



# LEAN MANUFACTURING TOOLS FOR PRODUCTIVE IMPROVEMENT IN THE PRODUCTION PROCESS OF SMOKED CHICKENS

Julio César Moyano Alulema<sup>1\*</sup>, Alcides Napoleón García Flores<sup>2\*</sup>, Andrés Iván Salvador Peña<sup>3\*</sup>, Ángel Geovanny Guamán Lozano<sup>4\*</sup>, Gloria Elizabeth Miño Cascante<sup>5\*</sup>

\*Escuela Superior Politécnica de Chimborazo, Faculty of Mechanics, Industrial Engineering, Riobamba, Ecuador.

<sup>1</sup>Email: [j\\_moyano@esPOCH.edu.ec](mailto:j_moyano@esPOCH.edu.ec), <sup>2</sup>Email: [alcidesg64@yahoo.es](mailto:alcidesg64@yahoo.es), <sup>3</sup>Email: [graninca777@hotmail.com](mailto:graninca777@hotmail.com),

<sup>4</sup>Email: [a\\_guaman@esPOCH.edu.ec](mailto:a_guaman@esPOCH.edu.ec), <sup>5</sup>Email: [gloriamino@yahoo.es](mailto:gloriamino@yahoo.es).

## Abstract

The main objective of this work is to demonstrate the applicability of the tools of Lean Manufacturing in the smoked chicken elaboration process in the Valtellina company of Píllaro canton, identifying the problems, quantifying the main waste of resources in order to improve the flow of process, eliminating those tasks that do not add value and allow it to adapt to market demands through process control tools such as the Kanban, which will allow me to level the production load and issue production orders. Lean Manufacturing a new production philosophy defines how to improve and optimize a production system focusing on identifying and eliminating all types of "waste", defined as those processes or activities that use more resources than strictly necessary. With this background the company Valtellina del Canton Píllaro province of Tungurahua has decided to implement the Lean Manufacturing methodology in the production line of smoked chicken since it is aware of the advantages it offers by establishing a takt time before the implementation of 6.4 min / chicken now with 3 min / chicken, decreasing activities that do not add value by 35%, improving with standardized work at 76%, improvement of the production process by 68%. The improvement achieved in the production of smoked chicken was evaluated; By eliminating lean waste the production time was reduced by 22.8 minutes. In addition, the percentage of order fulfilment with Lean manufacturing in the company was increased to 73%.

**Keywords:** Lean Manufacturing; 5 S; Takt Time; Processes.

## 1. INTRODUCTION

In Ecuador the Lean Manufacturing is unknowledged, specially in local businesses and small companies. The benefits that are shown, doesn't convince the companies, but the countless successes that Lean Manufacturing implementation

has had, with a solid commitment, ensures a trusted positive result, "Is a fabrication methodology that search's the optimization through all the value process by the elimination of losses and seeks the incorporation of quality and at the same time following the principle of cost reduction". (Ohno, 1990)

The main objective of Lean Manufacturing is to eliminate the "waste" for the best quality product for the client, coming also with the best service and the minor lapse of delivery to the lowest cost possible. Table 1 shows the causes and effects of overproduction

**Table 1: Causes and effects of overproduction**

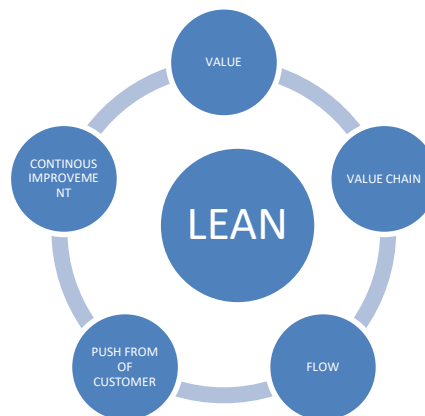
Causes	Effects
Inoperative Processes	Excessive Stock
Systems " Just in case"	Excessive workforce
Lack of communication	Unnecessary of tools and equipment
Wrong automatization placed	Overabundance capacity
Long change time	Big batch lots of production
Planning absence	Lots of security
Planning in supply and not in consume	Work repeat

Source: (Concha Guaylla , 2013)

In modern days the companies emphasize the importance of material control, assuring the optimization of existing, processes and the registry of finished products, generating an efficient process which generates better profitability. Lean Manufacturing purpose is to obtain products and services by managed processes, in a way that the product flows in a constant and regular way. The processes must be integrated through activities that are conferred to the product value (eliminating the ones that doesn't). The production and movement of the product must be in small batch lots and with swift to answer, also adding the new lowest costs. In this way there is no need for: stocks, materials/products in process or finished; this generates faster responds and new reductions in the spending, thanks to the non-inactive material existence.

Finally, the quality is assured in every stage of the process, without the needing of additional controls, this means new savings in the expense and more agile respond due to non-requirement of reprocesses.

**Figure1. Lean Principles**



Source: (Reséndiz Olguín, 2009)

Lean manufacturing is a philosophy of management focused to the reduction of the eight types of “wastes” (overproduction, waiting time, transport, excessive process, inventory, defects and movement, sub-used human potential) in manufactured products. Erasing the waste upgrades the quality and the time of production, including the cost reduction. (Lazala, 2011).

El Lean Manufacturing se materializa en la práctica a través de la aplicación de una amplia variedad de técnicas que pueden implantarse de forma independiente o conjunta, atendiendo a las características específicas de cada caso. Su aplicación debe ser objeto de un diagnóstico previo que establezca la hoja de ruta idónea. (Hernández, 2013).

Lean Manufacturing materializes in the practice through the application of a extends variety of techniques that can be implemented in single or on set, attending to the specific characteristics of each case; the application should be subject of a previous diagnostic which stablish the document of the ideal way.

For the implementation of the line that was studied, start with 5 S, Table 2 concept that shouldn't be nothing new for any company, but unfortunately, it is. It's a technique that is applied worldwide with excellent results, because of its simple and effective way, reason of this, it is applied as the main tool to implement in on-going Lean Manufacturing companies. It produces tangible and quantifiable for everyone, with a great visual and high impact component in a short range time. Is an indirect form to make the personal feel the importance of minimal things, this generates an involvement with the being and the direct approach of quality with immediate matters, resulting in a positive attitude.

**Table 2: Summary of 5 S Technique**

<b>SEIRI Disjoin and Eliminate</b>	<b>SEITON Fix and Recon</b>	<b>SEIDO Daily cleaning</b>	<b>SEIKETSU Following the first three steps, ensure a safe environment</b>	<b>SHITSUKI Building the habit</b>
Disjoining the necessary from the non-necessary	Identify necessary things	Clean after mess	Determine methods of order and cleaning	Do the order and the cleaning with all the works of a workspace
Leave only the necessary in the workspace	Assign places in the ground for elements and actions	Periodic cleaning	Apply the main method in every workspace	Teach the operators to do the order and the cleaning
Eliminate the non-necessary	Put every item in its designated area	Systematic Cleaning	Elaborate and specific standard for every workstation	Update the operators formation when there is any change
Periodic check of non-necessary things	Check that everything is in its place and everything has a place	Check systematically the cleaning of each workspace	Check that there is an working standard in every workstation	Create a permanent system of audit for floor and 5 S

Source: (Hernández Matías, 2013)

There are following tools in Lean Manufacturing. Which are a set of techniques of control and visual communication that have for objective to ease the knowledge of the system status and the advance of the upgrade actions to the employees.

The control and visual communication have much benefits, one of those the quick catchment of its messages and the fast broadcast of the information. The motivation augments when the worker has a chance to contribute and receive

acknowledgments. The visual management boards or any other type of communication techniques, are excellent spaces which serve as methodological framework for the orientation of the flow of ideas (Hernández, 2013).

The constant upgrade consists in the persistent fight against the waste. The main pillar for winning this battle is the teamwork under what is called Kaizen spirit, true driving system of the success of Lean in Japan. Kaizen means “change to upgrade”; it derives from Kai-change and Zen-good. (Reséndiz Olguín, 2009). “Just in time” (which is also used JIT, by its acronym), is a philosophy that defines the way a system of production should be optimized

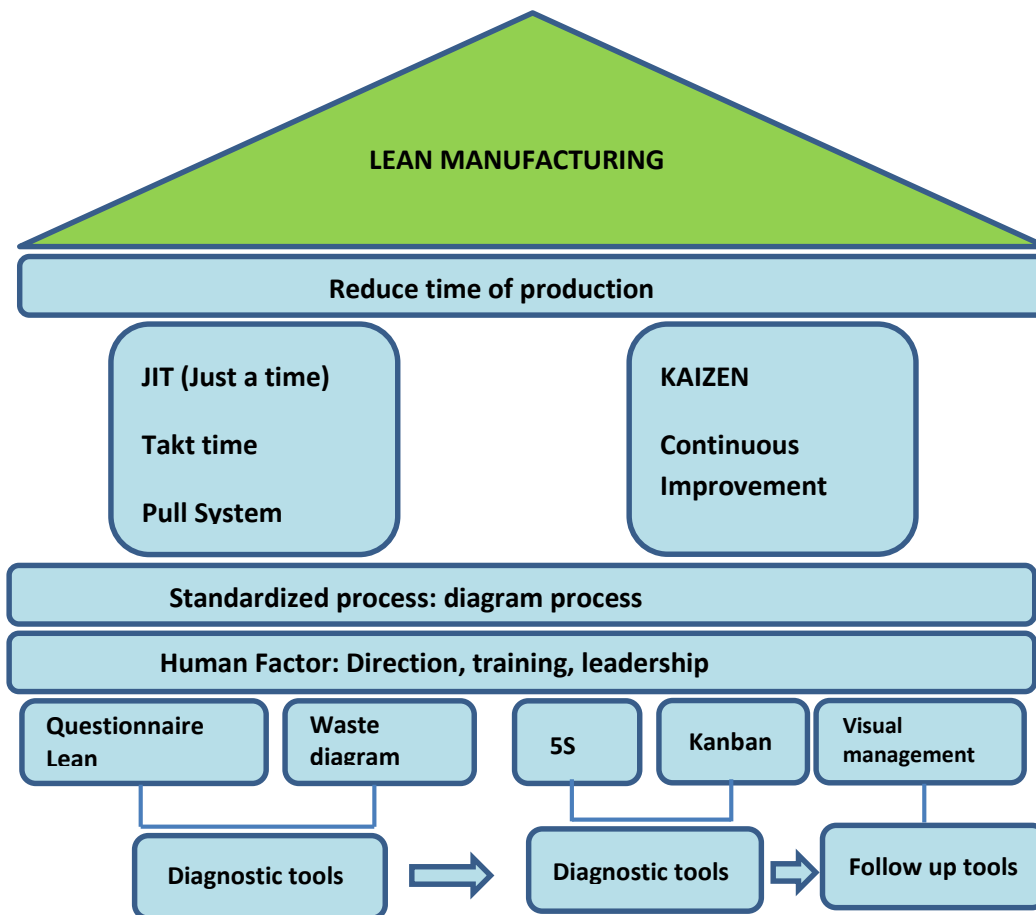
The JIT has 4 essential objectives:

- Evidence the main problems
- Eliminate the wastes
- Search for the simplicity
- Design systems for problem identification

## 2. METHODOLOGY

The methodology used in smoked chickens is following the Lean Manufacturing house detailed in figure 2, where it has diagnostic implement, operative implement and following implement, which followed with a human commitment can standardize the process with “pull production”, just in time, with a continuous upgrade for the reduction of the waste in the production, reason of study.

**Figure 2: Lean Manufacturing structure**



Source: author’s adaptation

An application of the questionnaires and interpretations of Lean focus, standardized work, Lean, continuous improvement, production process, five S. Calculus del Task time is made.

In the same way, the results obtained by the questionnaire surveys in a 24 people population. For the applying of the method, we use the following equation:

$$\alpha = \frac{K}{K - 1} \left[ 1 - \frac{\sum S_i^2}{S_T^2} \right]$$

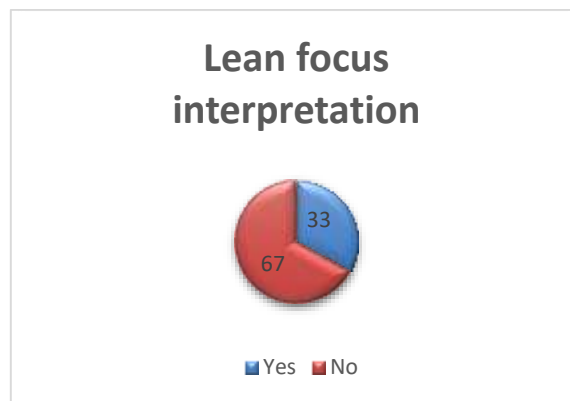
- K: The number of items
- SSi2 : Sum of Items Variances
- ST2 : Variance of the sum of items
- $\alpha$  : Cronbach's Alpha coefficient

### 3. RESULTS

As an initial part of the work, the evaluation of the company against the Lean Manufacturing techniques is carried out through the application of the lean evaluation questionnaires detailed below.

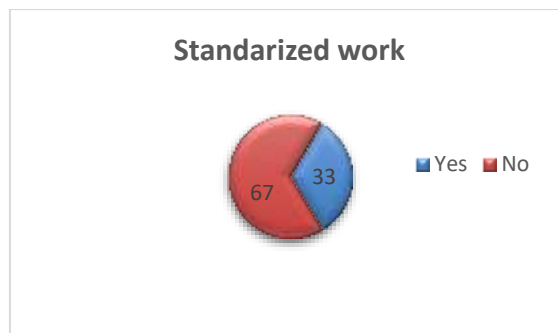
Figure 3. Lean questionnaire, Lean focus interpretation, Table, Lean questionnaire, continuous improvement, Lean questionnaire, Production process, Lean questionnaire, five S.

**Figure 2. Lean focus interpretation**



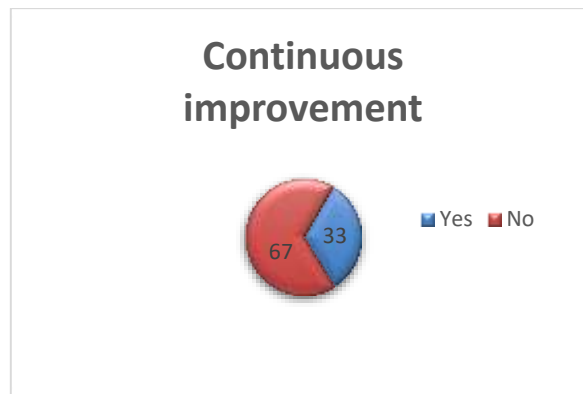
Sources: Authors

**Figure 3. Standardized work**



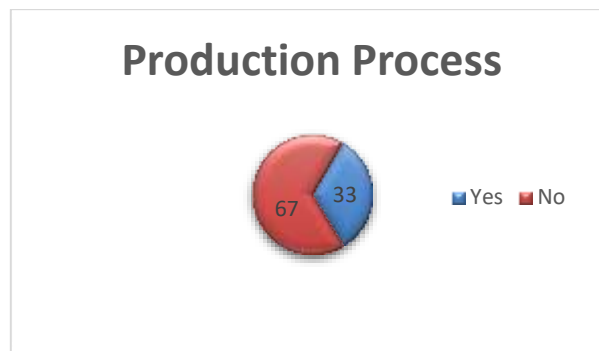
Source: Authors

**Figure 4. Continuous improvement**



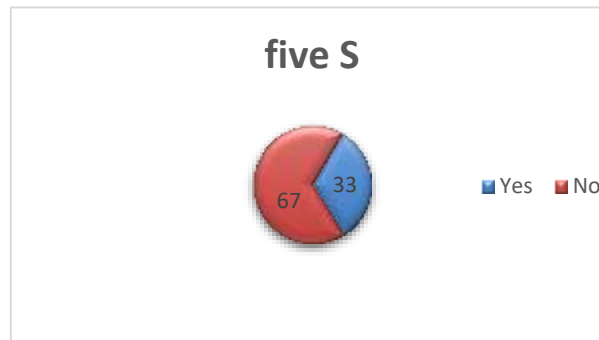
Source: Authors

**Figure 5. Production Process**



Source: Authors

**Figure 6. Five S**



Summarizing the questionnaires in table 3 where you have a 38% fulfillment

**Table 3: Lean questionnaire summary**

Elements	Number of questions	Rating
Lean Focus Interpretation	11	20
Standardized Work	6	11
Continuous Improvement	8	10
Production Process	10	31
Five S	14	23
<b>Total</b>	<b>49</b>	<b>95/245</b>
<b>Fulfillment Percentage</b>		<b>38%</b>

Source: Authors

To validate the questionnaire of the interviews, the Cronbach's Alpha method is used, which indicates whether an instrument adequately measures the variables (Interpretation of the lean focus, Standardized work, Continuous improvement, Production process, Five S) which try to evaluate with ease and efficiency form 4

We use the following equation to apply the method:

$$\alpha = \frac{K}{K - 1} \left[ 1 - \frac{\sum S_i^2}{S_T^2} \right]$$

- K:** The number of items
- SSi<sup>2</sup>:** Sum of Items Variances
- S<sub>T</sub><sup>2</sup>:** Variance of the sum of items
- α:** Cronbach's Alpha coefficient

The interpretation of the value of cronbach's alpha coefficient will be that, the closer the index approaches the end of 1, the better the reliability, considering a respectable reliability from 0.80.

To apply the method, the questionnaire was completed by the manager, the production manager and the thesis student; the result obtained is detailed below:

**Table 4. Validation of the Questionnaire**

	Lean focus interpretation											Standardized work						
	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	
	2	2	3	2	1	4	2	1	5	3	4	4	2	5	2	1	2	
	1	2	2	1	1	3	2	1	4	2	5	3	2	3	1	2	1	
	1	2	1	1	1	3	1	1	4	1	4	3	1	4	1	1	1	
variance	0.2	0	0.7	0.2	0	0.2	0.2	0	0.2	0.7	0.2	0.2	0.2	0.7	0.2	0.2	0.2	
	Continuous improvement								Production Process									
	I18	I19	I20	I21	I22	I23	I24	I25	I26	I27	I28	I29	I30	I31	I32	I33	I34	I35
	1	1	2	1	4	1	1	1	4	3	4	5	3	5	3	1	4	4
	1	1	2	2	3	2	1	1	4	4	4	3	2	5	2	1	3	4
	1	1	1	1	3	1	1	1	3	3	4	4	2	5	2	1	3	4
variance	0	0	0.2	0.2	0.2	0.2	0	0	0.2	0.2	0	0.7	0.2	0	0.2	0	0.2	0
	I36	I37	I38	I39	I40	I41	I42	I43	I44	I45	I46	I47	I48	I49	total			
	1	2	2	2	2	2	1	3	3	3	2	3	1	2	122			
	1	1	2	2	2	1	1	2	2	2	2	2	1	2	104			
	1	1	2	2	2	1	1	2	2	2	2	2	1	2	95			
variance	0	0.2	0	0	0	0.2	0	0.2	0.2	0.2	0	0.2	0	0	126			
$\sum S_i^2$	8.44														$S_T^2$			
Cronbach alpha	0.95																	

Source: Authors

The Cronbach coefficient is equal to 0.95, which indicates that the reliability of the questionnaire is respectable.

Once the lean diagnostic tools have been applied, the process diagram is made, form 7, where the activities to be executed from the entry of the raw material to the output of the product are detailed.

**Figure 7: Smoked chicken process diagram**

PROCESS DIAGRAM									
<b>Company :</b> VALTELLIN A		<b>Process:</b> Processing of smoked chicken				<b>Study N°</b> 1		<b>Sheet N°</b> 01	
<b>Department:</b> Production		<b>Analyst:</b> Ivan Salvador				<b>Method:</b> currently		<b>Date :</b> 2017-09-14	
<b>Unit</b>				<b>Transportation</b>	<b>Inspection</b>	<b>delay</b>	<b>storage</b>	<b>Description of process</b>	
80 chicken					0.25			Reception and Quality Analysis of the Raw Material	
				0.08				Transport of the raw material from the reception area to the work table 1.	
								Cleaning	
								heavy	
				0.08				Transport of chickens from work table 1 to work table 2.	
	3		0.08					Preparation of the Brine.	
	4		0.15					Injection of brine in the chicken.	
	5		0.08					Submersion of the chickens in a brine container.	
	3	8		0.16				Transport of the container from work table 2 to the cold room.	
	6		3.00					Maceration of the chicken.	
	4			0.08				Transport of macerated chickens from the cold room to the smoking ovens.	
	7		0.25					Place the macerated chickens on the rods of the oven.	
	8		2.00					Smoked.	
	9		0.25					Extraction of smoked chickens in a container.	
	5	4		0.08				Transport of the container from the ovens to the work table 3.	
	10		0.50					Cooling.	
	11		0.10					Heavy 2.	
	12		1.00					Packaging	
	6	4		0.08				Transportation of the finished product from work table 3 to the cold room.	



		1					-	storage
<b>Total</b>	<b>24</b>	<b>7.66</b>	<b>0.56</b>	<b>0.25</b>	<b>0.00</b>	<b>0.00</b>		
<b>Total hours</b>	<b>8.47</b>							

Source: Authors

Similarly according to the information of the unsatisfied demand table 3 proceeds to calculate the takt time

**Table 3. Unsatisfied Demand for Smoked Chickens**

years	Projected offer (Kg/daily)	Projected Demand (Kg/daily)	Unsatisfied Demand (Kg/daily)	Unsatisfied Demand (Kg/year)
2013	79,38	225,91	-146,53	-53483,48
2014	83,35	237,20	-153,85	-56155,27
2015	87,52	248,49	-160,97	-58754,63
2016	91,89	259,78	-167,88	-61277,93
2017	96,49	271,07	-174,58	-63721,37
2018	101,31	282,35	-181,04	-66080,96
2019	106,38	293,64	-187,27	-68352,51

Source: Valtellina Company, 2017

Takt time is defined as the time a product must be produced to meet the needs of the client.

$$Takt = \frac{Takt\ time}{Required\ Production}$$

In theory; The normal working day of the company should be 8 hours a day (480 minutes) and the production required should be that necessary to cover the unmet demand for smoked chicken, which is 174.58 Kg per day, equivalent to approximately 96 4-pound chickens. With these data the takt time is equal to:

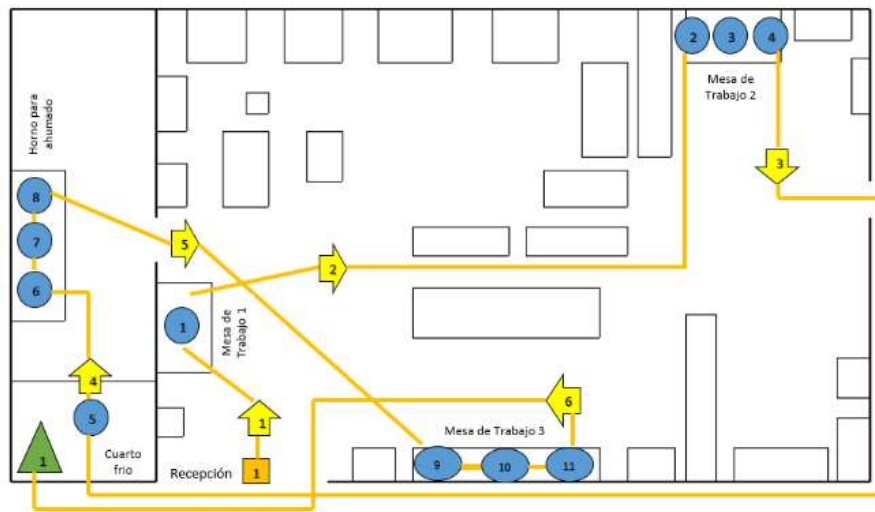
$$Takt_{theoric} = \frac{480}{96} = 5\ min/chicken \quad (1)$$

In practice; The maximum production capacity of the company is 80 chicks per day in a working time equal to 8.47 hours approximately (508.2 minutes).

$$Takt_{real} = \frac{508.2}{80} = 6.4\ min/chicken \quad (2)$$

As you can see the company Valtellina is producing with a takt time greater than required; following the route diagram presented in figure 8.

**Form 8: Smoked chicken route diagram**

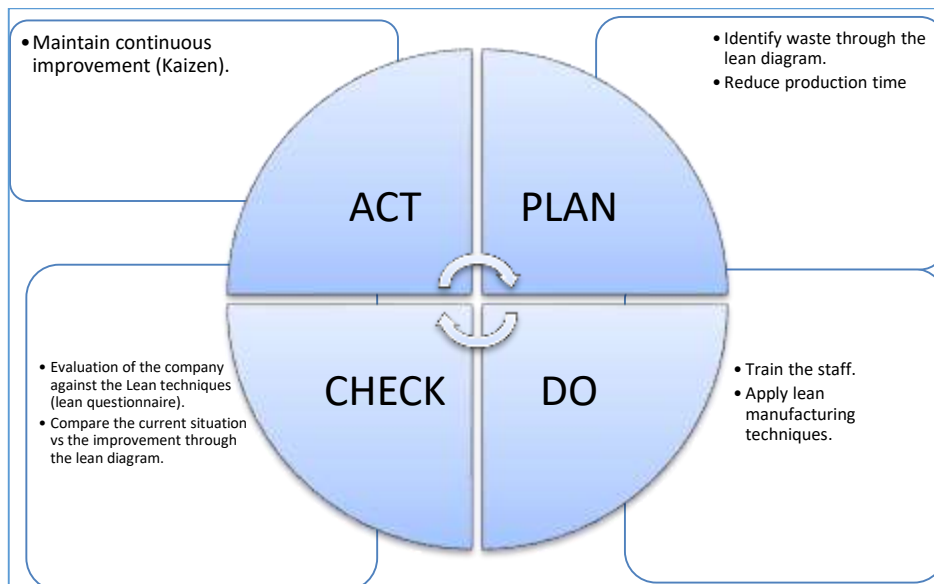


Source: Authors

In the previous form the process of smoked chicken is explained from the moment it enters until the delivery of the finished product.

Following the Lean philosophy, the Kaizen starts from the identification of the waste that can be presented in the smoked chicken production process in order to establish the continuous improvement techniques that can be applied in the process. To achieve this objective, the methodology detailed in the following figure 9 is established.

**Form 9. Methodology for the application of lean manufacturing**



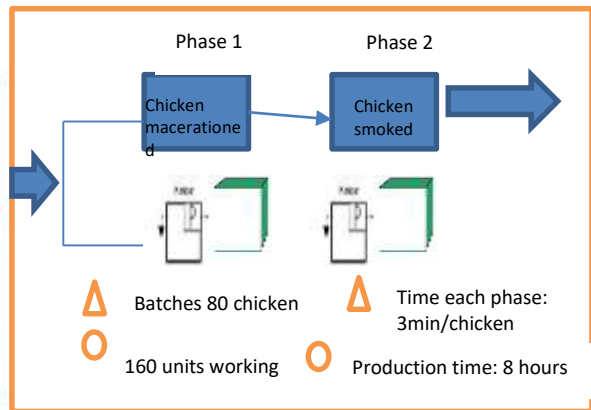
Source: PDCA Circle, Author modified

To make the improvement in the process Kanban is used, which are identification cards of the product, which is in the process of mashing and another that is in the process of smoking. The meaning of Kanban in Japanese is

"instruction label" and consists of a manual information system to control production; Its main objective is to be a work order, which gives us information about the amount of chicken that will be produced

In the production of smoked chickens, two production kanban cards will be used, which give authorization to a process to manufacture a fixed number of products.

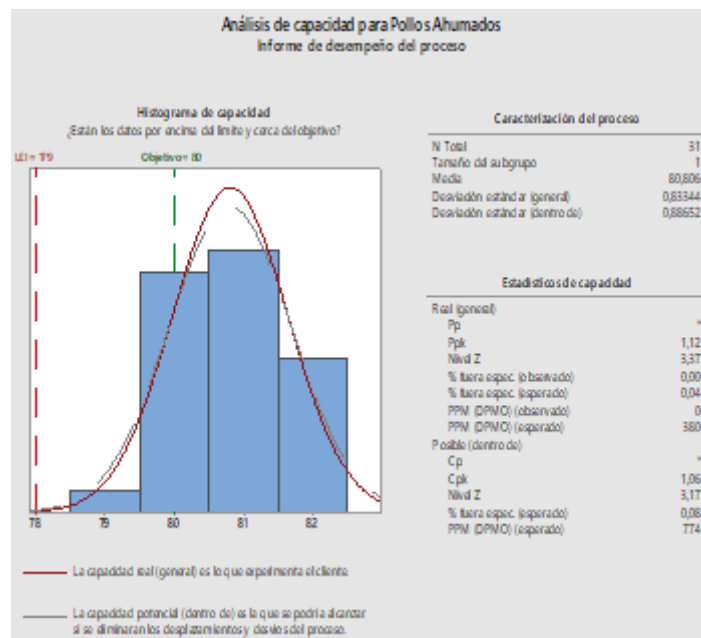
**Form 10: Kanban cards**



Source: Authors

For the verification of the process, figure 11, we proceed to make a capacity diagram showing the number of units produced, the limit values.

**Form 11: Histogram of capacity of the smoked chicken production process**



Source: Authors

Giving the following data as a conclusion

<b>LEAN INDICATORS</b>		
<b>INDICATOR</b>	<b>Without Lean</b>	<b>With Lean</b>
<b>Production time</b>	8.47 horas	8.09 horas
<b>Takt time</b>	6.4 min/chicken	3 min/chicken (Pull system)
<b>Value adding activities</b>	60%	95%
<b>No value adding activities</b>	40%	5%
<b>Work areas</b>	Disordered	Clean and Ordered
<b>Lean focus interpretation</b>	36%	76%
<b>Standardized work</b>	37%	73%
<b>Continuous improvement</b>	25%	65%
<b>Production Process</b>	62%	68%
<b>Five S</b>	33%	79%

Source: Authors

#### **4. CONCLUSIONS**

The current situation of the company was evaluated against lean manufacturing techniques; the score obtained in the evaluation questionnaire was 97/255, which indicates a percentage of compliance equal to 38%, that is, the situation of the company is deficient.

In the production of chickens the following lean waste was identified and eliminated: transport, movement and inventory or stock; the cause of these wastes is the lack of order and cleanliness in the production areas, so the operating lean manufacturing tools that were applied were 5'S, which resulted in a production time of 8.09 hours.

The improvement achieved in the production of smoked chicken is evaluated; By eliminating lean waste the production time was reduced by 22.8 minutes. In addition, the percentage of Lean manufacturing compliance in the company was increased to 73%.

## BIBLIOGRAPHY

- [1] Concha Guaila , j. g., & Barahona Defaz , B. I. (2013). *mejoramiento de la productividad en la empresa induacero cia. ltda. en base al desarrollo e implementación de la metodología 5s y vsm, herramientas del lean manufacturing*. riobamba.
- [2] Hernández Matías, J. C., & Vizán Idoipe, A. (2013). *Lean manufacturing*. Madrid.
- [3] INSHT. (2016). *Evaluación de las condiciones de trabajo*. Barcelona: Centro Nacional de Condiciones de trabajo .
- [4] Lazala, N. (18 de 12 de 2011). *Lean Manufacturing y sus herramientas*. Recuperado el 01 de 25 de 2018, de <http://www.eoi.es/blogs/nayellymercedeslazala/2011/12/18/lean-manufacturing-y-sus-herramientas/>
- [5] Ohno, T. (1990). *The Machine that Changed the World*.
- [6] Reséndiz Olguín, E. (2009). *lean manufacturing como un sistema de trabajo en la industria manufacturera: un estudio de caso*. México.
- [7] RIESGOS, S. N. (2013). *Plan Institucional de Emergencias para centros Educativos*. QUITO.
- [8] Pro optim. 2017. Las 5s – Beneficios de la quinta – SHITSUKE / Disciplina. [En línea] 27 de 09 de 2017. <http://blog.pro-optim.com/las-5s/las-5s-beneficios-de-la-quinta-shitsuke-disciplina/>.
- [9] Reséndiz Olguín, Enrique . 2009. *lean manufacturing como un sistema de trabajo en la industria manufacturera: un estudio de caso*. México : s.n., 2009.
- [10] Salud, Organización Mundial de la. 1922. 1922.
- [11] Sango Casa, Hector Homero. 2014. *gestión para la prevención de riesgos laborales en los talleres del gobierno autónomo descentralizado provincial de napo*. Napo : ESPOCH, 2014.
- [12] Vera, Quelmis. 2011. *Uso de condimentos con especias en la elaboración de pollo ahumado* . Manabí : s.n., 2011.