A

Lean Six Sigma Project

To

Reduce Waste and Variability

In

A

Confectionery

Manufacturing

BY

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Abstract

Candy industry is facing challenges in production waste. Because of the strict regulations and specifications that assure food safety, production needs to meet high standard requirements to deliver final product to the customers. One of the principal problems industry has now a day is throwing away rubbish food that can be eaten, but that does not completely satisfy specifications. Candy manufacturers need to focus daily in these requirements so waste can be reduced. Specifications where not accomplished, and machinery malfunctions impacted directly in the quality of the final product. Turning it out into waste. The purpose of this work was to reduce 10% of the waste in a lollipop production line in a Confectionery Company in Mexico. Supporting the project in Lean Six Sigma methodology, taking as support DMAIC tool. Throughout this work efforts realized in an international to decrease variation in the cooking process of the candy will be described, to understand how 270 kilograms of candy waste per day were reduced in a 36.51%. This investigation may be relevant for professionals involved in food, confectionery and candy industry. But also for engineers looking for a classic Lean Six Sigma Project and its development.

Keywords

Process improvement, Food Industry, Candy Industry, Waste Reduction, Confectionery Industry, Continuous improvement, Lean Six Sigma, DMAIC.

1. Introduction

Satisfying world's lollipop demand requires a 24/7 production, high standard, controlled operations, and hard work. An actual problem candy industry is facing now a day is food wasted because of high standards non- compliance. According to Tatum (2017) product that was checked and found to be slightly off spec but is still good to eat is thrown to rubbish. Companies cannot assume contamination risks delivering final products, but these strict specifications conclude in one of the biggest amount of waste in industry. Another challenge being faced by the industry is machinery malfunctions. If a machine involved directly in food production has a defect, it will impact directly on quality and food safety specifications. Machinery needs to be working perfectly and aligned to FDA regulations.

An international confectionary manufacturing organization placed in the north part of México with more than 3,000 associates, it is having problem in the Lollipop Production Line since 2017 to middle 2018 (when this continuous improvement project began), which contribute with the second most wasteful line from the 14

Production lines available in this organization. Therefore, the purpose of this paper is to reduce 10% of lollipop waste.

There are several approaches of continuous improvement projects, such as Lean, Kaizen event, Lean Six Sigma, and others. Considering that this improvement project was focused on reduction of waste and variability, a decision was made to use the Lean Six Sigma approach with the DMAIC (define, measure, analyze, improve, and control) methodology and document this project as a case study.

The remaining sections of this paper are structured as follow. First, research methodology includes information about the confectionary company were the project was conducted and a description of the activities or tools used to collect the data in each step of the DMAIC. Second, the section of results was split in five subsections, one for each phase of the DMAIC. Lastly, in the conclusion section, was included a summary of the findings, limitations of the research, and future work.

During the definition of the project a brief analysis in the Lollipop Production Line was needed in order to define the problem since the actual waste indicators per shift were not valid. The results of the analysis are that there are four critical areas that were waste is collected during production, but waste collected is generated during different processes. In the next figure, lollipop production process is presented.

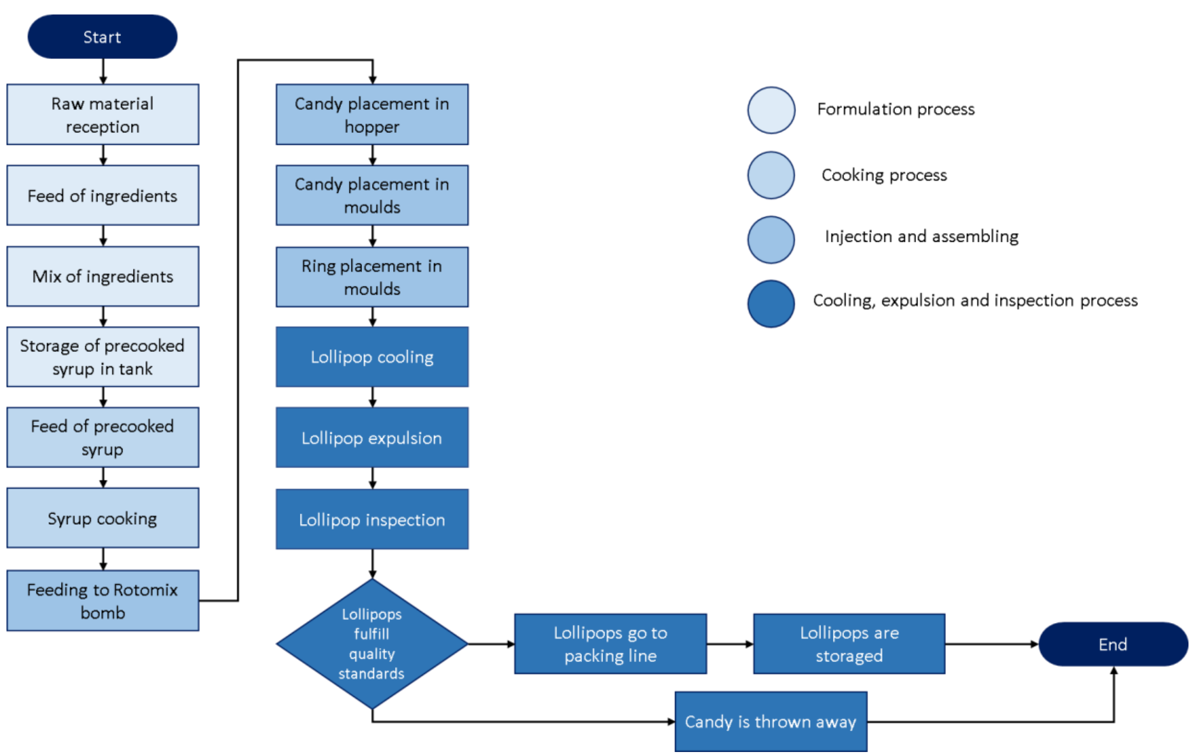

Figure 1. Lollipop production process

During the definition of the project measurements reflected the following areas:

Dropper Zone: Post-dosing process of the pallet, it consists of expelling the candy from the mold so that it continues its way to the cooling tunnel. In this area, the injection of caramel process is the cause of the waste in this zone.

Cooling tunnel: The Cooling Tunnel is responsible for the reduction of the temperature in the candy so that it solidifies and get accepted in quality tests. In this zone, the caramel remains on the sides of the cooling tunnel because the pallet is thrown off in the cooling process and falls out of the band that leads the pallets to the inspection area.

Diverters: By means of two channels the candy that was to be fed to the caramel hopper is diverted when a change of flavor is made or when the hopper candy has to be emptied because it does not meet the quality standards.

Inspection zone: Area at the end of the cooling tunnel, where an operator, quality test, is responsible for separating the pallets that do not meet quality requirements. In this area waste is not generated, only the waste generated in the injection of caramel process and ring assembly process

With a measurement of 11 labor shifts (12 hours per shift), an average of 135 kg of caramel waste per shift was collected and 90% of the waste concentrates in the Inspection and Dropper Zones, with 69% and 21% respectively. With the obtained measurements, the particular objectives were defined, as well as the general objective.

The next figure 2 shows sub processes involved in waste production.

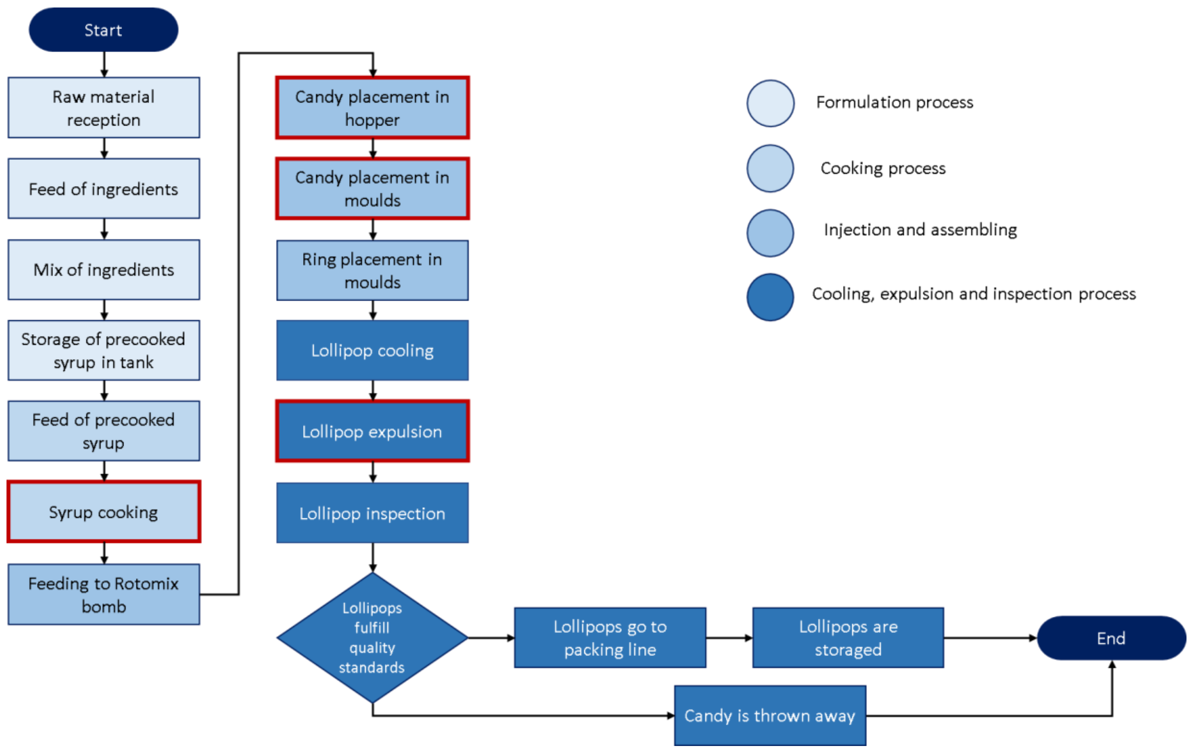

Figure 2 Waste Sub processes generators

2. Description of methodology

This is a Lean Six Sigma project using the DMAIC methodology. This methodology aims to reduce waste or variability and has 5 phases: Define, measure, analyze, improve, and control. It is an iterative method that follows a structured and disciplined format based on a hypothesis, experimentation, and an evaluation to confirm or reject the previous stated hypothesis according to McCarty et al. (2004). For each phase of the methodology, different tools to collect dada and analyze these data:

a. Define the necessity from which the project is going to take place, the scope, project goal, team members, the areas involved to achieve the goal, and timeframe chart Bersbach (2009). It is also important to define the process involved in candy production. According to Manene (2011), flow and process diagrams are tools that helps to understand correctly the different phases of any process and its operation, and, therefore, allows to understand it try to improve its procedures.

b. Measure process performance and assess the measuring system if required (Brue, 2002). Tools used in this phase were historic data given by the company, interviews with different workers involved directly in the production process and a waste system established by the authors. This system registered waste produced in each production turn.

c. Analyze data obtained from the current status of the process and determine the causes and opportunities for improvement. With the historic data and the waste system established by the authors Pareto diagrams were made. Also, to know variables involved in the process authors made design of experiments and regressions.

d. Improve process performance through the implementation of actions defined by the LSS project team (Orozco & Jaramillo, 2013). Several actions were proposed and using a decision matrix (criteria: cost, time, training needed, complexity, and impact), the LSS project team selected 8 actions that most contribute to the achievement of the general objective of this project.

e. Control is, focused on sustaining the improvements in order to obtain a long-term impact. During this LSS project the following tools were used: by using statistical tools, non-statistical techniques, establishing KPI (Key Process Indicators).

Descriptive information about the results obtained in each of the five phases of the DMAIC were documented in the following section.

3. Application of Methodology

3.1 Define

In order to know what the real problem in the company was, the first thing to do, following DMAIC methodology, was to define the problem. For that matter, analysis of historic records to establish the behavior of the production line and to see when the problem was originated. Analyzing this records, the production line was the second line generating more waste in the company since 2017; with a total loss of $370,000 USD. Focus was made on solving this problem in this line because it had that had most of the waste. The Ishikawa Diagram also made a correct analysis of the problem which would be shown below.

The identification of independent and dependent variables that influence in the waste of sub processes is an important step in any project related with Six Sigma, because controlling these variables will impact directly in the reduction of the variance. To identify the relationship between the dependent and independent variables the application of a XY matrix was necessary. According to Afza (2017) the matrix XY serves to compare alternatives to a solution, demonstrate cause and effect, or reduce potential causes to a problem. The independent variables, x, are the technical parameters of the process. The dependent variables, Y, are requirements for the process and for the client; quality and packers.

The entitlement tool gives the best result obtained in a defined period of time according to Williams, B. & Cygi, C (2014). Using the historical waste data of the lollipop production line from 2017 and the start of 2018, a goal of a maximum of 32% waste reduction was calculated. An established goal of 10% waste reduction was concluded. In order to achieve that 10% of average waste reduction, a Pareto's diagram to identify

Which processes had the greatest impact on the production's waste. The injection and the expulsion processes were known to be the new intervention objectives to achieve the goal. So knowing the variables, how the process works and making initial pilot measurements, the three objectives established were:

1. General objective: 10 % reduction of average waste in turn.
2. Specific objective: 12 % reduction of average waste in turn in injection process.
3. Specific objective: 10% reduction of average waste in turn in expulsion process.

3.2 Measure

Once the processes that generated waste were defined, the measure phase was crucial to develop the improvement project. The team work established a waste measurement system, in which the operators measured out the waste in kilograms in the sub-processes. In this way, a Pareto analysis could be made, helping zooming in the crucial sub-processes that impacted the most in the production of waste.

This measurement system worked the whole project, and it functioned as a scoreboard to see how waste increased or decreased daily. After analyzing eleven production shifts, the results showed that the two sub processes that were generating more waste were the cooking and expulsion process. Graphs at control phase will show results of this measurement system.

3.3 Analyze

Analyze stage in the project requires experience and data. A key task in this stage is the time spent during production and maintenance. Living the process from A to Z clarifies and sustains the analysis of any problem. The team spent hours in the three shifts measuring the amount of waste and analyzing maintenance practices, which made up easy the symptoms collection. During DMAIC stages, recollect symptoms, these symptoms were displayed in an Ishikawa diagram as shown in Figure 4.3, dividing it by machines, personnel, materials, method, measurement and environment. According to Pérez, A. (2015) Ishikawa diagram helps in the processing, organization and prioritization of new information. In this way, information can be integrated in a simple way, making easier analysis of solutions, and obtaining a global structured vision of the problem, so the real causes can be identified.

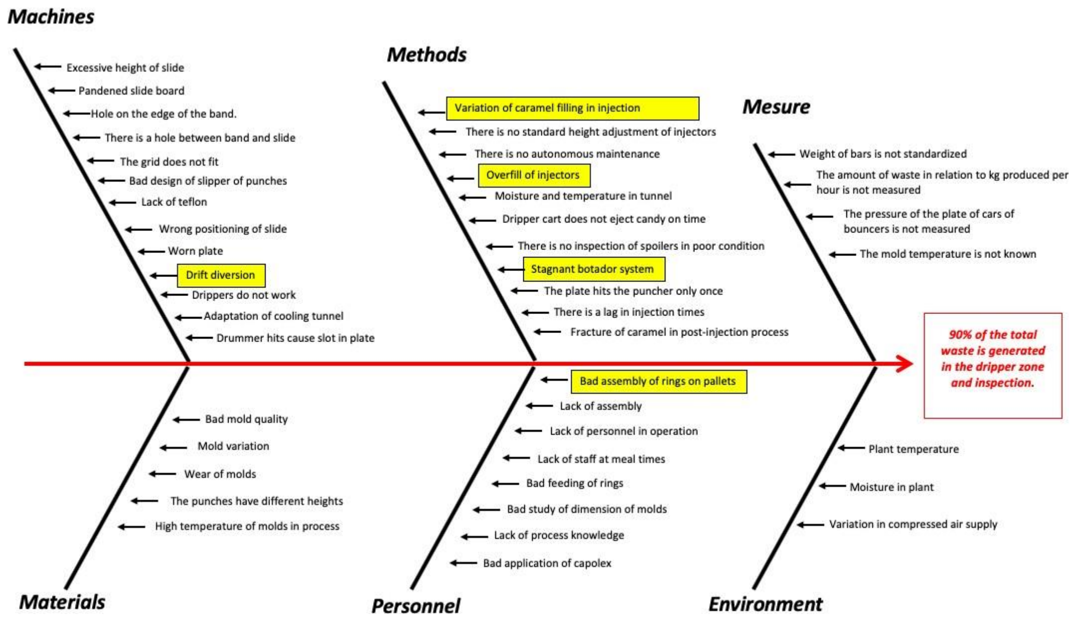

Figure 3. Ishikawa diagram

After the categorization of 11,400 lollipops by defect, the team found that with the use of a Pareto Diagram that 80% of the defects which caused waste came from the process of injections and a bad insertion of the lollipop’s ring. Pareto´s Diagram is a useful tool which let visualize the majority of the problems and their root causes- With the 20% of the defect types, you can obtain the 80% of its totality. It represents a major help identifying the factors that impact on a determined situation. Making efforts to focus on better results (Galgano, 1995).

Completing the two analysis with symptoms and defects, a 5 Whys analysis was made to clarify symptoms and, to finally, obtain the root causes of the problem.

Identification of two main root causes:

1. There is not an operation standard established for the injection of caramel process.
2. Specifications and process for replacing critical components of machines were uncontrolled.

3.4 Improve

According to Turrent, A.L. (2015), improvement is not an easy stage, due to the fact that creative ideas are not always viable for the practice. Another situation it needs to be controlled relates with the factors selected to decide whether a solution is feasible in process conditions What Turrent recommends is to start a Pilot improvement and measure results of it, if it works, replicate in a big scale with similar processes, if not, learn and create again a better solution.

During the stage of improvement, solutions are to be designed in collaboration with the most efficient and experienced team leader of the process. The daily interviews with the Lollipop Production operators and team leaders were the source of valid information to propose solutions.

A prioritization exercise that consists of punctuating solutions against decision factors (Medina et al. 2010) with 13 proposal solutions resulted with the selection of 7 solutions.

1. Implementation of cleaning inspection and lubrication standard (CIL):
2. Injector Standardization
3. Nozzles and injectors replacement system
4. Standardize candy levels in the injection hopper
5. Standardize temperature levels in the injection hopper
6. Detection system for damage molds
7. Revision and replacement system for molds

3.5 Control

The solutions implemented need to be controlled in order to keep solutions for a long term. Developing a template and implementing it as a key to control solutions. The template is called Control Document and since implementations were in a short period of time and the project has a scalable focus, the Control Document had as reference the structure as the Standard Operation Procedure Document, document that all operators understand and use for its operations. The template includes the following sections:

In the first section, Objective, the goal of the implementation has to be define. In the second section, Scope, it is established what will the solution reach, in this case all the solutions had the same scope. The third section, Responsibilities, the personnel responsible for compliance with the procedure is establish. The fourth section, Procedure, is the one that describes the process where the solution will be applied, for example, the standard procedure of candy level in the process of injecting caramel into the mold. In the same section requirements and specs to comply with the process are also establish, if they are not met, the Control Plan is consulted. The procedure section has a Flow Chart and image to represent the process in graphically. The fifth section includes the optimal operating parameters. The control section is to control modifications in the document including the version, date, revision, responsible/role and comments.

In the following figures 5 to 7, the results of the implemented solutions are shown. In which the general objective was accomplished, reducing 36.51% of the caramel waste, second objective, reducing the average waste in injection process, had a reduction of 31.62%. And for the last objective, reduction of average waste in expulsion process accomplished 53.93%.

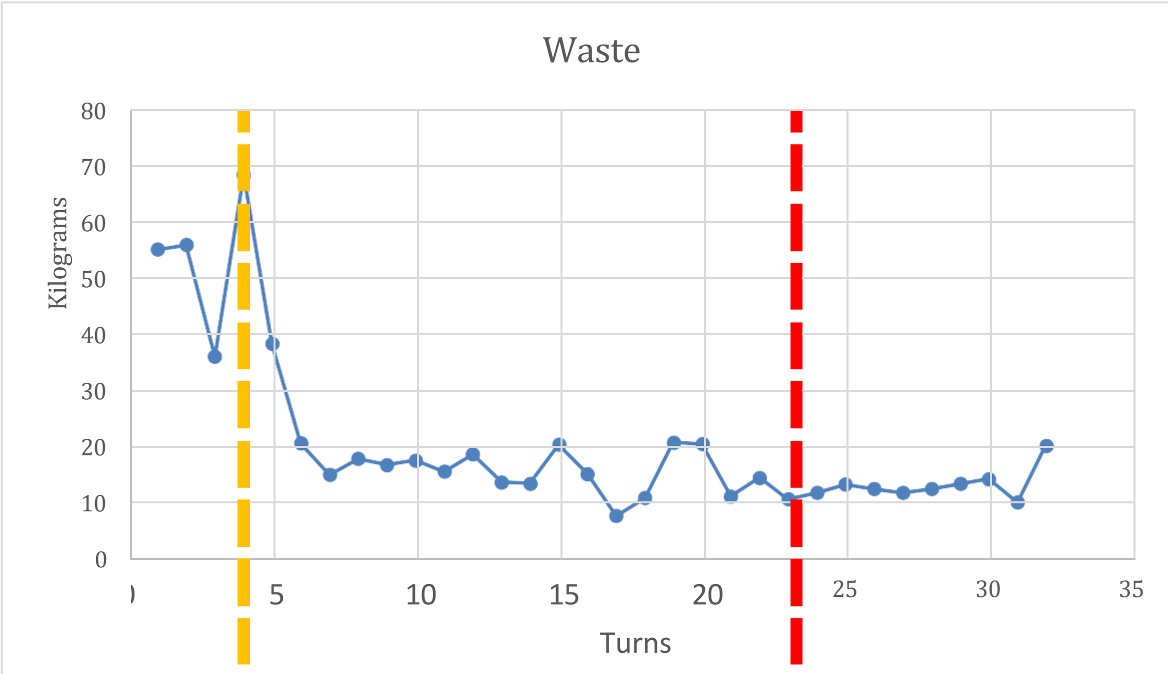

Fig. 5 Waste in expulsion process

This graph has two lines, the first one shows an intervention made in the beginning of the project and the second one shows the last intervention with all the solutions explained before.

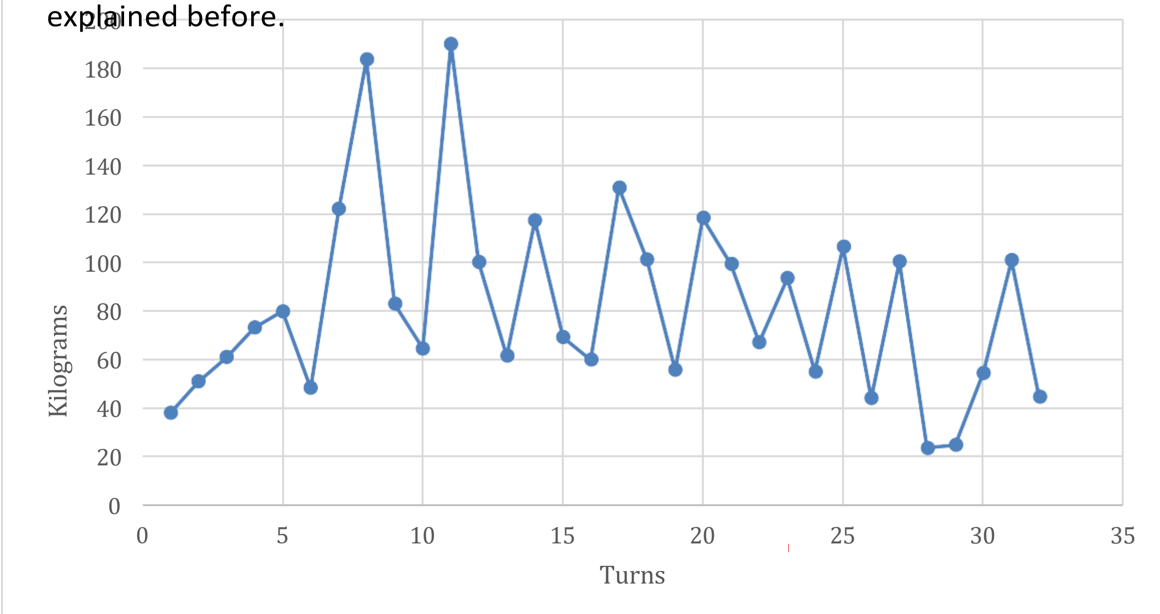

Fig 6. Waste in injection process

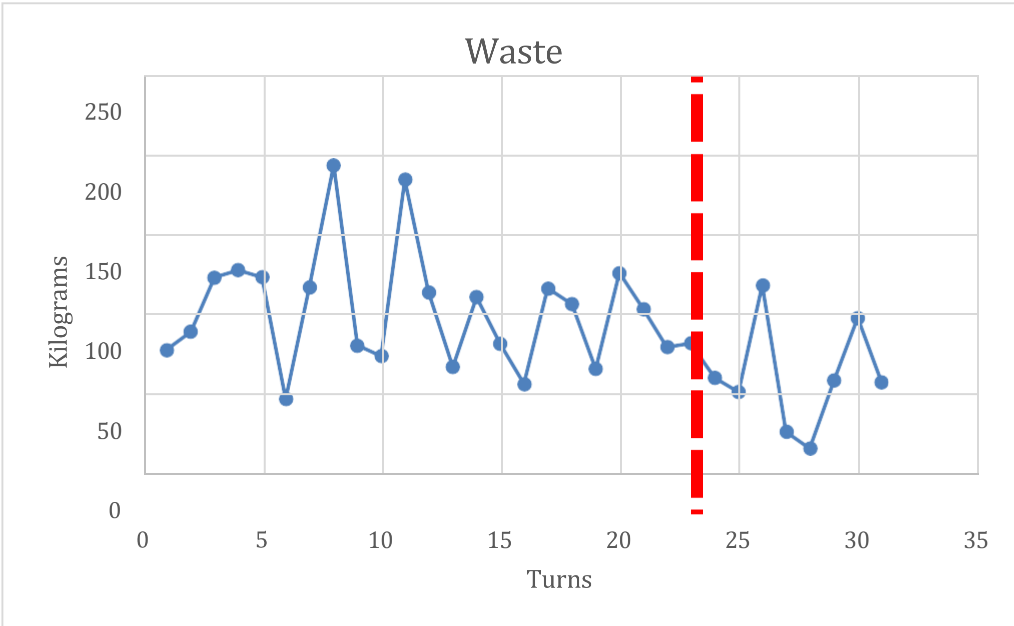

Fig 7. General waste

4. Conclusions

Results of the project surpassed authors and the company expectancies. The general objective was accomplished, reducing 36.51% of the caramel waste, 26.51% more than the general objective established in the definition stage. For the second objective, reducing the average waste in injection process, the reduction was a 31.62%, exceeding initial objective in 19.62%. For the last objective, reduction of average waste in expulsion process, initial objective was surpassed with 43.93%, obtaining a final reduction of 53.93%.

It is important to mark that the success of the project was accomplished with the support of the production line leaders, operators, and maintenance technicians due to the valuable information provided by their experience in the field. The involvement of each person in the production plant was a key factor for decision making in the different stages of the project.

And as a final learning, it is crucial that involved parties must have the same objective, so that the solution is systematic. It will lead to better control in the future. A contingency plan must be devised to positively affect all the people involved. Continuous improvement with the appropriate tools will guarantee foresight for the evasion of all emerging restrictions and incidents.

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