and the execution of the plan from the previous week (15 min)<br>3. Analyse problems and difficulties felt – use the 5 whys technique (15 min)<br>4. Define priorities for next week (15 min) |

*Table 4-20: Monthly meetings plan*

| | |
|---|---|
| Monthly meeting | **Meal Solutions' Management Team** |
| Place | Office meetings room |
| Duration | 3 hours |
| Mediator (controls duration and topics) | Meal Solutions Director |
| Working order | 1. Analyse monthly KPIs from In & Out sections (45 min) |

| | |
|---|---|
| | 2. Analyse monthly KPIs from the Preparations section (45 min)<br>3. Analyse monthly KPIs from the Cooking sections (45 min)<br>4. Discuss problems and needs for every section – report important matters from previous meetings (30 min)<br>5. Define short term actions and strategies (15 min) |

**Improvement Action Proposal Q:** Suggestions box for all employees. Aiming to promote new ideas, continuous improvement and the involvement of the entire team, the suggestions box would be related to a continuous improvement project where new ideas are evaluated and implemented when possible, praising the employees who provide them. Also, a sense of satisfaction among the work force could be measured from time to time (with a survey e.g.), providing more opportunities for change and improvement. An example of the possible procedure to be adopted for this project is presented on Table 4-21.

*Table 4-21: Action Q procedure proposal*

| | |
|---|---|
| Procedure | 1. Provide forms for workers to fill (leave them next to the box)<br>2. Install suggestions box<br>3. Display the regulations, intent and benefits of this project in the information boards<br>4. Worker fills the form and leaves it in the box (anonymously or not)<br>5. MP collects forms by the end of every month<br>6. MP analyses and sends e-mail with meaningful ones to the MT<br>7. MT discuss suggestions and improvement actions at meetings<br>8. PL plans implementation actions<br>9. PL presents implementation plans in the monthly meeting<br>10. MT executes plan<br>11. MP processes praises and bonuses to most involved workers |

**Improvement Action Proposal R:** Substitute cans with beans and canned milk for plastic packages, with more quantity if possible. In the Preparations section, a lot of cans have to be opened daily, causing injuries and possibly developing WRMSDs, mainly on the up limbs, due to the type of movements, quantity, repetition and weight. Three examples are shown on Figure 4-60. HACCP rules also condemn this package because of the danger of a splinter of aluminium going into the food, which is not difficult. Regarding the canned milk, the issue is even worse because it as to be boiled inside the tin before being used, so the workers have to take of the label one by one.

*Figure 4-60: Examples of three types of different canned ingredients used in the Kitchen*

According to the observations made regarding all the types of beans, as presented on Table 4-22, the tested plastic bags would save **17 seconds for each unit** utilized. Moreover, the cans of beans weight 2,5 kilos with liquid, as opposed to the bags that have a drained weight of 2,5 kilos. In the Table, the total time refers to the time of the activity including all tasks like fetching material, taking the garbage bags out or cleaning the work station; the activity time is the time solely dedicated to the task (opening the cans/bags, draining the liquid (or not) and putting the product in the right container); the wasted time is the difference between the two first referred, meaning that is the time spent in transportation, motion, cleaning, littering, etc.

*Table 4-22: Results comparing the use of cans or bags*

| | Total time per unit [sec/unit] | Activity time per unit [sec/unit] | Wasted time [sec/unit] |
|---|---|---|---|
| **Can** | 52,00 | 19,82 | 32,18 |
| **Bag** | 35,22 | 15,00 | 20,22 |

As for the canned milk, a solution was found as presented on Figure 4-61. The utilized tins had 375 grams of product. This bucket contains 6,5 kilos of product. Furthermore, the new product is pre-cooked condensed milk, opposed to the little cans that had to be boiled, so the labels had to be removed one by one. Hence, the new bucket eliminates the need for boiling, for removing labels, for opening the tins and it has much more quantity per unit. It eliminates wasted time, unnecessary motion, transportation and tasks, as well as reducing danger for both employees and clients.

Therefore, by using alternatives to canned products, the activity time reduces, so as the ergonomic and HACCP hazards, increasing productivity and work conditions.


*Figure 4-61: Solution for canned milk*

**Improvement Action Proposal S:** Use frozen lemon juice instead of squeezing lemons. The lemon juice is frequently used to season the meat, amongst others. But the squeezing lemons activity is ergonomically atrocious and incredibly inefficient, due to the equipment used. The posture required is exemplified on Figure 4-62. Several equipment to automatize this task was already tried, but failed. The solution found is exemplified on Figure 4-63. This package contains 5 kilos of lemon juice. Admitting that one lemon provides approximately 0,033 kg of juice and that the average weight of one lemon is 60 grams, it would take around 9 kg or 150 lemons to produce 5 kg of lemon juice (the package equivalent).

The observations made allow to understand that squeezing 1 kg of lemons takes 14,31 seconds, but this task requires cutting the lemons in half, disposing used halves, pouring the juice into a larger container from time to time, etc. So the most accurate would be to consider the total time – 21,4 seconds per kilo or 1,29 seconds per lemon, as referred on Table 4-23. Hence, to produce 5 kg of lemon juice it would take around 3,2 minutes versus the 5 seconds it takes to pour the juice from the bottle. Meaning that this action saves **3,13 minutes** for every 5 kg of juice utilized.

*Table 4-23: Results from observation of the lemon squeezing task*

| | For 5 kg of lemon juice | | |
|---|---|---|---|
| | **Total Time [sec]** | **Activity Time [sec]** | **Waste [sec]** |
| **Squeezed Lemon** | 192,6 | 128,7 | 63,9 |
| **Frozen Juice** | 8,6 | 5,4 | 3,2 |

*Figure 4-62: Squeezing lemons activity's posture example*

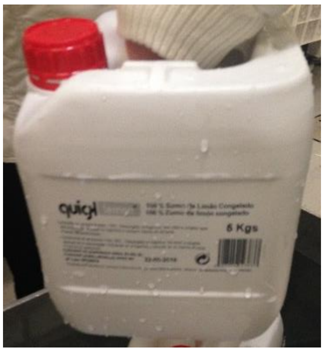



*Figure 4-63: New frozen lemon juice packaging*

Therefore, by substituting fresh squeezed lemons with frozen lemon juice, the food quality can be maintained, but this dangerous task is eliminated, removing the ergonomic danger, unnecessary motion and wasted time, once again increasing productivity and the Kitchen's work conditions simultaneously.

## Implementation

As these actions can't all be implemented, at least at the same time, priorities have to be taken. Hence, brainstorming with the Kitchen management team has allowed the Priorities Matrix tool to be used once again to understand what and when to implement. The matrices comparing each improvement action proposal amongst each other for the top 5 criteria selected in the Analyse subchapter, are presented on Appendix H.

Looking at the improvement opportunities presented on the Analyse chapter, a matching can be done, because several proposals aim to help solve more than one problem at the time. This corresponding is presented on Table 4-24.

Table 4-24: Match between identified improvement opportunities and proposals

| | Improvement Opportunities | Proposed Actions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | reduce number of accidents and sick leaves | A | B | E | G | H | I | K | O | | |
| 2 | reduce exposure to dangerous situations | E | J | K | O | | | | | | |
| 3 | improve ergonomic conditions for static activities | A | B | | | | | | | | |
| 4 | reduce loads moving and lifting | G | H | I | | | | | | | |
| 5 | improve employees motivation and satisfaction | B | P | Q | | | | | | | |
| 6 | increase employees involvement in continuous improvement | P | Q | | | | | | | | |
| 7 | reduce opportunities for defect/failure | D | J | K | M | N | O | | | | |
| 8 | eliminate NVA activities | C | D | E | F | I | M | N | O | R | S |
| 9 | reduce production stoppages due to faulty equipment | K | | | | | | | | | |
| 10 | new/upgraded equipment and materials | C | G | H | I | K | | | | | |
| 11 | improve space and work organization | D | E | F | J | L | N | O | P | | |
| 12 | eliminate unnecessary transportation | C | D | E | F | I | N | O | | | |

All the improvement actions proposed concerning ergonomic conditions refer to the motion waste type.

According to the correspondence presented above on Table 4-24, some improvement actions were not evaluated in every matrix because of the punctuation obtained by the improvement opportunities in the improvement opportunities matrices presented on the Analyse phase (Appendix E). The final priorities matrix is presented on Appendix I. These follow the same method and use the same evaluation grids as in the Analyse stage.

The results are shown here on Table 4-25. The red values indicate that those proposals were not accepted and are not going to be implemented in a near future. They might possibly be considered if the Group allows the company to invest more money in the facilities enhancement. The green values indicate that these actions will be considered, but at different implementation times.

The **project plans** presented for each action proposal refer objectives, problems addressed, timings, people responsible and action plans. These are presented on Appendix J.

An improvement suggestion for the future is presented on Appendix K, regarding the actions discarded by the Priorities Matrix tool method.

*Table 4-25: Results for the Final Priorities Matrix for the improvement proposals*

| | | |
|---|---|---|
| S | Lemon juice | 9% |
| R | Bags instead of cans | 9% |
| L | Scullery team leader | 8% |
| F | Disposable gloves holder | 7% |
| E | Knife holder | 6% |
| M | Change labels printing order | 6% |
| N | Organization boards | 5% |
| D | Blades support identification | 5% |
| K | Preventive maintenance plan | 5% |
| A | High benches for static effort | 5% |
| P | Team meetings plan | 5% |
| Q | Suggestion box | 5% |
| J | Faulty equipment signaling | 5% |
| H | Self-tilting lift | 4% |
| I | Treadmill for dry goods room | 4% |
| B | Ergonomic gymnastics | 3% |
| O | Marks on the floor | 3% |
| G | Self-levelling turntable | 3% |
| C | Waste conduit | 3% |

In order to summarize the Improve phase actions impact, Table 4-26 represents the chosen improvement actions (from the previous analysis results shown on Table 4-25) and their impact on the chosen KPIs and relevant matters to this case study, like food safety and quality.

*Table 4-26: Improvement actions impact summary*

| | | Improvement Actions | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **KPI** | **Before** | A | D | E | F | J | K | L | M | N | P | Q | R | S | **After** | **Predicted Improvement %** | **Predicted Improvement [Hours]** | **Predicted Improvement [Ton]** |
| **Waste** | **62%** | | | | | | | | | | | | | | **38%** | **24%** | **1735** | **1 362** |
| Waiting time | 11% | | X | | | X | X | X | | X | X | | | | 7% | 3% | 244 | 192 |
| Transportation | 25% | | X | X | X | | | X | X | X | X | | | | 16% | 9% | 671 | 527 |
| Over-processing | 18% | | X | X | | X | X | X | X | X | X | | | | 10% | 8% | 556 | 437 |
| Motion | 8% | X | | X | X | X | | | | X | | | X | X | 5% | 3% | 218 | 171 |
| **Productivity** | **785 Kg/h** | | | | | | | | | | | | | | **971 kg/h** | **186 kg/h** | | |
| increase | | X | X | X | X | X | X | X | X | X | X | X | X | X | - | 19% | | |
| **Work Conditions** | | | | | | | | | | | | | | | - | **30%** | | |
| Accidents | 48 | | X | X | | X | X | | | | | X | X | X | 30 | 37% | | |
| Absenteeism | 25% | X | | | | | X | X | | | X | X | | | 18% | 28% | | |
| Turnover | 5,3 | X | | | | | X | X | | | X | X | | | 4 | 25% | | |
| **Ergonomic Conditions** | | | | | | | | | | | | | | | - | **3%** | | |
| Physical exertion | 55% | X | | | | | X | | | | | | X | X | 43% | 12% | | |
| Heavy loads | 19% | | | | | | X | | | | | | X | | 17% | 2% | | |
| Exposure time | 14% | X | | | | | X | | X | | | | X | X | 10% | 4% | | |
| Work pressure | 8% | | | | | | | | | X | X | X | | | 7% | 1% | | |
| Repetition | 6% | | | | | | X | | X | | | | X | X | 5% | 1% | | |
| Awkward Postures | 3% | X | | | | | X | | | | | | X | X | 2% | 1% | | |
| **Food** | | | | | | | | | | | | | | | - | - | | |
| Safety (HACCP) | | | | | X | X | X | X | | X | | | X | | - | - | | |
| Quality | | | | | | X | X | | X | X | X | | | | - | - | | |

On the "Before" column of the table the results from the Measure phase indicators are presented: on the Waste topic, the indicator represents wasted time in each of these waste types, according to the observations made; the productivity presented in Kg/h refers to 2014 data; the accidents indicate the number of accidents in 2014; the absenteeism rate is presented in the form of percentage of total absence days versus total working days in 2014; the turnover rate refers to average number of new employees per month from 2013 to April 2015. Regarding the ergonomic conditions topic, the indicators presented refer to the employees' perception, according to the survey answers: physical exertion is perceived as very bad by 55% of the inquired population; heavy loads is admitted to be the number one issue in the Odivelas Kitchen - 19% of the population classified "lifting heavy loads" as the worst activity; 14% refer prolonged static activities as the worst activity performed; 8% say is working under pressure from superiors; repetitive tasks are classified by 6% of the staff as the worst tasks; and performing activities in awkward postures comes fifth in this ranking with 3% of the votes, although the researcher noted the majority of the activities being completed in wrong postures by the Kitchen's staff.

Having this indicators as starting point, then each improvement action is noted as having or not impact in each indicator (the "X" means it has impact). The "After" column will indicate the possible improvement achieved by implementing these actions. The previous calculations made about possible savings or increased productivity for the company presented above on each improvement action description are not repeated here. Hence, in a simplistic way, the impact of each action is calculated, providing the final predicted improvement percentage which is then translated to production time increase (hours) and production quantities increase (kilos). This way, a predictable improvement in productivity, working and ergonomic conditions is summarized providing a clearer idea of the benefits of implementing these improvement proposals.

## 2015 Indicators

The production indicators for 2015 and their comparison with the previously presented indicators from 2014 are shown on Table 4-27. Is possible to see that all the indicators had positive growth when comparing with the previous year. And, most of all, the main goal "<u>reducing operational costs to 1€/kg</u>" was not only accomplished but exceeded – average operating costs in 2015 were **0,90€/kg**.

With these indicators is also possible to calculate the Kitchen's productivity in 2015 as following:

$$Productivity = \frac{6848402}{7344} = \mathbf{932,5\ kg/h}$$

This represents a **16% improvement** concerning last year's value. Is important to notice that the predicted improvement was 19% (971 kg/h) regarding the implementation of all improvement actions and, some of them, are only going to be implemented in 2016.

The next stage in the DMAIC cycle will show how to control the obtained gains, so not to lose the investment made with these implementations.

Table 4-27: 2015 production results and comparison with 2014 results

| Indicators | 2015 | 2014 | Variation |
|---|---|---|---|
| **Total Production [kg]** | 6 848 402 | 5 766 692 | **16%** |
| **Average Production / FTE [kg]** | 3724 | 3 144 | **16%** |
| **Average Personnel Cost per Kg [€]** | -0,32 | 0,39 | **-24%** |
| **Total Operating Costs per Kg [€]** | -0,90 | 1,06 | **-18%** |

## 4.5 CONTROL

At this stage of the project development, the commitment from all parts involved is crucial. The implemented improvement actions need to be accompanied in order to guarantee its continuity. Some of the implementations call for new work methods, so training to all employees involved is required.

All the control measures hereon appointed are included in the project plans on Appendix J.

The control plan presented for all actions (except actions S and R, referred next) include visual control from the management team, namely the production director, and the piloting of the designated performance indicators. The accompaniment of the indicators should follow this guidelines:

- **Waste**: conduct time studies about the processes identified as problematic on the scheduled team meetings
- **Productivity**: design a chart where the daily Kitchen's productivity is noted down and put it on the plant's management meetings room. Put a second chart with the same information, but parcelled out by section. Discuss this information with the entire team when high and low points are hit and also during the management meetings.
- **Quantity produced:** design a chart where the daily production gets noted down and exhibit it on the information board in the social area for everybody to see. Discuss ups

and downs with the team to disclosure their insights about these variations. Use the 5 whys technique.

- **Production costs**: use this data as advice to keep watch over all the other production indicators, once that increased productivity implicates either more quantity produced or fewer resources, while higher costs are a symptom of decreased efficiency. The food cost per kilo should indicate the state of affairs.
- **Number of accidents and their causes**: schedule semi-annual overviews on the accidents history and their causes. Any alarming situations should be brought to light at the management meetings. The goal is zero accidents, always.
- **Absence rate**: look semi-annually for long-term absenteeism cases in the company's records and use the 5 whys technique to disclosure the true causes. Keep track of all long-term absences and present the conclusions in the management meetings. Also, the costs and implications of each absent worker should be noted down immediately and presented to the entire team, using the information boards existent in the social area.
- **Turnover rate**: develop a record system similar to the accidents one. To each worker that leaves or is admitted, a form should be filled indicating the reasons and other relevant information. Hence, more information can be retrieved from this rate. This information should be analysed annually, so as the costs implied in each action. Solutions should be discussed amongst the management team.
- **Employees' satisfaction, motivation and perception of the work conditions**: ask weekly for the workers' opinions, suggestions and insights. Note down the most important for further discussion. Conduct an annual survey and present the data for debate in the first management meeting of the following year.

The Improvement Actions **S** and **R -** substitute canned products and lemon juice – have a different control plan. And being that these implementations are the biggest priority, control actions are already being performed. These include <u>visual control</u> to the picking, preparations and cooking procedures from the responsible people in each working area. These procedures follow the same logic as other similar products/packages already used. Simultaneously, <u>food quality control</u> is required, once that the biggest impediments to these implementations was the possibility of deteriorating the food quality and finding the suppliers that provided the products needed and fulfilled the Kitchen's HACCP standards. This is up to the HACCP Kitchen's coordinator that must take samples of several different outputs using the modified ingredients, guaranteeing that there is no quality degradation. Also, the Meal Solutions marketing manager is looking for insights about these products from the company's customers, when performing the programmed market researches.

Actions **J** (equipment signalling), **M** (tags printing order), **N** (organization boards), **P** (team meetings) and **Q** (suggestion box) also require <u>training</u> so that workers don't reject changes merely due to unfamiliarity. An accompaniment from the management team short after the implementation dates is essential to guarantee that training was effective. If not, measures have to be taken so that the improvement continuity is not compromised.

Summing up, by implementing the indicators working norms as defined, the employees' training and the visual control is expected that the improvement actions remain operational and effective. The predicted control on the Kitchen's process will allow a more efficient and productive process, with less waste; a more motivated and involved team, wanting to contribute to the company's success; less defects, implying a better quality; improved work and space organization; and lower operational costs, meaning best results.

# 5 CONCLUSIONS AND FUTURE WORK

On the sixth and final chapter of this dissertation, the conclusions reached by developing this case study are presented summarily, followed by the limitations encountered during the research and application of the proposed method. Finally, some future work proposals are presented.

## 5.1 CONCLUSIONS ABOUT THE CASE STUDY

Through the study developed here was possible to show the impact that the Lean Six Sigma and Ergonomics disciplines might have on a company's continuous improvement, even one with a high level of complexity.

The utilized holistic approach, adapted from the DMAIC methodology, has proven to be an organized and sequential method of easy implementation which focus on improving and guaranteeing the best performance of a productive system, through different angles. The synergies shared helped complement and enhance the Lean Six Sigma philosophy. This methodology can be applied to any other type of study, especially if regarding the food industry.

In order to develop the proposed methodology, having in mind the project's main focuses – productivity and ergonomics, the improvement opportunities were identified in the Define stage of the cycle through the VOC and VOE tools which helped sustain the information contained on the CTQ tree. The objectives stated on the Project Charter included increasing productivity by 20% through waste elimination (25% less waste); increasing work and ergonomic conditions, therefore decreasing workers' fatigue and dissatisfaction; utilization of ergonomic principles to help increase the Kitchen's efficiency.

On the Measure phase, the most important KPIs were identified and measured. The survey answered by the Kitchen's staff was a pivotal tool to help understand the underlying problems and the workers' perception of the work and ergonomic conditions. The fact that it was not possible to administrate the survey again after the implementations, makes it impossible to quantify the improvement regarding the staff's perception. Also, the ABC analysis was a most helpful tool to select which processes to analyse, once that the Kitchen's process complexity doesn't allow a thorough study on all processes.

The Analyse stage began by trying to understand the underlying causes for the decreased productivity experienced in the Kitchen, through the Fishbone diagram, and by analysing the results from the Measure phase. This led to some conclusions which formalized the improvement opportunities used to design the improvement proposals next. The brainstorming tool was the pillar on this stage of the cycle. So, before drawing the improvement proposals, the Priorities Matrix tool was utilized to help understand the priority improvement opportunities, narrowing down the scope. At this point, the Improve stage was eminent. Hence, focusing on the selected improvement opportunities, several proposals were considered and project plans formalized, based on Ergonomics and Lean Six Sigma principles, like Kaizen and 5S philosophies or like the 7 wastes concept. Once again, the Priorities Matrix had to be used in order to help focusing the investment on the top necessities of the company. This was also due to the project's restrictions. After applying this tool, the chosen improvement actions started to be implemented by the Kitchen's management team, according to the schedules and responsibilities defined in their project plans. The Control phase was structured together with the improvement actions plan, aiming to sustain the gains achieved.

It was not possible to measure the defined KPIs after these implementations. Therefore, the improvement impacts were predicted together with the management team. Although the 2015 production indicators improved in line with the expectations, giving a sense of achievement to this project. The productivity increased by 16% in comparison with 2014 indicators, which relates to the 16% increase in production capacity. The company's main goal of decreasing operational costs to 1 €/kg was surpassed, achieving 0,90 €/kg which corresponds to an 18% decrease when comparing to 2014. This means that efficiency has also increased – the same amount of resources produced 16% more output.

Summing up, the implemented improvement actions seem to have had a positive impact on the production processes of Odivelas Kitchen, even if a thorough KPIs analysis was not possible after the implementations. The researcher together with the Kitchen's management team worked tirelessly towards continuous improvement and productivity and efficiency gains, never overlooking the safety, health and well-being of the staff.

## 5.2 LIMITATIONS

The research limitations regarded mainly the difficulties in finding previous studies on Industrial Kitchens with similar production processes to Pingo Doce's one. Also, the implementation of Lean Six Sigma and Ergonomics principles on any type of food industry companies was scarce. Most studies on the food sector companies revolve around food safety and HACCP standards.

As previously mentioned on the Background chapter, Dora et al. (2013) refer a study by Luning, Marcelis, & Jongen (2002) that attributed low impact of lean manufacturing to the unique characteristics of the food sector including short shelf-life, heterogeneous raw materials, seasonality, and varied harvesting conditions. Furthermore, the authors talk about a complex production chain and complicated network of many suppliers and buyers hugely affect storage, conditioning, processing, packaging and quality control. All these factors might be attributing to the difficulty level of lean initiative in the food processing SMEs. The researcher encountered these limitations throughout the development of this case study.

Also, the restrictions mentioned on the Project Charter in the Define stage of the DMAIC cycle were confirmed. The project's duration was not enough to fully implement the proposed improvement actions, measure the results after the implementations and perform a committed accompaniment as the Control phase requires. This was also due to the lack of a dedicated team to develop this project. The researcher developed it with the immeasurable aid of the Kitchen's management team, but this team was not dedicated to the project. The third referred restriction was "money" because the Meal Solutions Company does not have available money to invest. The last limitation mentioned was the HACCP rules, because in any food production facilities, especially when producing ready-to-eat products, food safety is imperative and above all other concerns. Thus, it restricts production processes and improvement ideas.

Regarding the holistic approach utilized, the difficulty resided on putting together all the mentioned disciplines without disregarding any of their basic principles and thinking of them as complementary. The DMAIC methodology provides an organized but hard to follow routine, once that a lot of iterations are needed, especially during the Measure, Analyse and Improve phases, on a real and highly complex environment.

## 5.3 Future Work Proposals

As referred in the Improve stage, priorities had to be considered to implement the proposals presented. Therefore, the six rejected proposals plans are presented on Appendix K as a suggestion for future improvement implementations, as mentioned before.

Additionally, the researcher identified some suggestions for future work throughout the study.

1. Create a permanent continuous improvement team, preferably with people from the company, who already know the complexities of the process, but trained on Kaizen.
2. Create a materials' database, linking each product to the necessary materials to produce it, so to balance the production, avoid stoppages and bottlenecks (design a daily production plan to the Scullery section), as well as have a clear perception of the materials needed at every time.
3. Implement the utilization of visual boards to accompany the daily, weekly, monthly and annual KPIs.
4. Resolve the software limitation that prevents employees from recording the temperature of intermediate cooked preparations. It only allows to record the temperature of the final

product, making employees record it on paper, preventing efficiency and deteriorating food safety standards.

5. Work on a better solution for the transportation boxes for the deserts. These are assembled manually every day by one or two employees per day.

These and any other future improvement should be considered on an ever stronger continuous improvement culture within the Meal Solutions Company.

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# APPENDICES

## Appendix A: Survey

**Por favor responda a TODAS as questões de forma legível.** Sinta-se à vontade para acrescentar comentários.

1. A que **zona/equipa** pertence atualmente? Assinale com X

Receção ☐ Picking ☐ Preparação ☐ Confeção ☐ Copa ☐ Expedição ☐

2. Já trabalhou em **outras secções?** Qual/quais? Assinale com X

Receção ☐ Picking ☐ Preparação ☐ Confeção ☐ Copa ☐ Expedição ☐

3. Na sua opinião, como classifica o seu **ambiente de trabalho?** Assinale com um X em cada coluna

| Esforço Físico | | Organização do Trabalho | | Instalações | | Temperatura | | Limpeza | |
|---|---|---|---|---|---|---|---|---|---|
| Muito forte | | Muito boa | | Muito boas | | Muito quente | | Muito bom | |
| Forte | | Boa | | Boas | | Quente | | Bom | |
| Fraco | | Má | | Más | | Frio | | Mau | |
| Muito fraco | | Muito má | | Muito más | | Muito frio | | Muito mau | |

4. Escolha a ZONA que considera que precisa de **maior esforço físico**: Assinale com X

Receção ☐ Picking ☐ Preparação ☐ Confeção ☐ Copa ☐ Expedição ☐

5. Escolha as **3 PIORES atividades**, na sua opinião, realizadas na Cozinha.

Classifique com **9, 5 e 1 (sendo 9 a pior)**.

| | |
|---|---|
| Movimentar cargas pesadas | |
| Levantar cargas pesadas | |
| Fazer uma tarefa muito tempo na mesma posição | |
| Fazer uma tarefa num espaço frio | |
| Estar durante muito tempo num espaço frio | |
| Fazer tarefas que penso serem inúteis | |
| Tarefas manuais com muito peso (mexer alimentos, por exemplo) | |
| Repetir o mesmo movimento muitas vezes | |
| Trabalhar em posições desconfortáveis | |
| Andar grandes distâncias para realizar tarefas | |
| Trabalhar com material/equipamento em más condições | |
| Lidar com cheiros desagradáveis | |
| Trabalhar em locais desagradáveis (limpeza, ruído, organização, ...) | |
| Trabalhar com equipamento perigoso | |
| Trabalhar com material quente | |
| Trabalhar com equipamentos de proteção individual (luvas, máscaras,...) | |
| Movimentar material com dimensões/formas estranhas | |
| Movimentar material muito quente/frio | |
| Trabalhar com máquinas (sopas, sobremesas, expedição,...) | |
| Trabalhar com muita pressão dos superiores | |

6. Classifique **globalmente** as condições do seu trabalho. Assinale com X

| Muito bom | | Bom | | Mau | | Muito mau | |
|---|---|---|---|---|---|---|---|

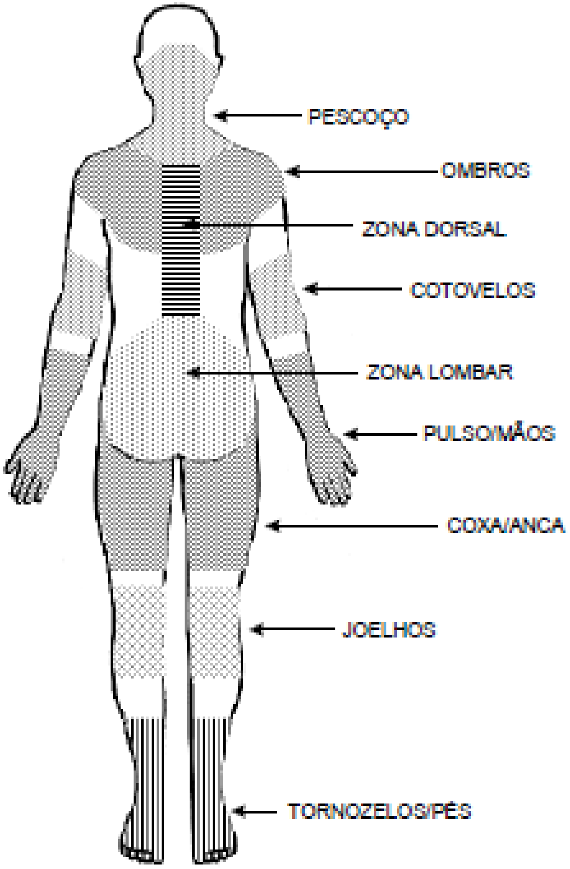
7. Sente **desconforto físico** no seu trabalho? Assinale com X

| Nunca | | Raramente | | Quase sempre | | Sempre | |
|---|---|---|---|---|---|---|---|

8. Sentiu **dores ou desconforto físico** durante o último ano? Assinale com X

SIM ☐ → **Pergunta 9**
NÃO ☐

9. Assinale com X na imagem as zonas onde teve **dores ou desconforto no último ano:**




10. **Estas dores impediram que viesse trabalhar?** Assinale com X

SIM ☐ → Durante quanto tempo? ________________________________
NÃO ☐

**11.** Deixe algumas **sugestões** sobre o que pode ser melhorado, tanto no seu posto como no funcionamento da Cozinha em geral, **comentários** ou **reclamações**.

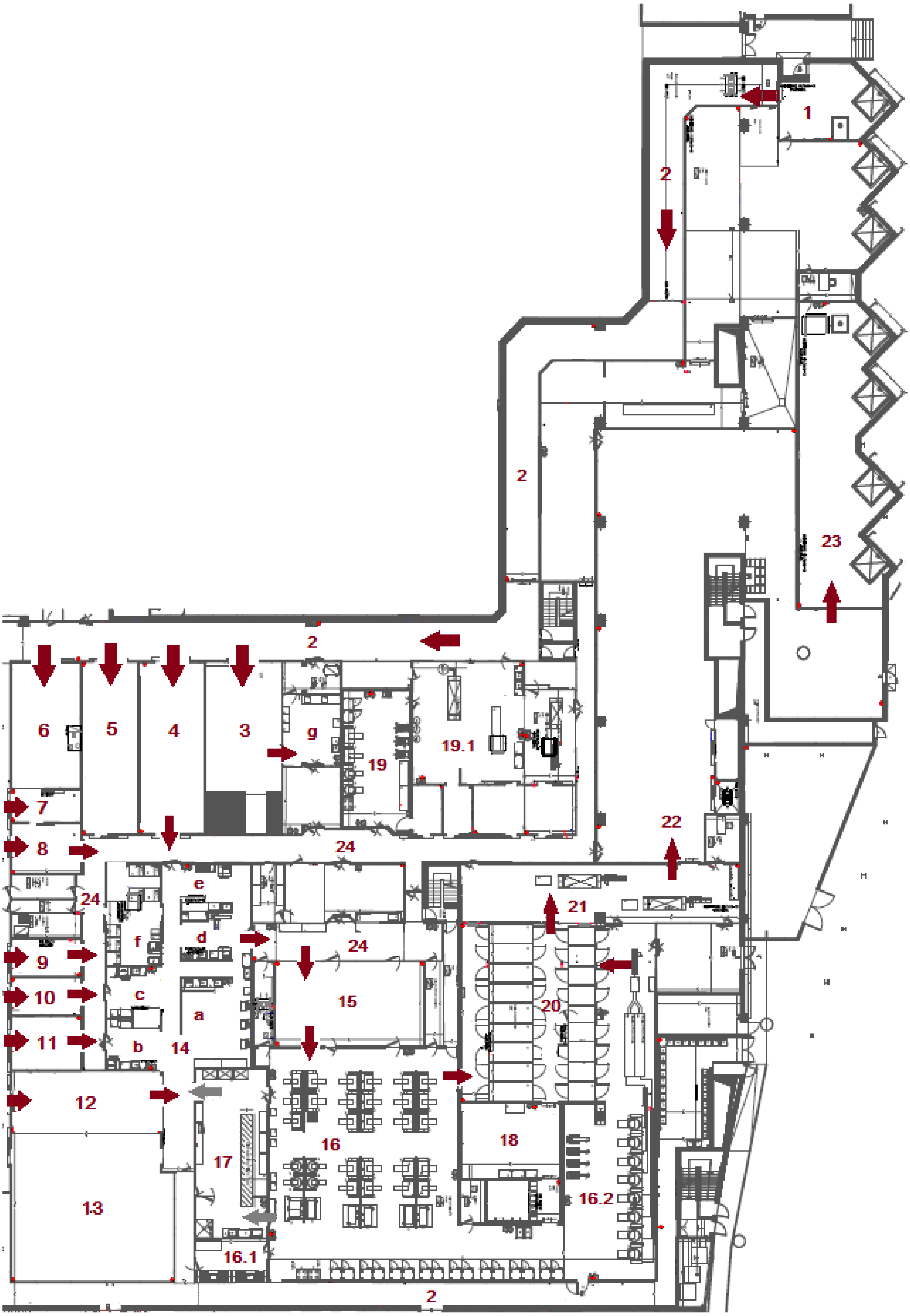
**Sexo:** Masculino ☐ Feminino ☐

**Idade:** 16-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56-65 ☐ > 65 ☐

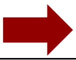
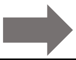
**Há quanto tempo** trabalha na Cozinha de Odivelas? ________ Anos + ________ Meses

Obrigado pela sua ajuda.

Appendix B: Kitchen's Layout



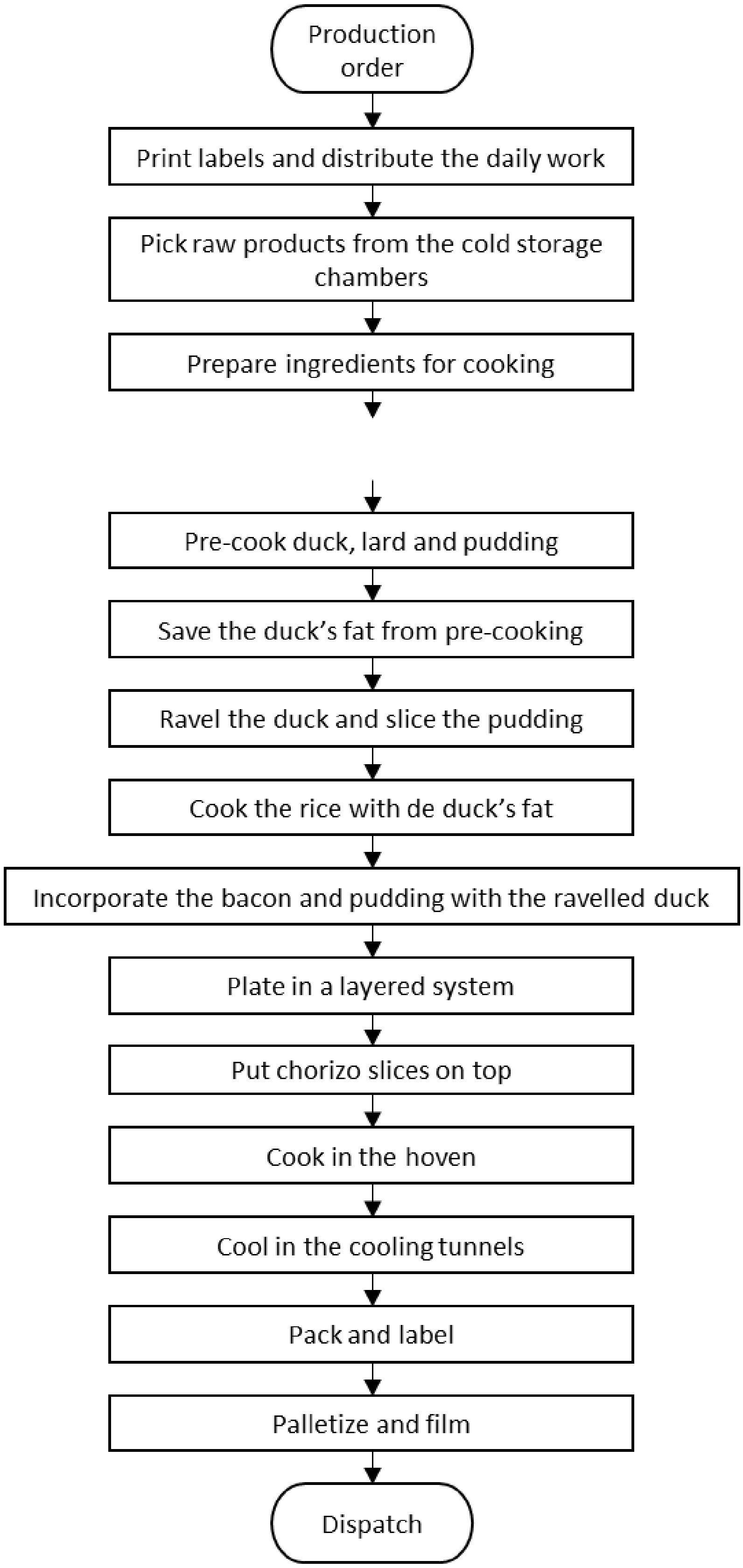
**Caption:**

| | |
|---|---|
|  | Indicate the foodstuff way through the kitchen |
|  | Indicate the materials way back into the flow |
| **1** | Reception of materials |
| **2** | “dirty” corridor |
| **3** | Dry goods storage room |
| **4** | Dairy storage room |
| **5** | Ready-to-use materials storage room |
| **6** | Frozen goods storage room |
| **7** | Room to remove packaging from frozen goods |
| **8** | Frozen goods pre-chamber |
| **9** | Fresh fish storage room |
| **10** | Fresh red meat storage room |
| **11** | Fresh white meat storage room |
| **12** | Dry codfish storage room |
| **13** | Fruit and vegetables storage room |
| **14** | Preparation section |
| **14-a** | Fruits, vegetables and herbs work station |
| **14-b** | Pre-washed and packed vegetables work station |
| **14-c** | Meat work station |
| **14-d** | Fish work station |
| **14-e** | Dairy work station |
| **14-f** | Soaking room for codfish |
| **14-g** | Dry goods work station |
| **15** | Final picking room |
| **16** | Cooking section |

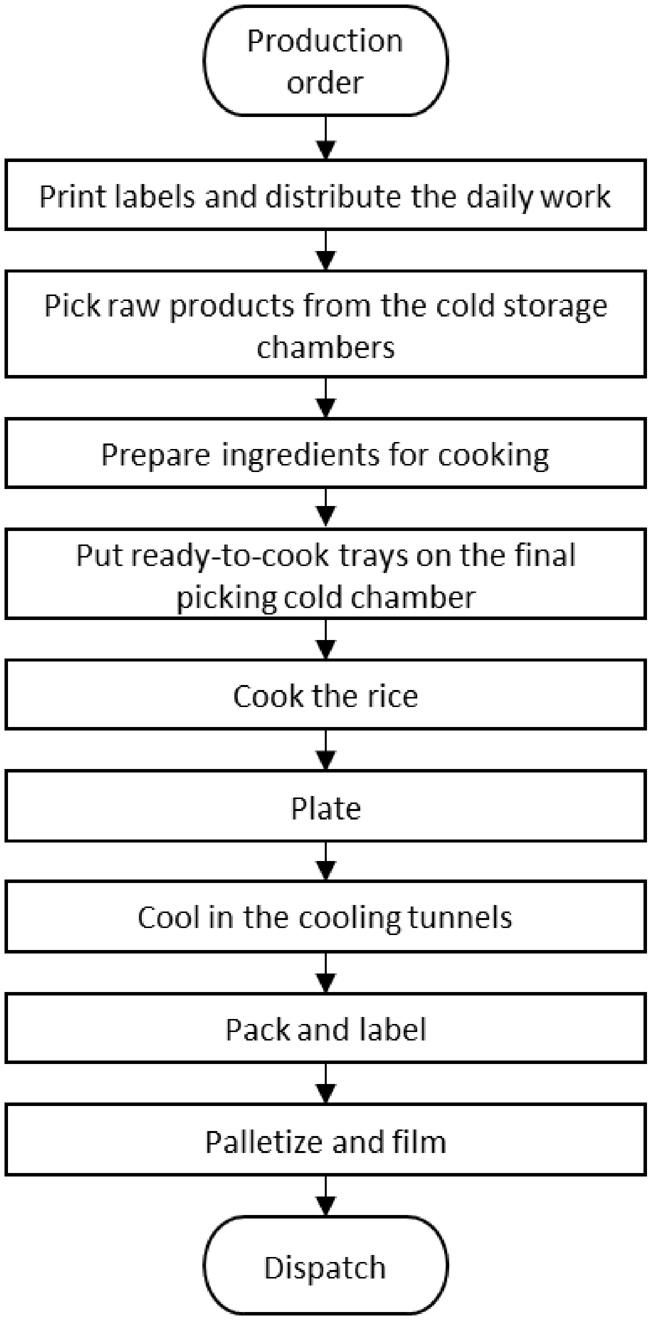
| | |
|---|---|
| **16.1** | Deep fry work station |
| **16.2** | Soups work station |
| **17** | Scullery |
| **18** | Cooking cold work station |
| **19** | Deserts work station |
| **19.1** | Deserts packing room |
| **20** | Cooling chambers room |
| **21** | Packing section |
| **22** | Expedition section |
| **23** | Dispatching area |
| **24** | “clean” corridor |

Appendix C: Top 5 sellers' flowcharts

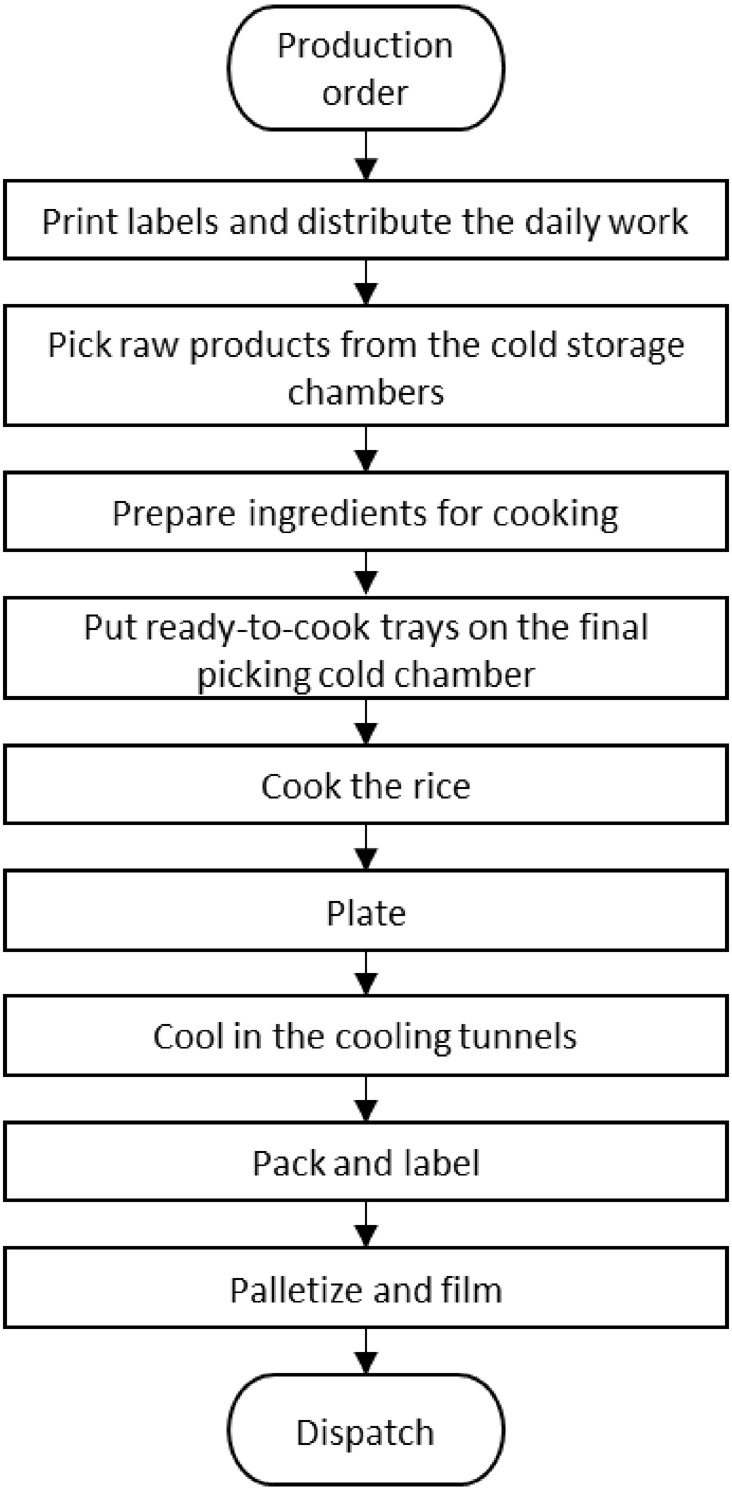
1. Arroz de Pato



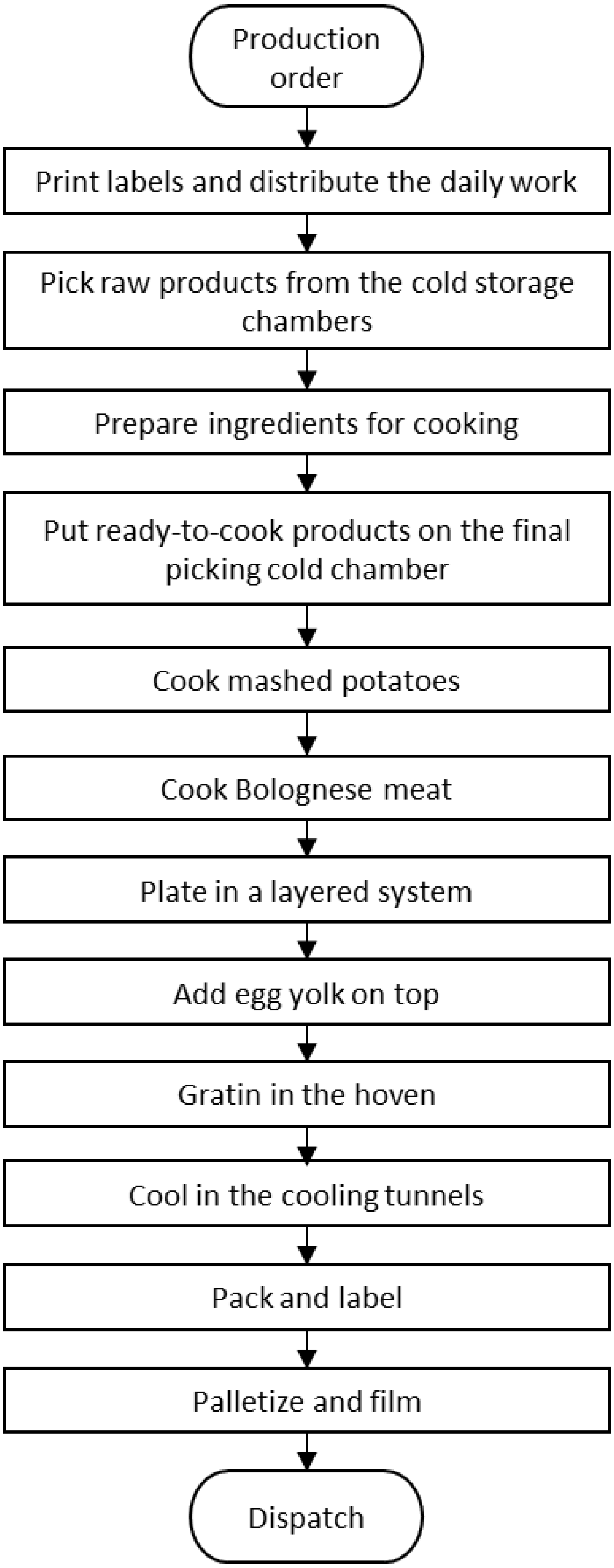
2. Arroz Branco



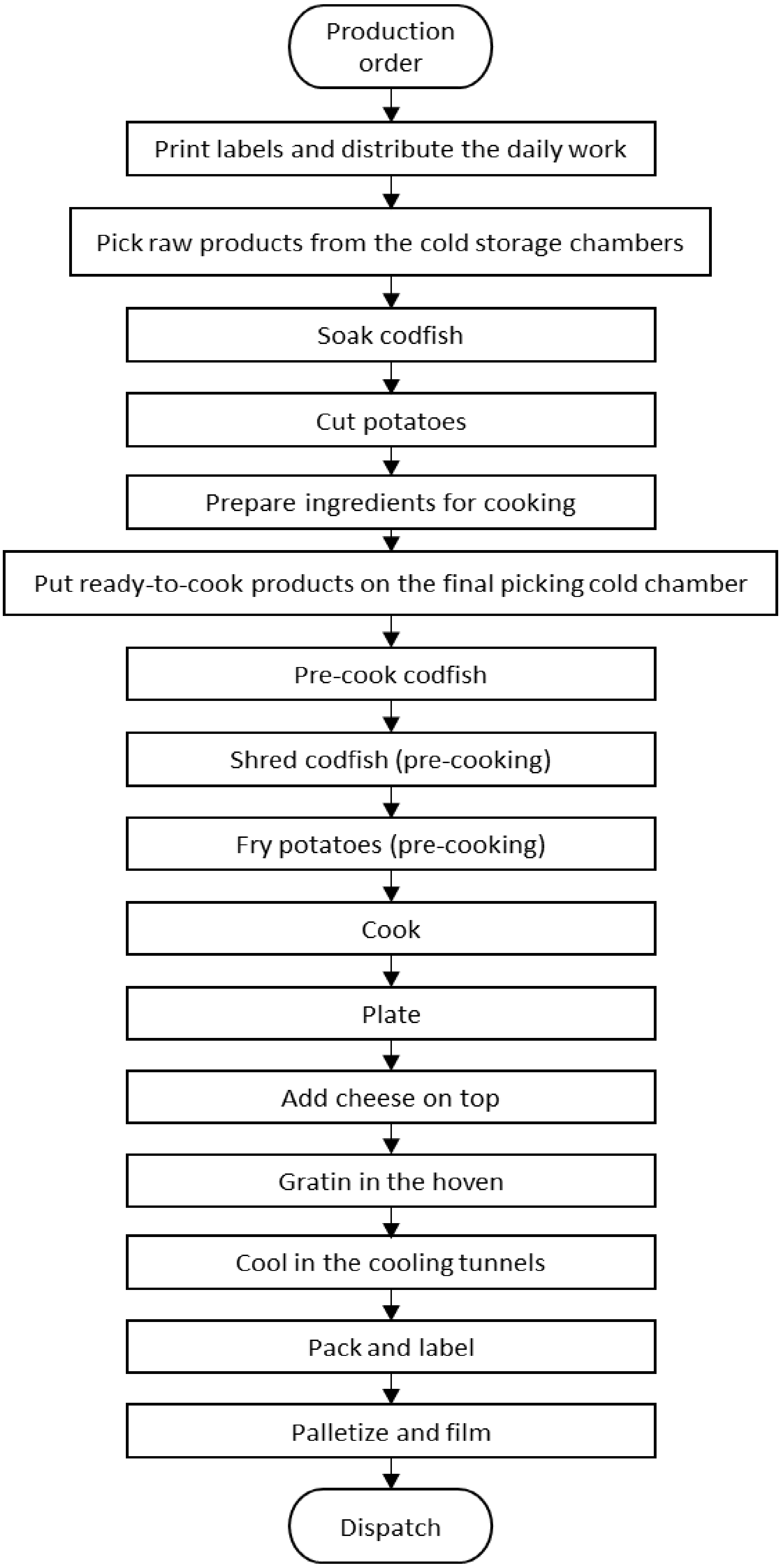
3. Bacalhau spiritual



4. Empadão de carne



5. Bacalhau com natas



Appendix D: Criteria Matrix

| | Criteria being compared to | | | | | | | | | | | | | | | | | | Row Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Low investment cost | Maximum use of existing resources | High potential money savings | High improvement potential for process flow | High improvement potential for defects reduction | High improvement potential for ergonomic conditions | High improvement potential for working conditions | High customer satisfaction potential | High employee motivation potential | Minimum negative impact on other processes | Ease of implementation | High probability of quick results | Minimum number of people involved for implementation | High employee involvement potential | High improvement potential for work organization | Minimum complexity | Minimum need for employees' formation | Current availability for implementation | | |
| | **Criteria** | a | b | c | d | e | f | g | h | i | j | k | l | m | n | o | p | q | r | | |
| a | Low investment cost | | 5 | 2 | 2 | 2 | 2 | 2 | 2 | 5 | 5 | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 2 | 61 | **13%** |
| b | Maximum use of existing resources | 0,1 | | 1 | 2 | 0,2 | 2 | 2 | 2 | 2 | 5 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 0,2 | 25,5 | **5%** |
| c | High potential money savings | 0,2 | 1 | | 2 | 1 | 2 | 2 | 2 | 2 | 5 | 2 | 2 | 5 | 2 | 2 | 2 | 5 | 2 | 39,2 | **8%** |
| d | High improvement potential for process flow | 0,2 | 0,2 | 0,2 | | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 5 | 5 | 1 | 1 | 1 | 5 | 0,2 | 26,8 | **6%** |
| e | High improvement potential for increasing productivity | 0,2 | 2 | 1 | 1 | | 1 | 1 | 1 | 1 | 2 | 2 | 5 | 5 | 2 | 1 | 1 | 5 | 1 | 32,2 | **7%** |
| f | High improvement potential for ergonomic conditions | 0,2 | 0,2 | 0,2 | 1 | 1 | | 2 | 1 | 1 | 2 | 2 | 5 | 5 | 2 | 1 | 2 | 5 | 1 | 31,6 | **7%** |
| g | High improvement potential for working conditions | 0,2 | 0,2 | 0,2 | 1 | 1 | 0,2 | | 1 | 1 | 2 | 1 | 5 | 5 | 2 | 1 | 2 | 5 | 0,2 | 28 | **6%** |
| h | High customer satisfaction potential | 0,2 | 0,2 | 0,2 | 1 | 1 | 1 | 1 | | 1 | 2 | 1 | 5 | 5 | 2 | 1 | 2 | 2 | 1 | 26,6 | **6%** |
| i | High employee motivation potential | 0,1 | 0,2 | 0,2 | 1 | 1 | 1 | 1 | 1 | | 2 | 1 | 5 | 5 | 1 | 0,2 | 1 | 2 | 0,2 | 22,9 | **5%** |
| j | Minimum negative impact on other processes | 0,1 | 0,1 | 0,1 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | | 0,2 | 2 | 2 | 2 | 2 | 1 | 5 | 0,1 | 15,8 | **3%** |
| k | Ease of implementation | 0,2 | 1 | 0,2 | 1 | 0,2 | 0,2 | 1 | 1 | 1 | 2 | | 5 | 5 | 2 | 1 | 1 | 5 | 0,2 | 27 | **6%** |
| l | High probability of quick results | 0,1 | 1 | 0,2 | 0,2 | 0,1 | 0,1 | 5 | 0,1 | 0,1 | 0,2 | 0,1 | | 1 | 0,1 | 0,1 | 0,2 | 0,1 | 0,1 | 8,8 | **2%** |
| m | Minimum number of people involved for implementation | 0,1 | 1 | 0,1 | 0,2 | 0,1 | 0,1 | 5 | 0,1 | 0,1 | 0,2 | 0,1 | 1 | | 0,1 | 0,1 | 0,2 | 0,1 | 0,1 | 8,7 | **2%** |
| n | High employee involvement potential | 0,1 | 0,2 | 0,2 | 1 | 0,2 | 0,2 | 0,2 | 0,2 | 1 | 0,2 | 0,2 | 5 | 5 | | 1 | 0,2 | 5 | 0,2 | 20,1 | **4%** |
| o | High improvement potential for work organization | 0,1 | 0,2 | 0,2 | 1 | 1 | 1 | 1 | 1 | 2 | 0,2 | 1 | 5 | 5 | 1 | | 1 | 5 | 0,2 | 25,9 | **6%** |
| p | Minimum complexity | 0,1 | 1 | 0,2 | 1 | 1 | 0,2 | 0,2 | 0,2 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | | 2 | 0,2 | 16,1 | **3%** |
| q | Minimum need for employees' formation | 0,1 | 1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,2 | 0,2 | 0,1 | 0,1 | 5 | 5 | 0,1 | 0,1 | 0,2 | | 0,1 | 12,7 | **3%** |
| r | Current availability for implementation | 0,2 | 2 | 0,2 | 2 | 1 | 1 | 2 | 1 | 2 | 5 | 2 | 5 | 5 | 1 | 1 | 1 | 5 | | 36,4 | **8%** |
| | **Column Total** | 2,5 | 17 | 6,5 | 17,7 | 12,1 | 13,3 | 26,7 | 15 | 21,6 | 35,9 | 17,7 | 68 | 71 | 27,3 | 20,5 | 21,8 | 62,2 | 9 | **465,3** | **100%** |

Appendix E: Improvement Opportunities Matrices

| For criterion: a. Low investment cost | | 1 reduce number of accidents and sick leaves | 2 reduce exposure to dangerous situations | 3 improve ergonomic conditions for static activities | 4 reduce loads moving and lifting | 5 improve employees motivation and satisfaction | 6 increase employees involvement in continuous | 7 reduce opportunities for defect/failure | 8 eliminate NVA activities | 9 reduce production stoppages due to faulty equipment | 10 new/upgraded equipment and materials | 11 improve space and work organization | 12 eliminate unnecessary motion | Row Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Improvement Opportunities** | | | | | | | | | | | | | | |
| 1 | reduce number of accidents and sick leaves | | 1 | 1 | 5 | 0,1 | 0,2 | 1 | 0,1 | 2 | 5 | 1 | 1 | 17,4 | **10%** |
| 2 | reduce exposure to dangerous situations | 1 | | 1 | 2 | 0,2 | 0,2 | 1 | 0,1 | 2 | 5 | 1 | 1 | 14,5 | **8%** |
| 3 | improve ergonomic conditions for static activities | 1 | 1 | | 1 | 0,1 | 0,2 | 0,2 | 0,2 | 1 | 2 | 1 | 1 | 8,7 | **5%** |
| 4 | reduce loads moving and lifting | 0,1 | 0,2 | 1 | | 0,1 | 0,2 | 0,2 | 0,2 | 1 | 2 | 1 | 0,2 | 6,2 | **3%** |
| 5 | improve employees motivation and satisfaction | 5 | 2 | 5 | 5 | | 1 | 1 | 1 | 2 | 5 | 1 | 1 | 29 | **16%** |
| 6 | increase employees involvement in continuous improvement | 2 | 2 | 2 | 2 | 1 | | 1 | 0,2 | 2 | 5 | 1 | 1 | 19,2 | **11%** |
| 7 | reduce opportunities for defect/failure | 1 | 1 | 2 | 2 | 1 | 1 | | 0,2 | 2 | 5 | 1 | 1 | 17,2 | **10%** |
| 8 | eliminate NVA activities | 5 | 5 | 2 | 2 | 1 | 2 | 2 | | 2 | 5 | 2 | 1 | 29 | **16%** |
| 9 | reduce production stoppages due to faulty equipment | 0,2 | 0,2 | 1 | 1 | 0,2 | 0,2 | 0,2 | 0,2 | | 2 | 1 | 0,2 | 6,4 | **4%** |
| 10 | new/upgraded equipment and materials | 0,1 | 0,1 | 0,2 | 0,2 | 0,1 | 0,1 | 0,1 | 0,1 | 0,2 | | 0,1 | 0,1 | 1,4 | **1%** |
| 11 | improve space and work organization | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0,2 | 1 | 5 | | 1 | 14,2 | **8%** |
| 12 | eliminate unnecessary motion | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 5 | 1 | | 17 | **9%** |
| | **Column Total** | 17 | 15 | 17 | 23,2 | 5,8 | 7,1 | 8,7 | 3,5 | 17,2 | 46 | 11,1 | 8,5 | **180,2** | **100%** |

| For criterion: | | Improvement Opportunities | | | | | | | | | | | | Row | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **c. High potential money savings** | | reduce number of accidents and sick leaves | reduce exposure to dangerous situations | improve ergonomic conditions for static activities | reduce loads moving and lifting | improve employees motivation and satisfaction | increase employees involvement in continuous improvement | reduce opportunities for defect/failure | eliminate NVA activities | reduce production stoppages due to faulty equipment | new/upgraded equipment and materials | improve space and work organization | eliminate unnecessary motion | **Total** | **%** |
| **Improvement Opportunities** | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| 1 | reduce number of accidents and sick leaves | | 1 | 1 | 2 | 1 | 1 | 0,2 | 0,1 | 0,2 | 0,2 | 0,2 | 0,1 | 7 | **4%** |
| 2 | reduce exposure to dangerous situations | 1 | | 1 | 0,2 | 0,2 | 0,2 | 0,2 | 0,1 | 0,2 | 0,2 | 0,2 | 0,2 | 3,7 | **2%** |
| 3 | improve ergonomic conditions for static activities | 1 | 1 | | 1 | 1 | 2 | 0,2 | 0,1 | 0,2 | 0,2 | 0,2 | 0,1 | 7 | **4%** |
| 4 | reduce loads moving and lifting | 0,2 | 2 | 1 | | 2 | 2 | 1 | 1 | 2 | 2 | 0,2 | 1 | 14,4 | **9%** |
| 5 | improve employees motivation and satisfaction | 1 | 2 | 1 | 0,2 | | 0,2 | 1 | 0,1 | 0,2 | 0,2 | 0,2 | 0,1 | 6,2 | **4%** |
| 6 | increase employees involvement in continuous improvement | 1 | 2 | 0,2 | 0,2 | 2 | | 1 | 0,2 | 1 | 2 | 1 | 1 | 11,6 | **7%** |
| 7 | reduce opportunities for defect/failure | 2 | 2 | 2 | 1 | 1 | 1 | | 0,2 | 1 | 0,2 | 0,2 | 0,2 | 10,8 | **7%** |
| 8 | eliminate NVA activities | 5 | 5 | 5 | 1 | 5 | 2 | 2 | | 1 | 2 | 1 | 1 | 30 | **18%** |
| 9 | reduce production stoppages due to faulty equipment | 2 | 2 | 2 | 0,2 | 2 | 1 | 1 | 1 | | 1 | 1 | 1 | 14,2 | **9%** |
| 10 | new/upgraded equipment and materials | 2 | 2 | 2 | 0,2 | 2 | 0,2 | 2 | 0,2 | 1 | | 0,2 | 0,1 | 11,9 | **7%** |
| 11 | improve space and work organization | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | | 0,2 | 17,2 | **10%** |
| 12 | eliminate unnecessary motion | 5 | 2 | 5 | 1 | 5 | 1 | 2 | 1 | 1 | 5 | 2 | | 30 | **18%** |
| **Column Total** | | 22,2 | 23 | 22,2 | 9 | 23 | 11,6 | 12,6 | 5 | 8,8 | 15 | 6,4 | 5 | **164** | **100%** |

| For criterion: | | Improvement Opportunities | | | | | | | | | | | | Row | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **e. High improvement potential for increasing productivity** | | reduce number of accidents and sick leaves | reduce exposure to dangerous situations | improve ergonomic conditions for static activities | reduce loads moving and lifting | improve employees motivation and satisfaction | increase employees involvement in continuous improvement | reduce opportunities for defect/failure | eliminate NVA activities | reduce production stoppages due to faulty equipment | new/upgraded equipment and materials | improve space and work organization | eliminate unnecessary motion | **Total** | **%** |
| **Improvement Opportunities** | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| 1 | reduce number of accidents and sick leaves | | 1 | 2 | 1 | 1 | 2 | 0,2 | 0,2 | 0,2 | 0,2 | 1 | 0,2 | 9 | **6%** |
| 2 | reduce exposure to dangerous situations | 1 | | 1 | 0,2 | 0,2 | 1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,2 | 0,1 | 4,1 | **3%** |
| 3 | improve ergonomic conditions for static activities | 0,2 | 1 | | 0,2 | 1 | 2 | 0,2 | 0,2 | 0,2 | 0,2 | 1 | 0,2 | 6,4 | **4%** |
| 4 | reduce loads moving and lifting | 1 | 2 | 2 | | 2 | 2 | 1 | 0,2 | 1 | 1 | 2 | 1 | 15,2 | **10%** |
| 5 | improve employees motivation and satisfaction | 1 | 2 | 1 | 0,2 | | 0,2 | 0,1 | 0,2 | 0,2 | 0,2 | 1 | 0,2 | 6,3 | **4%** |
| 6 | increase employees involvement in continuous improvement | 0,2 | 1 | 0,2 | 0,2 | 2 | | 0,2 | 0,2 | 1 | 0,2 | 1 | 0,2 | 6,4 | **4%** |
| 7 | reduce opportunities for defect/failure | 2 | 5 | 2 | 1 | 5 | 2 | | 0,2 | 1 | 0,2 | 1 | 1 | 20,4 | **13%** |
| 8 | eliminate NVA activities | 2 | 5 | 2 | 2 | 2 | 2 | 2 | | 2 | 2 | 2 | 1 | 24 | **15%** |
| 9 | reduce production stoppages due to faulty equipment | 2 | 5 | 2 | 1 | 2 | 1 | 1 | 0,2 | | 1 | 1 | 1 | 17,2 | **11%** |
| 10 | new/upgraded equipment and materials | 2 | 5 | 2 | 1 | 2 | 2 | 2 | 0,2 | 1 | | 1 | 0,2 | 18,4 | **12%** |
| 11 | improve space and work organization | 1 | 2 | 1 | 0,2 | 1 | 1 | 1 | 0,2 | 1 | 1 | | 0,2 | 9,6 | **6%** |
| 12 | eliminate unnecessary motion | 2 | 5 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | | 21 | **13%** |
| **Column Total** | | 14,4 | 34 | 17 | 8 | 20,2 | 17 | 8,8 | 2,9 | 8,7 | 8,1 | 13,2 | 5,3 | **158** | **100%** |

| For criterion: | | Improvement Opportunities | | | | | | | | | | | | Row | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **f. High improvement potential for ergonomic conditions** | | reduce number of accidents and sick leaves | reduce exposure to dangerous situations | improve ergonomic conditions for static activities | reduce loads moving and lifting | improve employees motivation and satisfaction | increase employees involvement in continuous improvement | reduce opportunities for defect/failure | eliminate NVA activities | reduce production stoppages due to faulty equipment | new/upgraded equipment and materials | improve space and work organization | eliminate unnecessary motion | **Total** | **%** |
| **Improvement Opportunities** | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| 1 | reduce number of accidents and sick leaves | | 1 | 0,2 | 0,2 | 1 | 2 | 5 | 2 | 5 | 1 | 2 | 1 | 20,4 | **11%** |
| 2 | reduce exposure to dangerous situations | 1 | | 1 | 1 | 1 | 2 | 5 | 2 | 5 | 1 | 2 | 1 | 22 | **12%** |
| 3 | improve ergonomic conditions for static activities | 2 | 1 | | 1 | 1 | 2 | 5 | 2 | 5 | 2 | 2 | 2 | 25 | **13%** |
| 4 | reduce loads moving and lifting | 2 | 1 | 1 | | 1 | 2 | 5 | 2 | 5 | 2 | 2 | 2 | 25 | **13%** |
| 5 | improve employees motivation and satisfaction | 1 | 1 | 1 | 1 | | 2 | 5 | 2 | 5 | 2 | 1 | 1 | 22 | **12%** |
| 6 | increase employees involvement in continuous improvement | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | | 2 | 1 | 5 | 1 | 0,2 | 0,2 | 10,4 | **5%** |
| 7 | reduce opportunities for defect/failure | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,2 | | 0,1 | 1 | 0,1 | 0,1 | 0,1 | 2,1 | **1%** |
| 8 | eliminate NVA activities | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 1 | 5 | | 2 | 1 | 1 | 1 | 12 | **6%** |
| 9 | reduce production stoppages due to faulty equipment | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 1 | 0,2 | | 0,2 | 0,1 | 0,1 | 2,2 | **1%** |
| 10 | new/upgraded equipment and materials | 1 | 1 | 0,2 | 0,2 | 0,2 | 1 | 5 | 1 | 2 | | 1 | 1 | 13,6 | **7%** |
| 11 | improve space and work organization | 0,2 | 0,2 | 0,2 | 0,2 | 1 | 2 | 5 | 1 | 5 | 1 | | 1 | 16,8 | **9%** |
| 12 | eliminate unnecessary motion | 1 | 1 | 0,2 | 0,2 | 1 | 2 | 5 | 1 | 5 | 1 | 1 | | 18,4 | **10%** |
| **Column Total** | | 8,8 | 6,8 | 4,4 | 4,4 | 6,8 | 16 | 48 | 14 | 45 | 12,3 | 12,4 | 10 | **189,9** | **100%** |

For criterion:

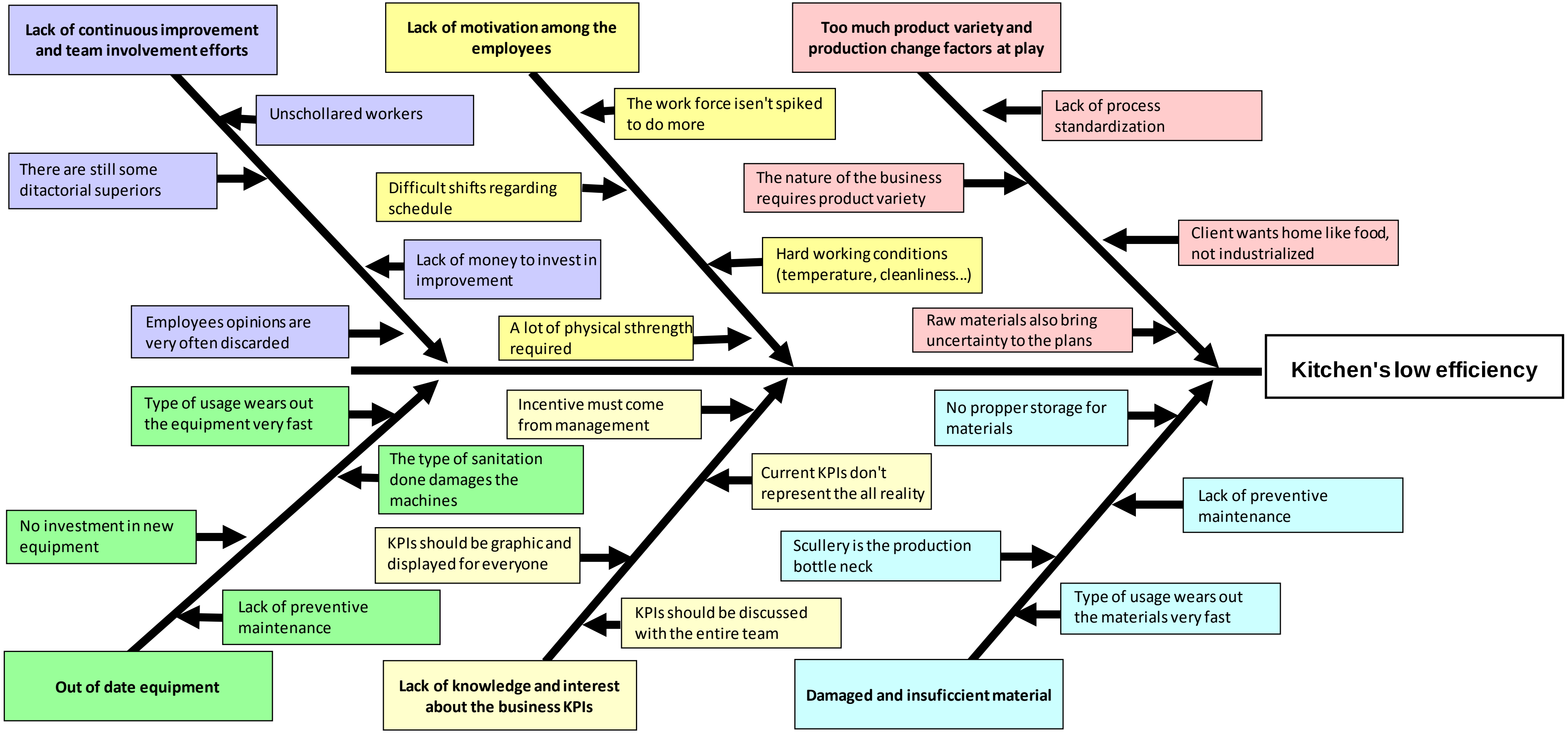
**r. Current availability for implementation**

| | **Improvement Opportunities** | 1 reduce number of accidents and sick leaves | 2 reduce exposure to dangerous situations | 3 improve ergonomic conditions for static activities | 4 reduce loads moving and lifting | 5 improve employees motivation and satisfaction | 6 increase employees involvement in continuous | 7 reduce opportunities for defect/failure | 8 eliminate NVA activities | 9 reduce production stoppages due to faulty equipment | 10 new/upgraded equipment and materials | 11 improve space and work organization | 12 eliminate unnecessary motion | **Row Total** | **%** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | reduce number of accidents and sick leaves | | 0,2 | 0,2 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 12,4 | **8%** |
| 2 | reduce exposure to dangerous situations | 2 | | 2 | 5 | 1 | 1 | 1 | 2 | 2 | 5 | 1 | 2 | 24 | **16%** |
| 3 | improve ergonomic conditions for static activities | 2 | 0,2 | | 2 | 0,2 | 1 | 1 | 1 | 0,2 | 2 | 0,2 | 1 | 10,8 | **7%** |
| 4 | reduce loads moving and lifting | 1 | 0,1 | 0,2 | | 0,2 | 0,2 | 0,2 | 0,2 | 0,1 | 1 | 0,2 | 0,2 | 3,6 | **2%** |
| 5 | improve employees motivation and satisfaction | 1 | 1 | 2 | 2 | | 2 | 1 | 2 | 1 | 5 | 1 | 1 | 19 | **12%** |
| 6 | increase employees involvement in continuous improvement | 0,2 | 1 | 1 | 2 | 0,2 | | 1 | 1 | 1 | 2 | 1 | 1 | 11,4 | **7%** |
| 7 | reduce opportunities for defect/failure | 1 | 1 | 1 | 2 | 1 | 1 | | 1 | 1 | 2 | 1 | 1 | 13 | **8%** |
| 8 | eliminate NVA activities | 0,2 | 0,2 | 1 | 2 | 0,2 | 1 | 1 | | 0,2 | 2 | 1 | 1 | 9,8 | **6%** |
| 9 | reduce production stoppages due to faulty equipment | 1 | 0,2 | 2 | 5 | 1 | 1 | 1 | 2 | | 2 | 1 | 1 | 17,2 | **11%** |
| 10 | new/upgraded equipment and materials | 0,2 | 0,1 | 0,2 | 1 | 0,1 | 0,1 | 0,2 | 0,2 | 0,2 | | 0,1 | 0,2 | 2,6 | **2%** |
| 11 | improve space and work organization | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 5 | | 1 | 17 | **11%** |
| 12 | eliminate unnecessary motion | 1 | 0,2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | | 12,2 | **8%** |
| | **Column Total** | 11 | 5,2 | 13 | 26 | 6,9 | 11 | 9,4 | 13 | 8,7 | 30 | 8,5 | 10 | **153** | **100%** |

Appendix F: Final Priorities Matrix for the Analysis phase

| | Improvement Opportunities | a. Low investment cost | | c. High potential money savings | | e. High improvement potential for defects reduction | | f. High improvement potential for ergonomic conditions | | r. Current availability for implementation | | Row Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0,13 | | 0,08 | | 0,07 | | 0,07 | | 0,08 | | | |
| 1 | reduce number of accidents and sick leaves | 0,10 | 0,013 | 0,04 | 0,004 | 0,06 | 0,004 | 0,11 | 0,007 | 0,08 | 0,006 | 0,03 | 8% |
| 2 | reduce exposure to dangerous situations | 0,08 | 0,011 | 0,02 | 0,002 | 0,03 | 0,002 | 0,12 | 0,008 | 0,16 | 0,012 | 0,03 | 8% |
| 3 | improve ergonomic conditions for static activities | 0,05 | 0,006 | 0,04 | 0,004 | 0,04 | 0,003 | 0,13 | 0,009 | 0,07 | 0,006 | 0,03 | 6% |
| 4 | reduce loads moving and lifting | 0,03 | 0,005 | 0,09 | 0,007 | 0,10 | 0,007 | 0,13 | 0,009 | 0,02 | 0,002 | 0,03 | 7% |
| 5 | improve employees motivation and satisfaction | 0,16 | 0,021 | 0,04 | 0,003 | 0,04 | 0,003 | 0,12 | 0,008 | 0,12 | 0,010 | 0,04 | 10% |
| 6 | increase employees involvement in continuous improvement | 0,11 | 0,014 | 0,07 | 0,006 | 0,04 | 0,003 | 0,05 | 0,004 | 0,07 | 0,006 | 0,03 | 7% |
| 7 | reduce opportunities for defect/failure | 0,10 | 0,013 | 0,07 | 0,006 | 0,13 | 0,009 | 0,01 | 0,001 | 0,08 | 0,007 | 0,03 | 8% |
| 8 | eliminate NVA activities | 0,16 | 0,021 | 0,18 | 0,015 | 0,15 | 0,011 | 0,06 | 0,004 | 0,06 | 0,005 | 0,06 | 13% |
| 9 | reduce production stoppages due to faulty equipment | 0,04 | 0,005 | 0,09 | 0,007 | 0,11 | 0,008 | 0,01 | 0,001 | 0,11 | 0,009 | 0,03 | 7% |
| 10 | new/upgraded equipment and materials | 0,01 | 0,001 | 0,07 | 0,006 | 0,12 | 0,008 | 0,07 | 0,005 | 0,02 | 0,001 | 0,02 | 5% |
| 11 | improve space and work organization | 0,08 | 0,010 | 0,10 | 0,009 | 0,06 | 0,004 | 0,09 | 0,006 | 0,11 | 0,009 | 0,04 | 9% |
| 12 | eliminate unnecessary motion | 0,09 | 0,012 | 0,18 | 0,015 | 0,13 | 0,009 | 0,10 | 0,007 | 0,08 | 0,006 | 0,05 | 12% |
| | **Column Total** | 0,13 | | 0,08 | | 0,07 | | 0,07 | | 0,08 | | **0,43** | **100%** |

Appendix G: Cause-and-Effect Diagram



Appendix H: Improvement action proposals Matrices

For criterion: **a. Low investment cost**

| | Improvement Proposals | High benches for static effort | Ergonomic gymnastics | Waste conduit | Blades support identification | Knife holder | Disposable gloves holder | Self-levelling turntable | Self-tilting lift | Treadmill for dry goods room | Faulty equipment signaling | Preventive maintenance plan | Scullery team leader | Change labels printing order | Organization boards | Marks on the floor | Team meetings plan | Suggestion box | Bags instead of cans | Lemon juice | Row Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | | |
| A | High benches for static effort | | 2 | 5 | 0,2 | 1 | 1 | 5 | 5 | 5 | 0,2 | 0,2 | 2 | 1 | 1 | 2 | 0,2 | 1 | 1 | 1 | 33,8 | 7% |
| B | Ergonomic gymnastics | 0,2 | | 2 | 0,2 | 0,2 | 0,2 | 2 | 2 | 5 | 0,2 | 0,2 | 0,2 | 1 | 0,2 | 1 | 0,2 | 0,2 | 1 | 0,2 | 16,2 | 3% |
| C | Waste conduit | 0,1 | 0,2 | | 0,1 | 0,1 | 0,1 | 0,2 | 0,2 | 0,2 | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,2 | 0,1 | 0,1 | 0,1 | 0,1 | 2,3 | 0% |
| D | Blades support identification | 2 | 2 | 5 | | 1 | 1 | 5 | 5 | 5 | 0,2 | 2 | 0,2 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 38,4 | 8% |
| E | Knife holder | 1 | 2 | 5 | 1 | | 1 | 5 | 0,1 | 5 | 0,2 | 2 | 0,2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 30,5 | 6% |
| F | Disposable gloves holder | 1 | 2 | 5 | 1 | 1 | | 5 | 0,1 | 5 | 0,2 | 2 | 0,2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 30,5 | 6% |
| G | Self-levelling turntable | 0,1 | 0,2 | 2 | 0,1 | 0,1 | 0,1 | | 1 | 1 | 0,1 | 0,1 | 0,1 | 0,2 | 0,1 | 1 | 0,1 | 0,1 | 0,2 | 0,2 | 6,8 | 1% |
| H | Self-tilting lift | 0,1 | 0,2 | 2 | 0,1 | 5 | 5 | 1 | | 1 | 5 | 0,1 | 5 | 0,2 | 0,1 | 1 | 0,1 | 0,1 | 0,2 | 0,2 | 26,4 | 5% |
| I | Treadmill for dry goods room | 0,1 | 0,1 | 2 | 0,1 | 0,1 | 0,1 | 1 | 1 | | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 1 | 0,1 | 0,1 | 0,2 | 0,2 | 6,6 | 1% |
| J | Faulty equipment signaling | 2 | 2 | 5 | 2 | 2 | 2 | 5 | 0,1 | 5 | | 1 | 0,2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 34,3 | 7% |
| K | Preventive maintenance plan | 2 | 2 | 5 | 0,2 | 0,2 | 0,2 | 5 | 5 | 5 | 1 | | 1 | 2 | 2 | 5 | 1 | 1 | 2 | 2 | 41,6 | 8% |
| L | Scullery team leader | 0,2 | 2 | 5 | 2 | 2 | 2 | 5 | 0,1 | 5 | 2 | 1 | | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 38,3 | 8% |
| M | Change labels printing order | 1 | 1 | 5 | 1 | 1 | 1 | 2 | 2 | 5 | 1 | 0,2 | 0,2 | | 1 | 1 | 0,1 | 0,2 | 1 | 1 | 24,7 | 5% |
| N | Organization boards | 1 | 2 | 5 | 1 | 1 | 1 | 5 | 5 | 5 | 1 | 0,2 | 0,2 | 1 | | 2 | 1 | 1 | 1 | 1 | 34,4 | 7% |
| O | Marks on the floor | 0,2 | 1 | 2 | 0,2 | 0,2 | 0,2 | 1 | 1 | 1 | 0,2 | 0,1 | 0,2 | 1 | 0,2 | | 0,1 | 0,2 | 1 | 1 | 10,8 | 2% |
| P | Team meetings plan | 2 | 2 | 5 | 1 | 1 | 1 | 5 | 5 | 5 | 1 | 1 | 1 | 5 | 1 | 5 | | 1 | 2 | 2 | 46 | 9% |
| Q | Suggestion box | 1 | 2 | 5 | 1 | 1 | 1 | 5 | 5 | 5 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | | 2 | 2 | 39 | 8% |
| R | Bags instead of cans | 1 | 1 | 5 | 0,2 | 1 | 1 | 2 | 2 | 2 | 1 | 0,2 | 0,2 | 1 | 1 | 1 | 0,2 | 0,2 | | 1 | 21 | 4% |
| S | Lemon juice | 1 | 2 | 5 | 0,2 | 1 | 1 | 2 | 2 | 2 | 1 | 0,2 | 0,2 | 1 | 1 | 1 | 0,2 | 0,2 | 1 | | 22 | 4% |
| | **Column Total** | 16 | 26 | 75 | 11,6 | 18,9 | 19 | 61 | 42 | 67,2 | 15,5 | 11,7 | 12 | 21,6 | 14,8 | 33,2 | 9,4 | 10,4 | 19,7 | 18,9 | **503,6** | **100%** |

| For criterion: | | Improvement Proposals | | | | | | | | | | | | | | | | | | | Row | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **c. High potential money savings** | | High benches for static effort | Ergonomic gymnastics | Waste conduit | Blades support identification | Knife holder | Disposable gloves holder | Self-levelling turntable | Self-tilting lift | Treadmill for dry goods room | Faulty equipment signaling | Preventive maintenance plan | Scullery team leader | Change labels printing order | Organization boards | Marks on the floor | Team meetings plan | Suggestion box | Bags instead of cans | Lemon juice | **Total** | **%** |
| **Improvement Proposals** | | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | | |
| A | High benches for static effort | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| B | Ergonomic gymnastics | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| C | Waste conduit | | | | 1 | 1 | 1 | | | 1 | 2 | | 1 | 0,2 | 0,2 | 1 | 2 | | 1 | 1 | 12,4 | 7% |
| D | Blades support identification | | | 1 | | 1 | 1 | | | 1 | 1 | | 1 | 0,2 | 1 | 1 | 2 | | 0,2 | 0,2 | 10,6 | 6% |
| E | Knife holder | | | 1 | 1 | | 1 | | | 1 | 2 | | 1 | 1 | 1 | 1 | 5 | | 0,2 | 1 | 16,2 | 9% |
| F | Disposable gloves holder | | | 1 | 1 | 1 | | | | 1 | 2 | | 1 | 1 | 1 | 1 | 5 | | 0,2 | 1 | 16,2 | 9% |
| G | Self-levelling turntable | | | | | | | | | | | | | | | | | | | | | 0% |
| H | Self-tilting lift | | | | | | | | | | | | | | | | | | | | | 0% |
| I | Treadmill for dry goods room | | | 1 | 1 | 1 | 1 | | | | 1 | | 0,2 | 1 | 1 | 1 | 2 | | 0,2 | 0,2 | 10,6 | 6% |
| J | Faulty equipment signaling | | | 0,2 | 1 | 0,2 | 0,2 | | | 1 | | | 0,2 | 0,2 | 0,2 | 0,2 | 2 | | 0,1 | 0,1 | 5,6 | 3% |
| K | Preventive maintenance plan | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| L | Scullery team leader | | | 1 | 1 | 1 | 1 | | | 2 | 2 | | | 1 | 1 | 2 | 5 | | 1 | 1 | 19 | 10% |
| M | Change labels printing order | | | 2 | 2 | 1 | 1 | | | 1 | 2 | | 1 | | 1 | 2 | 5 | | 1 | 1 | 20 | 11% |
| N | Organization boards | | | 2 | 1 | 1 | 1 | | | 1 | 2 | | 1 | 1 | | 1 | 2 | | 0,2 | 0,2 | 13,4 | 7% |
| O | Marks on the floor | | | 1 | 1 | 1 | 1 | | | 1 | 2 | | 0,2 | 0,2 | 1 | | 2 | | 0,2 | 0,2 | 10,8 | 6% |
| P | Team meetings plan | | | 0,1 | 0,2 | 0,1 | 0,1 | | | 2 | 0,2 | | 0,1 | 0,1 | 0,2 | 0,2 | | | 0,1 | 0,1 | 3,5 | 2% |
| Q | Suggestion box | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| R | Bags instead of cans | | | 1 | 2 | 2 | 2 | | | 2 | 5 | | 1 | 1 | 2 | 2 | 5 | | | 1 | 26 | 14% |
| S | Lemon juice | | | 1 | 2 | 1 | 1 | | | 2 | 5 | | 1 | 1 | 2 | 2 | 5 | | 1 | | 24 | 13% |
| **Column Total** | | 0 | 0 | 12,3 | 14 | 11 | 11,3 | 0 | 0 | 16 | 26,2 | 0 | 8,7 | 7,9 | 11,6 | 14,4 | 42 | 0 | 5,4 | 7 | **188,3** | **100%** |

According to the Improvement Opportunities matrix on Criterion c., these proposals will not be considered

| For criterion: e. High improvement potential for increasing productivity | | A High benches for static effort | B Ergonomic gymnastics | C Waste conduit | D Blades support identification | E Knife holder | F Disposable gloves holder | G Self-levelling turntable | H Self-tilting lift | I Treadmill for dry goods room | J Faulty equipment signaling | K Preventive maintenance plan | L Scullery team leader | M Change labels printing order | N Organization boards | O Marks on the floor | P Team meetings plan | Q Suggestion box | R Bags instead of cans | S Lemon juice | Row Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Improvement Proposals** | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | | |
| A | High benches for static effort | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| B | Ergonomic gymnastics | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| C | Waste conduit | | | | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 0,2 | 1 | 1 | | | 1 | 2 | 16,2 | **7%** |
| D | Blades support identification | | | 0,2 | | 1 | 0,2 | 0,2 | 0,2 | 2 | 2 | 1 | 0,2 | 0,2 | 1 | 1 | | | 0,2 | 1 | 10,4 | **4%** |
| E | Knife holder | | | 1 | 1 | | 0,2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 14,2 | **6%** |
| F | Disposable gloves holder | | | 1 | 2 | 2 | | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | | | 1 | 2 | 20 | **8%** |
| G | Self-levelling turntable | | | 1 | 2 | 1 | 1 | | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 16 | **7%** |
| H | Self-tilting lift | | | 1 | 2 | 1 | 1 | 1 | | 1 | 2 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 16 | **7%** |
| I | Treadmill for dry goods room | | | 1 | 2 | 1 | 0,2 | 1 | 1 | | 2 | 1 | 1 | 0,2 | 1 | 1 | | | 1 | 1 | 14,4 | **6%** |
| J | Faulty equipment signaling | | | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | | 0,2 | 0,1 | 0,1 | 0,2 | 0,2 | | | 0,1 | 0,1 | 2,4 | **1%** |
| K | Preventive maintenance plan | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | | 0,2 | 0,2 | 1 | 1 | | | 0,2 | 0,2 | 11,8 | **5%** |
| L | Scullery team leader | | | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 5 | 2 | | 2 | 5 | 5 | | | 2 | 5 | 34 | **14%** |
| M | Change labels printing order | | | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 5 | 2 | 0,2 | | 2 | 2 | | | 1 | 2 | 24,2 | **10%** |
| N | Organization boards | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 0,1 | 0,2 | | 1 | | | 1 | 1 | 13,3 | **6%** |
| O | Marks on the floor | | | 1 | 1 | 1 | 0,2 | 1 | 1 | 1 | 2 | 1 | 0,1 | 0,2 | 1 | | | | 0,2 | 0,2 | 10,9 | **5%** |
| P | Team meetings plan | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| Q | Suggestion box | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| R | Bags instead of cans | | | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 5 | 2 | 0,2 | 1 | 1 | 2 | | | | 2 | 21,2 | **9%** |
| S | Lemon juice | | | 0,2 | 1 | 1 | 0,2 | 1 | 1 | 1 | 5 | 2 | 0,1 | 0,2 | 1 | 2 | | | 0,2 | | 15,9 | **7%** |
| | **Column Total** | 0 | 0 | 13 | 21,2 | 14,2 | 9,2 | 12 | 12 | 16,2 | 40 | 17,2 | 7,2 | 8,5 | 18,2 | 21,2 | 0 | 0 | 11 | 20 | **240,9** | **100%** |

According to the Improvement Opportunities matrix on Criterion e., these proposals will not be considered

| For criterion: | | Improvement Proposals | | | | | | | | | | | | | | | | | | | Row | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **f. High improvement potential for ergonomic conditions** | | High benches for static effort | Ergonomic gymnastics | Waste conduit | Blades support identification | Knife holder | Disposable gloves holder | Self-levelling turntable | Self-tilting lift | Treadmill for dry goods room | Faulty equipment signaling | Preventive maintenance plan | Scullery team leader | Change labels printing order | Organization boards | Marks on the floor | Team meetings plan | Suggestion box | Bags instead of cans | Lemon juice | **Total** | **%** |
| **Improvement Proposals** | | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | | |
| A | High benches for static effort | | 1 | 5 | | 2 | 5 | 1 | 1 | 1 | | | 5 | | | 2 | 2 | 2 | 2 | 1 | 30 | **13%** |
| B | Ergonomic gymnastics | 1 | | 5 | | 2 | 5 | 1 | 1 | 1 | | | 5 | | | 2 | 2 | 1 | 2 | 1 | 29 | **13%** |
| C | Waste conduit | 0,1 | 0,1 | | | 0,2 | 1 | 0,2 | 0,2 | 0,2 | | | 2 | | | 1 | 1 | 1 | 1 | 0,2 | 8,2 | **4%** |
| D | Blades support identification | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| E | Knife holder | 0,2 | 0,2 | 2 | | | 2 | 0,2 | 0,2 | 0,2 | | | 2 | | | 2 | 2 | 1 | 1 | 0,2 | 13,2 | **6%** |
| F | Disposable gloves holder | 0,1 | 0,1 | 1 | | 0,2 | | 0,2 | 0,2 | 0,2 | | | 2 | | | 2 | 2 | 0,2 | 0,2 | 0,2 | 8,6 | **4%** |
| G | Self-levelling turntable | 1 | 1 | 2 | | 2 | 2 | | 1 | 1 | | | 5 | | | 2 | 2 | 1 | 2 | 1 | 23 | **10%** |
| H | Self-tilting lift | 1 | 1 | 2 | | 2 | 2 | 1 | | 1 | | | 5 | | | 2 | 2 | 1 | 2 | 1 | 23 | **10%** |
| I | Treadmill for dry goods room | 1 | 1 | 2 | | 2 | 2 | 1 | 1 | | | | 5 | | | 2 | 2 | 1 | 2 | 1 | 23 | **10%** |
| J | Faulty equipment signaling | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| K | Preventive maintenance plan | | | | | | | | | | | | | | | | | | | | | 0% |
| L | Scullery team leader | 0,1 | 0,1 | 0,2 | | 0,2 | 0,2 | 0,1 | 0,1 | 0,1 | | | | | | 0,2 | 0,2 | 0,2 | 0,2 | 0,1 | 2 | **1%** |
| M | Change labels printing order | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| N | Organization boards | | | | | | | | | | | | | | | | | | | | 0 | 0% |
| O | Marks on the floor | 0,2 | 0,2 | 1 | | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | | | 2 | | | | 1 | 0,2 | 1 | 0,2 | 6,8 | **3%** |
| P | Team meetings plan | 0,2 | 0,2 | 1 | | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | | | 2 | | | 1 | | 1 | 1 | 0,2 | 7,6 | **3%** |
| Q | Suggestion box | 0,2 | 1 | 1 | | 1 | 2 | 1 | 1 | 1 | | | 2 | | | 2 | 1 | | 2 | 1 | 16,2 | **7%** |
| R | Bags instead of cans | 0,2 | 0,2 | 1 | | 1 | 2 | 0,2 | 0,2 | 0,2 | | | 2 | | | 1 | 1 | 0,2 | | 0,2 | 9,4 | **4%** |
| S | Lemon juice | 1 | 1 | 2 | | 2 | 2 | 1 | 1 | 1 | | | 5 | | | 2 | 2 | 1 | 2 | | 23 | **10%** |
| **Column Total** | | 6,3 | 7,1 | 25 | 0 | 15 | 26 | 7,3 | 7,3 | 7,3 | 0 | 0 | 44 | 0 | 0 | 21,2 | 20,2 | 10,8 | 18 | 7,3 | **223** | **100%** |

According to the Improvement Opportunities matrix on Criterion f., these proposals will not be considered

| For criterion: | | Improvement Proposals | | | | | | | | | | | | | | | | | | | Row | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **r. Current availability for implementation** | | High benches for static effort | Ergonomic gymnastics | Waste conduit | Blades support identification | Knife holder | Disposable gloves holder | Self-levelling turntable | Self-tilting lift | Treadmill for dry goods room | Faulty equipment signaling | Preventive maintenance plan | Scullery team leader | Change labels printing order | Organization boards | Marks on the floor | Team meetings plan | Suggestion box | Bags instead of cans | Lemon juice | **Total** | |
| **Improvement Proposals** | | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | | |
| A | High benches for static effort | | 2 | | 0,2 | 0,2 | 0,2 | | | | 0,2 | 0,2 | 1 | 1 | 1 | 2 | 1 | 1 | 0,1 | 0,1 | 10,2 | **4%** |
| B | Ergonomic gymnastics | 0,2 | | | 0,2 | 0,2 | 0,2 | | | | 0,1 | 0,1 | 0,2 | 1 | 0,2 | 1 | 0,2 | 0,2 | 0,1 | 0,1 | 4 | **2%** |
| C | Waste conduit | | | | | | | | | | | | | | | | | | | | 0 | **0%** |
| D | Blades support identification | 2 | 2 | | | 1 | 1 | | | | 0,2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 0,2 | 0,2 | 14,6 | **6%** |
| E | Knife holder | 2 | 2 | | 1 | | 1 | | | | 0,2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 0,2 | 0,2 | 14,6 | **6%** |
| F | Disposable gloves holder | 2 | 2 | | 1 | 1 | | | | | 0,2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 0,2 | 0,2 | 14,6 | **6%** |
| G | Self-levelling turntable | | | | | | | | | | | | | | | | | | | | 0 | **0%** |
| H | Self-tilting lift | | | | | | | | | | | | | | | | | | | | 0 | **0%** |
| I | Treadmill for dry goods room | | | | | | | | | | | | | | | | | | | | 0 | **0%** |
| J | Faulty equipment signaling | 2 | 5 | | 2 | 2 | 2 | | | | | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 24 | **9%** |
| K | Preventive maintenance plan | 2 | 5 | | 1 | 1 | 1 | | | | 1 | | 2 | 1 | 2 | 5 | 2 | 2 | 0,2 | 0,2 | 25,4 | **10%** |
| L | Scullery team leader | 1 | 2 | | 1 | 1 | 1 | | | | 0,2 | 0,2 | | 1 | 1 | 2 | 1 | 1 | 0,2 | 0,2 | 12,8 | **5%** |
| M | Change labels printing order | 1 | 1 | | 1 | 1 | 1 | | | | 1 | 1 | 1 | | 1 | 2 | 1 | 1 | 0,2 | 0,2 | 13,4 | **5%** |
| N | Organization boards | 1 | 2 | | 1 | 1 | 1 | | | | 1 | 0,2 | 1 | 1 | | 2 | 1 | 1 | 0,2 | 0,2 | 13,6 | **5%** |
| O | Marks on the floor | 0,2 | 1 | | 0,2 | 0,2 | 0,2 | | | | 0,2 | 0,1 | 0,2 | 0,2 | 0,2 | | 0,2 | 0,2 | 0,1 | 0,1 | 3,3 | **1%** |
| P | Team meetings plan | 1 | 2 | | 1 | 1 | 1 | | | | 1 | 0,2 | 1 | 1 | 1 | 2 | | 0,2 | 0,1 | 0,1 | 12,6 | **5%** |
| Q | Suggestion box | 1 | 2 | | 1 | 1 | 1 | | | | 1 | 0,2 | 1 | 1 | 1 | 2 | 2 | | 0,2 | 0,2 | 14,6 | **6%** |
| R | Bags instead of cans | 5 | 5 | | 2 | 2 | 2 | | | | 1 | 2 | 2 | 2 | 2 | 5 | 5 | 2 | | 1 | 38 | **15%** |
| S | Lemon juice | 5 | 5 | | 2 | 2 | 2 | | | | 1 | 2 | 2 | 2 | 2 | 5 | 5 | 2 | 1 | | 38 | **15%** |
| **Column Total** | | 25 | 38 | 0 | 14,6 | 14,6 | 15 | 0 | 0 | 0 | 8,3 | 10,2 | 16 | 15,2 | 15,4 | 36 | 22,4 | 14,6 | 4 | 4 | **253,7** | **100%** |

According to the Improvement Opportunities matrix on Criterion r., these proposals will not be considered

## Appendix I: Final Priorities Matrix for the Improve stage

| | | Criteria being compared to | | | | | | | | | | Row | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | a. Low investment cost | | c. High potential money savings | | e. High improvement potential for defects reduction | | f. High improvement potential for ergonomic conditions | | r. Current disponibility for implementation | | Total | % |
| | Improvement Proposals | 0,13 | | 0,08 | | 0,07 | | 0,07 | | 0,08 | | | |
| A | High benches for static effort | 0,07 | 0,009 | 0,00 | 0,000 | 0,00 | 0,000 | 0,13 | 0,009 | 0,04 | 0,003 | 0,02 | 5% |
| B | Ergonomic gymnastics | 0,03 | 0,004 | 0,00 | 0,000 | 0,00 | 0,000 | 0,13 | 0,009 | 0,02 | 0,001 | 0,01 | 3% |
| C | Waste conduit | 0,00 | 0,001 | 0,07 | 0,006 | 0,07 | 0,005 | 0,04 | 0,002 | 0,00 | 0,000 | 0,01 | 3% |
| D | Blades support identification | 0,08 | 0,010 | 0,06 | 0,005 | 0,04 | 0,003 | 0,00 | 0,000 | 0,06 | 0,005 | 0,02 | 5% |
| E | Knife holder | 0,06 | 0,008 | 0,09 | 0,007 | 0,06 | 0,004 | 0,06 | 0,004 | 0,06 | 0,005 | 0,03 | 6% |
| F | Disposable gloves holder | 0,06 | 0,008 | 0,09 | 0,007 | 0,08 | 0,006 | 0,04 | 0,003 | 0,06 | 0,005 | 0,03 | 7% |
| G | Self-levelling turntable | 0,01 | 0,002 | 0,00 | 0,000 | 0,07 | 0,005 | 0,10 | 0,007 | 0,00 | 0,000 | 0,01 | 3% |
| H | Self-tilting lift | 0,05 | 0,007 | 0,00 | 0,000 | 0,07 | 0,005 | 0,10 | 0,007 | 0,00 | 0,000 | 0,02 | 4% |
| I | Treadmill for dry goods room | 0,01 | 0,002 | 0,06 | 0,005 | 0,06 | 0,004 | 0,10 | 0,007 | 0,00 | 0,000 | 0,02 | 4% |
| J | Faulty equipment signaling | 0,07 | 0,009 | 0,03 | 0,003 | 0,01 | 0,001 | 0,00 | 0,000 | 0,09 | 0,007 | 0,02 | 5% |
| K | Preventive maintenance plan | 0,08 | 0,011 | 0,00 | 0,000 | 0,05 | 0,003 | 0,00 | 0,000 | 0,10 | 0,008 | 0,02 | 5% |
| L | Scullery team leader | 0,08 | 0,010 | 0,10 | 0,009 | 0,14 | 0,010 | 0,01 | 0,001 | 0,05 | 0,004 | 0,03 | 8% |
| M | Change labels printing order | 0,05 | 0,006 | 0,11 | 0,009 | 0,10 | 0,007 | 0,00 | 0,000 | 0,05 | 0,004 | 0,03 | 6% |
| N | Organization boards | 0,07 | 0,009 | 0,07 | 0,006 | 0,06 | 0,004 | 0,00 | 0,000 | 0,05 | 0,004 | 0,02 | 5% |
| O | Marks on the floor | 0,02 | 0,003 | 0,06 | 0,005 | 0,05 | 0,003 | 0,03 | 0,002 | 0,01 | 0,001 | 0,01 | 3% |
| P | Team meetings plan | 0,09 | 0,012 | 0,02 | 0,002 | 0,00 | 0,000 | 0,03 | 0,002 | 0,05 | 0,004 | 0,02 | 5% |
| Q | Suggestion box | 0,08 | 0,010 | 0,00 | 0,000 | 0,00 | 0,000 | 0,07 | 0,005 | 0,06 | 0,005 | 0,02 | 5% |
| R | Bags instead of cans | 0,04 | 0,005 | 0,14 | 0,012 | 0,09 | 0,006 | 0,04 | 0,003 | 0,15 | 0,012 | 0,04 | 9% |
| S | Lemon juice | 0,04 | 0,006 | 0,13 | 0,011 | 0,07 | 0,005 | 0,10 | 0,007 | 0,15 | 0,012 | 0,04 | 9% |
| | Column Total | 0,13 | | 0,08 | | 0,07 | | 0,07 | | 0,08 | | 0,43 | 100% |

## Appendix J: Project Plans for the Improvement Actions to be implemented

**Improvement Action S:**

| | |
|---|---|
| **Title** | **Frozen lemon juice instead of fresh squeezed lemons** |
| **Intention** | Eliminate a task that consumes a lot of unnecessary time and is ergonomically atrocious due to the equipment used, especially when the lemon juice is mainly utilized to season other foodstuff. |
| **Objective** | Increase productivity by eliminating NVA activities<br>Reduce the occurrence of accidents<br>Reduce absence rate<br>Reduce turnover rate<br>Increase employees' motivation and satisfaction |
| **Problems addressed** | Loss of productivity due to the workers' fatigue accumulation<br>Wasted time performing non-value-added activities<br>Development of WRMSDs due to repetition and posture<br>Physical exertion perceived as very high by workers at both sections, specifically prolonged static effort<br>High number of absences and sick leaves<br>Work and ergonomic conditions perceived as bad |
| **Threats** | Maintain food quality<br>Supplier that meets the Kitchen's HACCP standards |
| **Conclusion date** | 31st of July 2015 |
| **Project Owner** | Production director |

### ACTIONS, DATES AND RESPONSIBILITIES

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Ask for budgets** | 1/Mar/15 | Budget | LR |
| **Test product** | 15/Apr/15 | Product quality approved | VE |
| **Approve suppliers standards and product specifications** | 30/Apr/15 | Approval from HACCP dep | AF |
| **Insert new product in the computers system** | 30/Apr/15 | Operational new code | GP |

| | | | |
|---|---|---|---|
| **Approval to buy** | 30/Apr/15 | Approval document | PL |
| **Order first batch** | 15/May/15 | Order to supplier | LR |
| **Define working procedures** | 15/May/15 | Working method plan | PL/CS/LR/SS |
| **Control** | | Visual control | Management team |
| | | Food quality control | HACCP responsible |

**Improvement Action R:**

| | |
|---|---|
| **Title** | **Substitute canned products** |
| **Intention** | Eliminate a task that consumes a lot of unnecessary time, is ergonomically disapproved and presents health risks to both workers and clients. Concerns the Preparations section. |
| **Objective** | Increase productivity by eliminating NVA activities<br>Reduce work and HACCP risks<br>Reduce the occurrence of accidents<br>Reduce absence rate<br>Reduce turnover rate<br>Increase employees' motivation and satisfaction |
| **Problems addressed** | Identified risk according to HACCP standards<br>High number of accidents, absences and sick leaves<br>Loss of productivity due to the workers' fatigue accumulation and wasted time performing non-value-added activities<br>Physical exertion perceived as very high<br>Work and ergonomic conditions perceived as bad |
| **Threats** | Maintain food quality<br>Supplier that meets the Kitchen's HACCP standards |
| **Conclusion date** | 31st of July 2015 |
| **Project Owner** | Production director |

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Ask for budgets** | 1/Mar/15 | Budget | LR |
| **Test product** | 15/Apr/15 | Product quality approved | VE |
| **Approve suppliers standards and product specifications** | 30/Apr/15 | Approval from HACCP dep | AF |
| **Insert new products in the computers system** | 30/Apr/15 | Operational new codes | GP |
| **Approval to buy** | 30/Apr/15 | Approval document | PL |
| **Order first batch** | 15/May/15 | Order to supplier | LR |
| **Define working procedures** | 15/May/15 | Working method plan | PL/CS/LR/SS |
| **Control** | | Visual control | Management team |
| | | Food quality control | HACCP responsible |

**Improvement Action L:**

| | |
|---|---|
| **Title** | **Dedicated team leader for the Scullery section** |
| **Aim** | Improve the Scullery work and space organization, eliminating inefficiencies and better motivating the team. Reduce/eliminate wasted time, unnecessary motion and production stoppages due to lack of material in both Preparations and Cooking sectors. |
| **Objective** | • Eliminate material shortage, eliminating wasted time and production stoppages<br>• Improve sanitation quality<br>• Improve hygiene and safety conditions<br>• Increase productivity<br>• Improve work and space organization |
| **Problems Addressed** | • Production stoppages due to lack of material |

| | |
|---|---|
| | • Waste (material and motion)<br>• Lack of organization perceived by the Scullery workers<br>• Pour sanitation perceived by the employees<br>• Defects and extra physical effort for using the wrong material for a certain task (when the right one is missing) |
| **Threats** | • Changing schedules and staff<br>• Resistance to change |
| **Conclusion Date** | 1st of October 2015 |
| **Project owner** | Production director |

### ACTIONS, DATES AND RESPONSIBILITIES

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Action approval from entire management team** | 31/Aug/15 | Approval | PL |
| **Appoint Team Leader (TL)** | 10/Sep/15 | RH staff changes | PL |
| **Communicate to the team** | 14/Sep/15 | Team Meeting | PL |
| **Organize team functions** | 28/Sep/15 | Scullery team meeting | PL/New TL |
| **Initiate function as TL** | 1/Oct/15 | | PL |
| **Work plan for the Scullery in 2016** | December 2015 | Daily production plan and objectives | New TL |
| **Control** | | Visual control | MT |
| | | Pilot KPIs | PL/MT |

**Improvement Action F:**

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|---|---|
| **Title** | **Disposable gloves holders in each work station** |
| **Aim** | Fix disposable gloves holders in each work station of both the Preparations and Cooking sections. Disposable gloves is the single most used PPE in this sections. Workers are always |

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|---|---|
| | looking for it because they are in card boxes, so anyone can move them. |
| **Objective** | • Reduce wasted time<br>• Reduce unnecessary motion<br>• Improve working conditions<br>• Increase productivity<br>• Improve space organization |
| **Problems Addressed** | • Working conditions<br>• Wasted time (NVA)<br>• Unnecessary motion<br>• Lack of organization<br>• Productivity |
| **Threats** | • Difficult to sanitize<br>• Employees don't use new instrument (resistance to change)<br>• Need for refill |
| **Conclusion Date** | 31st of October 2015 |
| **Project owner** | Production director |

## Actions, dates and responsibilities

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Define size, requirements, quantity and spots** | 1/Aug/15 | Design | JC/AF/PL |
| **Ask for budget** | 15/Aug/15 | Budget | JC |
| **Approve budget and project** | 1/Sep/15 | Approval | PL |
| **Test instrument** | 15/Sep/15 | Product approved | JC/AF |
| **Approve suppliers standards and product specifications** | 30/Sep/15 | Approval from HACCP dep | AF |
| **Order to supplier** | 10/Oct/15 | Order | JC |
| **Fix holders in right places** | 31/Oct/15 | | JC |
| **Brief workers** | 31/Oct/15 | Team meetings | PL |
| **Control** | | Visual control | MT |
| | | Pilot KPIs | PL/MT |

**Improvement Action E:**

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|---|---|
| **Title** | **Knife holders in each working station of the Preparations section** |
| **Aim** | By putting knife holders that are easy to use, the workers can put down the tool while performing a task, without causing arm to them or any other person and avoiding somebody to waste time looking for it later. |
| **Objective** | • Reduce wasted time and motion looking for tools<br>• Reduce exposure to dangerous situations<br>• Reduce number of accidents<br>• Increase productivity<br>• Improve space organization |
| **Problems Addressed** | • Number of accidents<br>• Wasted time (NVA)<br>• Unnecessary motion<br>• Lack of organization in the work space<br>• Productivity |
| **Threats** | • Sanitation problems<br>• Workers don't use the new instrument |
| **Conclusion Date** | 31st October 2015 |
| **Project owner** | Production director |

ACTIONS, DATES AND RESPONSIBILITIES

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Define size, requirements, quantity and spots** | 1/Aug/15 | Design | JC/AF/PL |
| **Ask for budget** | 15/Aug/15 | Budget | JC |
| **Approve budget and project** | 1/Sep/15 | Approval | PL |
| **Test instrument** | 15/Sep/15 | Product approved | JC/AF |
| **Approve suppliers standards and product specifications** | 30/Sep/15 | Approval from HACCP dep | AF |
| **Order to supplier** | 10/Oct/15 | Order | JC |
| **Fix holders in right places** | 31/Oct/15 | | JC |
| **Brief workers** | 31/Oct/15 | Team meetings | PL |

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| **Control** | | Visual control | MT |
| | | Pilot KPIs | PL/MT |

**Improvement Action M:**

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|---|---|
| **Title** | **Change the printing order of the tags in the Preparation section** |
| **Aim** | Eliminate the NVA task of ordering the tags according to its reference (product) |
| **Objective** | • Eliminate waste<br>• Reduce misinformation<br>• Reduce production flaws<br>• Increase productivity<br>• Improve work organization |
| **Problems Addressed** | • Tags are printed according to its production order<br>• Time wasted performing NVA activities<br>• Lack of work organization<br>• Rework due to mistakes |
| **Threats** | • Solution needs intervention from outside the Kitchen's team (shared computing and systems team)<br>• Lack of control over the priority given to the project |
| **Conclusion Date** | 31st August 2015 |
| **Project owner (PO)** | Production director |

ACTIONS, DATES AND RESPONSIBILITIES

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Get information about the intervention needed** | 30/Jun/15 | E-mail | PL |
| **Formalize intervention request** | 15/Jun/15 | Submit request on the Group's intranet | PL |
| **Request approval** | | Approval | DSI |
| **Perform intervention** | 31/Aug/15 | Printing order changed | DSI |

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| **Test** | | | Preparations Team |
| **Control** | | Visual control | MT |
| | | Training | PO |
| | | Pilot KPIs | PL/MT |

**Improvement Action N:**

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|---|---|
| **Title** | **Work organization boards on the Preparations room and the Final Picking room** |
| **Aim** | Organize work so to reduce communication shortages and production flaws, using a visual and instinctive tool for everybody. In the final picking room it would also eliminate the NVA task of arranging the materials by reference. |
| **Objective** | • Reduce/eliminate NVA activities<br>• Reduce communication problems<br>• Reduce production defects<br>• Increase productivity<br>• Improve work and space organization |
| **Problems Addressed** | • Tags are left around the room unattended (possible lost or damage implicating production defects)<br>• Wasted time and motion<br>• Lack of work organization<br>• Communication problems<br>• Lost/mix up of products on the final picking room<br>• One FTE/day adds no value |
| **Threats** | • Employees don't adopt the new work method<br>• Final picking room might not have enough space |
| **Conclusion Date** | 31st October 2015 |
| **Project owner (PO)** | Production director |

ACTIONS, DATES AND RESPONSIBILITIES

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Define spots, measures and requirements of the boards** | 30/Jun/15 | Design | PL/CC |
| **Define better method to organize final picking room** | 15/Jul/15 | Room design | PL |
| **Ask for budget** | 15/Aug/15 | Budget | JC |

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|---|---|---|---|
| **Approve suppliers standards and product specifications** | 29/Aug/15 | Approval from HACCP dep | AF |
| **Approve project** | 30/Aug/15 | Approval | PL |
| **Order necessary material to supplier** | 15/Sep/15 | Order | JC |
| **Install boards** | 31/Oct/15 | Operational tools | JC |
| **Brief the Preparations team workers** | 31/Oct/15 | Team meeting | SS |
| **Control** | | Visual control | MT |
| | | Pilot KPIs | PL/MT |
| | | Training | PO |

**Improvement Action D:**

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|---|---|
| **Title** | **Blades identification panel in the Preparations section** |
| **Aim** | Use an identification panel next to the blades holder on the wall, so to better organize the work space and allow a visual identification of the needed tools. This decreases the time spent looking for the right tool and the probability of production defects to occur, increasing productivity. |
| **Objective** | • Reduce wasted time and motion<br>• Reduce defects number<br>• Increase productivity |
| **Problems Addressed** | • Wasted time in NVA tasks<br>• Number of defects and rework<br>• Lack of work organization |
| **Threats** | • Wear/damage identification panel due to sanitation |
| **Conclusion Date** | 31st of October 2015 |
| **Project owner** | Production director |

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Define spots, measures and requirements of the panel** | 30/Jun/15 | Design | SS/CC |
| **Ask for budget** | 15/Aug/15 | Budget | JC |
| **Approve suppliers standards and product specifications** | 29/Aug/15 | Approval from HACCP dep | AF |
| **Approve project** | 30/Aug/15 | Approval | PL |
| **Order panel to supplier** | 15/Sep/15 | Order | JC |
| **Install panel** | 31/Oct/15 | Operational tools | JC |
| **Brief the Preparations team workers** | 31/Oct/15 | Team meeting | SS |
| **Control** | | Visual control | MT |
| | | Pilot KPIs | PL/MT |

**Improvement Action K:**

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|---|---|
| **Title** | **Preventive maintenance plan** |
| **Aim** | Plan and execute a preventive maintenance plan to all the Kitchen's equipment and instruments. The aim is to avoid accidents, dangerous situations, expedite production and decrease physical effort, hence improving work and ergonomic conditions. |
| **Objective** | • Reduce number of accidents<br>• Improve safety conditions<br>• Reduce production defects<br>• Increase productivity and efficiency<br>• Reduce investment in new equipment and materials |
| **Problems Addressed** | • Safety conditions in the work place<br>• Inefficiency due to malfunctioning equipment |

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| | • Wasted time<br>• Productivity<br>• Number of defects<br>• Investment in new material<br>• Number of accidents |
| **Threats** | • Lack of inventory on all material and tools<br>• Cannot interrupt production flow<br>• Currently there are too many small repairs needed<br>• Difficulty in executing a preventive plan when interventions are needed at all times because equipment is already wear out |
| **Conclusion Date** | 1st of February 2016 |
| **Project owner** | Maintenance coordinator |

## ACTIONS, DATES AND RESPONSIBILITIES

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Inventory all instruments and material** | 31/Oct/15 | Inventory | JC |
| **Define the plan schedule** | 31/Nov/15 | Maintenance Plan | JC |
| **Define stock of necessary basic tools and parts** | 31/Nov/15 | Maintenance Plan | JC |
| **Approve plan** | 15/Dec/15 | Approval | PL |
| **Buy necessary tools and parts** | 15/Jan/16 | Order | JC |
| **Brief workers** | 31/Jan/16 | Team meeting | JC |
| **Start executing the plan** | 1/Feb/16 | | JC |
| **Control** | | Visual control | MT |
| | | Pilot KPIs | PL/MT |

**Improvement Action A:**

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|---|---|
| **Title** | **High-sitting benches for long-time static activities** |
| **Intention** | Provide better work conditions, specifically regarding long-time static exertion activities, to diminish the probability of developing WRMSDs and consequently reduce the accidents, absence and turnover rates. The increase the employees' motivation and consequent rise in productivity can also be expected. |
| **Objective** | Reduce the occurrence of accidents<br>Reduce absence rate<br>Reduce turnover rate<br>Increase employees' motivation and satisfaction<br>Increase productivity |
| **Problems addressed** | Loss of productivity due to the workers' fatigue accumulation<br>Physical exertion perceived as very high by workers at both sections, specifically prolonged static effort<br>High number of accidents in the lumbar area<br>High number of absences and sick leaves<br>Work and ergonomic conditions perceived as bad |
| **Threats** | Storage space for the benches<br>Misuse of the benches |
| **Conclusion date** | 31st of November 2015 |
| **Project Owner** | Production Director |

ACTIONS, DATES AND RESPONSIBILITIES

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Ask for budgets** | 12/Jul/15 | Budget | JC |
| **Approval to buy** | 12/Ago/15 | Approval document | PL |
| **Order the benches** | 12/Sep/15 | Order to supplier | PL/JC |
| **Define rules and storage space** | 30/Oct/15 | Working method plan | PL/CS |

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|---|---|---|---|
| **Start using the benches** | 31/Nov/15 | | CS/PL |
| **Control** | | Visual control | MT |
| | | Pilot KPIs | PL/MT |

**Improvement Action P:**

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|---|---|
| **Title** | **Kaizen team meetings plan** |
| **Intention** | Accompaniment of the daily work results (KPIs), smoothing the communication amongst all levels of the hierarchy so to nurture a continuous improvement and more motivating environment |
| **Objective** | • Improve productivity and efficiency<br>• Efficient correction of small recurrent production problems<br>• Involvement of all employees in continuous improvement<br>• Motivate workers, improving work environment and personal satisfaction<br>• Promote a better communication between all workers |
| **Problems addressed** | • Lack of continuous improvement culture<br>• Lack of involvement and motivation of the staff<br>• High turnover rate<br>• Low sense of achievement and satisfaction<br>• Waste of knowledge from experience<br>• Communication problems between the levels of hierarchy |
| **Threats** | • No commitment to the meetings' plan due to lack of time<br>• Low commitment from workers (apprehension)<br>• Current company culture |
| **Conclusion date** | 1st of August 2016 |
| **Project Owner (PO)** | Production director |

## ACTIONS, DATES AND RESPONSIBILITIES

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Define meetings schedules and places** | 30/Jun/15 | Action plan | PL/CC |
| **Approve project** | 3/Jul/15 | Approval | PL |

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|---|---|---|---|
| **Brief management team (MT)** | 15/Jul/16 | Meeting | PL |
| **Brief workers** | 30/Jul/16 | Team meeting | PL/MT |
| **Start executing plan** | 1/Aug/16 | | PL/MT |
| **Control** | | Pilot KPIs | PL/MT |
| | | Training | PO |

**Improvement Action Q:**

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|---|---|
| **Title** | **Suggestions box for all employees** |
| **Intention** | Provide a possibly anonymous tool for all employees, aiming to promote new ideas, continuous improvement and the involvement of the entire team. The suggestions box would be related to a continuous improvement project where new ideas are evaluated and implemented when possible, praising the employees who provide them. |
| **Objective** | • Increase productivity<br>• Efficient correction of eventual production problems<br>• Continuous improvement of the Kitchen's process<br>• Involvement of all the work force<br>• Motivate workers, by listening to their experience<br>• Promote a healthier work environment |
| **Problems addressed** | • Lack of continuous improvement culture<br>• Lack of involvement from staff<br>• Low motivation and satisfaction among the staff<br>• Waste of the workers' experience<br>• Communication problems |
| **Threats** | • Workers low education level<br>• Language issues (international workers)<br>• Low initiative (workers might be apprehensive)<br>• Current company's culture |
| **Conclusion date** | 1st of December 2015 |
| **Project Owner (PO)** | Production director |

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Define implementation plan** | 30/Jun/15 | Action plan | PL/CC |
| **Ask budget for “suggestions box”** | 15/Aug/15 | Budget | JC |
| **Design filling form** | 1/Sep/15 | Form | MP |
| **Approve project** | 30/Sep/15 | Approval | PL |
| **Order suggestions box** | 15/Oct/15 | Order | JC |
| **Control** | | Pilot KPIs | PL/MT |
| | | Training | PO |

**Improvement Action J:**

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|---|---|
| **Title** | **Signs for malfunctioning equipment** |
| **Intention** | Provide a visual and clear signalling tool to indicate if the equipment has problems, is totally disabled or if it is under maintenance. This can streamline communication, help organize the work and help deliver the maintenance plan. |
| **Objective** | • Reduce communication problems<br>• Improve the maintenance plan execution<br>• Improve safety and work conditions<br>• Increase productivity<br>• Eliminate production stoppages/defects due to equipment<br>• Improve space organization |
| **Problems addressed** | • Productivity, meaning production stoppages and defects<br>• Exposure to dangerous situations<br>• Number of accidents<br>• Wasted time and motion<br>• Lack of work and space organization |
| **Threats** | • Misuse of the tool or lack of acceptance from staff<br>• Damage or loss of the signs<br>• Lack of compliment to signs’ procedure requirements |
| **Conclusion date** | 1st of September 2015 |
| **Project Owner (PO)** | Production director |

| Action | Deadline | Result | Responsibility |
|---|---|---|---|
| **Define signs message and subsequent procedure** | 30/Jun/15 | Action plan | JC/CC |
| **Signs designing** | 5/Jul/15 | Design | CC |
| **Ask for budget** | 10/Jul/15 | Budget | JC |
| **Approve project** | 20/Jul/15 | Approval | PL |
| **Order signs to supplier** | 30/Jul/15 | Order | JC |
| **Provide signs for utilization** | 15/Aug/15 | | PL |
| **Brief workers** | 15/Aug/15 | Team meeting | SS/CS/LR/JC |
| **Control** | | Visual control | MT |
| | | Pilot KPIs | PL/MT |
| | | Training | PO |

Appendix K: Suggestions for Future Improvement Actions

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|---|---|
| **Title** | **Self-tilting lift** |
| **Intention** | Provide equipment for lifting and tilting heavy loads, so to relieve the physical effort needed from the Kitchen workers, improving work and ergonomic conditions |
| **Objective** | • Increase productivity/Reduce waste<br>• Improve Kitchen's performance<br>• Reduce physical effort and probability of developing WRMSDs<br>• Reduce number of accidents and absence rate<br>• Reduce personnel costs |
| **Problems addressed** | • High physical exertion perceived by employees<br>• Possible development of WRMSDs – high absence rate<br>• High number of accidents due to moving, handling and lifting heavy loads<br>• Wasted time and motion<br>• Workers motivation and satisfaction |
| **Threats** | • High investment cost<br>• Hard to quantify savings gained from implementation |

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|---|---|
| **Title** | **Treadmill for Dry Goods Room** |
| **Intention** | Install a treadmill between the Dry goods Preparations area and the Dry goods storage room, so to improve the work efficiency and reduce physical effort, wasted time and motion. |
| **Objective** | • Streamline the Dry goods Preparation process<br>• Eliminate NVA tasks, like unnecessary motion<br>• Reduce physical exertion (moving heavy loads)<br>• Improve working conditions<br>• Improve space and work organization |
| **Problems addressed** | • Wasted time and motion (NVA activities)<br>• Physical exertion perceived by workers<br>• Poor work and space organization |
| **Threats** | • High investment cost<br>• Construction needed<br>• Hygiene restrictions (HACCP) |

| | |
|---|---|
| **Title** | **Gymnastics at work or Ergo-motility** |
| **Intention** | Reduce probability of developing WRMSDs and fatigue accumulation, increasing productivity, motivation and satisfaction, therefore reducing absence and turnover rates. |
| **Objective** | • Reduce absence rate<br>• Reduce turnover rate<br>• Increase productivity due to workers' motivation<br>• Reduce number of accidents |
| **Problems addressed** | • Loss of productivity due to workers' fatigue<br>• Number of long term absences<br>• Number of accidents<br>• High turnover rate – perceived bad working conditions |
| **Threats** | • Lack of ideal location for the classes<br>• Necessary materials<br>• Unsuitable clothing<br>• Need for personnel with the required expertise |

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|---|---|
| **Title** | **Paint marks on the floor** |
| **Intention** | Better organize the work space, namely the Preparations, Cooking and Scullery sections, storage rooms and chambers. Paint the floor, delimitating the areas determined for each purpose (working, circulation and storage zones). |
| **Objective** | • Reduce wasted time and motion<br>• Reduce number of accidents<br>• Increase productivity and efficiency<br>• Improve work organization<br>• Improve safety and hygiene conditions |
| **Problems addressed** | • General lack of organization and of signalling<br>• Mix ups and loss of products and materials<br>• Unnecessary motion<br>• Problems in inventory – which imply costs<br>• Lack of space organization and hygiene conditions<br>• Production defects (rework)<br>• Accidents due to misplaced materials |
| **Threats** | • Shortage of space<br>• Work space flexibility compromised<br>• High investment costs of implementation and maintenance |

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|---|---|
| **Title** | **Self-levelling turntable** |
| **Intention** | Provide equipment to lift pallets, relieving the physical exertion by allowing workers to access the products in a correct posture (bring objects to power zone). This would improve ergonomic conditions and prevent the development of WRMSDs. |
| **Objective** | • Increase productivity/Reduce waste<br>• Improve Kitchen's performance<br>• Reduce physical effort and probability of developing WRMSDs<br>• Reduce number of accidents and absence rate<br>• Reduce personnel costs |
| **Problems addressed** | • High physical exertion perceived by employees<br>• Possible development of WRMSDs – high absence rate<br>• High number of accidents due to moving, handling and lifting heavy loads in wrong postures<br>• Wasted time and motion<br>• Workers motivation and satisfaction |
| **Threats** | • High investment cost<br>• Hard to quantify savings gained from implementation |

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|---|---|
| **Title** | **Garbage conduit** |
| **Intention** | Built a garbage conduit underground with openings in every working station of the Preparations area |
| **Objective** | • Eliminate wasted time, motion and NVA tasks<br>• Eliminate cost of buying garbage bags (1.400€/month)<br>• Improve productivity<br>• Improve safety and hygiene conditions |
| **Problems addressed** | • Cost of garbage bags<br>• Wasted time and motion<br>• Working conditions<br>• Physical exertion<br>• Organization of work space |
| **Threats** | • I tis necessary to build from scratch. Current plant restrictions don't permit this intervention<br>• Garbage container must be below the plant level<br>• Hygiene restrictions (HACCP) |