UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

Colegio de Ciencias e Ingenierías

Lean Six Sigma en la Industrial Panadera: Análisis de Reducción de Desperdicios en una Panificadora

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Trabajo de fin de carrera presentado como requisito

para la obtención del título de

INGENIERO INDUSTRIAL

Quito, 20 de diciembre de 2021

UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

Colegio de Ciencias e Ingenierías

HOJA DE CALIFICACIÓN
DE TRABAJO DE FIN DE CARRERA

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Quito, 20 de diciembre de 2021

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RESUMEN

El Covid afectó seriamente a las pequeñas y medianas empresas. Para sobrevivir dentro de la nueva normalidad, estas deben ser competitivas dentro del mercado, minimizar el desperdicio y la falta de estandarización que generan costos extras y pérdidas. Lean Manufacturing, Control de Calidad y Pruebas Sensoriales permiten eliminar el desperdicio, estandarizar procesos y aumentar la capacidad, eficiencia y eficacia de los procesos dentro de la empresa. En el presente estudio se utiliza la metodología DMAIC en una panadería para minimizar el desperdicio en el proceso de producción de Croissants de Chocoavellana, centrado en el subproceso de relleno de chocolate y los costos asociados a este desperdicio. Se utilizan cartas de control, cálculos de eficiencia y capacidad del proceso para hacer una evaluación del sistema, posteriormente implementar mejoras y comparar el sistema actual con el pasado.

Palabras clave: Seis Sigma, DMAIC, Croissant, Chocoavellana, Prueba Triángulo, Chi-Cuadrado, Capacidad

ABSTRACT

Covid seriously affected small and medium-sized companies. To survive in the new normal, they must be competitive in the market, minimize waste and lack of standardization that generate extra costs and losses. Lean Manufacturing, Quality Control and Sensory Testing allow eliminating waste, standardizing processes and increasing the capacity, efficiency and effectiveness of the processes within the company. This study uses the DMAIC methodology in a bakery to minimize waste in the production process of Chocoavellana Croissants, focusing on the chocolate filling sub-process and the costs associated with this waste. Control charts, efficiency and process capability calculations are used to evaluate the system, then implement improvements and compare the current system with the past.

Key words: Six Sigma, DMAIC, Chocoavellana Croissant, Triangular Test, Chi-Squared, Capacity

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INTRODUCTION

Ecuador registered the first case of Covid-19 on February 29, 2020. As the days went by, the health situation gradually worsened, and Ecuador was not prepared to face the pandemic (National Geographic, 2020). On March 16, 2020, the President of Ecuador declared a State of Emergency throughout the Ecuadorian territory, and drastic measures were taken to contain the spread of the virus (Secretaria General de Comunicación de la Presidencia, 2020). It was decreed that from March 17, 2020, the working day was suspended in both public and private establishments, excluding neighborhood stores, supermarkets, food production companies, financial institutions, health centers, security companies, and digital delivery platforms (Secretaria General de Comunicación de la Presidencia, 2020). Additionally, there was a curfew for people and vehicles (Secretaria General de Comunicación de la Presidencia, 2020). This greatly hindered the development of domestic trade and therefore affected the economy. In a study conducted by the Central Bank of Ecuador, in 2020 between March and December, there was a drop of $16,382 in national income and 532,359 people lost their jobs, the sector with the highest rate of layoffs was Accommodation and food services (Coba, 2021).

Small and medium-sized businesses, also known as SMEs, were severely affected during the pandemic. SMEs represented approximately 95% of productive units in Ecuador (Rodríguez & Aviles, 2020). They represent 60% of sources of employment and 80% belong to services and commerce (Llerena, 2021). Given their importance, the reactivation and promotion of these companies are vital to improving the Ecuadorian economy.

San Francisco Food Service S.A. is a medium-sized company that was registered in the Superintendence of Companies in 2015. The present study will have an exclusive focus on the bakery area, which has been operating for about 20 years with different company names, from 2015 to the present it operates under San Francisco Food Service S.A. This bakery is considered artisanal and has a French approach; it produces about 39 different varieties of bread (USFQ, s.f). The bread production allows supplying bakery products to all points of sale of San Francisco Food Service S.A. These products are available to the Universidad San Francisco de Quito community, since most of all the points of sale are located inside the university campus. However, it also serves the external public through Ambrosia Bakery (USFQ, s.f).

The San Francisco Food Service bakery was forced to reduce costs due to the economic impact of the pandemic. Therefore, one of the changes was to alter the recipe and presentation of the Nutella Croissant, one of the best-selling breads; however, no consumer tests were conducted to see if this new formulation would be accepted in the market. This also had an operational impact, the production processes changed and now this bread has longer preparation time. With the help of Len Manufacturing, Six Sigma, Quality Control Charts, Financial Analysis, and Sensory Analysis , an optimal presentation for the customer and viable for the company will be found, thus maximizing customer satisfaction and minimizing production costs.

LITERARY REVIEW

Taichi Ohno, the creator of the Toyota Production System (Liker J.K, 2005), founded lean manufacturing and created a world-class phenomenon due to its ability to improve quality, cost reduction, and flexibility (K. Mohan Sharma, S. Lata, 2018). Lean manufacturing can be defined as a philosophy that focuses on identifying and eliminating waste that might be related to

error throughout a production system (Rahman, Sharif, Esa, 2013). It also manages to tackle activities that add no value to an operation (Kharub, Ruchitha, Hariharan, Shanmukha, 2021) to reformulate the existing manufacturing process, increasing profit and customers perception of a certain product (Nallusamy,2020)(Arunagiri, Suresh, Jayakumar, 2020).

Similarly, Six Sigma focuses on boosting economic gain by the improvement of processes and reduction of variability. It utilizes a statistical approach to find defects, understand their root cause and finally eliminate them. By doing so the process also becomes much more predictable, helping in the decision-making for future improvements (Bożek, Hamrol, 2012). The statistical measure known as standard deviation or sigma represents variability, therefore the goal of any organization is to reach Six Sigma, process represents a nonconformity rate to be as low as 3.4 defects per one million likely to emerge (Bożek, Hamrol, 2012).

As a result of incorporating elements of Lean Manufacturing's process improvement tools and Six Sigma's data analysis tools, Lean Six Sigma Sigma became a powerful work philosophy with its main focus being continuous improvement and full utilization of resources within a company (Socconini, 2020) .

According to a study conducted by Mariusz Bożek, Adam Hamrolby, 2012 in a manufacturing enterprise, following the Lean Manufacturing assumption that states that only 5-15% of all activities add value to a product helped the enterprise reduce its lead time significantly from 10 days to 1 by eliminating actions that represented waste. Similarly, the cause and effect diagram and 5's techniques have helped a juice manufacturing company tackle waste, minimize their defective products, manage their workspace, eliminate bottlenecks, and

standardize processes that will help the company maintain all new implementations in the form of a control plan (Kharub Ruchitha, Hariharan, Shanmukha, 2021).

MOTHODOLOGY

The Six Sigma DMAIC methodology, used in this study, helps to identify various improvement opportunities by filtering a complex problem with uncontrolled variables to a situation where quality can be controlled (Nandakumar, Saleeshya & Harikumar, 2020).

DEFINE

During the first stage of any project, planning is key. Therefore, utilizing a project charter (Gido, Clements, & Baker, 2018) will keep track of the essential requirements, execution plan, the project's alignment to the organizational goal, setting boundaries, and having a well-defined problem to tackle the following phases (Socconini, 2020). Identifying the baseline or project As-Is will also be crucial to understand how the process is unfolding throughout the different stages (Starns,2019).

MEASURE

The measure phase will mainly focus on data collection. After the documentation of activities and the time associated with it, tools such as the Value Stream Map (VSM) will be used to determine the ones that do not add value to the final product (Kharub, Ruchitha, Hariharan, Shanmukha, 2021). Additional financial data will be collected in order to understand the relationship between waste and financial impact in the company (Hofer, Eroglu, Rossiter, 2012).

ANALIZE

After data is collected, it will be analyzed to identify root causes and discuss possible solutions (Srinivasan, Mathu, Prasad, 2014). Control charts will be used to determine if a specific process can be considered under control by analyzing variation (Gaynor, 1984).

Additional tools may be used depending on potential problems that might arise in the previous phases.

IMPROVE

During the improvement phase, there are two essential parts: the improvement of the process itself and the validation of its proposition (Socconini, 2020). Improvements that are viable for the company must be proposed, taking into account implementation time, cost, and available resources (Pyzdek & Keller, 2001). Some Lean manufacturing tools to be used are Kanban, and Poka-Yoke (Nandakumar, Saleeshya & Harikumar, 2020). Additionally, a consumer evaluation will be conducted to observe the impact of a new size for the croissant in the consumer's behavior (Nandakumar, Saleeshya & Harikumar, 2020). For the improvement validation part, histograms, capacity measurements and before and after comparisons will be used. (Socconini, 2020).

CONTROL

In this stage, the improvements previously implemented must be controlled and followed up so that the company remains in a process of continuous improvement (Socconini, 2020). The main tool to be used in this phase will be the Control Plan, which allows for long-term stability in the execution of the redesigned activities (Srinivasan, Muthu, Devadasan & Sugumaran, 2016). This tool consists of a list of activities that the organization must complete to standardize

the process and minimize variations. This tool also provides documented evidence that can be used in future projects.

RESULTS

DEFINE

The definition phase started by gathering as much information as possible to get a clear picture of the current state of the company and to identify the activities that need improvement (Palange Dhatrak,2020). The type of bread produced was divided into families and the quantity sold of each type of bread since the company opened after the closure of Covid-19. With this information, two Pareto diagrams were made, with which the product family and key products contributing to the majority of the company's sales were identified and limit the investigation to those products (Jing-jing, Tian; Sun, Ning, Song; Yang, Zhi-fa, Huan-jing Zeng; et al). Figure 1 shows the product families and those accounting for 80% of sales are Croissants, Buns, and Molds. In Figure 2 these products included butter croissant, whole wheat croissant, cornbread, water bread, Choco Avellana croissant, ciabatta bread, and sourdough bread.

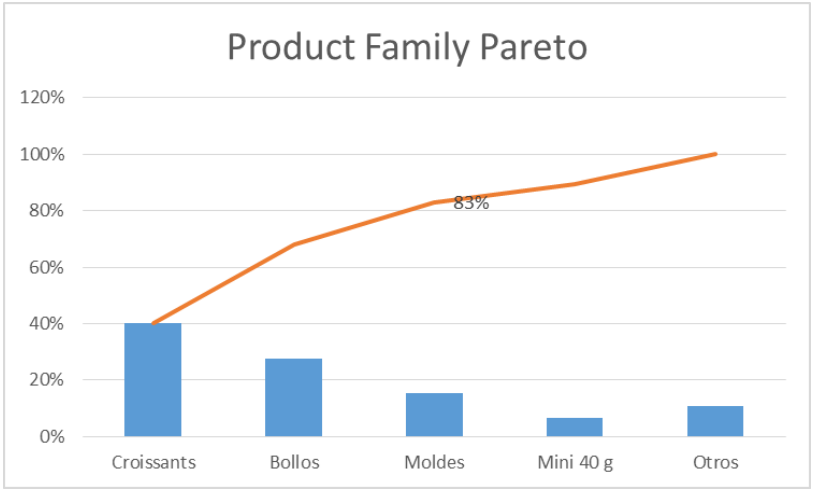

Figure 1. Sales per product families

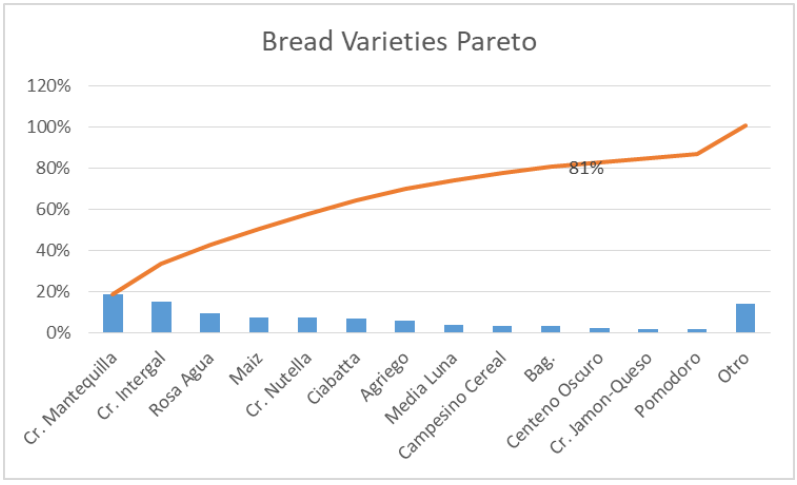

Figure 2. Sales per individual bread

Additionally, in research conducted prior to Covid-19 by Catena USFQ, a nine-question survey of 120 people was conducted in order to understand consumer consumption behavior and product perception. One of the questions asks about the product that consumers buy the most. As seen in Figure 3, it is the Nutella Croissant, which is the same as the chocoavellana croissant, except that the chocolate was changed to reduce production costs. Nutella is more expensive than chocoavellana.

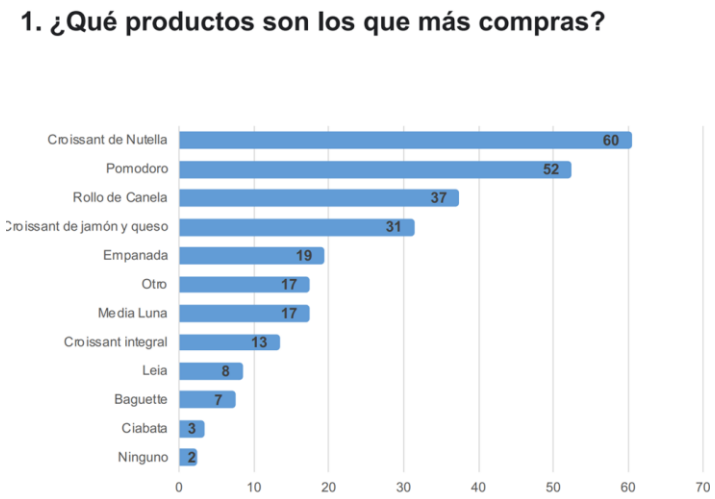

Figure 3. CATENA questioner

After the identification of the main products, the next step was to go to the production area in order to locate the problem areas and possibly identify one type of bread that will become candidates to become the main focus of the analysis. The following days information was gathered about the production process of each of these products by talking to all staff members and observing their every move. Even though the production process of the dough itself had little to nonsignificant waste because the staff was diligent in weighing all ingredients and making sure all quantities were correct, the filling process was the exact opposite. During the filling process for chocoavellana croissant there was a remarkable amount of chocolate waste of over 5gr of chocolate per croissant that was not considered by the administration. The only bread that required filling out of the previously mentioned products is the chocoavellana croissant, therefore it will be the focus throughout the following analysis.

A Project Charter was made to establish the limits, goals, responsibilities, and deadlines of the project (Gido, Clements, & Baker, 2018). As a business case, it was established that the performance of the net weight of Choco Avellana within the croissant does not comply with the declared weight of 20 - 25 g, which causes financial problems and lack of standardization both in

the production process and in the finished product. This project seeks feasible solutions to standardize the production process and chocolate filling in order to minimize waste and time.

Business Case			
As a company, the net weight performance of the chocolate inside the chocoavellana croissant is not weighing the declared weight of 20 to 25 [g]. This is causing financial problems due to chocolate waste, which costs around $24.55 per month.			
General Objective	**Objectives**	**Linea base**	**Ahorro**
Find an affordable solution to standardize the weight of chocolate filling found in each loaf. Improve operations within the chocolate filling process.	Standardize chocolate weight	25g	5g
	Minimize chocolate waste	5g	1g
	Decrease production time	24.5 h	23 h
	Increase profit margin	30%	35+%
Initial Scope (Includes)	**Does not include**		
Chocolate croissant	Mini Chocolate Croissant		

Figure 4. Project charter

MEASURE

The main characteristic to be measured was established, in this case the weight of the chocolate filling that goes into the croissant was chosen because it has a direct impact on the production cost due to the fact that the chocolate is the most expensive ingredient, and the company already has a standard weight. The company had established that in order for the chocoavellana croissant to have a profit margin of 35% the chocolate that fills a croissant must be between 20 and 25 grams.

To determine if the standard weight was met, first the number of croissants that were going to be measured were established. Being that the production department baked 78 chocoavellana croissants daily, a weekly population product population of 552 was set and used in the following formula to justify the sample size (Valdivieso Valdivieso,2011).

$$n = \frac{Z^2 pqN}{NE^2 + Z^2 pq}$$

From the previous formula a sample size of 222 was set, therefore in one week data from the three operators with different levels of experience and that are capable of operating the machine were collected.

The documentation of all the actions that made up the process were a key component to identify all the sources of waste (Kharub, Ruchitha, Hariharan, Shanmukha, 2021).The decision of dividing the production of the chocoavellana croissant into these two different sub processes was made: the making of dough and the filling of the croissant with chocolate.

The making of the dough included weighing all the ingredients used to make croissant dough, mixing, laminating, and freezing the dough overnight.

On the other hand, the filling process consisted of three activities. The first one being cutting the croissant in half , the second activity includes filling the croissant through the initial cut, finally the croissant is decorated with chocolate in order to hide the cut.

With a clear understanding of the overall process, measurements were taken . As soon as the croissants got out of the oven and finished the cool down process, a scale was used to weigh the 78 croissants from that batch. Following, an operator made a cut in the middle of the croissant and proceed to fill it with the chocolate shown in Figure 7. After all croissants were filled, weight measurement of the filled croissant was taken again. This process was repeated with the three operators that can operate the filling machine to get a fair comparison due to the fact that the filling activity is very manual, and the outcome will depend a lot on the operator’s technique.

Figure 5. Croissant filling process

In order to obtain how much chocolate filling went into each croissant the following formula was used

$$\boldsymbol{Weight\ of\ the\ chocolate\ filling}: Filled\ croissant - Baked\ croissant\ without\ filling$$

With this data on hand the short-term capacity was calculated because all the data was calculated in a small amount of time (Socconini, 2021). The lower specification limit and the upper specification limit were set by the company as the goal weight of the chocolate filling at 20g and 25g respectively. With the data previously collected we get a Cp value of 0.17 and a Cpks of 0.060.

From the previous calculation we can conclude that the process is not capable due to the Cp being less than one. When comparing the Cpki and the Cpks we use the lower value, in this case the Cpks and the interpret this as the process not being centered in the center but around the upper specification limit (Socconini, 2021).

ANALIZE

An analysis was made of the waste of chocolate that remains in the chocolate containers. It was observed in the data collection that the operators remove the chocolate from the container with a metal spoon, which does not allow the chocolate to be removed in its entirety and a lot of

product is left in the container, which is discarded. Figure 8 shows the waste in grams and dollars that the company incurs. The containers that were discarded were weighed and the average was 75.16 g, which represents $5.19 per week. Figure 9 shows the of croissants that can be filled with the waste, which are 21 breads per week.

	Weight [g]	Retail Price [$]	RRP per gram
Chocoavellana inside a whole jar	750	7.4	0.010
Chocoavellana waste	75.16	0.74	-
Approximate weekly waste	526.12	5.19	-

Table 1. Chocolate waste in grams and dollars

	Daily unit	Weekly unit
Croissants that can be filled with waste	3	21

Table 2. Unitary filling loss

In this phase, the data collected at the production plant was analyzed. As mentioned in the measurement phase there are two processes. One for the dough and the other for the chocolate filling. To analyze the data, it was decided to use IMR control charts, because a total inspection of three different batches was performed with operators with different experience (Delgado, 2016). As can be seen in Figure 10, the chart is under control since there are no points outside the limits and no patterns are found. When looking at Figure 11, there are points outside the limits, therefore the chocolate Filling process should be revised since it is not under control.

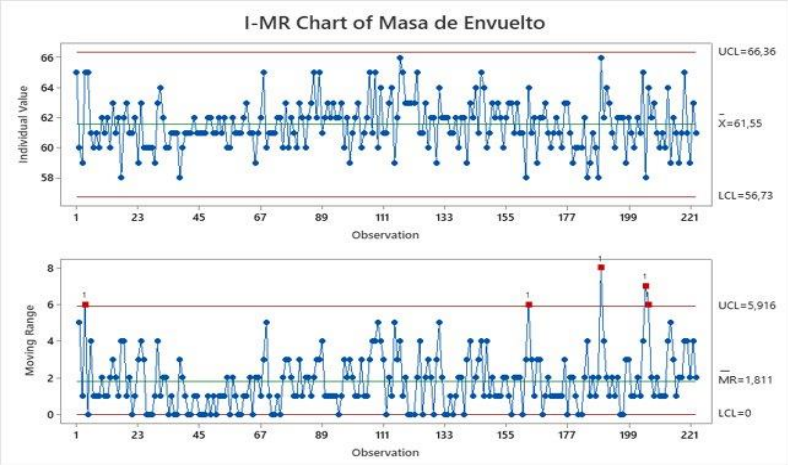

Figure 6. IMR control chart for weight masa de envuelto before implementations

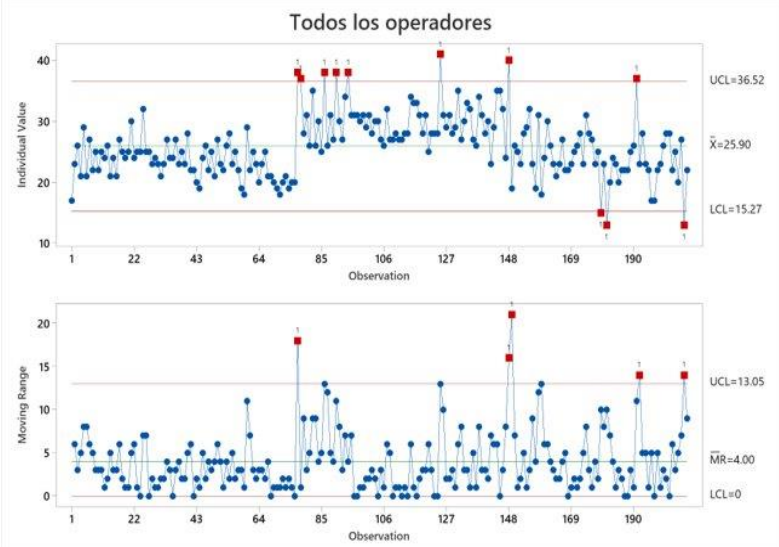

Figure 7. IMR control chart for weight of chocolate filling before implementation

After analyzing the control charts, an Ishikawa diagram was made to relate the problem to the possible causes (Rodriguez, 2017). The problem that was found is that the croissants do not meet the specifications given by management. To find the possible causes covering the whole process, the 6Ms were used, which are the following: Methods, Labor, Materials, Machine, Measurement and Mother Nature (Gwiazda, 2006). Some of the possible causes

considered most relevant are; the nozzle of the injector is not suitable for croissants, since it is a churro injector and the tip of the injector is flat which does not allow the injection of the croissant as it hurts the bread. Additionally, the filling schedule coincides with the end of the shift, the process is too long, the chocolate is too thick and there are discrepancies in the measuring method. These possible causes are a starting point to consider possible improvements in the execution phase.

In addition, a benchmarking analysis was performed, since this allows the company to study and compare itself with the competition in order to develop competitive advantages by adopting existing creative and innovative practices (Mora & Schupnik, 2009).

As mentioned before, the company's injector is not suitable for injecting croissants because it has a flat tip that does not allow injecting the bread without hurting it. When researching about the croissant injectors, it was found that the only difference with the one in the production plant is the tip, so the idea of adapting the tip arose. For this, the properties of the material must be investigated so that later the appropriate manufacturing process for the material can be chosen. The nozzle of the injector is made of AISI 304 stainless steel, which has heat resistance, corrosion resistance, and good processability and is usually used for food machinery (Material Mundial, 2020). Good processability refers to the ease of using different mechanical processes for transformation, such as cutting, sanding, welding (Dilluns, 2017).

Additionally, a benchmarking analysis was performed, since this allows the company to study and compare itself with the competition in order to develop competitive advantages by adopting existing creative and innovative practices (Mora & Schupnik, 2009). Chocoavellana croissants from three different competitors were purchased and compared with the company's breads. Within this analysis, the type of filling, weight, price per croissant and cost per gram

were compared. Tables 1, 2 and 3 are presented below, where A represents the company under study and C1, C2 and C3 represent the competition. Table 1 shows the filling information for each company, where C1 and C3 bake the dough and chocolate, which is not a possible solution for the company under study, since this was done in the past, but the quality of the dough was affected because it gave the impression that the dough was raw. C2 injects the chocolate, which is what the company tried to do, but unfortunately the injector it has is a churro machine with a flat tip, which does not allow the bread to be injected. As can be seen in Table 2, the bread with the highest weight is that of the company under study. Similarly, the price of croissant in Table 3 and the price per grammage in Table 4 are the highest for the company under study.

Type of Filling	
A	Spread
C1	Baked
C2	Injected
C3	Baked

Table 3. Filling comparison

Weight [g]	
A	99
C1	81
C2	95
C3	76

Table 4. Weight comparison

Price per Croissant [$]	
A	1.60
C1	1.25
C2	1.30
C3	0.75

Table 5. Price comparison

Price per gram [$/g]	
A	0.0162
C1	0.0154
C2	0.0137
C3	0.0099

Table 6. Price per gram comparison

Within the analysis of the measurement system, the percentage of effectiveness of the system was calculated using (Socconini, 2021). Where correctly filled Croissants refers to those that comply with the filling specification given in management, which corresponds to 20 to 25 grams of chocoavellana per loaf, and the total number of filled croissants represents the totality of the batch produced. As mentioned above, three different operators with different levels of experience were analyzed and the results presented in Table 5,6,7 confirm that the level of experience is closely related to the percentage of effectiveness.

$$Percentage\ of\ effectiveness = \frac{Correctly\ Filled\ Croissants}{Total\ Number\ of\ filled\ Croissants}$$

Operator 1	
Properly Stuffed Croissants	54
Total of Croissants Filled	79
% of effectiveness	68,35%

Table 7. Porcentage of effectiveness for operator 1

Operator 2	
Properly Stuffed Croissants	1
Total of Croissants Filled	72
% of effectiveness	1,00%

Table 8. Percentage of effectiveness for operator 2

Operator 3	
Properly Stuffed Croissants	34
Total of Croissants Filled	72
% of effectiveness	47,00%

Table 9. Porcentage of effectiveness for operator 3

IMPROVE

To start, after realizing that the filling machine could be easily manipulated without causing any detrimental damage to the injector the decision to cut its tip to mimic a needle was taken, therefore allowing the croissant to be injected and reducing the activities to only 2. The new filling process includes the injection of chocolate into the croissant and the decoration Figure 13.

Figure 8. Filling process after implementation

After the implementation of the new pointed tip, and the definition of a new filling policy to standardize the amount of chocolate that goes into each croissant, all data was collected again from the filling process. First, all operators capable to operating the filling machine were giving instruction as to how many squirts of chocolate were necessary to meet the company's needs. After the operators were aware of the new changes that were made to the process, the data from each croissant weight was collected again using the same operator as the first data collection.

After the data was collected, control charts were made in order to see how the new implementations affected the chocolate filling process as seen in Figure 14.

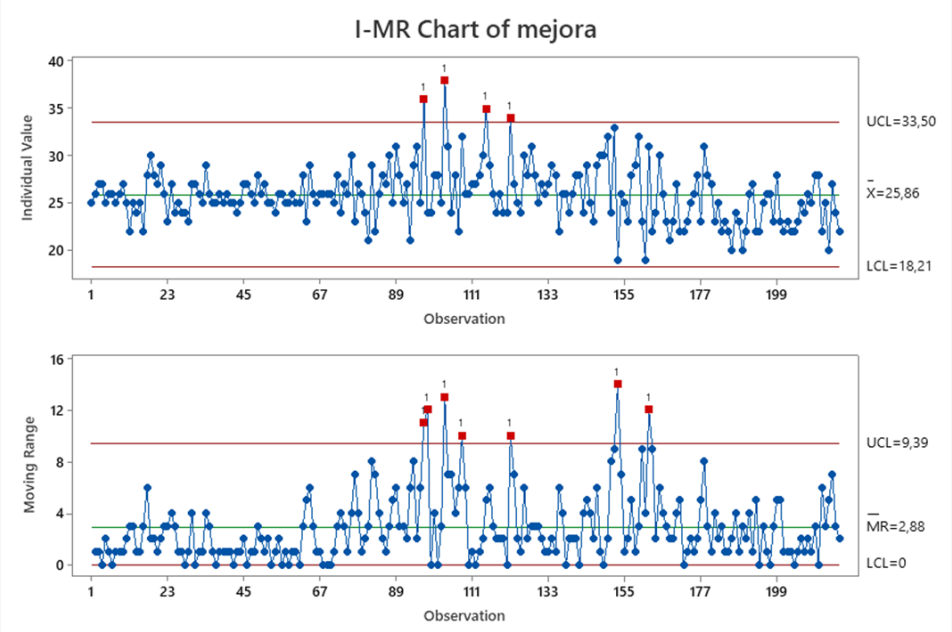

Figure 9. IMR control chart for weight of chocolate filling before implementation

The control charts show that most of the process is under control, however, there still are some points over the upper control limit (Gaynor, 1984). Those points belong to the batch made by the operator with the least experience; therefore, it took longer to adjust to the new process.

The calculation of the process capacity was also repeated after making the necessary changes to the process giving a Cp of 0.87 and a Cpks of 0.042.

Meaning that the Cp has improved from 0.17 to 0.41 and the Cpks has gone from 0.060 to 0.042. However, the process is still not capable, and the date is also centered in the upper specification limit (Socconini, 2021). This can be due to the process being mainly manual and chaotic, therefore human error is prone to happen especially with the implementation of a new activity within a process.

Similarly, the efficiency was re calculated as shown in Table 8,9,10.

Operator 1	
Properly Stuffed Croissants	36
Total of Croissants Filled	74
% of effectiveness	49,00%

Table 10. Porcentage of effectiveness for operator 1 after the implementation

Operator 2	
Properly Stuffed Croissants	24
Total of Croissants Filled	72
% of effectiveness	33,00%

Table 11. Porcentage of effectiveness for operator 2 after the implementation

Operator 3	
Properly Stuffed Croissants	24
Total of Croissants Filled	72
% of effectiveness	33,00%

Table 12. Porcentage of effectiveness for operator 3 after the implementation

Both operator 2 and 3 increased their effectiveness significantly however operator 1 had a slight decrease. This can be attributed to the chaotic nature of the time when the data was collected and the fact that there was no visual aid to remain them that the process had changed. This will later be fixed with help of a poka yoke.

Additionally, supplies such as rubber spatulas were added to the chocolate filling area to help get most of the chocolate out of the jar and reduce the amount leftover in the jar and then thrown away (Hofer, Eroglu, Rossiter, 2012). After this implementation, the chocolate left in the jar weekly that was thrown away went from an average of 526g to 141g. With this, the monetary weekly loss associated with this waste went from $ 5,19 to $1.40.

Waste [g]		
	Before	After
Diary	75	20
Weekly	526	141

Table 13. Chocolate waste in grams before and after the implementation

Waste [g]		
	Before	After
Diary	0,74	0,20
Weekly	5,19	1,40

Table 14. Chocolate waste in dollars before and after the implementation

When exploring the variables that are directly connected to the production cost, the weight of both the croissant dough and its corresponding chocolate filling came up. According to Ecuadorian normalization agency INEN "bread should be sold by weight", however this is not the case in most business therefore the weight variable can be modified and not influence the price the costumers pay. If the weight of the croissant decreased, the production cost would also decrease and by default the profit margin would increase.

However, for this to work the costumer had to not be able to perceive a difference to not affect the customers behavior. A discriminative test knows as the triangular test was the way to go, keeping in mind that "this test is used to determine an unspecified sensory difference between two treatments. The assessor is presented with three samples, advised that one may be different, and asked to identify which is the different sample" (Chapman & Hall, 1992). In the croissant's case, two croissants of 70g of dough and 25g of filling were presented and one of 65g of dough and 20g of filling which was the new proposed weight that was stabled because according to the staff it was the lower the weight can go without been perceived as different by the customers.

The presentation order of the three croissants was key in order to reduce bias, therefore the presentation of two X's and one Y was used. "This allowed the test to have six orders: YXX, XYX, XXY, XYY, YXY and YYX" (Chapman & Hall, 1992). All three variables had different codifications that allowed the analyst to know the X's and Y as seen in Figure 15. Each presentation was used 8 different times, with a total number of assessors of 48. The number of assessors was determined by the given budget to conduct this test and previous that have studies that have stated that any number of assessors over 20 is significant for this test (Yang, Robin 2006).

Figure 10. Variables for the triangular test

This test also required the correct location that would allow the assessors to focus on the asked questions and reduce external factors that would influence their decision such as smells, lighting of the room and possible distractions (Domínguez, 2007). To ensure all the conditions were met, the test was conducted in a room designed for food tasting that facilitated all the conditions mentioned before. Upon entering, the assessors had to fill out a questionnaire that contained the following questions:

- Are you over 18 years of age?
- Do you attend USFQ?

- Do you consider yourself a frequent consumer of the croissant de chocoavellana? (No sea Malito, Cafetería Hall Principal, Ambrosia, Ápice)

If the assessor answers all the questions with a “YES”, they had passed the filter questions and were allowed to participate in the study. The first question was asked for ethical purposes, the second questions referred to finding if the assessor belong to the target market of chocoavellana croissants buyers. Finally, the last question refers to whether the consumer is familiarized with the product in question. These questions allowed the analyst to determine if the assessor was qualified to give reliable data that will contribute to the study.

After the assessor passed the filter questions, they were allowed into the tasting room and the three samples were placed on a table with another questionnaire shown in Figure 16 and a glass of water to clean cleanse the palate after each bite.

Instructions: Using your senses of smell, sight, touch and taste, evaluate the following breads and **indicate which is different**. You can use water after tasting each bread to cleanse your palate. Remember, there are no wrong answers and if you are not sure, please guess.			
	19SM99	19PB91	19SM98
Mark with an X the square that corresponds to the bread you think is different.			

Figure 11. Instructions for the triangular test

Once the answers for all 48 assessors were in Table 13, these were analyzed. With a chi-squared test we were able to see how well the observed data adjusted to the expected data. The hypothesis for this test included as the expected value, the probability of an assessor guessing the correct answer, in this case this probability is 1 out of the 3 presented samples. Therefore, when having 48 assessors, the expected value is 16 per sample.

$$H_{0=}The\ data\ met\ the\ expected\ distribution$$

$H_{1=}$*The data does not meet the expected sistribution*

Expected	
19PB91	16
19AS98	16
19SM99	16

Observed	
19SM99	14
19AS98	11
19PB91	23

Table 15. Expected data vs. Observed data

With help of the Minitab software, a chi-squared of 4.875 was obtain Figura 17. With an alpha of 95% and 2 degrees of freedom from pre calculated tables we compare the obtained statistic to 5.99, because 4.875 is not greater that 5.99 we cannot reject the null hypothesis. Therefore, the assessors could not detect any difference between the 70g chocoavellana croissant and the 65g chocoavellana croissant.

Chi-Square Test

N	DF	Chi-Sq	P-Value
48	2	4.875	0.087

Figure 12. Chi-Squared test result in Minitab

Even though the analysis showed promising date, the implementation of a new chocoavellana croissant cannot yet be done until the decision maker of the company authorized this change. After this decision is made, a poka yoke will be implemented as seen in Figure 18 in order to prevent human error by reminding the operator how many chocolate squirts are required to meet the standard (Nandakumar, Saleeshya & Harikumar, 2020).

Figure 13. Poka yoke improvement proposal

If the company chooses to implement the new chocolate the new 65g dough with 20 g of chocolate filling, there will be an estimated saving of $0.08 per croissant as shown in Figure 19.

Bread 70g/30,8g	
Dough	$ 0,098
Chocolate	$ 0,385
Total	$ 0,483

Bread 65g/20g	
Dough	$ 0,092
Chocolate	$ 0,251
Total	$ 0,343

Difference
$ 0,080

Table 16. Estimated savings after the implementation of the 65g croissant

CONTROL

For the company to control its processes and maintain a process of continuous improvement in the long term, a control plan must be established (Socconini, 2020). The FMEA, which stands for Failure Mode and Effects Analysis, is a tool for keeping a record of observations to control products that do not meet specifications. cations. Figure 19 shows the format that the operators in charge of filling the Croissants must fill out.

Within this document, operators should weigh 3 pieces of bread per batch at random after the croissant comes out of the oven and after it has been filled (INEN, 2012). The measurement should be done in this way because the bread loses weight during baking as the water in the

dough evaporates (Perez et al, n.d). Once weighed, if the product is not within the limits, the bakery manager should be notified so that he can take corrective actions such as training.

Step	What are we controling?	Criteria	Input/Output	Specification limits	Measuring method	Location	Control method	sample size	Frequency
Chocolate filling	Weight	CC	Output	20-25 [gr]	Weigh the croissant as soon as it gets out of the oven and is finished cooling down.Weigh again after the croissant is filled and subtract the two weight in order to get the weigh of the filling	Production plant	Compare the measured weight with the specification limits	3 croissants per batch	Once a month

Who registers	Where to register	Decision making rules	Document Number
The operator incharge of the filling process	Registration sheet	If the measured weigh in not the specified , the operator should inform the chief backer of the situation.	-

Figure 14. FMEA

CONCLUSIONS

In conclusion, the study demonstrates a practical case in a medium-sized Ecuadorian company where it was possible to minimize waste and find viable solutions through the DMAIC methodology, which allows transforming large problems into smaller and more manageable problems. The Lean Manufacturing philosophy was used to minimize the Chocoavellana waste. Quality Tools were used to show the past state of the Croissant Dough and Croissant Filling processes and to take corrective actions to increase the company's effectiveness and efficiency. Discriminatory sensory tests were also carried out to see if the consumer perceives the difference in weight of the product.

On the other hand, the main objective of this study was to minimize the waste produced in the bread making process by using Lean Manufacturing tools and Quality Control to reduce costs, and this was achieved through the implementation of low-cost solutions. In the definition stage, it was possible to understand the company and see where it was failing and in which area an exhaustive analysis was needed to improve it. In the define and analyze stage it was seen how the company had incapable processes, operators with different levels of experience and capacity

to perform their work, and with this it was possible to determine the causes why the company was not complying with the specifications given by management. By finding the root causes of the failure of their processes, solutions were established to eradicate these errors, including the adaptation of the tip of the injector. This solution is low cost and allowed to reduce the croissant filling process time. Changing the metal spoon for a silicone spatula significantly reduced the waste of chocolate hazelnut that remained on the walls of the containers. Before the implementation, the company was losing $5.19 per week and after the implementation this loss was reduced to $1.40 per week. The Pokayoke allows operators to remember how much the injector discharges each time the lever is lowered. Additionally, in a study conducted by Catena USFQ prior to the pandemic, consumer surveys were conducted, and consumers suggested improving the price of the product as they considered it to be high. A triangle test was performed where it was found that by lowering 5 grams of dough and 5 grams of chocoavellana the consumer does not perceive the difference. The advantage of this change in the product is that the variation in the amount of hazelnut injected would be reduced since the operators would only have to lower the lever twice. The company has two options to lower the price of its product and it is recommended to make an analysis of consumer behavior and see if the demand increases or in turn increase the profit margin. While it is true that after the improvements were implemented, the process is still unable to produce the product, this is because the company has not yet made a decision on the amount of chocolate to be injected.

Finally, many limitations were present at the time of this study because the lack of communication between management, production and finance affected the execution of activities. Similarly, the data collection process was complicated because having each loaf labeled was essential to calculate the weight of chocolate, but many times the operators moved

the loaves and another batch had to be measured, which meant measuring another day since only one batch was produced per day. On the other hand, the company was reluctant to share its sales information, supplier purchases and recipes, which slowed down the financial analysis. Many operators felt that our work threatened their jobs and that our objective was to criticize their work, with the passage of time and after changing our attitude in data collection, the rejection ended.

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