

**Implementation of the lean ergonomics approach to process performance improvement****Implementación del enfoque lean ergonomics para la mejora de desempeño de procesos**

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**Abstract**

Actually market is subject to constant change which forces organizations to innovate with new strategies that provide greater productivity to maintain a competitive advantage, one of the flexible tools used are Lean systems. However, in most of the improvements registered in these systems, the non-ergonomic elements have not been considered as waste, which have high costs for companies. This document presents an approach to integrating Lean systems with Ergonomics, the main tools used were Value Stream Mapping, SIPOC, Kaizen, REBA Method and NIOSH. As a result, a risk identification was obtained in 86% of the 26 activities of three processes analyzed, mainly by postures, manual lifting of loads and repetitiveness, with the improvements developed, the 25 controlled risks were reduced high to medium or low and obtained an average reduction of 32% in the cycle time of operations, making each process more efficient.

**Lean Manufacturing, Ergonomics. Improvement of processes**

**Resumen**

Los constantes cambios en el mercado obligan a las organizaciones a innovar con nuevas estrategias que brinden mayor productividad para mantener una ventaja competitiva, una de las herramientas ampliamente utilizadas son los sistemas Lean. Sin embargo, en la mayoría de las mejoras registradas en estos sistemas no se han considerado los elementos disergonómicos como un desperdicio, los cuales generan altos costos para las empresas. En este documento se presenta un enfoque de integración de los sistemas Lean con la Ergonomía, las principales herramientas utilizadas fueron Value Stream Mapping, SIPOC, Kaizen, Método REBA y NIOSH. Como resultado se obtuvo una identificación de riesgos en el 86% de las 26 actividades de tres procesos analizados, principalmente por posturas, levantamiento manual de cargas y repetitividad, con las mejoras desarrolladas se lograron reducir los 25 riesgos considerados altos a medio o bajos y se obtuvo una reducción promedio del 32% en el tiempo de ciclo de las operaciones, haciendo más eficiente cada proceso.

**Manufactura Esbelta, Ergonomía, Mejora de Procesos**

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## Introduction

The model on the integration of ergonomics and lean manufacturing systems based on the various tools has been presented in various organizations, (Srinivasa and Malay, 2016). While current perspectives consider lean manufacturing as a socio-technical system according to Cullinane, Bosak, Flood, and Demerouti, (2014), with a focus beyond workshop skills to reflect a broader management philosophy that incorporates tools and Human resource practices. Monroe, Fick, & Joshi, (2012), adds that a cost-saving analysis can be performed to demonstrate the impact that ergonomic elements can have on a project specifically increasing productivity and quality can be traced and quantified as a tracking metric.

A common tool to analyze and improve production processes is the Value Stream Mapping (VSM), it is a lean tool that aims to reduce waste. Integrating ergonomics into VSM allows simultaneous consideration of the production system's performance and physical risk factors for the development of skeletal muscle disorders in the manufacturing industry, (Jarebrant, et al., 2015). Lean Ergonomics improves the factors of the work environment in a "Value Stream Mapping" tool of lean manufacturing by identifying risks in the workstation where it evaluates each work activity of the process, (Kasper, 2017).

Prins (2004) explains that through the use of lean strategies with ergonomic principles, safety and job satisfaction tools, both workers and the general process can benefit. Mulyati, Suharno and Muharom, (2015) indicate that the combination of lean thinking and ergonomics are the result of a system where not only the worker is as efficient, but also safe and comfortable while trying to produce the best possible product. Cirjaliu & Draghici, (2016) mention that the differences between Lean theory and the needs of employees for feedback and participation directly with the company, helps reduce stress in lean manufacturing through misunderstanding, collaboration internal between employees and managers. In 2015 Dos Santos, Vieira, and Balbinotti developed an investigation within an automobile vehicle production factory, where Lean Manufacturing tools were implemented adding ergonomic evaluation and working conditions.

In this case, the reduction between the periods from 2013 to 2015 was analyzed until the month of March, a reduction of 23% was obtained compared to the performance in the company. In the work presented by Mulyati, Suharno and Muharom (2015), they applied the lean ergonomics philosophy in a cookie plant in the Yogyakarta region, Indonesia, where ergonomic waste was identified; the most important was the movement that must be resolved immediately with improvements in the vertical and horizontal design.

The great growth in manufacturing has created a lot of economic, environmental and social problems around the world generating the rapid elimination of local waste, (Kumar, 2014). Companies are looking for solutions to increase flexibility and reduce delivery time, the global market is forcing companies to find new ways to reduce costs while maintaining or increasing their quality level. However, Márquez, (2012) mentions that ergonomic principles continue to be second. Solís and Madriz, (2009) complement that many of the risk factors such as strength, repetition and inappropriate postures are the result of an inefficient and poor design of work environments and bad practices in them.

Kim (2017) mentions that when Lean tools are implemented effectively, a culture of worker participation and empowerment is created and a positive work environment is established in which changes in the workplace are expected and accepted. Certainly, the improvement in the work environment achieved by the slender manufacturing is desirable, because through the organization and description of the activities to be carried out, there is a greater control of movements and flow of materials / people in the work stations, which eventually reduces workers' exposure to unplanned injuries and accidents, (Peralta et al, 2017).

According to Yang, Hong, and Modi, (2011), lean manufacturing is complemented by other tools that help balance lines, supply flow of parts and products, identify the process value chain, without neglecting safety and ergonomics. Morse in 2014 concludes that the need for rapid employee participation to adapt and meet demands, the right combination of security, and satisfaction to avoid conflicts.

**Methodology**

Subjects of study

The present study is carried out in a pork processing company, specifically in the area of processing within the processes of Smoked Sausage, Sausage Mixing and Sausage, Brine. It is a company dedicated to processing and marketing pork and its derivatives nationally and internationally, has a capacity of 500 tons of monthly production, has 165 people, the main customers are national.

Process

Preparation of the Current VSM: at this stage the operations are analyzed through the Value Stream Mapping VSM tool to know the current situation of the processes, where the following elements should be considered:

Process Diagram Elaboration. Analyze the supply chain in detail for each process using the SIPOC Diagram.

Ergonomic Risk Identification. Identify risks in each of the process operations using the BRIEF / BEST Method, determining their risk condition.

Ergonomic Risk Assessment. Evaluate workstation activities using ergonomic methods according to the results of the risk identification in order to define redesign options that reduce risk and obtain acceptable levels of exposure for the worker.

Development of the future VSM. At this stage, ergonomic improvements will be integrated into a future VSM to compare the previous efficiency with the current one in the operations of the processes and the assessment of the ergonomic risks found, it should be considered:

Design of Improvement Proposals. Establish improvement actions using Lean tools to reduce waste that occurs during processes, considering ergonomic conditions and factors. Ergonomic Risk Assessment. Evaluate the activities in the work stations with the implementation of improvements to verify changes as interaction between the human being and the elements used in the operations of the process.

Design of a control plan. As a last stage, a control plan for the assurance of continuous improvement should be developed, establishing a matrix of priorities and responsibilities, structuring the design, selection and control methods to reduce process variation.

Materials

- Nordic Questionnaire
- BRIEF / BEST questionnaire
- Photographic camera
- Fields of evaluation methods
- Ergo Soft Pro 4.0 software
- Microsoft Visio Professional 2016

**Results**

The SIPOC tool was used to visualize the study area in detail and learn about the operations involved in each process, see tables 1-3. Adding elements such as activities to be carried out, the person in charge of said activity, who provides it, specifying the entrance of the process, its exit and the client, resulting in the analysis of the current situation of each operation during its process and identify the personnel that works , which benefits the next stage of this study, facilitating its identification and risk assessment.

Sipoc "Smoked Embutido Process"						
Exercise	Responsible	Provider	Entry	Process	Exit	Client
Take product to the sausage area	Massage Operator	Massage	Raw Material (product)	The necessary amount of product is provided	Necessary product in the area	Sausage
Prepare machine	Inlay Operator	Cleaning	Clean machine parts	The correct parts are placed on the machine	Armed machine	Sausage
Load tova	Sausage operator	Massage	Raw material in the area	With the help of a bucket the operator made the product to the hopper until it was filled	Loaded hopper	Sausage
Prepare molds	Sausage operator	Cleaning	Molds with cover	The molds are unpacked and placed on the worktable	Ready molds on the work table	Sausage
Prepare stoking	Sausage operator	Warehouse	Stokin and Liquid Smoke	The stokin is bathed and squeezed in liquid smoke	Smoked stoking	Sausage
Embed and weigh	Sausage operator	Warehouse	Stokin and scale	The product is stuffed in smoked stoking	Product stuffed in stokin with the correct weight	Molding
Mold and cover	Sausage operator	Cleaning	Molds with cover	The product embedded in the mold is placed and accommodated	Sausage product molded	Cage
Place in cage	Sausage operator	Cleaning	Cage	Product is put molded in the cage	Cage-molded product	Cooking Room

**Table 1** SIPOC of the Smoked Sausage process

Sipoc "Chorizo Mixing and Sausage Process"						
Activity	Responsible	Provider	Entry	Process	Exit	Client
Take product to the area	Grinding operator	Grinding	Raw material (product)	The necessary amount of product is provided	Product in the production area	Mixer
Load	Grinding operator	Grinding	Raw material in the area	The meat is loaded by an elevator	Meat in process make mixed	Mixer
Ingredient Preparation	Mixer operators	Cooling room	Soy, coloring, marinade	Preparation of mp in tubs to be loaded	Ingredients preparation	Mixer
Mix	Mixer operators	Warehouse	Ingredients	Turn on mixing machine	The mixture of soy, marinade, coloring	Mixer
to download	Mixer operators	Warehouse	Tubs, packs	A tub or packs is placed under the mixer	Mixed product	Mixer
Inlay	Sausage operator	Mixer	Packets	Place product in packs	Inlaid and labeled product	Stuffer
Monitor	Employee	Stuffer	Weighing machine	Product weighing is done	But allowed	Packing

**Table 2** SIPOC of the Chorizo Mixing and Sausage process

SIPOC "Salmuera Process"						
Exercise	Responsible	Provider	Input	Process	Exit	Cliente
Agitator Filling	Brine operator	Ingredient Warehouse Office	Production program	Program Analyzed	Program analyzed	Operator de salmuera
Go for ingredients	Responsible	Provider	Water	Water supply on agitator	Water in agitator	Brine area
Place ingredients in table	Brine operator	Ingredient Warehouse Office	Plastic soap with ingredients	Transport ingredients to table	Ingredients placed on table	Brine operator
Empty ingredients	Brine operator	Water store	Ingredients on table	Add ingredients in shaker	Ingredients inside stirrer	Brine operator
Shake	Brine operator	Ingredient Store	Energized Agitator	Stir mixture of ingredients with water	Stirred mixture	Brine operator
Download	Brine operator	Brine operator	Stirred mixture	Download	Brine	Injection area

Table 3 SIPOC of the Brine process

Risk identification was carried out using the BRIEF / BEST method. The Brief / Best method was of great support in this study to identify the ergonomic risks that exist in each activity of the process and the part of the human body that is exposed to an injury and / or occupational disease, in addition in this survey they are considered physical pressures such as vibrations, low temperatures, problems with gloves etc. With the application of this method the identification of risks of each operation was obtained by process, where the anatomical regions of the human body exposed to suffer an injury or disease is: neck, back and hands.

Table 4 shows that in the Smoked Sausage process an ergonomic evaluation is required in all its operations except number 1, in Mixing and Chorizo sausage in most of its activities with the exception of operation 1 and 12 because it is under the level of risk, and for the last in the brine process in all but the initial activity.

Process	Operations	Risk value	Risk level
Smoked Sausage	1	>9	Low
	3, 4, 5	10 - 29	Medium
	2, 7, 6	<30	High
Sausage Mix and Sausage	3, 12	>9	Low
	1, 2, 5, 6, 7, 8, 9, 10, 11	10 - 29	Medium
	4	<30	High
Brine	1	>9	Low
	2, 3, 5	10 - 29	Medium
	4, 6	<30	High

Table 4 Risk Identification BRIEF / BEST Method of the Processed are

According to the results of the risk identification, the ergonomic methods to be used were determined, in the processes of Smoked Sausage and Brine, its main activities of suffering any injury is according to the Brief / Brest is due to improper postures and manual handling of loads, evaluating with REBA and NIOSH Method, for the process of Mixing and Sausage Sausage also identified risks by manual handling of load but with displacement and repetitive movements for them the MAC method and erg / IBV will be used respectively. To carry out this stage, a video was taken of the entire cycle of each process to determine the positions to be evaluated.

Risk assessment process Smoked Sausage. This process has 6 operations: Activities 1, 2, 4, 5 and 6 were high-risk identification due to inappropriate postures, so an ergonomic evaluation was carried out with the REBA Method. The positions are shown in Annex 1.

Reba Method "Smoked Embutid Process"												
Position	Operation	Trunk	Neck	Legs	Right arm	Left arm	Forearm Der.	Left forearm	Right wrist	Left wrist	Final score	Acceptable
1	1. Prepare Machine	2	7	3	3	5	5	5	1	1	3	Green
1	two.	6	3	3	3	5	5	5	3	1	5	Green
2	Load	8	1	7	3	2	1	1	7	1	10	Red
3	Hopper	8	7	2	8	8	1	1	1	1	10	Red
1	4. Prepare Stokin	4	7	3	5	5	5	5	1	1	5	Green
2		4	1	3	5	5	5	5	1	1	7	Green
3		4	1	3	7	5	5	1	7	1	6	Green
1	5. Stuff and weigh	4	7	3	2	2	5	5	1	1	6	Green
2		4	1	5	5	3	5	1	1	1	9	Red
3		4	7	3	5	5	5	5	1	1	9	Red
1	6. Mold and Cover	8	1	5	7	2	5	1	1	1	9	Red
2		6	7	5	5	3	5	1	1	10	9	Red
3		8	7	5	7	3	5	5	1	1	9	Red

Table 5 Ergonomic evaluation of the Smoked Sausage process with REBA Method

The results of the evaluation using the NIOSH Method are the following: in the operation of preparing molds, an index of 0.66 was obtained for the origin, which indicates that the level of risk is low, however, for the destination, the horizontal position exceeds the centimeters allowed by the method, so for the purposes of the calculation the maximum amount allowed by the method was taken as a reference.

Therefore, it is obtained that there is a high risk, from the ergonomic point of view this task must be modified. For the activity to accommodate in a cage, an index of 0.97 for the origin and of 1.38 for the destination was obtained, which means that there is low risk for the origin and a moderate risk for the destination when carrying out the activity, however, the operators they may suffer injuries if they continue to do so in the same way, so it is convenient that tasks of this type must be redesigned or assigned to selected workers under control, see Table 6.

Niosh Method		H	V	D	A	F	C	O	F	A	Inds	Acceptabl
		M	M	M	M	M	M	M	M	T	s	e
Prepare Molds	Weight: 5.2 Kg	Origin	0.7	0.9	0.9	1	0.8	1	1	1	0.51	Green
	Frequency: 3	Destination	0.4	0.9	0.9	0.7	0.5	1	1	1	1.26	Yellow
Accommodate in cage	Weight: 10.5 Kg	Origin	0.7	1	0.9	1	0.7	1	1	1	0.97	Green
	Frequency: 4	Destination	0.8	0.8	0.9	0.9	0.7	1	1	1	1.15	Yellow

Table 6 Ergonomic evaluation of the Smoked Sausage process with NIOSH Method

Chorizo Mix and Sausage process risk assessment. This is one of the processes with more operations for the manufacture of its products has 12 activities which were applied different ergonomic methods such as the REBA Method to evaluate postures, ERGO / IVB repetitive movements, and the MAC Method for manual handling of loads with movement, taking as reference the following parts of the human body: neck, legs, forearm, wrist, trunk and other factors such as grip and load weight, in the Annex 2 the postures are shown, the postures evaluated with the REBA method are shown.

Table 7 shows the results according to the REBA Method for this process were in operations 1, 4, 9, 10 and 11 high risk, immediate action is recommended, operations 2, 5, 6, 7 and 12 is risk It is necessary to take preventive measures, activities 3, 6 and 8 are of negligible low risk and do not require analysis or preventive action.

During the identification of risks of operations with repetitive movements, such as the Embedding and Monitoring activity, this analysis was carried out using the ERGO / IVB Repetitiveness Method, generating immediate action results because they are high risk, causing the Be exposed to injuries in the future or suffer from a work-related illness. The following graph represents the color of red is the score that is 4 very high, see table 8


Position	Operation	Método Reba "Proceso Salmuera"										Final score	Acceptable
		Trunk	Neck	Legs	Right arm	Left arm	Right forearm	Left forearm	Right wrist	Left wrist	Final score		
1	1. Tank Filling	1	1	1	5	4	2	1	3	2	6	6	Yellow
1	2. Go for ingredients	3	3	2	4	4	2	2	2	2	12	12	Red
1	3. Place Ingredients on Table	4	3	2	2	2	2	2	3	3	11	11	Red
1	4. Empty Ingredients in Shiree	3	3	1	2	2	2	2	2	2	9	9	Yellow
1	5. Shake	5	3	3	3	3	2	2	3	3	11	11	Red
1	6. Download	2	2	1	1	1	2	2	1	1	3	3	Green
1	7. Washing	3	2	1	5	5	2	2	3	3	9	9	Yellow

Table 7 Ergonomic evaluation of the Sausage Mixing and Sausage process with REBA Method

ERGO / IBV Method	Inlay		Monitoring	
	Punctuation	Acceptable	Punctuation	Acceptable
Factors	100		100	
Exposition (%)	100		100	
Arms repetitiveness	57		57	
Repetitive Hands	50		50	
CP Neck Risk	IV	Red	IV	Red
MP Neck Risk	IV	Red	IV	Red
LP Neck Risk	IV	Red	IV	Red
Hand Risk	IV	Red	IV	Red

Table 8 Ergonomic evaluation with the ERGO / IVB Method of the Sausage Mixing and Sausage process

Manual handling of loads was assessed using the MAC Method, obtaining a 14-point record, which according to the conditions represents a high risk and immediate actions during activities 1, 2, 3, 6, 7 and 10 see table 9.



MAC method		
Factors	Punctuation	Acceptable
Load weight and frequency	4	Yellow
Distance from hands to lumbar region	6	Red
Asymmetric load	0	Green
Postural restrictions	1	Green
Hand-object coupling	0	Green
Surface (floors)	2	Yellow
Other environmental factors	1	Yellow
Transfer distance	0	Green
Obstacles	0	Green

Table 9 Ergonomic evaluation with the MAC Method of the Sausage Mixing and Sausage process

Risk evaluation process Brine. The ergonomic risks of the 7 activities of the brine process were evaluated, in order to raise awareness of the level of risk, taking into account the positions and handling of operator loads, see Annex 3. With the application of the REBA Method they obtained the following results: with a level of Medium risk, only operation 1 what needs to be taken, High risk activities 2, 3, 4, 5, and 7 being urgent corrective action to improve the positions of the operator, and Low risk only operation 6, see table 10.

Position	Operation	REBA METHOD "CHORIZO MIX AND EMBUTIDO"										Final score	Acceptable
		Trunk	Neck	Legs	Right arm	Left arm	Right forearm	Left forearm	Right wrist	Left wrist	Final score		
1	1. Load Soy	4	3	1	4	4	1	1	3	3	10	10	Yellow
1	2. Load Coloring	3	2	1	3	1	1	1	2	1	5	5	Yellow
1	3. Mix Soy with Dye	2	2	1	1	3	1	1	1	1	3	3	Green
1	4. Load Meat	4	2	2	2	1	1	1	1	1	8	8	Yellow
2	4. Load Meat	4	3	1	2	2	1	2	1	1	9	9	Yellow
1	5. Preparation of Adobo	3	2	1	4	4	1	1	3	3	7	7	Yellow
1	6. Load Adobo	3	3	1	4	3	1	1	3	2	7	7	Yellow
1	7. Load Butter	3	2	1	3	2	1	2	1	1	5	5	Yellow
2	7. Load Butter	4	2	1	3	2	1	1	1	1	6	6	Yellow
1	8. Mix Meat	2	2	1	2	3	2	2	1	1	3	3	Green
1	9. Download	5	2	1	2	4	2	2	2	3	9	9	Red
2	9. Download	4	3	1	4	3	2	1	2	1	9	9	Red
1	10. Weigh Mix	4	2	2	2	2	2	1	1	1	8	8	Red
1	11. Embed	4	2	1	3	4	2	1	2	1	8	8	Red
1	12. Monitor	3	2	1	3	3	1	1	1	1	5	5	Yellow

Table 10 Ergonomic evaluation with the REBA Method of the Brine process

For the evaluation of cargo handling, the NIOSH method was used; 3 activities were identified where the operator performs load lifting tasks, where all operations have a high risk; Immediate action is required. (see table 11).

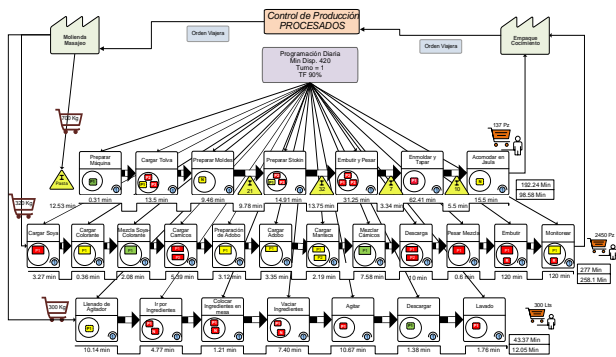
Niosh Method		HM	VM	DM	AM	FM	CM	OM	PM	AT	Index	Acceptable
Go for ingredients	Weight: 25 Kg Frequency: 5	0.83	0.85	0.88	1	0.8	0.95	0.6	1	1	3.52	Yellow
Place ingredients on table	Weight: 8 Kg Frequency: 9	0.44	0.93	1	1	0.91	0.95	0.6	1	1	3.23	Red
Empty ingredients in shaker	Weight: 17 Kg Frequency: 1	0.4	0.93	0.95	1	0.88	0.95	0.6	1	1	3.89	Red
		0.6	0.82	0.95	0.71	0.88	0.95	0.6	1	1	4.11	Red

Table 11 Ergonomic evaluation with the NIOSH Method of the Brine process

**Value flow map of the Processed Area**

The VSM represents the current situation processed area divided into the processes of Smoked Sausage, Mix and Sausage Sausage, and Brine; which indicates the way in which the process flows, operating times, requirements, inventories, pieces per batch and the flow of customer and supplier information. It also shows the result of the ergonomic evaluation for each process and operation indicating the level of risk of each posture evaluated and method used, using a circle and boxes of red, yellow and green.

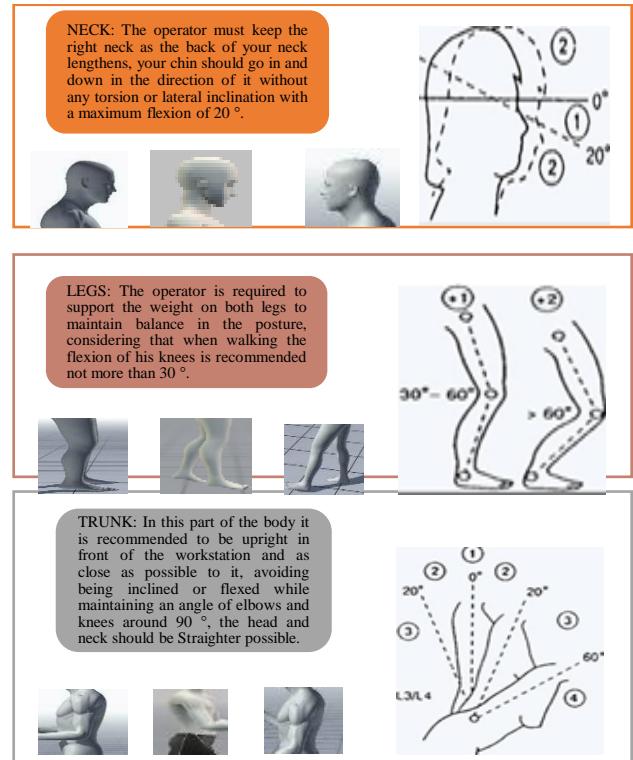
The manufacturing times of the processes are the following in Smoked Sausage of 147.37 min for the production of 1 lot corresponding to 137 pcs of the stubborn product, the Chorizo Mixing and Sausage process is 277 min per batch in pieces are 2450 of the product ranch sausage, and finally in brine for each batch 300 liters is produced to supply the processes of the processed area, see figure 1.



**Figure 1** Current VSM with Ergonomic Evaluation of the Processed Area  
Source: Self Made

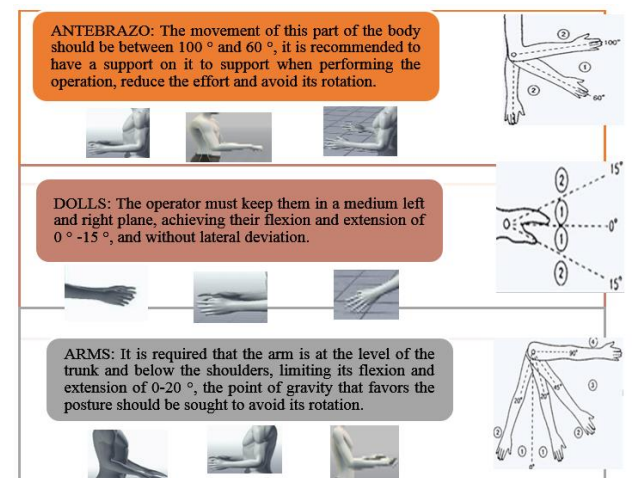
**Improvement proposals design**

The correct positions that operators must perform to reduce or eliminate the risk during their activities were established, for this purpose they propose to use some Lean tools to eliminate the waste generated in the process such as unnecessary movements.



**Figure 2** Proposals for positions Evaluated with the REBA Group a Method

In group A, the anatomical region of the trunk predominates with a high score and with a greater risk factor than the other parts of the body, it is necessary for the operator to adopt neutral positions, the position of the spine must retain its natural curvatures and avoid turning and sudden changes in position, in addition to having working conditions according to their physical dimensions and ability to increase their productivity avoiding any work-related injury or illness.



**Figure 3** Proposals of positions Evaluated with the REBA Group B Method

In group B the arms are mainly exposed to be damaged, so it is recommended that the tool to be used is close to the operator's body and better yet have some auxiliary element that helps to counteract the weight of the tool.

Design of Proposals for improvement in Cargo Handling Postures. In the processes of Smoked Sausage and Brine, the NIOSH method was used because the manipulation of the weight is manual (see figure 4), while for MACL Sausage Mixing and Sausage the MAC Method was used due to the fact that there is movement when loading the weight during its operations, to improve the position of the worker, the design proposals must be applied in the equipment that transports the material, in this way the operator automatically changes his posture.

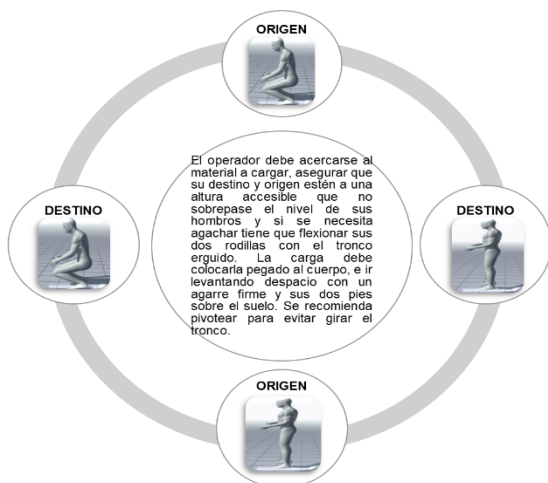


Figure 4 Proposals of positions Evaluated with the NIOSH Method

In the Smoked Sausage process it is proposed: Establish a Poka Yoke that helps to standardize the distance to which the materials used during the process should be.

A worktable with adjustable height, such as the one you already have, but a range that the operator can move it to a higher level because the current one can only decrease its height and it is at a very low level to the person who is in the work station. For the Filling in Hopper it is proposed to use the same mechanism of other processes for the filling of hoppers by means of a vertical elevator

Chorizo Mixing and Sausage Process proposes the following: A supermarket at the beginning of the process and after preparation of marinade with the purpose of eliminating some operations and reducing its time, is to keep the materials in containers, and in turn place kanban of withdrawal that indicates to the warehouse area and supplies the process of the raw material that is needed. Acquiring a stainless-steel shovel with the measures of 500-700 grams, 10 x 10 x70 cm will be used for the Unloading activity, thus reducing the operation time and eliminating the operator's risk posture.

To improve the Embedding operation where risk factors due to repetitive movements were found, it is recommended that the equipment be put into automatic mode and in this way the operator can engage in another activity and eliminate his risky posture. Another proposal is to handle the loads with a utility cart to reduce the times and improve the evaluation of the MAC Method and the risk to the operator for moving the material.

Brine Process is proposed:

Install an intercom, in the brine area since before the discharge is performed, the operator has to communicate with the operator of the injection area through an intercom that is installed in a neighboring area to the brine called the area of weighing ingredients. Where the operator has to leave to that place traveling a distance of 15 meters. Performing this improvement will reduce the time interval between agitation and discharge activities where a dead time of 6.04 minutes is averaged.

Improvement Analysis of the Smoked Sausage Process. The efficiency of the process operations was calculated obtaining a time reduction of 76.42 minutes, which in percentage represents 39.7 for a batch of 137 pieces, see table 12.

	Efficiency	
	Min	Pieces
Current	192.24	137
Improved	115.82	137
Saving	76.42	
	39.7%	

Table 12 Efficiency Improvement in the Smoked Sausage Process.

The VSM Futuro also included proposals that are part of the process, such as a supermarket and Kanban with the purpose of supplying raw material in a timely manner and requested, two Kaizen were represented representing the proposed Poka Yokes in order to expedite the process and reduce time in operations, see figure 5.

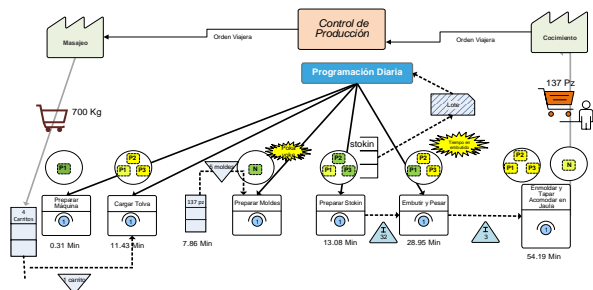


Figure 5 VSM Future of the Smoked Sausage Process

Analysis of Improvements in the Sausage Mixing and Sausage Process. The efficiency in the mixing and sausage of sausage was calculated in which a batch of 600 kg usually produces 2450 pieces in a time of 277 minutes, with the implementation of improvements and corrections of postures the production time of a batch at 179 minutes saving 98 minutes, see table 13.

Mixing and Sausage Efficiency			
	Min	Pieces	Lot
Current	277	2450	600 kg
Improved	179	2450	600 kg
Saving	98	35.37%	

Table 13 Efficiency Improvement in the Chorizo Mix and Sausage Process  
Source: Self Made

As can be seen in the VSM Future, activities 1, 2, 6 and 7 were grouped in a single operation to what was called loading ingredients, using the tools Lean the supermarket and KanBan helps the operator manage the materials of a more efficient way since supplies will be supplied 2 times. Therefore, a single step was effectively achieved, leaving as a result loading ingredients activity 1, 3 minutes the cycle time and activity 4 of 5 minutes the cycle time, see figure 6.

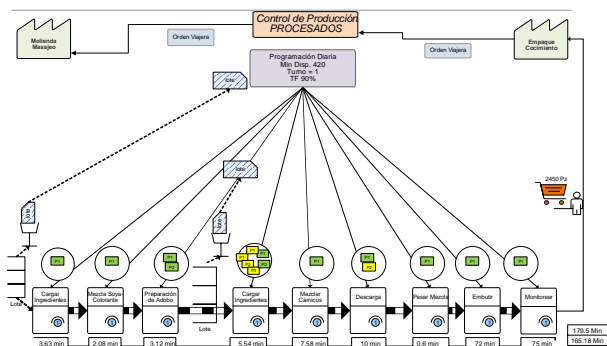


Figure 6 VSM Future of the Chorizo Mixing and Sausage Process

Analysis of Brine Process Improvements. The improvement of efficiency in the brine process considering that each batch has 300Kg of which 300lts of brine leave and normally during one shift 8 lots are processed in 347 min, with the implemented improvements of inferfon and postural correction in the operators its improvement is improved manufacturing time up to 21.6%, see table 14.

Brine Efficiency			
	Min	Pieces	Lot
Current	347	2400 lts	8
Improved	272	2400 lts	8
Saving	75	21.6%	

Table 14 Efficiency Improvement in the Brine Process  
Source: Self Made

Ergonomic evaluation was performed again in the brine process, instructing the operator of the positions that must be adopted as can be seen in figure 7. A considerable reduction in ergonomic risks was achieved. The risk was lowered to a low level, in the same way in the evaluation through NIOSH it was lowered in the high risk levels to a low risk level.

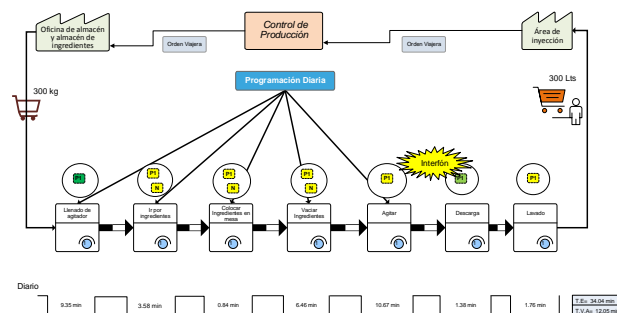


Figure 7 VSM Future of the Brine Process



**Design of a Control Plan**

This tool helps the process to monitor each of the proposals made during its operations, determining the critical variables, as a result of the risks that exist are suffering from occupational diseases and injuries, the person responsible for each improvement and monitoring is designated as a method of control was proposed to make a checklist specifying the positions of the operator and the time it takes to perform it.

**Proposal Benefit Cost**

The cost of selling 1Kg of Tozinet is \$ 87.00 pesos of which 61% are costs and 39% profit, for each piece you earn \$ 33.39 pesos. The application of improvements in this process has a cost of \$ 80,371.00 pesos, but your investment would be recovered no later than 30 days considering that for each lot there are 54 more pieces earning \$ 1,803.06 pesos and normally 3 lots are produced daily, in 30 days \$ 162,275.4 pesos.

The daily production for the sausage mixing and sausage process is 2,450 pieces in 179 minutes, saving 100 minutes, which can be made up to 3 lots in the working day, multiplying the 3 lots by 2450 pieces by the price of the product in its presentation of 250gr is \$ 16.00 pesos, the company obtains \$ 55, 272.00 pesos in profit for 3 lots, for 1 lot it gets \$ 18,424.00, considering that 53% of the sale price is cost and 47% profit, see table 15.

	Proposal	Cost
Smoked Sausage Process	Fiberglass Tape	\$371.00
	Vertical Bucket Elevator	\$80,000.00
Chorizo Mix and Sausage Process	Supermarket	\$10,500.00
	Rotor change to equipment	\$8,000.00
	Stainless steel shovel	\$400.00
Brine Process	2 Interphone	\$1,798.00

**Table 15** Cost of proposals

To complement this study, an investigation was carried out to determine the expense that can be presented to an organization if the human factor is injured by any anomaly in its working life, see table 16.

González, (2015) mentions what cost is generated at a company for a disability to its worker is \$ 209.00 pesos considering that it is increasing over the years, while Banda, (2016) comments that the average cost for an accident at work is 200 thousand pesos, this will depend on the degree of physical damage that the worker is caused, on the other hand a carelessness can cause until death that according to (Álvarez, 2016) the obligation of the employer towards the family of the deceased is to pay compensation of 5,000 days of minimum wage, corresponding to 350,500 pesos, which are borne by the IMSS if the employee was insured, as established in Federal Labor Law in its article 502.

Cost	
Inability	\$209.00
Accident	\$200,000.00
Death	\$350,000.00

**Table 16** Cost of risks

**Acknowledgments**

The work team thanks all the participants for their interest and collaboration during the data collection. Thanks also to the university (Instituto Tecnológico de Sonora) for its support and facilities for the development of the project, this publication was funded by PFCE2019.

**Conclusions**

Based on the study and results of the Lean Ergonomics project applied to the different processes, the objective of increasing efficiency is achieved through Lean tools and ergonomic evaluations, improving on average 32% the operating times of each process, in turn It decreases and / or eliminates the level of risk of each activity to be carried out, allowing the operator to work in appropriate conditions and do his job in a safe way. Implementing the improvements has a cost, however, not attending to the needs of the process and the human factor generates accidents, diseases that lead to days of disability and even death, causing a higher cost for the organization and damage to the operator. Recent studies (Bertolini et al., 2013; Montero, 2016; Vinodh & Joy, 2012) co-report that Lean Manufacturing is a system that focuses on the reconfiguration of manufacturing systems, tries to offer the highest possible value to customers with The least use of resources of all kinds, has its origin in the Toyota production system and consists of a method to systematically reduce waste.

In addition (Alpenberg and Scarbrought, 2016; Arezez et al, 2014; Dotoli, 2015) mention that this approach has become very popular among manufacturers, services and large commercial areas. Today, it is the best-known method for industrial improvement and acts at work through a set of group activities that pursue the benefit of the organization.

It is very important to follow up on the improvements and proposals made, as well as adopt the Lean culture in all the processes of the company. It is also highly recommended that the operator carry out the proposals for improvement on the postures that must be corrected since they have a high frequency of realization, in order to avoid injuries, fatigue, and disorders that may arise from performing their activities with erroneous positions. , and thereby prevent the detonation of skeletal muscle disorders.

The key factors that can be supported are cost, quality, delivery, safety and morale, through simplified thinking that will help reduce costs, require less labor, increase product development, it will achieve better quality and generate huge profits, (Thurston and Ulmer, 2016).

It is recommended and important that employees be trained about the Lean Ergonomics philosophy so that they understand it, know how to carry it out and integrate it as part of the process.

According to Arce, Romero, & Leon, (2017) Lean tools and practices have provided companies with significant help to meet the waste challenge, therefore, it has been possible to promote productivity and other key performance indicators. There are several cases of (Abuthakeer et al., 2010; Bertolini et al., 2013; Chong et al., 2013; Kumar et al., 2016; Lacerda et al., 2016) where they have reported positive results after implementation, how to shorten delivery times, reduce inventories of work in progress, increase the value-added relationship and among others.

It is necessary to follow up with the established control plan and its proposed frequency, since this tool is new for organizations and its implementation requires changes which are required to be monitoring until the process flows.

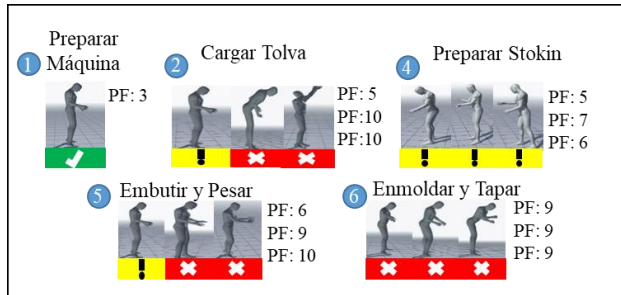
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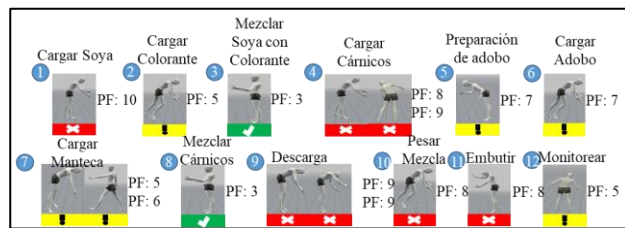
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Annexes



Annexes 1 Ergonomic evaluation positions of the Smoked Sausage process with REBA Method

Source: Self Made



Annexes 2 Ergonomic evaluation positions of the Chorizo Mixing and Sausage process with REBA Method

Source: Self Made



Annexes 3 Ergonomic evaluation positions of the Brine process with REBA Method

Source: Self Made