Identification and Waste Reduction in the Bakery Industry Through Continuous Improvement Techniques

Henrique José Raposo Victorino

hhenrique1994@hotmail.com

Instituto Superior Técnico, Lisbon, Portugal

March 2019

Abstract

With the continuous growth of business competitiveness, it is extremely important for any organization to develop successful strategies to please the customers and at the same time reduce the overall costs associated with services and products. One of the aspects worth improving is the amount of waste produced. In this context, the following work focused on promoting waste reduction in a food production line of Bimbo Donuts, Lda, Grupo Bimbo's factory in Mem Martins. The strategy used by the company was the implementation of a PDCA cycle, a Lean methodology supported by visual observation, sampling and several continuous improvement tools such as Pareto diagrams for critical spots/events identification and 5-Whys Analysis to identify their root causes. In the end, some improvement actions have been done as well as the observation of their effect on the line's waste levels. The main goals of this project consisted in decreasing the waste percentage and increasing the line's OEE value, however, due to some uncontrollable factors such as unplanned stoppages during production, the final values obtained showed a waste increase from 4.8% to 5.3% and an OEE decrease from 74.1% to 60.4% when compared to the values reported in 2017 by the company.

Keywords: Lean, Continuous improvement, Waste, Food production lines, OEE.

1. Introduction

1.1 Lean Philosophy

Nowadays customers are demanding a lot from the enterprises regarding their products and services, putting them under a big pressure by other companies [1]. That said, there's a constant need to optimize service quality and at the same time reduce the overall costs. Lean is a worldwide used philosophy with an increased popularity amongst current organizations [2] and Grupo Bimbo is no exception.

Presenting as main goals the identification of customer value, management of the value stream, the use of "pull" mechanisms and the pursuit of perfection [3], lean thinking also provides several continuous improvement tools useful in all types of waste reduction related to processes. Some of them can be summed up like this:

1) Verification Sheet: In any improvement process monitoring, it is extremely important since it helps reading the situation through data collection. This collection is usually done in verification sheets customized in terms of format and parameters by whoever used them. It can be very useful due to its simplicity and easy handling [4].

2) Pareto Diagram: Based on what we call the Pareto Principle, also known as the "Rule of (80/20), that says that about 80% of events come from about 20% of causes [5], it's possible to build diagrams pointing out that same minority of causes considered the key to a successful improvement in order to allocate resources more efficiently after collecting data.

3) 5-Whys Analysis: Born at the time of the Toyota Production System development [6], this is one of the most important tools used to identify the root causes responsible for problems affecting certain processes. It consists in repeatedly asking the question "Why?" enough times (at least five times) to discover the real causes of problems and develop suitable countermeasures [6], however there are situations where this can be done asking only two or three times [7].

Continuous improvement processes often present themselves as a cycle, starting with data collection and analysis and passing through the construction of an improvement plan and its application as well as a subsequent assessment of the results. The last stage comprises change consolidation in case of success, otherwise there are lessons to be learned and formalized before entering the first stage again [8]. This can be described as a PDCA cycle, as shown by Figure 1:

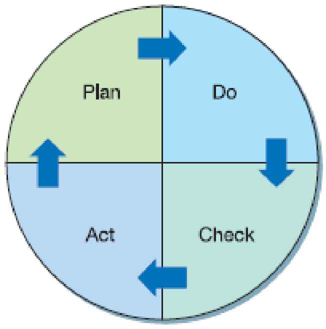

Figure 1 – Continuous improvement as a PDCA cycle [8].

To stablish goals, measure performance and reinforce positive behaviors, the implementation of Key Performance Indicators (KPI) is crucial [9]. For improved profitability, there are all kinds of KPI's, and Overall Equipment Effectiveness (OEE) is one of them [9]. OEE is defined as a measure of total equipment performance, that is, the degree to which the equipment is doing what it's supposed to do [10]. It's very useful to track improvements over a certain period of time and to identify and measure losses of three important aspects: availability, performance and quality [11]. In practical terms, OEE can be calculated like this:

$$OEE = Availability \times Performance \times Quality \quad (1)$$

The "availability" component is the ratio between the actual and the planned operating time (Eq. (2)) and can be affected by unplanned maintenance, minor stoppages or set-up and change-over.

$$Availability = \frac{Actual\ Operating\ Time}{Planned\ Operating\ Time} \quad (2)$$

The "performance" component is the ratio between actual and theoretical production (Eq. (3)) and can be affected by speed losses (can also be seen as the ratio between actual and ideal production speed).

$$Performance = \frac{Actual\ Production}{Theoretical\ Production} \quad (3)$$

The "quality" component is the ratio between non-defective and total units produced

(Eq. (4)) and depends on the defects occurring in the production stages.

$$Quality = \frac{Non\text{-}defective\ Units\ Produced}{Total\ Units\ Produced} \quad (4)$$

1.2 Bimbo Donuts, Lda

Located in Mem Martins, Bimbo Donuts, Lda is a factory recently acquired by Grupo Bimbo responsible to produce bakery and pastry products helping the company being market leader in those two areas in Portugal and Spain [12]. Currently, its production is spread over six different production lines and the work developed aimed to decrease waste levels in Line C, previously considered the most problematic one, where sweet and salty cakes are produced. Grupo Bimbo is also highly recognized as a pioneer at introducing sliced white bread in those two countries [12].

2. Methods

In order to achieve the intended waste reduction in Line C, it was applied a continuous improvement approach, often incorporated in Lean thinking. The global methodology followed is resumed by Figure 2:

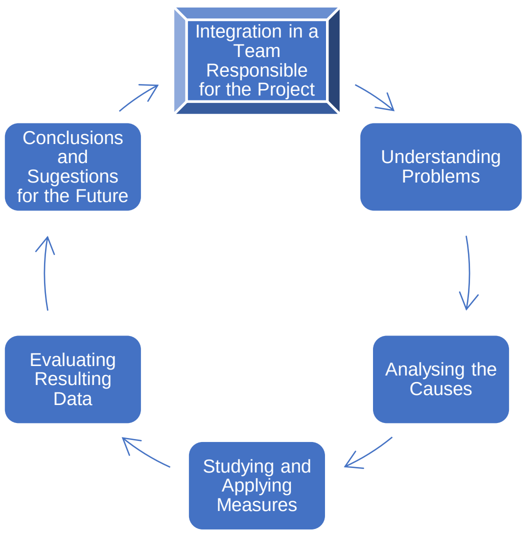

Figure 2 – Methodology usually followed by Grupo Bimbo in continuous improvement projects, acting as a PDCA cycle.

2.1 Integration

The first step towards the end of the cycle is an integration in the facility, keeping track of all the basic concepts about the production lines as well as hygiene and security protocols. After that, it was time to meet the rest of the team which was composed by engineers from all departments and an operator working daily in Line C. This way, there´s a shared knowledge from all the areas making easier the brainstorm process to achieve efficient resolutions.

2.2 Initial Data Collection

After getting used to the factory environment and to the Line C's production routines, the identification of waste spots was essential. It was possible to see that those spots are always equipped with waste bags to carry all the defective products detected during production. Then, data collection took place, through direct observation in all spots using customized verifications sheets. Date, duration, type of product, spot and observed defects were the most important aspects of any sample resulting from the created collection system. The sampling only covered periods of continuous production. That way, without non-planned stoppages interference, speed production could be assumed to be approximately the same in every sample thus this variable would be eliminated. It was also stipulated that each sample should last at least 20 minutes and all this process should be done regarding the production of sweet cake (Type 1 and 2) and the two varieties of salty cake (Hot Dog Bun and Burger Bun). Unfortunately, there were several variable factors that couldn't be eliminated during the sampling, like the shift, the person responsible for a certain task or even the number of workers available at the time.

2.3 Treatment of the Data

First of all, the information collected in each sample was downloaded to the computer to run a basic statistical analysis using available tools in Microsoft® Excel. It was possible to calculate each defect's frequency in each sample (events/hour):

$$Sample\ Freq.(events/h) = \frac{N^{\underline{o}}\ events}{Time\ (h)} \quad (5)$$

With the frequency values obtained, it was possible to reach the average values for all the observed defects:

$$Aver.Freq.\left(\frac{events}{h}\right) = \frac{x_1+x_2+\cdots+x_n}{n} = \frac{1}{n}\sum x_i \quad (6)$$

In this case, *n* is the sampling size and x_i is the defect's frequency associated with sample *i*.

In the end, those values were the ones used to reflect the Line C's real production performance before addition of any improvements. To stablish priorities more efficiently, the average values were used to build several Pareto diagrams, in which it could be identified the spots or defects that influence waste levels in a more meaningful way.

2.4 Analysis of Root Causes

After understanding the overall defects that contribute to the waste amount recorded and the most abundant ones, it's important to know exactly where they came from. For that, another continuous improvement tool was used: the 5-Whys Analysis. This way the real causes responsible for the central problems standing at the "surface" could be identified and thereafter allow to think of more efficient ways of reducing or even eliminating them. This analysis was made separately for the production of the three products studied as well as for the different Line C's spots previously identified.

2.5 Measures Implementation

Now that the root causes were visible for everyone, it was time to debate as a team in order to come up with an Action Plan divided by waste spots, where the main purpose was to definitely establish what measures should be taken, when and by whom. Preferably, their timing should be ordered according to their priority. In other words, and in an ideal scenario, the root causes responsible for the problems generating larger amounts of waste should be dealt with sooner than the others. However, that was not the case, as the chosen actions were scheduled based on the availability of each of the parties involved. Furthermore, before acting on the production itself it is important to restore basic conditions, since a lot of waste can be originated due to precarious conditions and not due to the need of process improvements. However, restoring basic conditions was done at the same time as applying improvement actions, based, once again, on availability.

Unfortunately, some of the measures in the Action Plan were not implemented, remaining on hold until a near future.

2.6 Final Data Collection and Evaluation

Being the measures implemented, a new sampling period was now needed, similar to the initial one (using the same verification sheets) but this time only targeting the Line C's critical spots, and once again done separately by product. This way the impact suffered by the production could be seen through comparison between the performance before and after changes carried out. Interpretation of the results lead to drawing conclusions regarding meeting or not the initially established goals for the project as well as to suggesting relevant subjects for future works to base on, trying to improve or even permanently fix other relevant inefficiencies.

3. Results and Discussion

3.1 Initial Line C's Situation

Taking a first look at Line C's performance after the initial data collection, it was possible to see the overall waste ratio regarding all the different line's spots, considering all three products being manufactured. All the spots were separated according to the processed product. Figure 3 shows this distribution in the form of a Pareto diagram, highlighting the most relevant spots associated to waste production:

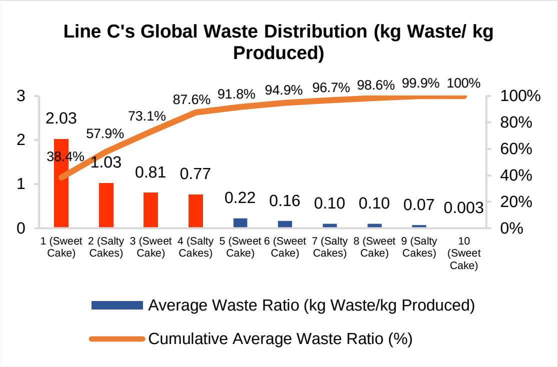

Figure 3 – Pareto diagram regarding the Line C's spots exhibiting waste production.

A clear contrast between spots 1 to 4 and spots 5 to 10 can be seen, as the first 4 represent 87.6% of total waste, in which Spot 1 dominates with a waste ratio of 2.03 kg waste/kg produced (38.4% of total waste). According to the Pareto Principle, these were the spots worth focus on if the main goal is overall waste reduction in Line C. Therefore, it's vital to understand how spots 1 to 4 bring up so much waste and what type of waste is that.

3.2 Study of Spots 1 to 4

Regarding Spot 1, which had the highest waste levels of all spots, it represents the individual packaging stage of sweet cakes (Type 1 and Type 2) and its waste distribution is shown by a Pareto diagram in Figure 4:

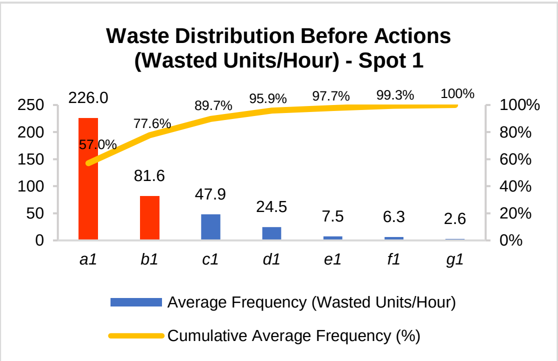

Figure 4 – Pareto diagram regarding inefficiencies leading to waste production observed in Spot 1.

This analysis showed that inefficiencies *a1* and *b1* are the most relevant ones, making a total of 77.6% of the overall waste exhibited in Spot 1. At this point, the 5-Whys Analysis tool was used by the team to identify possible root causes for the presented inefficiencies. Then, an Action Plan targeting Spot 1 was constructed leading to restoring basic conditions as well as implementing some improvement actions. After finishing this step, new data was collected, allowing a comparison between the moment before and after performing all the actions that were possible during the internship, available in Figure 5:

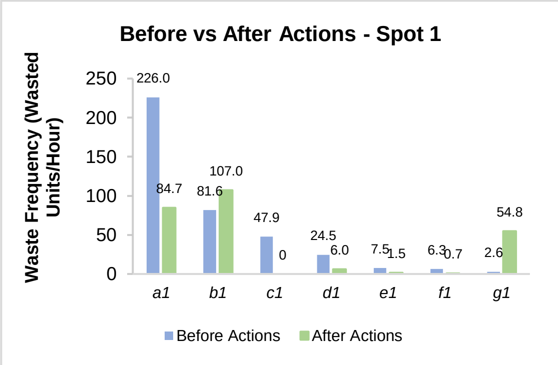

Figure 5 – Comparison between Spot 1's waste levels before and after improvement actions performed.

As expected, Spot 1 showed an overall decrease in waste levels, more specifically a decrease of 35.8%. This is mostly due to a very pronounced decrease observed in the inefficiency *a1*. The chosen measures had also a positive influence on inefficiencies *d1*, *e1* and *f1*. *c1* and *g1* weren't submitted to any improvement action. Unfortunately, due to several non-controllable circumstances such as machine failures, this particular stage of production wasn't flowing as usual, hampering the final data collection process. This way, the final data contained very few samples when compared to the initial one, causing a low statistical meaning in any comparison made.

However, the final data is a positive indicator of the impact caused by those actions.

Regarding Spot 2, it represents the packaging stage of Hot Dog Buns and Burger Buns and its waste distribution is shown in Figure 6:

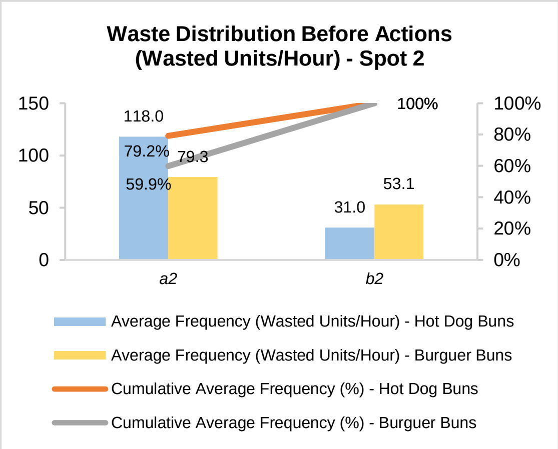

Figure 6 - Pareto diagrams regarding inefficiencies leading to waste production observed in Spot 2 (only salty cake production).

By visualizing this data, it is clear that waste production in Spot 2 was basically coming from two inefficiencies: *a2* and *b2*. In both Hot Dog and Burger Buns, *a2,* which is "defective packaging", showed to be the most relevant cause for waste generation representing 79.2% and 59.9% of the total waste for both salty cakes. Once again, after reaching to the respective root causes and building an Action Plan for Spot 2, basic production conditions were restored, and some improvement measures were applied. The final collected data and comparison with the initial one is displayed in Figures 7 and 8:

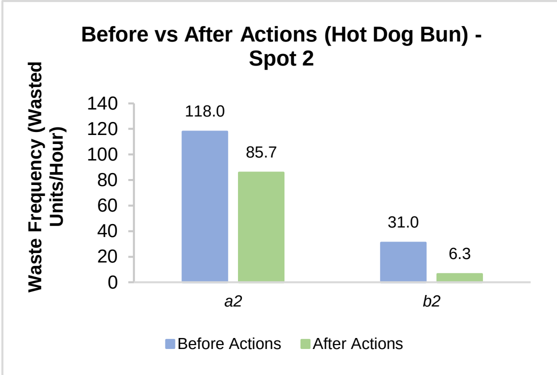

Figure 7 - Comparison between Spot 2's waste levels before and after improvement actions performed regarding Hot Dog Bun production.

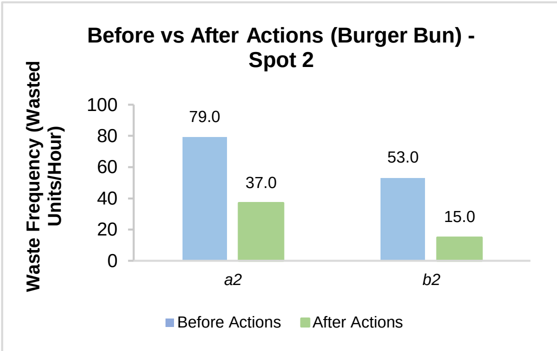

Figure 8 - Comparison between Spot 2's waste levels before and after improvement actions performed regarding Burger Bun production.

As a result of the actions taken, both inefficiencies decreased in Hot Dog Bun and Burger Bun production, inducing an overall waste decrease of 47.9% in Spot 2. However, some of the actions were not fully performed due to lack of workers at that time of the year, creating a global overburden. Therefore, their potential is expected to be greater when ideally put into practice.

Regarding Spot 3, it represents the demolding stage. Here, after getting out of the oven the cakes standing on molding plates are retrieved by a demolding machine to continue the rest of the process. Spot 7 also represents the same stage as Spot 3, but it only refers to the production of salty cakes (Hot Dog Bun and Burger Bun) while Spot 3 refers to the production of sweet cakes. Its waste distribution is shown in Figure 9:

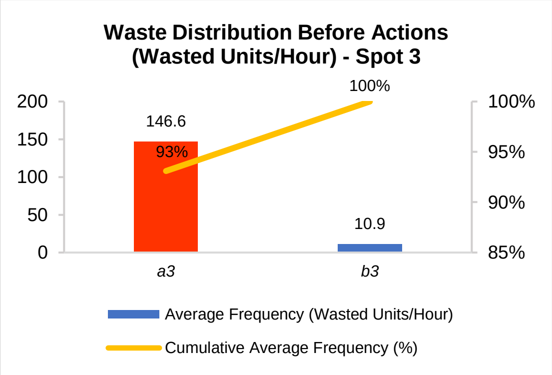

Figure 9 - Pareto diagram regarding inefficiencies leading to waste production observed in Spot 3 (only sweet cake production).

To make data collection easier, waste production in Spot 3 was only divided by two inefficiencies. *a3* is by far the most concerning and represents all the cake that was not demolded, remaining in the plates instead of being sent to the next stage. The final collected data and comparison with the initial one is shown in Figure 10:

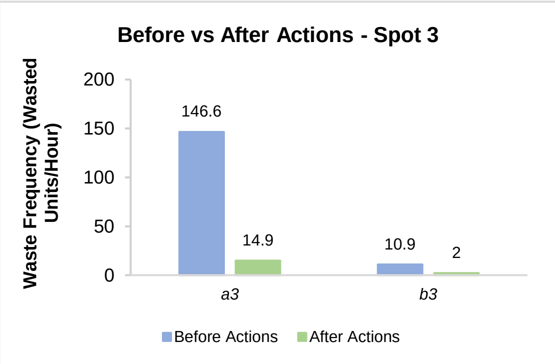

Figure 10 - Comparison between Spot 3's waste levels before and after improvement actions performed.

Looking at the previous comparison, it was possible to see a huge decrease in waste coming from Spot 3, resulting in an improvement of 89.3%. This was achieved only by restoring some basic conditions, namely replacement of demolding machine materials related to sweet cake demolding. This means that in normal conditions this stage should perform well if basic process conditions are kept over time. The logic is similar regarding the molding plates. If they are in good conditions, this stage will perform well, otherwise it will not. Unfortunately, those plates were not replaced before the end of the internship.

Finally, Spot 4 represents the salty cake's selection zone, where workers are responsible for manually rejecting any cake with no conditions to move to the packaging stage and adjusting the cake's position. Its waste distribution is shown in Figures 11 and 12:

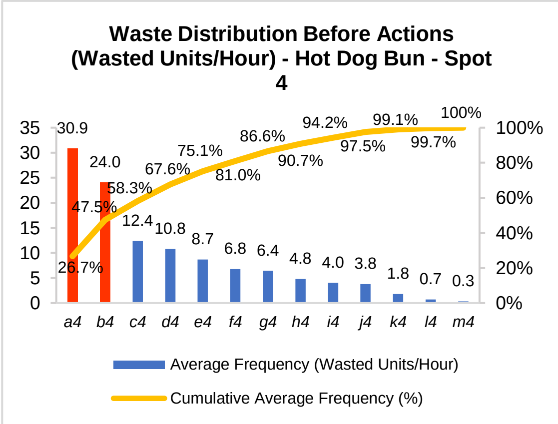

Figure 11 - Pareto diagram regarding inefficiencies leading to waste production observed in Spot 4 (only Hot Dog Bun production).

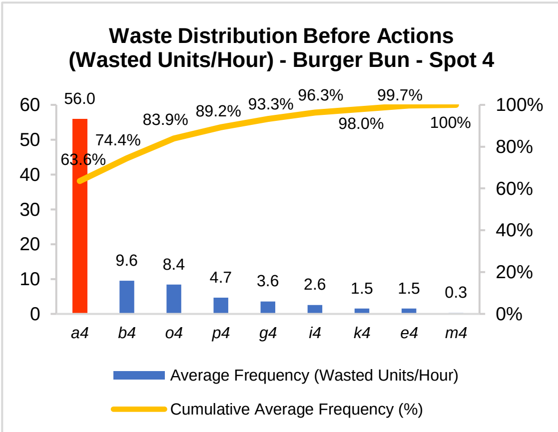

Figure 12 - Pareto diagram regarding inefficiencies leading to waste production observed in Spot 4 (only Burger Bun production).

These two distributions showed a dominance of inefficiency *a4* and also high waste levels in both products coming from inefficiency *b4*. However, most defects causing waste in Spot 4 are originated in previous production stages, only being spotted in the selection stage. Taking this into account, and after determining the root causes, restored basic conditions and implemented improvement actions were focused on other places in Line C, but interfering directly with Spot 4's waste levels. The final collected data and comparison with the initial one is displayed in Figure 13:

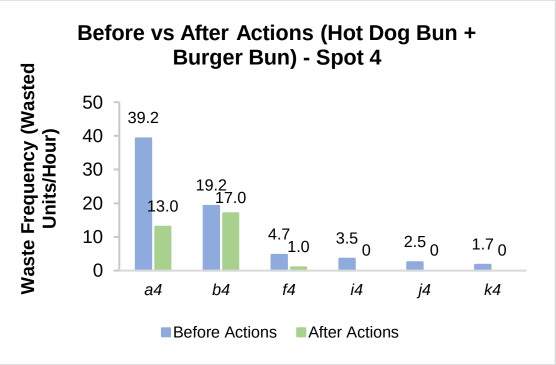

Figure 13 - Comparison between Spot 4's waste levels before and after improvement actions performed regarding Hot Dog Bun + Burger Bun production.

Globally, there was a decrease of 26.3% in total waste coming from Spot 4 after all actions. Figure 13 only shows a comparison between the initial and final situations of inefficiencies directly influenced by the implemented improvements. It can be seen a huge decrease in inefficiency *a4*, which is the formation of deformed cake. Restoring basic conditions in the first production stage was the key, replacing several worn materials. This is a good example of how important preventive maintenance can be in an industrial level. Interventions made in the packaging stage (Spot 2) also helped reducing waste in Spot 4, by promoting a *b4*, *f4* and *j4* decrease, since they were also being caused by non-planned stoppages in Spot 2. Unfortunately, just like what happened to data collection in Spot 1, the final number of samples were way less than the initial one. This make an honest comparison impossible. On the other hand, the few samples collected showed that those action may have been successful.

3.3 Performance Indicators

After collecting data, unearthing root causes, building Action Plans and implementing improvement measures, it was time to check the KPI (in this case the KPI used was the OEE) values obtained by the company in the last month of the project (September 2018). The main goal was to reduce the Line C's waste levels from 4.8% to 3.8% and increase the Line C´s OEE from 74.1% to 75.8% when comparing to the values regarding 2017. However, the waste levels raised to 5.3% and the OEE decreased to a final value of 60.4%. Since OEE values are influenced by all aspects related to production and not only its waste, the value obtained didn't confirm the improvements showed by the collected data. Breakdowns occurred frequently, raising non-planned stoppages and the production periods regarding set-up and change-over may have performed worse. In a way, the overall equipment's performance is expected to be lower in 2018 than in 2017 due to wear coming from additional months of use. The non-identified inefficiencies such as non-registered waste, non-declared stoppages, delays and minor stoppages also increased. Therefore, the OEE decrease was somewhat predictable. The increase in equipment breakdown also increases the waste amount and since this waste was not considered in the data collection as well as all the other factors mentioned, discrepancies were seen between the experiment's results and the official data obtained by the factory (waste level and OEE). Despite the decrease observed in terms of OEE value, the project was successful, since without its implementation this decrease would probably be more pronounced.

4. Conclusions

Previously to the project it was possible to see that aside from waste generation, Line C, responsible to produce sweet cakes (Type 1 and Type 2) and salty cakes (Hot Dog Bun and Burger Bun), also suffered from other problems such as machine breakdowns or a high frequency of minor stoppages. The correlation between some line stoppages and waste production is undeniable, therefore one of the ways to decrease waste levels is to target the right non-planned stoppages to avoid. Stoppages caused by breakdowns are also responsible for several spikes in waste levels, however they were not included in the collected data. So, controlling the overall non-planned stoppages during Line C's production could be the key to improve both availability and quality components of the OEE calculation and could be even more important than to optimize waste coming from regular production periods. Some workers' resistance to change old habits was also seen. This way improvement measures based on adding new standardized procedures and instructions and task awareness did not reach its maximum potential.

For any continuous improvement project to work it is necessary for everyone to make an effort, starting on labor force and ending on high ranked engineers. In this context the lack of motivation of the operators to do better is sometimes visible and interferes with the efficiency of daily tasks and with the replacement of workers when is needed. All of this increases waste production. Another important aspect is a good communication and frequent contact between the factory's departments because without it reducing waste as well as meeting other goals would be way more difficult. Therefore, an inclusion of at least one person from every department and a worker of Line C on the team was essential. Regarding all sorts of breakdowns, a good communication between the workers and the maintenance department will promote more proficient and quicker actions thus resulting in less waste.

From all the actions placed in the Action Plans, only some of them were actually implemented. The rest should be performed in a near future. The final data collection done in Spots 1 to 4 was not perfect either, since in Spot 1 and Spot 3 the final sample amount was just too short to be properly compared with the initial one. So, if possible, it would be interesting to continue the data collections in those spots to see if the observed tendency is somehow near the real effect of the actions on the respective waste levels.

In the dough preparation stage (first stage of production), there is a patent variability issue, in terms of the cake's size and weight. This directly affects almost every further production stages since the equipment is usually designed to process cake with a certain size or weight, otherwise waste levels will increase. Following this line of thinking, creating a new project focusing on the variability seen in the initial dough units could be a good idea in the future, sparing Line C from many unwanted stoppages and waste. Besides that, preventing lack of production workers should also induce a positive effect on the overall efficiency of Line C.

In the end, the importance of continuous improvement processes in organizations nowadays needs to be emphasized. When correctly applied, it can be a tool that leads a company step by step towards perfection, decreasing overall costs and increasing efficiency and quality levels.

5. References

[1] Ramadani, V., & Gerguri, S. (2011). Innovations: Principles and strategies. *Strategic Change*, *20*(3-4), 101-110.

[2] Leite, H. dos R., & Vieira, G. E. (2015). Lean philosophy and its applications in the service industry: A review of the current knowledge. *Production, 25*(3), *529–541.*

[3] Hines, P., Holweg, M., & Rich, N. (2004). Learning to evolve: A review of contemporary lean thinking. *International Journal of Operations & Production Management*, *24*(10), 994-1011.

[4] Mariani, C. A. (2005). Método PDCA e ferramentas da qualidade no gerenciamento de processos industriais: Um Estudo de Caso. *INMR-Innovation & Management Review*, *2*(2), 110-126.

[5] Sanders, R. (1987). The Pareto principle: Its use and abuse. *Journal of Services Marketing*, *1*(2), 37-40.

[6] Ohno, T. (1988). *Toyota Production System: Beyond Large-scale Production*. CRC Press.

[7] Benjamin, S. J., Marathamuthu, M. S., & Murugaiah, U. (2015). The use of 5-WHYs technique to eliminate OEE's speed loss in a manufacturing firm. *Journal of Quality in Maintenance Engineering*, *21*(4), 419-435.

[8] Slack, N., Brandon-Jones, A., & Johnston, R. (2013). *Operations management* (7th ed.). Pearson.

[9] Ahuja, I. P. S., & Khamba, J. S. (2008). Strategies and success factors for overcoming challenges in TPM implementation in Indian manufacturing industry. *Journal of Quality in Maintenance Engineering*, *14*(2), 123-147.

[10] Williamson, R. M. (2006). Using overall equipment effectiveness: The metric and the measures. *Strategic Work Systems, Inc*, 1-6.

[11] Muchiri, P., & Pintelon, L. (2008). Performance measurement using overall equipment effectiveness (OEE): Literature review and practical application discussion. *International Journal of Production Research*, *46*(13), 3517-3535.

[12] Bimbo Iberia. https://www.bimbo.pt/bimbo/bimbo-iberia. Accessed 24 November 2018.