APPLICATION OF THE ARENA SOFTWARE IN THE PROCESS OF FRENCH BREAD PRODUCTION IN A BAKERY LOCATED IN THE STATE OF MINAS GERAIS, BRAZIL

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Abstract *- To follow the technological evolution and the increase of market competitiveness, it is necessary to adopt new strategies that contribute in the productive process of a company. In this scenario, the process simulation has become a tool of paramount importance for organizations, enabling an analysis and improvement of processes through a virtual environment. The objective of this paper was to identify the bakery productive capacity of French bread and to analyze the changes made in the process after the product weight reduction. In order to enable this research, data were collected using the chrono-analysis process through visits to the company. The data were processed in the Arena software to simulate the production process and to compare the time consumed for the production before and after the reduction of the bread weight. A comparison of raw material costs was made to identify the most viable process for the organization. Additionally, a questionnaire was applied to the customers of the establishment to verify the degree of satisfaction with the modified product. This study made it possible to verify that the production process carried out after the French bread weight reduction increased production capacity by 30 units per recipe, reduced annual raw material costs by 11.73% and 86.36% of customers are satisfied with the weight of the product offered.*

Keywords: *Simulation, Arena, Production, French Bread.*

I. INTRODUCTION

With technological advances and increased competitiveness, companies look for strategies to increase their productivity, improve processing time, reduce costs and ensure customer satisfaction when delivering the product.

[1] affirm that to improve the productive performance of a company it is necessary that its tasks are comprised by a process perspective. According to [2], process management aims to achieve better results by improving processes.

Therefore, companies are using processes modeling and simulation, which according to [3], is a computational model that represents the behavior of a process, to then propose solutions to a problem. This tool made it possible to analyze and evaluate situations that would not be possible in real life.

The general objective of the work, implemented in a small bakery located in the state of Minas Gerais, Brazil, is to identify the productive capacity of French bread and to analyze the changes made in the production process after the reduction of the product weight. The specific objectives of the study are to analyze and compare both processes through the software Arena student 14. Deduct costs with raw material to financially identify the most viable process for the company and verify, through a questionnaire, the satisfaction of customers with the product offered after its weight change.

II. LITERATURE REVISION

A. Processes management

According to [4], the process approach allows a better detailing of the tasks performed, which is based on the sequences of their actions, such as following the system and redesign and

improvement of the process through the study of the work done.

For [1], process mapping is a method used through process management to improve business performance, allowing all manufacturing steps for a product or service to be detailed.

B. Cronbach'a Alpha

According to [5], Cronbach's alpha is a tool used to evaluate the reliability of a questionnaire applied in a study. This alpha measures the equivalence between the answers of a questionnaire by means of the answers profile study obtained by the interviewee.

C. Maple software

[76 states that software such as Matlab, Maple and Fortran make it feasible to generate random samples through variable input patterns. It is possible to statistically generate an order of random values that respect a normal distribution and then perform the appropriate modification of the values to obtain the desired arrangement.

D. Sample Calculation

For [7], it is necessary to admit a percentage of error when choosing statistically a portion of the population that constitutes a sample. [8] states that an adjustment index greater than 0,95 is very good and it is possible to obtain the number of respondents through the formula, $n_0 = \frac{p\,(1-p)\,Z^2}{e^2}$.

III. METHODOLOGY

The study was based on bibliographic research, through books, scientific articles, magazines and academic websites, from March to September of 2018, having as object of study a bakery located in Minas Gerais, Brazil.

A follow-up was performed on the production process of French bread from this bakery. In this follow-up were observed the production stages, length of processes, number of employees, work stations involved and the total production of 12 days, from March to August 2018.

Due to the company's availability, it was observed the behavior of 12 cycles of the production process, where the collected data were inserted in the software Maple 17, to generate statistically 51 samples. In order to guarantee the desired reliability in the generation of the samples, the sample calculation was used, which allowed to verify that for a monthly production of 58 recipes the total required to accomplish the simulation of this process is 51 units, considering a 95% confidence level.

The samples generated statistically by the software Maple, together with the data collected during the process mapping, allowed to perform a simulation in the Arena student software 14, in order to compare both productive processes performed by the bakery.

After the comparison of the processes, a survey was elaborated and applied to the customers of the establishment. This survey was intended to identify the customers satisfaction level with the product offered and to verify if there was the perception of the bread weight reduction. This questionnaire was validated through Cronbach's alpha with a reliability of 0.82. [9] states that this statistical technique uses a scale of 0 to 1 to evaluate the reliability of the questionnaire.

To achieve the results desired reliability obtained by the satisfaction survey, it was used the sample calculation, which made it possible to verify that for a population of 100 consumers of French bread the number of respondents required is 80 people, considering a confidence level of 95%.

The raw material costs were compared in both production processes to identify if there were changes in the disbursements made by the bakery. This comparison was made using data provided by the owner of the establishment. With this information, it was possible to verify the costs per revenue in the period of one month before the change in bread weight and one month after the change.

A. The process' flowchart

The bakery operates by shifts comprising the time from 5:00 a.m. to 10:30 p.m., during the seven days of the week. Although other baked goods are produced in this bakery, the French bread production was selected as the object of study. This selection was made because the French bread is the best selling product in the establishment, according to the owner.

The production process is performed in eight stages: preparation of the ingredients, dough preparation, cylinder, the dough separation and weighing, cylinder, divider, modeling of the loaves and baking the loaves. Fig. 1 shows the process of producing French bread.

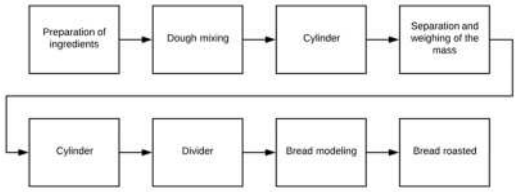

Fig. 1: Flow diagram of the French bread production process

As shown in Figure 1, the production of French bread begins with the separation and weighing of the ingredients, being performed by one collaborator. This process lasts six minutes, resulting in a dough of 108,91 lb.

After separating the ingredients, the same employee will perform the dough mixing process, this process was performed in twenty-five minutes with the support of an industrial mixer. Subsequently, the bulk goes to the cylinder until reaching the point of veil, responsible for smoothing the dough until reaching the elastic point, where it does not tear. This process lasts eight minutes and can be performed by one or two employees.

Thereafter, the dough is subjected to the separation and weighing process, where it is separated into 26 circular shaped portions, where each portion has 4.19 lb. This process is performed by one or two employees, varying according to the demand and lasts approximately seventeen minutes, when performed by one employee. The dough is wrapped in circular shape to facilitate the cutting process.

The dough returns to the cylinder, being opened in a circle shape, this processing lasts four minutes. Soon after the mass goes to the divider, it is distributed in a circular shape and cut into 30 pieces of approximately 0,14 lb each. The cutting process lasts seven minutes. Both processes are performed by one collaborator.

Then the dough follows to the modeler, responsible for curl the bread to its final appearance. This stage is executed by two collaborators. One collaborator is in charge of putting the dough in the modeler and the other one is in charge of removing and distributing the bulk in several pallets. The procedure observed lasts twenty-four minutes.

It is important to notice that this establishment has two types of pallets. One type has five rows that support a total of 25 loaves and the other type of pallet have six rows that accommodate a total of 30 loaves, where each row of the palette accommodates five loaves.

After completing the modeling process, the pallets proceed to the fermentation chamber, responsible for the growth of the dough until the moment it goes to the oven. The oven supports eight pallets and it is heated for fifteen minutes and the bread is roasted in exactly 20 minutes. In this process a single oven is used, although the establishment has two ovens.

It is noted that this initial dough of 108,91 lb yields 780 loaves of 0,13 lb each.

B. French bread production stages after weight change

After the French bread weight change, a new mapping of the productive process was carried out. The separation and weighing of the ingredients is performed by one collaborator and lasts for six minutes, resulting in a dough of 108,91 lb.

The dough mixing process was performed in twenty-five minutes with the participation of one collaborator. Subsequently the bulk was directed to the cylinder by the same employee, where the process lasted eight minutes.

The process of separation and dough weighing was performed in twenty minutes by one collaborator. This step provided the separation of 27 portions in the circular format, where each portion has 3,97 lb. Thereafter, the dough returns to the cylinder having an average duration of five minutes. The bulk goes to the divisor, which is responsible for the dough cutting process, resulting in 30 circular pieces of approximately 0,13 lb each. This process was performed by one collaborator and lasted eight minutes.

The dough modeling stage is performed by two employees in twenty-five minutes. Later the pallets are directed to the fermentation chamber, responsible for the growth of the bread until the moment of being baked. The baking process is carried out in an industrial oven for twenty minutes, and the oven has to be heated for fifteen minutes.

The production process after the reduction of 0,011 lb in the weight of each French bread allowed the production of 810 loaves per recipe, in which the unit has 0,12 lb.

C. Simulation Software: Arena

[10] states that the simulation in the Arena is performed through a logical-mathematical model that represents the flow of the studied process. This simulation is executed with the aid of the mouse, where it is not necessary to enter programming codes, since the creation of the simulation model is visual, graphic and integrated. For this model it is required to insert the statistical data collected from the studied system, which usually have values for the spaces, duration and available resources.

According to [11] the Arena software is composed of a group of blocks employed to detail a real process and operate as a

programming language command. The essential principles for the simulation in Arena are the individuals, instruments, procedures, among other processes that integrate workstations. This software represents an integrated graphic modeling, which comprises all the necessary resources for the process simulation, design and animation, statistical analysis and results analysis.

For [12], the software Arena allows to:

- Form your processes to define, to register and to communicate.
- Simulate the future performance of your system to identify opportunity for improvement.
- Have an overview of activities with graphic and dynamic animation.
- Analyze your system performance and confidently choose the best way to run your business.

IV. RESULTS AND DISCUSSION

A. Analysis of the French bread production

In order to analyze the performance of the French bread production process, a mathematical logic model was created through the Arena student software 14. Fig. 2 exemplifies the model created to demonstrate the performance of the processes.

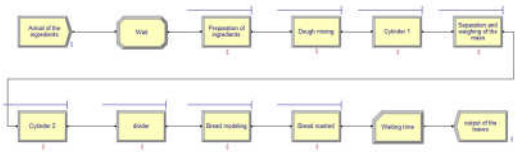

Fig. 2: exemplifies the model created to demonstrate the performance of the processes

Fig. 2 presents the simulation of the productive process of French bread made in a normal working day, which begins with the arrival of the ingredients and ends after the loaves are baked. This simulation was performed in the Arena software, which allowed to verify the behavior of each phase of the process and presented an average duration of 1 hour and 53 minutes.

After the reduction of 8% of the French bread weight, realized at the end of March 2018, a new production process simulation was developed in the Arena student 14 software. This simulation allowed the verification of the average duration of the current process of 1 hour and 56 minutes. During the process mapping, it was verified that after the change of the product weight that was a time increase of three minutes. This reduction allowed the initial dough of 108,91 lb yielded a total of 810 breads, increasing the productive capacity in 30 breads. This production time raise is justified by the addition of one piece of 3,97 lb to be rolled in the circular format and cut by the divider, in addition to the increase of 30 units of loaves to be modelled.

Through the use of Arena student 14 software it was possible to verify that both processes do not have a queue. Therefore, no changes were proposed in the flow or the acquisition of machinery.

B. Deduction of raw material costs

After verifying the increase in production capacity, a cost deduction was made to identify the expenses with the raw material in both processes. Tabele 1 shows the costs per revenue and Tabele 2 shows the costs of production during the year.

	Bread weight (lb)	Raw material costs (US$)	Unit cost (US$)	Yield
Before the change	0,13	$ 21,54	$ 0,027	780
After the change	0,12	$ 19,74	$ 0,024	810
Reduction	0,01	$ 1,80	$ 0,003	

Tabele 1: Deduction of costs by revenue

Tabele 1 exemplifies the raw material costs per revenue, which enables to verify that in the first process observed the disbursements with raw material was US$ 21,54. This revenue yields 780 loaves and the unit cost of bread was US$ 0,027. In the second process analyzed, the raw material cost was US$ 19,74 and yield per revenue was 810 loaves, due to the reduction of 0,011 lb in each unit. In this process the unit cost of bread was US$ 0,024 obtaining a reduction of US$ 0,003 per unit and US$ 1,80 per recipe.

Frequency	Yield	Before the change	After the change	Reduction
Daily	1.500	$ 41,42	$ 36,56	$ 4,86
Monthly	45.000	$ 1.248,62	$ 1.102,18	$ 146,44
Yearly	547.500	$ 15.117,06	$ 13.344,08	$ 1.772,98

Tabele 2: Deduction of production costs over the course of the year

Tabele 2 illustrates expenditure on the production of French bread during the year. Since daily production is 1.500 breads, the cost of raw material for the production of it went from US$ 41,42 to US$ 36,56, allowing daily savings of US$ 4,86. Annually 547.500 loaves are produced, so the cost of the raw material went from US$ 15.117,06 to US$ 13.344,08, generating an annual savings of US$ 1.772,98 to the bakery.

C. Application of customer satisfaction survey

After verifying the reduction of raw material costs for the production process, a questionnaire was developed to be applied to the bakery customers. The target audience for this survey

were clients who had at some point consumed French bread produced by the establishment. This survey was validated with five questions through Cronbach's alpha and applied to 88 clients, out of a total of 100 bread consumers. As shown in Table 3, the questionnaire allowed to identify that 86.36% of customers is satisfied with the weight and size of the product and did not perceive the change made by the bakery.

Question	Answers	Quantity	Percentage (%)
1	Satisfied with the weight of bread	76	86,36%
	Dissatisfied with the weight of bread	12	13,64%
2	Satisfied with bread size	76	86,36%
	Dissatisfied with bread size	12	13,64%
3	Satisfied with price of bread	67	76,14%
	Dissatisfied with price of bread	21	23,86%
4	Satisfied with the taste of the bread	81	92,05%
	Dissatisfied with the taste of the bread	7	7,95%
5	Satisfied with the product offered in the last six months	82	93,18%
	Dissatisfied with the product offered in the last six months	6	6,82%

Tabele 3: Customer satisfaction survey

Based on the results, it was verified that the production process after the reduction of 8% of the French bread allowed the increase of the productive capacity in 30 units and a reduction of 11.73% in the annual costs with raw material, represented by an amount of US$ 1.772,98. It was possible to verify that the customers did not realize the reduction in the weight of the product, being that 86.36% of the consumers is satisfied with the weight and size of the French bread.

V. CONCLUSIONS

It was recognized that the computational simulation together with the financial analysis of the disbursements is able to become a tool of great importance for the management of the productive process and permanence of the company in the market.

With the study of the production process of French bread, it was possible to conclude that there was an increase in production capacity of 30 units per revenue. The initial process had a yield of 780 loaves, after the reduction of 8% in product weight, to 810 breads per recipe, maintaining the daily production of 1.500 breads.

This change allowed a reduction of US$ 0,003 in the unit cost of bread, allowing the reduction of raw material costs by US$ 146,44 per month and US$ 1.772,98 per year. It was found that 86.36% of French bread consumers are satisfied with the weight and size of the product offered by the establishment and did not perceive its reduction. It is important to emphasize that this article does not aim to expose the quantitative results obtained by the application of satisfaction survey by the company's revenue.

Through the results obtained by the study, the bakery opted for the production process that has a yield of 810 loaves per recipe, in which the product unit went from 0,13 lb to 0,12 lb.

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