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Social behavior in an area of Medellin through Agent-Based Simulation

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Abstract

That arise within organizations, allowing decisions to be taken to benefit the improvement of the supply chain, from production logistics, inventories, supply and distribution, in order to optimize each of the processes, thus maximizing the profits of the organization. In the present study, a proposal is designed and developed to improve the food preparation process applying the simulation of discrete events. The applied methodology is based on the identification and recognition of the production process and analysis of the data provided by the company, finally the construction of a model and its simulation with the suggested proposals. To support the simulation process, the Simul8 software was used as an integrated environment tool for the situation presented, due to the flexibility of its use, in addition to the fact that it is possible to work with precision, various models applying simulation, and the friendly use in the model building process and the possibility of obtaining effective solutions to the organization's problems. The topic was approached as a case study, due to the descriptive situation of a specific situation. Favourable results were found to improve the food preparation process, allowing to find a balance between the foods that must be had in supply for the preparation of the restaurant order orders.

Keywords: Discrete simulation, Decision making, Healthy food, Supply chain, probability distribution function.

I. INTRODUCTION

It is important that companies play a vital role within the competitive environment, since it is the same companies that satisfy all kinds of social needs, such as the technological and economic development models of the countries. This is how organizations, as they evolved, tangible and intangible innovations appear, which forces them to modify their commercial strategies, as well as their way of working [1].

For companies to be competitive, they must make certain types of decisions, which will imply changes in the organization's productive systems [2], these results must be evaluated by engineering techniques to guarantee that the company is effectively on the right track. However, a simple evaluation of the results can be done through the support of the simulation of a model, which, although often not enough to determine the best decisions of the project, a more exploratory study is necessary to determine the most suitable combination. Adequate decisions that lead to the best project results [3].

These analysis and simulation models should be carried out in order to better understand complex systems, to innovate and experiment with new resources, processes, policies or systems with modern manufacturing expectations without the need to invest resources in prototyping real, gathering information and knowledge without disturbing the current system and with which decisions will finally be made [4].

In accordance with [5]. In production systems, methodologies are required for the description of the system and an event modeler must be available that can identify the variations of said system. This is how simulation is used as a technique that allows to simulate the behavior of a physical or theoretical system under certain operating conditions in order to analyze, study and improve the behavior of a system.

The present study is approached from the perspective of a case study, where it is necessary to use the discrete event simulation technique with applications of exponential, uniform and average probability distribution according to the activities that are handled within of the organization. Regarding the design of experiments, it is important to mention that according to [6], is the set of treatments applied to all possible combinations of the levels of various factors, where each factor will provide various treatments. In general, a factorial experiment allows the separation and evaluation of the effects of each of 2 or more factors that affect only one experimental unit, on the other hand, it also admits the identification of the instruments of interaction between 2 or more factors. .

The starting point is the analysis of the different processes within the supply chain of a healthy food restaurant which seeks to improve the food preparation process in which novelties have been found that prevent the company from having better competitiveness and satisfaction of the user of said service.

There have been several studies carried out where the integration of computational techniques applied to the food industry is used in order to optimize its processes, for the search for information, reliable sources were used such as indexed scientific articles of the last 10 years and of the which are framed in issues of the agri-food industry and companies focused on providing the food distribution service, where simulation techniques are used for the analysis and improvement of their processes.

The criteria for the search of keywords were carried out taking into account the search algorithms, guaranteeing a more efficient exploration and it was carried out in English and Spanish, since this selection of keywords is decisive to be located in a context of information search, in addition to giving an idea about the content of the article.

In [7] an investigation was carried out that consisted in the identification of models and indicators that serve for the analysis of managerial information and constitute key tools for decision-making by entrepreneurs of the food industrial sector in Culiacán, Mexico. The main findings make it possible to determine that the main models and indicators used by entrepreneurs in this sector are: liquidity, solvency, operating performance, stimulus programs and analysis of the capacity of employees, evolution of the competitive position and monitoring of objectives. Thus, it was also found that a high percentage of entrepreneurs do not make use of indicators such as: Discounted cash flow, return on investment, return on capital and added economic value.

In [8] the problem of dissatisfaction of restaurant customers due to long service times in times of high demand is addressed. Simulation is used as a strategy to model the customer service process, culminating in an increase in the number of customers that the restaurant is able to serve, which has brought about a strong increase in sales and profitability of the business.

For his part [9] present a methodology based on stochastic Petri nets to assess the impact caused by the capacity restrictions of the productive factors on the level of service in a mass-produced restaurant. The system under study is identified and a discrete simulation model is developed in Stochastic Petri nets, which takes into account the most representative components and characteristics of the system and their interrelations. The impact caused in the production and service stages could be identified, and the most critical and their effects were characterized.

The processes of continuous improvement in customer service are strengthened from the engineering processes and that is where [10] applies the ServQual method in restaurant service in order to obtain a measure of service quality. The procedure is complemented with the Petri net method, in order to evaluate the response capacity component in the provision of a service in the restaurant sector. Methodologically, continuous improvement was evaluated through customer satisfaction surveys. Subsequently, the simulation design in Petri nets was experimentally validated using Visual Basic. With the results obtained, improvements in the process were achieved, which are translated into recommendations, on topics such as: increase in restaurant staff, greater number of customers served, improvements in the efficiency and effectiveness of the service provided.

Finally, in [11] the process of home deliveries in a fast food restaurant is analyzed through the simulation of discrete events, through the development of a stochastic simulation model determining the number of homes needed to cover the demand. The input and output analyzes for the relevant simulation model are shown, as well as a detailed explanation of the algorithm (and its programming in Excel VBA) that generates these outputs. The ability to find confidence intervals for the expected number of motorcyclists required per hour is demonstrated with a fairly acceptable level of precision, as well as the number of replications necessary to reach this level.

After analyzing different situations in which the application of simulation is used to generate solutions in organizations, the case is presented that will be analyzed using simulation techniques.

II. DESCRIPTION OF THE PROBLEM

Today, healthy food has impacted the market in a significant way thanks to the use of fresh and healthy ingredients. In the "Healthy Food" restaurant, two processes are required for the production of products: first, there is the food preparation process and second, there is the customer service process. It should be noted that only the first process was taken into account to carry out the work, this given that the problem was identified in it. For the food preparation process, initially orders are made to suppliers, which depends on the amount of raw material that is held in storage. These orders arrive every week and in the event that some references are exhausted, the supplier is called to supply what is missing.

Figure 1 shows the layout of the floor corresponding to the restaurant, the kitchen and the product storage refrigerators. In particular, the premises functions as a distribution center, since orders for raw materials are received and stored on site; specifically, they are received in the morning hours and stored in an appropriate location.

Once the raw materials are stored, part of them remain in place to supply the same business and another part is distributed to other locations. After this process, the employees proceed to portion and pack the already portioned food. Before this packaging, it is verified that they are the grams required for each of the recipes, later, the packaged foods are stored in another refrigerator and each time an order is placed, these packaged foods are deducted from the inventory.

As mentioned previously, the model will only take into account the products that rotate the most, which are: Vegetable, falafel and Rice with vegetables. Continuing with the process, once the orders arrive, the food is prepared.

To this end, it is desired to simulate the production process in the restaurant, analyze and identify both endogenous and exogenous variables which generate a negative impact on the customer service process, thus giving delays caused by the time of preparation of products or because it is not counted with the optimal number of servers to provide good service to customers; Once the identified variables have been analyzed, two different simulated scenarios will be evaluated in order to issue a diagnosis that contributes to increased productivity. Some of the information on the process is presented in tables 1 and 2.

Fig. 1. Classification of ML algorithms

Table 1. Distributions and percentages given by the restaurant (Data provided by the company)

Actividad	Distribución	Parámetro
Llegada de domicilios	Average	60
Llegada de pedidos (local)	Exponencial	30
% Venta Carne vegetal Domicilios		30%
% Venta Carne vegetal Local		34%
% Venta Arroz Domicilios		36%
% Venta Arroz Local		26%
% Venta Falafel Domicilios		34%
% Venta Falafel Local		40%
Kilogramos Carne vegetal	Uniforme	LI: 43 - LS: 47
Kilogramos Papas	Uniforme	LI: 9 - LS: 11
Kilogramos berenjena	Uniforme	LI: 9 - LS: 11
Kilogramos Arroz	Uniforme	LI: 20 - LS: 24
Kilogramos apio para Arroz	Uniforme	LI: 30 - LS: 34
Kilogramos pimentón	Uniforme	LI: 5 - LS: 8
Kilogramos Maíz	Uniforme	LI: 12 - LS: 15
Kilogramos queso	Uniforme	LI: 18 - LS: 23
Kilogramos Falafel	Uniforme	LI: 7 - LS: 9
Paquetes Tortillas	Uniforme	LI: 38 - LS: 42
Kilogramos Pollo	Uniforme	LI: 28 - LS: 33

Table 2. Data taken from the variables (Data provided by the company)

Tiempos de porcionado de:									
Apio falafel	Pollo	Maíz	Berenjena	Pimentón	Carne vegetal	Arroz	Apio para arroz	Queso	Tortillas
337,27	862,4	374,45	834,44	119,28	834,44	120	834,44	97,74	40,77
343,51	868,09	574,66	737,28	630,12	737,28	120	737,28	169,13	31,66
490,03	811,87	517,1	839,54	1389,54	839,54	120	839,54	183,94	40,04
533,45	966,89	525,29	906,49	1169,46	906,49	120	906,49	216,71	11,59
372,51	880,11	549,11	718,42	697,14	718,42	120	718,42	58,92	31,2
390,01	838,32	511,45	904,74	598,4	904,74	120	904,74	128,25	37,72
561,27	927,35	584,94	945,34	3998,78	945,34	120	945,34	160,73	33,69
389,94	787,59	452,61	758,12	321,22	758,12	120	758,12	132,75	33,81
505,95	1040,36	543,36	998,09	592,69	998,09	120	998,09	160,3	60,16
343,06	882,36	596,89	989,95	323,65	989,95	120	989,95	101,26	47,65
520,14	718,07	404,08	794,66	371,35	794,66	120	794,66	85,11	30,12
371,56	1018,47	492,15	736,12	1764,38	736,12	120	736,12	129,56	30,42
309,21	861,14	497,4	914,96	355,61	914,96	120	914,96	236,12	28,51
595,52	939,49	574,9	927,64	2670,51	927,64	120	927,64	130,44	37,86
566,1	1004,49	535,27	811,09	204,8	811,09	120	811,09	160,32	46,2
325,12	750,91	597,87	830,41	1171,41	830,41	120	830,41	118,7	46,63
375,19	998,23	509,16	956,07	60,99	956,07	120	956,07	134,32	31,85
457,15	947,47	544,15	745,21	623,45	745,21	120	745,21	201,46	44,48
486,27	841,78	406,16	779,13	1561,72	779,13	120	779,13	164,06	50,68
415,98	701,59	565,75	706,69	283,05	706,69	120	706,69	205,37	30,79
378,44	876,09	551	781,5	2703,22	781,5	120	781,5	125,33	39,6
335,26	1033,29	485,71	861,06	5011,79	861,06	120	861,06	101,45	47,08
577,83	1067,04	452,3	990,18	203,76	990,18	120	990,18	134,89	22,05
450,45	1006,76	463,1	743,31	643,21	743,31	120	743,31	148,99	29,39
448,05	1054,09	493,14	703,01	249,18	703,01	120	703,01	203,13	41,99
364,49	770,28	499,97	905,24	2362,08	905,24	120	905,24	146,74	44,25
423,31	754,47	520,99	764,52	1334,44	764,52	120	764,52	175,29	47,83
556,58	1080,06	551,73	759,16	1395,36	759,16	120	759,16	193,95	41,86
355,43	1074,12	570,35	938,03	590,07	938,03	120	938,03	136,59	44,67
552,37	990,54	497,37	911,17	248,39	911,17	120	911,17	186,83	44,74
510,6	1015,6	565,49	819,27	607,01	819,27	120	819,27	128,34	39,97
494,85	811,74	521,74	886,18	283,89	886,18	120	886,18	114,22	38,95
465,65	826,8	480,22	771,18	232,77	771,18	120	771,18	203,16	39,95
422,1	946,76	522,07	875,52	773,5	875,52	120	875,52	147,19	40,19
519,14	925,5	556,85	871,21	1293,71	871,21	120	871,21	213,12	37,74
465,18	973,83	451,64	919,88	147,27	919,88	120	919,88	51,11	24,33
336,36	906,54	442,76	747,49	163,25	747,49	120	747,49	119,22	32,71
453,46	877,16	422,12	878,67	22,63	878,67	120	878,67	123,97	50,97
398,99	861,3	537,52	878,31	850,86	878,31	120	878,31	51,75	47,04

III. MODELING THE SITUATION

To develop the case study it was necessary to collect information on the operation of the company and its processes. Once the information was collected, it was necessary to use the SIMUL8 software, since it is “a software package for simulating discrete events. It allows you to create a visual model of the system under investigation by drawing objects directly on the screen ” [12].

The use of this tool served to reorganize the programming, with the necessary assumptions to be able to model the situation and in this way present the company with a proposal that allows it to make decisions about the changes that must be made in order to implement the pertinent actions to minimize the impact that is occurring.

Probability distributions.

In order to obtain a simulation model that faithfully represents the behavior of the real system, the data obtained from the system were adjusted to probability distribution functions by means of the Statgraphics software, with which the P-value test statistic was evaluated in different distributions such as Normal, Lognormal, Triangular, Weibull and Uniform, in order to identify which of these best fit with the observed data, table 3 below presents the results of the goodness of fit test with its respective P-value.

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Table 3. Results of the goodness-of-fit tests

Valor-P	Triangular	Exponencial	Lognormal	Normal	Uniforme	Weibull	Weibull (3 parámetros)
Apio falafel	0,398854	4,96E-09	0,853785	0,671665	0,808061	0,611369	0,811471
Pollo	0,309772	0	0,910259	0,892214	0,440509	0,53828	0,821029
Maíz	0,996228	0	0,766317	0,950617	0,018693	0,992159	0,994431
Berenjena	0,233719	0	0,732947	0,655875	0,888818	0,595674	0,548065
Pimentón	4,12E-05	0,765892	0,762066	0,0524343	0	0,806827	0,979456
Carne vegetal	0,233719	0	0,732947	0,655875	0,888818	0,595674	0,548065
Apio para arroz	0,233719	0	0,732947	0,655875	0,888818	0,595674	0,548065
Queso	0,666719	0,000018	0,440851	0,899204	0,26095	0,874119	0,826499
Tortillas	0,393168	3,58E-07	0,265675	0,757779	0,00638456	0,900359	0,949019

The analysis of the previous table was carried out by means of hypothesis tests as shown below.

Ho: the variable follows the evaluated distribution Vs.

Ha: the variable does not follow the evaluated distribution.

If the P-value test statistic is less than or equal to 0.05, it can be concluded with a 95% confidence level that the null hypothesis (Ho) is rejected and the variable does not follow the evaluated distribution.

If the P-value test statistic is greater than 0.05, it can be concluded with a 95% confidence level that the null hypothesis (Ho) is NOT rejected and the variable follows the evaluated distribution.

Table 4 presents the probability distribution chosen for each variable, specifying the parameters necessary for its generation, and the graphic adjustment of the probability distributions chosen to the histograms of the different variables is shown.

Table 4. Distribution selected according to the test.

variable	Elección	Parámetros		
Apio falafel	LogNormal	441,211	83,9775	
Pollo	LogNormal	910,471	106,717	
Maíz	Triangular	356,662	565,75	609,342
Berenjena	Uniforme	703,01	998,09	
Pimentón	Weibull (3 parámetros)	0,948989	874,523	22,63
Carne vegetal	Uniforme	703,01	998,09	
Apio para arroz	Uniforme	703,01	998,09	
Queso	Normal	145,653	45,612	
Tortillas	Weibull (3 parámetros)	5,89405	50,2565	-8,15446

Tests of goodness of fit.

After conducting the goodness-of-fit tests, the distributions that best fit the data were identified and the necessary parameters for their random generation were obtained from these.

Next, some of the histograms of the data in the system with their respective fit of the probability distribution function are presented in Figures 2 to 6.

For the variable celery falafel, a lognormal distribution is adjusted, with a mean of 441.2 as can be seen in Figure 2. This same distribution was adjusted for the chicken variable with a mean of 910.4.

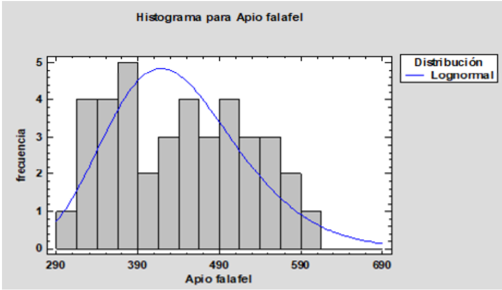

Fig. 2. Histogram for celery falafel with fit to Log normal distribution.

For the corn variable, a Triangular distribution is adjusted, with a mean of 565.7 as can be seen in Figure 3.

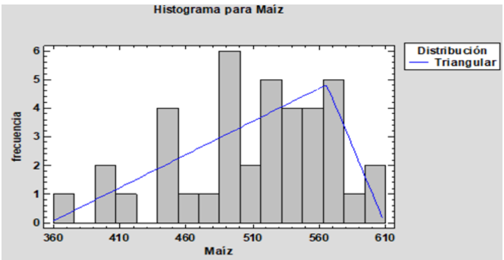

Fig. 3. Histogram for corn with adjustment to Triangular distribution.

For the eggplant variable, a Uniform distribution is adjusted, with a lower limit of 703 and an upper limit of 998, as can be seen in figure 4. This same distribution was adjusted for the variable celery for rice (with limits 703 - 998) and vegetable meat (with limits 703 - 998).

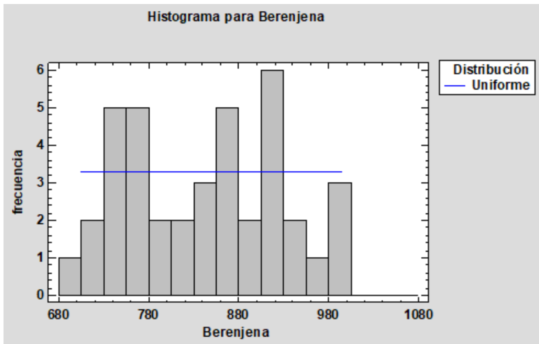

Fig. 4. Histogram for aubergine with adjustment to Uniform distribution.

For the paprika variable, a Weibull distribution is adjusted, with a mean of 874 as can be seen in figure 5.

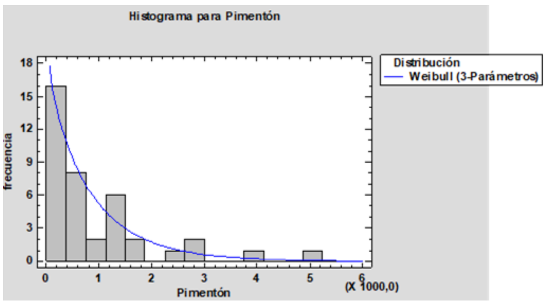

Fig. 5. Histogram for paprika with adjustment to Weibull distribution.

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For the cheese variable, a Normal distribution is adjusted, with a mean of 145.6 and a standard deviation of 45.6, as can be seen in Figure 6.

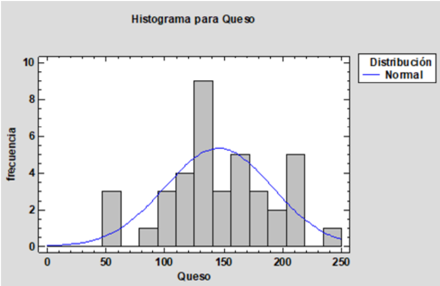

Fig. 6. Histogram for cheese with fit to Normal distribution.

Model development

Assumptions. They are defined as an assumption, theory or hypothesis to initiate a study or an analysis. For the present situation, the assumptions were established as follows:

a) It is based on the assumption of preparing three dishes: falafel, rice and vegetable meat, the recipes of which are listen in tables 5, 6 and 7 respectively.

Table 5. Recipe for falafel.

INGREDIENT	WEIGHT (gr)
falafel	150
dad	30
Eggplant	fifty
Celery falafel	twenty

Table 6. Recipe for rice.

INGREDIENT	WEIGHT (gr)
Celery rice	25
Rice	90
Peppers	25
Corn	25
Chicken	150

Table 7. Recipe for vegetable meat.

INGREDIENT	QUANTITY
Vegetable meat	200 gr
cheese	40 gr
Tortilla	2 units

The other assumptions defined for the case study are presented below:

b) The second assumption corresponds to the urgent order when the inventory of raw materials is less than the amount needed for a plate.
c) There are 6 external points of sale to which 30% of the received raw material is delivered.
d) The raw material warehouse is taken without receiving capacity for the refrigerator where the packed material is stored, which has a capacity of 50 portions of product.
e) A fixed time of 7 seconds is inferred for the verification of all products.
f) The packaging time of the products follows an exponential distribution with lambda of 30 seconds.
g) There are 5 workers in charge of portioning, verifying, packing and preparing the dishes.
h) It starts with an inventory of 500 grams in the raw material warehouse.

IV. DEFINITION OF VARIABLES

The variables that are identified in the system are classified as Endogenous, Exogenous and State. Which are defined according [13]:

- Exogenous variables represent actions influenced by the environment or external agents to the process, therefore they are not controllable; However, when exogenous variables are controllable by the system, they are called parameters and assume fixed values; the exogenous variables defined for this process are:

  Customer arrival distributions
  Number of workers (involved in all processes of the organization)
  Demand for local orders
  Demand for home orders
  Resource allocation

- Endogenous variables They are those that represent an activity that occurs internally in the system; the exogenous variables defined for this process are:

  Number of dishes sold for each type
  Average queue times
  Percentage of resource use
  Average queue orders
  Customer time in the system
  Inventory level of each ingredient
  Urgent orders

- The State variables. The state variables are derived from the endogenous ones, which show or reflect relevant characteristics of the system and the elements that compose it at the instant t that they are observed. The state variables defined for this process are:

Inventory level of each ingredient
Number of dishes sold for each type
Average queue times
Percentage of resource use
Average queue orders
Customer time in the system
Inventory level of each ingredient
Urgent orders

Results of the simulation model.

For the development of the simulation model, the SIMUL8 software was used, where from the information collected, the model of figures 7, 8 and 9 is obtained as a result.

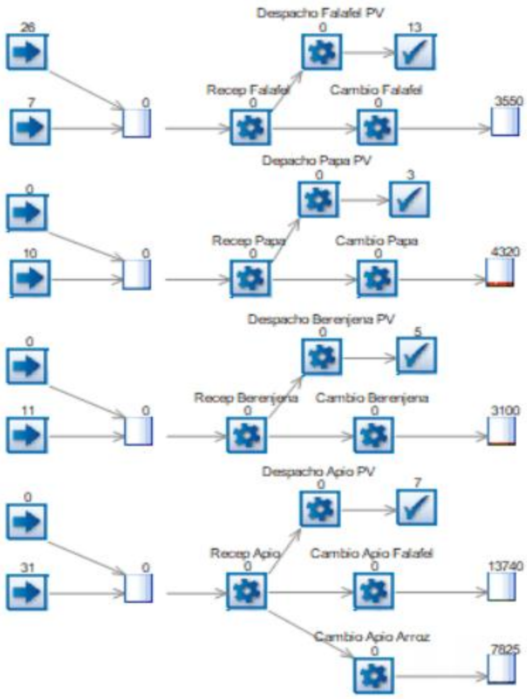

Fig. 7. Model in SIMUL8 for the supply stage.

It is observed as a result for the supply stage, a first step of reception of original and extraordinary orders of raw material, which is activated when a shortage is generated in the line or weekly, under the conditions previously described. After this, the raw material is sent to the six points of sale located in the city, for which 30% of the total volume is reserved. Finally, the raw material that remains in the plant is stored in the warehouse.

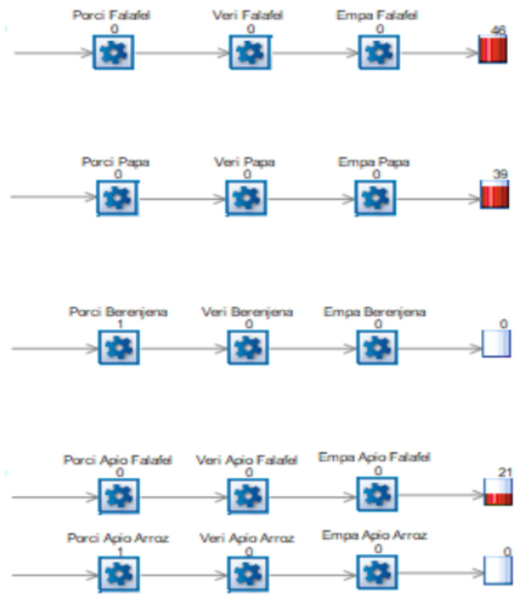

Fig. 8. Model in SIMUL8 for the dosing stage.

In the production process, there are three stages for each of the products, these stages are: portioning, verification and packaging, which share a common resource. The final storage of this product is restricted by the storage capacity of the refrigerator.

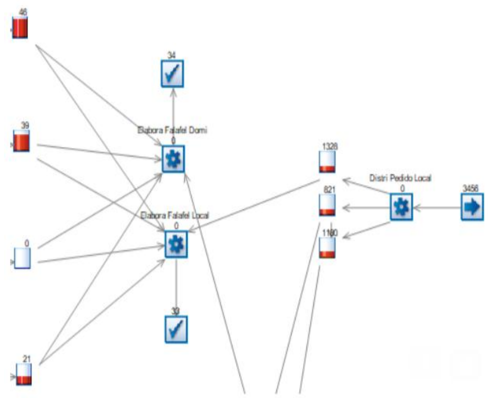

Fig. 9. Model in SIMUL8 for the distribution stage.

There are two sources of order, which are addresses and the commercial premises that the headquarters have for its operation. For each of these options there is a supply of the three products studied in the current model.

VERIFICATION AND VALIDATION

Through this step it is intended to analyze the existing coherence in the results of the model, versus the assumptions, parameters and established variables. In this sense, the variable number of workers is modified, going from 5 to 10 workers, for which it is expected that the number of orders handled will increase for each of the options.

Table 8. Verification and validation

		Número de trabajadores		Diferencia	Incremento
	Resultados	5	10	5	100%
Pedidos Atendidos Local	Falafel	309	501	192	62%
	Arroz	559	935	376	67%
	Carne Vegetal	306	497	191	62%
Pedidos Atendidos Domicilio	Falafel	309	502	193	62%
	Arroz	825	2220	1395	169%
	Carne Vegetal	306	497	191	62%

Indeed, it is observed that as the number of workers increases, there is a percentage increase in the increase in orders handled by the premises, such as orders handled by home, as can be seen in the last column of table 8.

V. RESULTS AND DISCUSSION

After analyzing the results obtained from the model, it is observed that some processes, such as portioning in a large amount of resources, present problems such as bottlenecks, for which it is suggested to make various changes in the line, such as balancing it. That allows a better distribution of the resources available at the time. Currently in the system there are emergency orders for raw materials such as falafel, rice, paprika, chicken and vegetable meat. This is closely related to the scorched products packed in the fridge, eggplant, chicken and vegetable meat. Additionally, there is a delay in the attention of a large number of orders (31952 orders at the local and 16104 at home).

EXPERIMENTAL DESIGN

According to the results obtained, the following experimental design is proposed for the identified processes:

- Variation of the capacity or the resource associated with the processes so that they adjust to the improvement needs of the organization.
- Support through an increase in capacity, the main bottlenecks that limit the general operation of the system.
- Identify critical resources, in order to increase their availability in the system and identify those resources that are not so relevant in order to adjust them to their necessary level.
- As many as parameters can be mentioned in the model, however, for the purposes of this model, the variation in the number of workers associated with the different activities will be analyzed.

Table 9. Result of the experimental design.

		Número de trabajadores		Diferencia	Incremento
	Resultados	5	10	5	100%
Pedidos Atendidos Local	Falafel	309	501	192	62%
	Arroz	559	935	376	67%
	Carne Vegetal	306	497	191	62%
Pedidos Atendidos Domicilio	Falafel	309	502	193	62%
	Arroz	825	2220	1395	169%
	Carne Vegetal	306	497	191	62%
Pedidos Adicionales		110	570	460	418%
Productos sin inventarios		3	3	0	0%

Although the number of additional orders decreases as the number of workers decreases, the number of orders fulfilled behaves inversely, increasing as the number of workers increases. With the above it is inferred that the number of workers is a determining factor in the performance measures of the model.

ANALYSIS REGARDING THE CONSULTED BIBLIOGRAPHY

According to the bibliographic review [6] the association of key performance indicators is presented that help to make a diagnosis of the system, complementing the simulation. In the case analyzed, no management indicators are presented that allow relating the results obtained with the financial status of the company or the costs it may incur, therefore it would be a good practice for the healthy food restaurant to develop management indicators for the control of the results of your company.

In [7], [8] and [9] the simulation model carried out coincides as the main objective to carry out a complete analysis of the waiting times of customers in the restaurant system before being served. In the case of the healthy food restaurant, thanks to the application in the SIMUL8 software it is possible to predict the average time in which a customer can be served due to an inefficient distribution of resources, which allows an action plan to be carried out to mitigate these effects.

In [10] a queuing system made up of customer orders to be sent is analyzed, in order to identify the optimal number of domiciliary necessary to supply the demand. In the case of the Healthy Food restaurant, a home delivery system for meals is not specified; however, the model presented in [10] is a basis with which this situation could be analyzed in the case of being implemented in the restaurant of the case analyzed.

VI. CONCLUSION

The previous report presents a complete analysis to a food preparation company, said analysis is developed through the simulation tool SIMUL8, following all the necessary steps to develop a simulation model in order to establish a solution to The problem presented, with the analysis developed in this report, identified downtime and bottlenecks, allowing the company to predict an increase in its productivity through a more efficient management of its resources. In the developed context, the validation and verification of the simulation model and its result are presented. The generated model has multiple benefits.

The previous analysis was developed using a simulation model, which allowed identifying the current state of the system without the need to make a direct observation on it and avoiding all possible consequences such as additional costs generated by the inefficient use of resources. To develop the previous model, it was necessary to identify all the processes that make up the system, how they are related and what are the operating times of each one, for which it was necessary to carry out a sampling and identify the probability distribution function that govern the data observed by means of a goodness-of-fits test applied to these distributions.

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