UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

Colegio de Ciencias e Ingenierias

Productivity analysis of the implementation of biosafety measures during COVID-19: A multi-case study

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Ingeniería Industrial

Trabajo de fin de carrera presentado como requisito
para la obtención del título de
Ingeniería Industrial

Quito, 22 de diciembre de 2020

UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

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HOJA DE CALIFICACIÓN
DE TRABAJO DE FIN DE CARRERA

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Quito, 22 de diciembre de 2020

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Lugar y fecha: Quito, 22 de diciembre de 2020

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RESUMEN

Esta investigación tiene como objetivo explorar el impacto en la productividad ocasionado por la implementación de medidas de bioseguridad para el COVID-19 en micro y pequeñas empresas (MiPEs) de alimentos y bebidas, utilizando la metodología DMAIC y proponer alternativas de mejora. El estudio se compone por 6 casos de estudios analizados para dimensionar el impacto de los cambios ocurridos por la implementación de medidas de bioseguridad a través de indicadores de productividad. El método de investigación fue una adición de los pasos iniciales de un marco lean six sigma (LSS) propuesto para pequeñas y medianas empresas (Pymes) con las fases de la metodología DMAIC. Se inicia con una encuesta de las medidas de bioseguridad aplicadas y se clasifican en empresas de manufactura y de servicio, luego se realizan entrevistas para establecer los problemas y cambios ocurridos y finalmente se solicitan videos para un análisis de indicadores de desempeño (KPIs) con los cuales se miden las actividades catalogadas como desperdicios. Como resultado, se obtuvieron los porcentajes que se atribuyen a las nuevas prácticas de bioseguridad aplicadas en cada empresa y se proponen herramientas y técnicas lean six sigma (LSS) para mitigar estos cambios. Esta investigación se diferencia a estudios previos debido a que se mide un distinto tipo de desperdicio ocasionado por problemas ambientales, de salud y seguridad que afectan a las operaciones regulares. Adicionalmente, al ser medida en una pandemia da una apertura a conocer a más profundidad sobre estos desperdicios. Los resultados obtenidos indican que sí existe un impacto en la productividad y es mayor en las empresas de servicio debido que han tenido que implementar más medidas para continuar operando. A pesar de que las actividades han sido catalogadas como desperdicios, no pueden ser eliminadas por lo que se proponen técnicas para mitigarlas.

Palabras clave: COVID-19, medidas de bioseguridad, MiPEs, DMAIC, productividad, residuos.

ABSTRACT

This paper aims to explore the impact on productivity caused by the implementation of biosafety measures for COVID-19 on micro and small (MSEs) food and beverage companies using the DMAIC methodology to propose practices to mitigate them. The investigation is composed by 6 cases study to obtain a dimension on the impact by measuring the changes through productivity indicators. The research method resulted on an addition of the initial steps of a proposed lean six sigma (LSS) framework for small and medium sized enterprises (SMEs) with the phases of the DMAIC methodology. It began with a survey of the applied biosafety measures and a classification of the companies in manufacturing and service, then interviews are carried out to establish the problems and changes occurred and, later videos are requested for an analysis of performance indications (KPIs) to measure the activities that are classified as waste. As a result, percentages attributed to each biosafety practice applied to each company are obtained and, lean six sigma (LSS) tools and techniques are proposed to mitigate them. This research is different from previous studies because of the measurement of a distinct type of waste caused by environmental, health and safety problems that affect regular operations. Additionally, measuring in a pandemic provides a deeper knowledge of these type of wastes. Results obtained indicate that there is an impact on productivity and is greater on service companies because they have had to implement more measures to continue operating. Despite being a waste, these activities are necessary, so a mitigation plan is needed.

Key words: COVID-19, biosafety measures, MSEs, DMAIC, productivity, wastes.

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1. INTRODUCTION

Micro and small enterprises are responsible for the growth of production, generating jobs, and moving the economy in developing countries such as Ecuador. With 899 205 companies registered in the Ecuadorian Internal Revenue Service (INEC, 2019) in the latest update, from which 97.94% are micro and small companies (INEC, 2019), Ecuador's financial system is pushed by these enterprises. They generate about 43.21% of jobs registered in the Ecuadorian Social Security Institute (INEC, 2019). Pichincha is the first province that concentrated the largest number of companies (23.75%) and jobs (34.58%) registered in Ecuador (INEC,2019).

In 2016, the production of food and beverages contributed the GDP in 4.67% (CFN, 2017). Moreover, it participated with 23.9% in the products exported by the country (CFN, 2017). These facts position food and beverage companies as a strong sector that supports Ecuador's GPD; therefore, reflecting in an economic growth. The continuity of production is essential when talking about the Food industry (Ani et al., 2016) because of to the need of supply and access to people for survival (Ani et al., 2016).

A shortage of food could trigger a global alarm, given that the pandemic is able to reduce more than 25% of labor availability (Ani et al., 2016). The German Federal Institute for Risk Assessment (BfR) (2020) mentions that SARS-CoV-2 could infect food when it is produced with unsanitary conditions in frozen or refrigerated goods. Similarly, viruses such as MERS and SARS-CoV-1 are known to last up to 2 years in frozen state (Ani et al., 2016). The scientific community, authorities, professionals, and food safety inspectors have determined measures for managing the spread of the virus by applying biosafety actions through the food supply chain (Ani et al., 2016). According to the stages of the food supply chain, critical safety measures are suggested to follow i.e., washing

hands, surface disinfection, etc., these essential activities must be done regular and continuously (Ani et al., 2016).

Coronavirus is a disease known to be transmitted between people through contact and respiratory droplets while coughing, sneezing, or exhaling (OMS, 2020) (MÍkva et al., 2016). Since there is no substantial evidence that demonstrates coronavirus could spread through food, Centers for Disease and Prevention informs that the risk of contracting COVID-19 by eating or handling food is unlikely (2020). However, there is a possibility of contamination if a person touches their mouth, throat, or eyes after having contact with a contaminated surface that somebody had infected with the virus by directly sneezing or coughing at the packaging (Ani et al., 2016).

The present work studies 6 micro and small food and beverage businesses and the impact of implementing biosafety measures during COVID-19 pandemic using the DMAIC method to propose solutions. The paper is structured as follows: Section 2 centers on literature review on LSS application on food processing MSEs and actions taken by food industries on a post-covid era. Section 3 covers the methodology applied. Section 4 introduces the multiple case studies. Section 5 presents lessons learned, and Section 6, findings.

2. LITERATURE REVIEW

2.1 Lean six sigma and food processing MSEs

Lean Six Sigma has been a distinctive approach for merging Lean and Six sigma philosophies which result in an improvement in quality and processes for enterprises (MÍkva et al., 2016) based on reducing variability and wastes by applying a combination of tools and techniques that focus on customer needs (Ani et al., 2016). The DMAIC method known for its 5 Phases: Define, Measure, Analyze, Improve and Control; is an improvement procedure that contributes to quality management and the design for new routines (MÍkva et al., 2016). This method solves

problems by carrying out role structure and focus on metrics (Ani et al., 2016). Meanwhile, Lean management is a philosophy centered in the elimination of wastes (MÍkva et al., 2016). Consequently, every action carried out must be for the benefit of the creating value for the customer (Arnheiter & Maleyeff, 2005).

Dora & Gellynck (2015) mentioned the challenges that previous authors have encountered when implementing Lean in food processing micro and small enterprises. They were puzzled towards the implementation process and the lack of money and time that they must invest for these practices (Dora et al., 2015; Matt & Rauch, 2013). Costa et al. (2020) acknowledged that embracing Lean Six Sigma practices in food industry is low in developed and developing countries, despite its effectiveness at improving performance causing questions about its true usefulness. The inability to implement Lean was due to a lack of step-by-step guide on how procedures should be conducted (Dora & Gellynck, 2015; Maneesh et al., 2011). Matt & Rauch (2013) findings mentioned that Lean methods could be implemented with proper planning reducing difficulties on the following processes. Lean implementation relies on data availability and customer feedback to be analyzed (Dora & Gellynck, 2015; Maneesh et al., 2011) that most MSEs do not possess. On the one hand, small companies have poor relationships with suppliers causing problems in fulfilling orders (Dora & Gellynck, 2015). Also, there are cultural factors and internal resistance that do not allow an acceptance within these enterprises (Dora & Gellynck, 2015; Matt & Rauch, 2013). Maeesh et al. (2011) found negligence in joining tool and techniques application with businesses goals; hence, a more detailed approach to initial issues was suggested before applying statistics to measure parameters of interest. Similarly, limited evidence was found about long-term benefits when using these tools (Maneesh et al., 2011; Matt & Rauch, 2013; V. Yadav et al., 2019).

Maneesh et al. (2011) proposed a 12-step framework to successfully implement Lean by changing culture organization focused on motivating employees from all levels to contribute to the process.

2.2 Post-covid era and food industry actions

Governments set protocols for food industries to safely operate due to the spread of COVID-19, followed by suggestions of food safety and health officials (Ghosh et al., 2020). Luckstead et al. (2020) mentions food processors took biosafety measurements according to the food supply chain stages (i.e., social distancing, shifts, etc.) to mitigate the risk of exposure to COVID-19. Despite these efforts, outbreaks occurred which forced facilities to reduce labor personnel for quarantine or shut down (Luckstead et al., 2020; Nakat & Bou-Mitri, 2021).

Singh et al. (2020) stressed the weaknesses found on the supply chain in food industries where products were lost, and demand was unfulfilled because of uncertainties in transportation and staff shortage. He demonstrated 3 scenarios focusing on logistics systems using a simulation model to create possible disruptions caused by the pandemic so he could provide mitigation plans to manage these type of situations (Singh et al., 2020). Different checklists have been created that continue to be updated as a guide for food companies to ensure safety during the COVID-19 pandemic (Nakat & Bou-Mitri, 2021). Nakat & Bou-Mitri (2020) developed a literature review of information from public sources, scientific articles, and web from the beginning of the pandemic to collect all the current information about COVID-19 specifically for the food industry about prevention and control measures. Findings showed the importance of revaluating risks to implement the appropriated tools, helps a smoother transition to the new normality.

Dora & Gellynck (2015) reviewed procedures suggested by ISO, BRC and HACCP where a combination of these practices was used to propose quality management that could be applied for

small and medium food processing enterprises and ensured food safety. Similarly, Fragapane et al. (2020) carried out literature reviews of the supply chain resilience to create new alternatives that could be applied during COVID-19 pandemic. Meanwhile, Golan et al. (2020) mentioned the use of Industry 4.0 technologies such as autonomous mobile robots that can improve productivity and flexibility in production better than traditional material handling. A qualitative exploratory study during COVID-19 pandemic concluded that SMEs are not interested in applying Lean Six Sigma practices now because of time and money given that they consider other issues as more urgent (Syaputra et al., 2020).

3. PROJECT METHODOLOGY

This research is based on a multiple case studies of food and beverage micro and small businesses using the DMAIC method to ensure food safety by reducing the impact in productivity of biosafety protocols stablished to minimize the spread of COVID-19. The objective is to understand in what measure these new biosafety activities have affected productivity in macro processes of micro and small food and beverage companies in Pichincha.

3.1 Study population, sample, and sampling.

Pichincha´s province gathers 23.75% of companies in Ecuador and 34.58% of jobs (INEC, 2019), which makes it the one with more relevance for this study. The criteria used to choose a MSE from the food and beverage sector was being a company with less than 50 employees and 1 000 000 USD in sales according to Andean Community of Nations (2017). The sample was selected using a non-probabilistic convenience sampling. This type of sample was chosen because of the accessibility, availableness, and willingness to participate withing the members of the target population that met the criteria (Clark, 2017; Etikan et al., 2016). The period of relevance for this study is from March 17, 2020 with the declaration of a state of exception due to public health

emergency throughout Ecuadorian territory for confirmed coronavirus cases (Moreno, 2020) and the declarations of the COVID-19 pandemic by the World Health Organization (2020) until November 2020.

Using public research directories from tributary institutions and technical body in charge of controlling organizations under the law in Ecuador (Superintendencia de Compañías, 2020; SRI, 2020) a conjoint database was created. Companies were filtered based on The International Standard Industrial Classification of All Economic Activities (ISIC). According to the user manual, the first alphabetic code is used to recognize the section and the next 2-digit numerical code to identify the division (República del Ecuador, 2010). For this study, all codes involving the transformation process of food were considered (República del Ecuador, 2010; INEC, 2010). Currently, in Pichincha there are 2 320 MSEs of the food and beverage sector that fulfill all the requirements to participate and have been active of at least 3 years old (Superintendencia de Compañías, 2020; SRI, 2020). The sample used was 6 micro and small food and beverage companies. The sample will be analyzed in two subgroups: manufacturing and service companies, from which 3 are manufacturers and 3 service enterprises.

3.2 DMAIC approach

DMAIC stands for Define, Measure, Analyze, Improve and Control: a problem-solving method commonly used for quality and process improvement (Khan Asif & Chakrabortty, 2013; Mast & Lokkerbol, 2012) for a better operational performance and satisfying customer needs (Mishra & Kumar Sharma, 2014; A. Yadav & Sukhwani, 2016). This methodology has great benefits by allowing different tools and techniques to be applied for each phase (Khan Asif & Chakrabortty, 2013) that depends on the information needed.

Maneesh et al. (2011) proposed a 12-step procedure to facilitate the execution of Six Sigma culture inside small and medium enterprises (SMEs). This research modifies the DMAIC methodology (Hakimi et al., 2018; Kaushik & Kumar, 2017) and Maneesh et al. (2011) roadmap that takes into consideration the challenges that these types of enterprises face. Due to time limitations, this study reached the Analyze phase as shown in Figure 1.

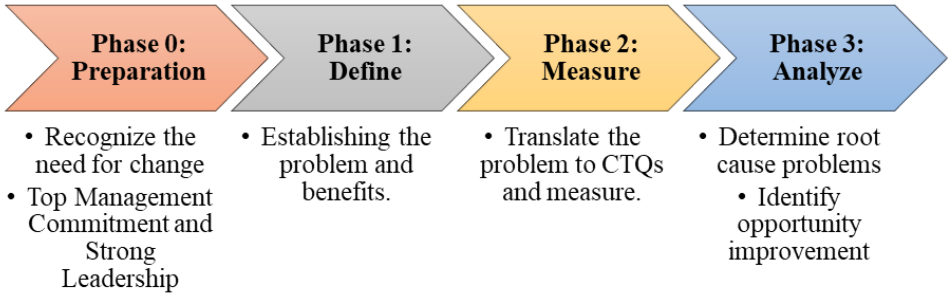

Figure 1. DMAIC methodology with addition of initial steps of Maneesh et al. framework for small and medium enterprises (SMEs)

Preparation phase allows senior management to understand the importance of change and invest time in implementing new tools and techniques for improvement (Maneesh et al., 2011). The pandemic has force companies to adapt and take new channels for supplying the customers, pushing them to change by selling through technological platforms or home deliveries (Bakalis et al., 2020); these events push enterprises to acknowledge the need for change. Also, the commitment that management must assume is a critical factor that impacts on a successful adoption of these concepts, since the heads must encourage employees to support (Dora et al., 2015; Maneesh et al., 2011; V. Yadav et al., 2019). Likewise, these types of companies are known for having small personnel with limited skills (Dora & Gellynck, 2015) that should be trained to improve the embracement of changes (Dora et al., 2015; Maneesh et al., 2011; V. Yadav et al., 2019).

During Define phase, a Supply, Input, Process, Output and Customers diagram (SIPOC) for all companies was constructed to recognize obstacles for internal and external clients, and in manufacturing process (Mishra & Kumar Sharma, 2014), this tool will help to identify the impact on all stages. Since biosafety measures are applied in all macro-processes of companies, SIPOC is used to obtain a broad image of the repercussion of these activities (Shaikh & Kazi, 2015). Additionally, a 5W1H (why, when, who, where, what, and how) (Ani et al., 2016) tool was used to provide a systematic view to help in data collection by recognizing the underlying problems by identifying the root cause and not symptoms (Gangidi, 2019).

Measure phase is characterized for establishing performance measures to detect problems (Maneesh et al., 2011), where KPIs are set to measure productivity and capture the changes caused by the implementation of new biosafety activities. Also, data gathering along with data assessment is realized in all the participant enterprises (Hakimi et al., 2018). Data gathering is realized through video analysis (Bärring et al., 2017) using data collection sheets.

Analyze phase is focused on identifying in what measure these new activities have caused an impact on macroprocesses. The risk of contamination is greater when the supply chain has more interactions (Ghosh et al., 2020; Luckstead et al., 2020; Mollenkopf et al., 2020; Rizou et al., 2020; Singh et al., 2020), meaning this tool will give a clear idea of who interacts throughout each process (Mishra & Kumar Sharma, 2014) to emphasize the analysis on these activities. An Ishikawa is applied to understand the causes that contribute the problematic (Ani et al., 2016) during COVID-19 sanitary emergency. Potential solutions are proposed to minimize root causes.

3.3 Cases studies

This section focuses on the application of the DMAIC methodology on six (6) food and beverage micro and small enterprises.

3.3.1 Preparation phase.

According to Maneesh et al. (2011) three characteristics are key to initialize a project: recognize the need to change, commitment of top management and training. Due to the fluctuations on usual business core caused by COVID-19 pandemic, managers needed to implement new actions to ensure safety of workers and clients. Also, requirements of risk institutions established companies to comply with biosafety measures to continue with operations safely. These actions promoted a constant communication between management and workers. The willingness to participate in the study is considered as an awareness factor for change.

3.3.2 Define phase.

An initial evaluation highlighted that all the companies are composed by 4 macro-processes shown in Figure 2. The reception and storage process are fulfilled since they have suppliers who provide them with the necessary items according to their need. The productive process constitutes the transformation of raw materials into food, meaning the use of machinery or preparation of food. Handling the finished product entails the packaging process and storage of the food. Finally, the delivery process where the costumer receives the product.

Figure 2. Macro-processes considered for Food and Beverage companies studied.

Given the abrupt interruption that the pandemic caused, these enterprises faced several issues during the lockdown. A pareto analysis was developed to understand the most critical challenges found during these months shown in Figure 3. Despite the challenges, costumers and demand started to increase since September 2020 when exception status was lifted. Mobility and

curfew restrictions where withdrawn which allowed people to develop activities freely while maintaining social distancing and using masks.

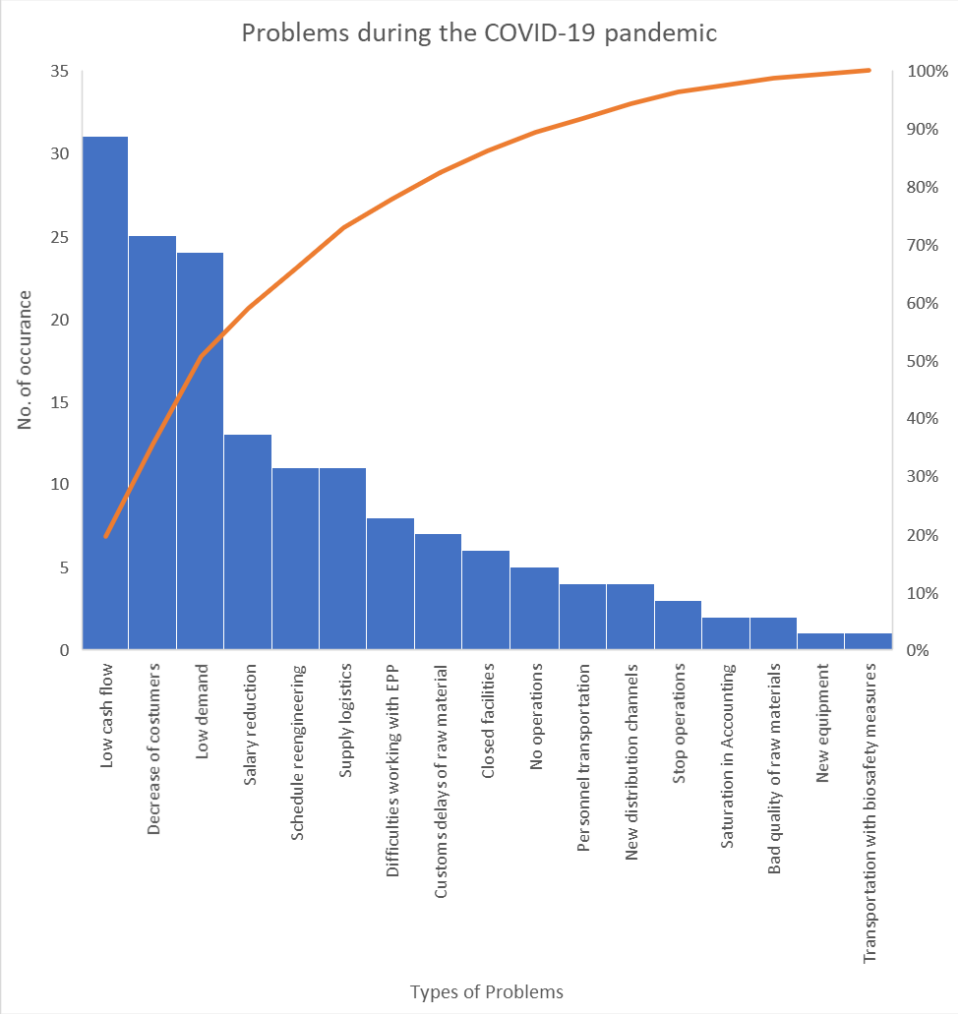

Figure 3. Pareto of challenges faced by companies studied from March 2020 to October 2020.

As demand began to increase, operations resume normally during full working hours. This raised new problems for workers during these months. Also, due to the limited personnel owners are commonly the managers. A 5WIH Analysis was used to understand where the problem occurred shown in Figure 4. The analysis began with the hypothetical question of what problems are caused by new biosafety measures.

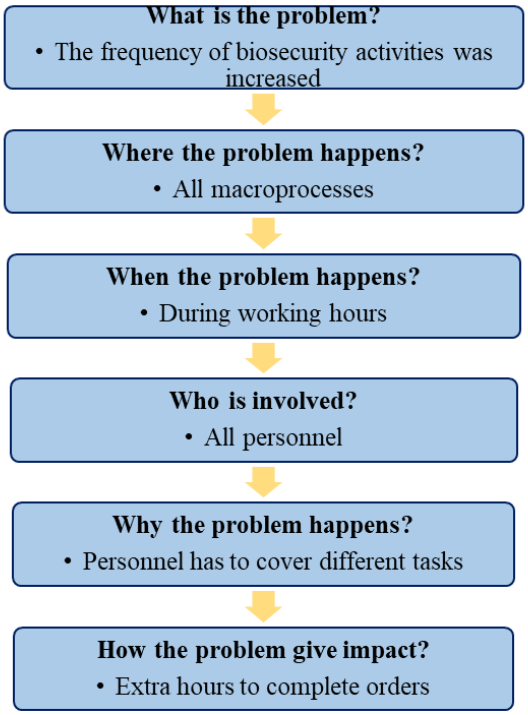

Figure 4. 5WIH created from interviews with participants.

Since six companies were analyzed, a classification was made between them based on the structure of business. A SIPOC diagram is created for all companies to understand fully their differences to classified them. SIPOC diagrams for all companies are shown on Appendix A, B, C, D, E and F. Companies are categorized in food manufacturers, and food and beverage services.

Manufacturers are centered on producing products before consumption and can be storage. Similarities between manufacturing companies were found on requirements for functioning and from clients. A SIPOC diagram for food manufacturers type is outlined in Figure 5.

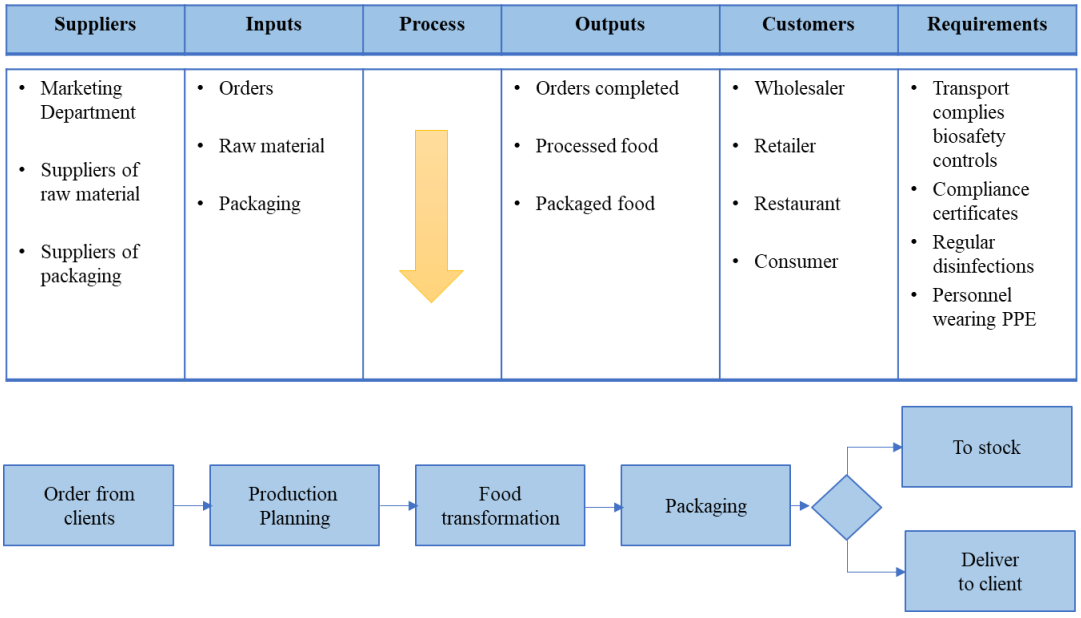

Figure 5. SIPOC for food manufacturers studied

Meanwhile, services are made and consumed simultaneously, and they cannot be storage. A SIPOC diagram for food and beverage services is shown in Figure 6. Between services, similar elements were found on the process for attending the costumer, output for services provided, and requirements from the final consumer.

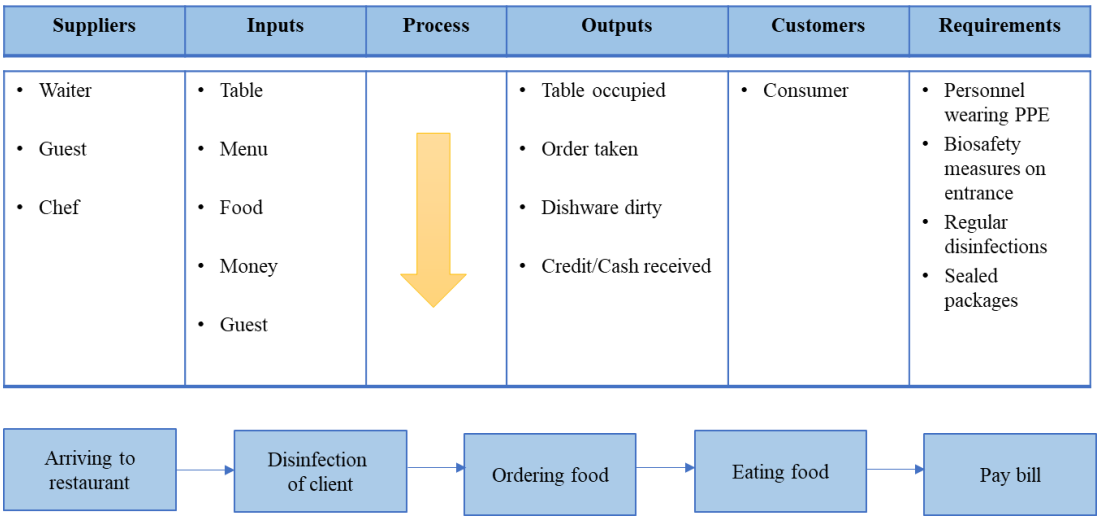

Figure 6. SIPOC for food and beverage services studied.

A summary of general information of participants is outlined in Table 1. This information confirmed that participants had all the requirements needed to participate in the study. Also, general information of how companies market their products.

Demographic Information			
		n	**Frequency**
Subsector	Food Manufacturer	3	50%
	Food and Beverage Service	3	50%
Years on the market	<10	2	33%
	>10	4	67%
Number of employees	<10	3	50%
	>10	3	50%
Main Customer	Other company	3	50%
	Customer	3	50%
Distribution Channels	Direct	4	67%
	Indirect	0	0%
	Both	2	33%
GMP Certification	Yes	1	17%
	No	5	83%
Working hours	8 hours	4	67%
	12 hours	2	33%

Table 1. Demographic information of participants.

Moreover, a questionnaire was realized to get an insight of what biosafety practices these companies applied in each of their macroprocesses that could affect productivity. The delivery process was considered only for companies who had their own vehicles and employees for these activities. Relevant results of the questionnaire are shown on Table 2. For later analysis, companies will be referred as M1, M2 and M3 for manufacturing, and S1, S2 and S3 for services.

		Yes		No	
Variable	**Category**	**n**	**Frequency**	**n**	**Frequency**
Preventions kits	Food and Beverage Service	3	100.00%		
	Food Manufacturer	3	100.00%		
Delivery Service	Food and Beverage Service	2	66.67%	1	33.33%
	Food Manufacturer	1	33.33%	2	66.67%
Thermometer	Food and Beverage Service	3	100.00%		
	Food Manufacturer	3	100.00%		
Communication campaigns	Food and Beverage Service	1	33.33%	2	66.67%
	Food Manufacturer	3	100.00%		
Mobilization	Food and Beverage Service	1	33.33%	2	66.67%
	Food Manufacturer	1	33.33%	2	66.67%
Written biosafety protocol	Food and Beverage Service	2	66.67%	1	33.33%
	Food Manufacturer	2	66.67%	1	33.33%
Vulnerable groups	Food and Beverage Service			3	100.00%
	Food Manufacturer	2	100.00%	1	33.33%
Signage	Food and Beverage Service	3	100.00%		
	Food Manufacturer	2	66.67%	1	33.33%
Daily control of symptoms	Food and Beverage Service	2	66.67%	1	33.33%
	Food Manufacturer	3	100.00%		
Distance of 2 meters	Food and Beverage Service	3	100.00%		
	Food Manufacturer	2	66.67%	1	33.33%

Table 2. Results of biosafety questionnaire relevant for analysis of new activities.

3.3.3 Measure phase.

The measure phase includes the data collection process to determine the factors that affect productivity. Due to the classification made on the define phase, KPIs to measure productivity in all the macroprocesses are established according to these types. The measurable activities are evaluated by the frequency and duration each new biosafety activity was taken place. Muchiri and Pintelon (2008) categorized production losses into groups depending on the cause of loss. In this study the environmental, health and safety problems groups was measured. Table 2 and Table 3 shows the division of planned activities and unplanned activities with the corresponding specifications for each one.

Planned Downtime	Considerations
Change to uniform Usual disinfection politics Usual hand washing politics Usual changing gloves politics Lunch break	All activities that were carried out regularly before the pandemic. The frequency of the activities and the time they contributed to each activity is considered.

Table 3. Activities considered as planned downtime for study.

Unplanned Downtime	**Considerations**
Employee Entry Symptoms Controls Employee Leaving Symptoms Controls New disinfection politics due to COVID-19 New hand washing politics due to COVID-19 New changing gloves politics due to COVID-19	All new activities and biosecurity controls implemented by the pandemic. It only takes into consideration the new frequencies of the activities and the overtime that these new activities take.

Table 4. Activities considered as unplanned downtime for study.

Thus, for this case study, the new frequencies and overtime for activities was considered to analyze the impact new biosafety activities due to COVID-19 that have affected productivity. For manufacturer companies 4 KPIs were taken into account; meanwhile, for service companies 3 KPIs were considered shown on Table 4. These KPIs where selected given that they can measure globally the changes that occurred on all macro-processes when implementing new biosafety activities.

Food Manufacturer	Food and beverage service
Availability Rate (AR)	Availability Rate (AR)
Non-value-added activities	Non-value-added activities
Idle time	Idle time
Performance rate	

Table 5. KPIs used to measure productivity.

3.3.3.1 Availability rate (AR).

Availability rate considers planned activities essential to production before COVID-19, referring them as the usual activities carried out, and unplanned activities implemented during the pandemic. New biosafety measures have been implemented during working hours without changes to daily routines. Formula 1 is used to calculate the KPI.

$$(1)\ AR = \frac{Operating\ Time}{Loading\ Time} \times 100\ \%$$

where,

$$(2)\ Loading\ Time = Total\ Available\ Time - Planned\ Downtime$$

$$(3)\ Operating\ Time = Loading\ Time - Unplanned\ Downtime$$

The percentage of unplanned downtime attributed to new biosafety measures for each company that reduces availability is in Table 5. Results reflected that the increase of frequency and overtime have affected the actual production and service time. Even though both types of companies have less available time, calculations indicated that food and beverage services have been more affected.

Manufacturer	Percentage	Service	Percentage
M1	6.40%	S1	7.28%
M2	5.00%	S2	8.33%
M3	2.50%	S3	5.45%

Table 6. Percentage of reduction of availability caused by implementation of new biosafety measures.

3.3.3.2 Non-value-added activities.

Value-added work was determined as those actions that add value for the customer, and he is willing to pay for. Other activities were considered as waste, where efficiency can be traduced to loss of cost, commonly known as muda. New biosafety measures were identified according to the waste classification in Table 6.

Processes	Muda identify
Employee entry controls	Waiting
Employee leaving controls	Waiting
New politics of washing hands	Waiting
New politics of disinfection	Waiting
New politics of changing gloves	Waiting

Table 7. Classification of muda of new biosafety measures.

The results on Table 7 show that new frequencies and extra work have contributed to an increase in the percentage of activities that do not add value to the final product. Employee controls and new politics caused a stoppage in daily activities which provokes disruptions on the transformation process of food to complete these activities for safety.

Manufacturer	Percentage	Service	Percentage
M1	3.70%	S1	9.39%
M2	2.96%	S2	6.85%
M3	1.95%	S3	4.76%

Table 8. *Percentage of non-value-added activities caused by the implementation of new biosafety measures.*

3.3.3.3 Idle time.

Idle time is the quantity of time spent waiting for machinery to be used or nonproductive time por employees. In terms of costs, is paid time where employees or equipment is stopped. Work stoppages for washing hands, controls, and disinfections caused production and transformation processes to be delay. Equation 4 was used to obtain the percentage of idle time recognized as new biosafety politics.

$$(4)\ AR = \frac{Operating\ Time}{Loading\ Time} \times 100\ \%$$

The calculations obtained reflected a contribution of idle time, where employers were being paid for nonproductive activities. Results are shown in Table 8. The redistribution of tasks, caused by adding these activities, has increased the time employees direct to actions that the customer is not willing to pay.

Manufacturer	Percentage	Service	Percentage
M1	4.30%	S1	7.28%
M2	5.00%	S2	7.71%
M3	2.50%	S3	5.45%

Table 9. Percentages of Idle time attributed of new biosafety activities.

3.3.3.4 Performance rate.

Performance rate was calculated only for manufacturing companies. Since the studied activities represent idling and a reduction of speed when producing, they affected the performance of the process. Equation 5 was used to obtain the performance rate affected by biosafety activities:

$$(5)\ Performance\ Rate = \frac{Actual\ Output - Speed\ Loss}{Theoretical\ Output} \times 100\ \%$$

Results that contribute to a decrease on performance are shown in Table 9. The time spent on these activities, when returning to normal demand, will cause a quantity of units lost in production per day. This implies that machines will need to increase speed or reduce idling time to accomplish the same planning as before the implementation of biosafety protocols.

Manufacturer	Percentage	Quantity	Unit
M1	4.00%	300	Units lost per day
M2	3.00%	48	Units lost per day
M3	3.00%	20	Units lost per day

Table 10. Percentages of performance rate decrease, and units lost attributed of new biosafety activities.

3.3.4 Analyze phase.

During this phase, a brainstorming session helped the construction of an Ishikawa diagram to establish the causes for the problematic. Figure 7 shows the causes found for the decrease in productivity attributed to new activities. Biosafety activities are categorized as non-value-added activities that are necessary, despite being a waste. Government regulations and requirements for functioning, such as protocols, were established. These measures cannot be eliminated because of the risk COVID-19 represents to humans, but they can be minimized.

As results on the Measure phase shown, service companies had a greater impact caused by the implementation of new activities. This occurs because this type of companies needed to strengthen their sanitary controls. Since manufacturing enterprises are subject to more controls for

functioning, they already had established more careful controls for plant disinfections and employee's sanitary politics. Also, because of the type of clients each type of company supplies, the requirements changed. Meaning, wholesalers, and retailers asked manufacturer to comply with certain politics, even before, to receive their products.

Unlike workers of manufacturing companies, service employees recently implemented the used of personal protective equipment (PPE) which became one of the issues that supported the decrease in speed to complete orders. They mention that the discomfort from using PPE causes them to need more breaks to be able to work during the day. However, food manufacturers are affected by the loss of units when normal demand returns. Actions such as increasing speed or reducing idle time are going to be needed. For this type of companies, the capacity of machinery plays an important role. Depending on the free capacity each machine has, the effects can be controlled. However, since they are micro and small companies, the investment for machinery with more capacity is usually lower, which indicates that the machinery on many occasions is almost at its maximum capacity. This can cause losses of clients and demand not fulfilled.

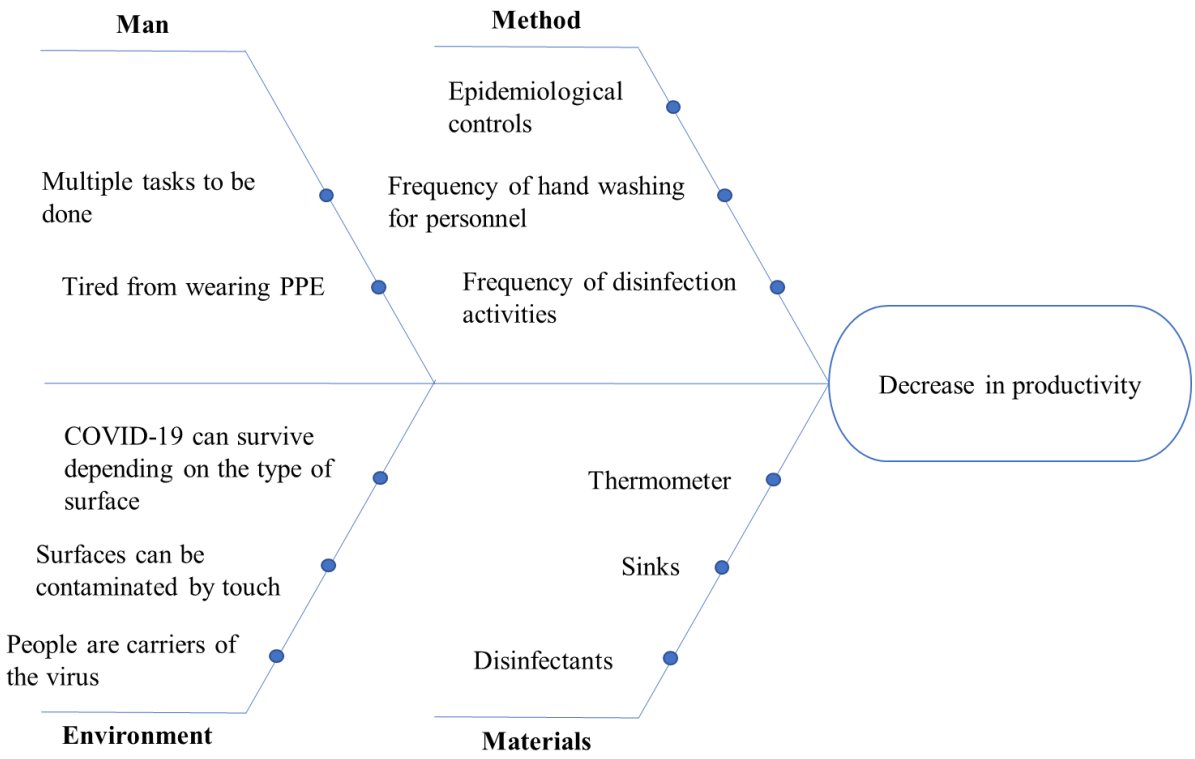

Figure 7. Ishikawa of investigation question

After this analysis, the following tools and techniques were proposed to minimize the effect these activities have on productivity. Tools were proposed based on the reality of micro and small enterprises. As literature review supported, applying ease-to-use techniques could promote a Lean and Six Sigma thinking inside these companies.

3.3.4.1 Standardized work.

Standardization is a tool that enables the reduction of costs by ensuring a logical sequency of processes (MÍkva et al., 2016). For biosafety measures, despite of being stated, there is not an established correct order to realized them. Applying this tool by creating a standardization of process, controls can reduce the errors in orders that delay the process.

The standards should be used on:

- Entrance requirements.

- Frequency of hand washing.
- Steps for disinfections according to areas.

When applying standardization to these processes, a reduction out time will be achieved, since a chronological order will be determined attaining activities to be realized faster and more effectively.

3.3.4.2 5s.

5s is a methodology known for maintaining organization, cleanness, and effective workplace (Michalska & Szewieczek, 2007). By implementing the 5 steps of 5s technique, spaces designated for biosafety activities can be found easily.

The technique should be used on:

- Creation of entrance stations
- Kits for disinfection according to areas

Due to the need of having entrance controls for employees and visitors, time was wasted when looking for the materials needed for controls. Implementing stations with all the material needed will reduce waiting for workers to continue with add-value activities and for costumers to receive a good service. Also, since not all areas can be disinfected with the same products, creating kits according to their needs will reduce the time spent on switching disinfectants.

3.3.4.3 Visual controls.

Visual controls allow people to understand and perform tasks faster. Locating visual controls on strategic areas where biosafety activities were performed will allow workers to reduce time by following instructions.

This controls should be used on:

- Sinks to explain the procedures of washing hands.

- Disinfections areas with instructions of procedures.
- Floor marks for locating disinfection supplies.

4. CONCLUSIONS

The indicators used to measure productivity showed that there is in fact an impact on productivity caused by the implementation of biosafety activities. These KPIs where used to measure specifically the changes attributed to new biosafety measures classified as environmental, health and safety wastes. The impact on each company relied on what activities they adopted to mitigate the risk of COVID-19. Since not all the companies implemented the same activities with equal frequencies, effects were different. Because of these activities, workers have more precautions that reduces their normal pace of work. Service companies have more frequent disinfection activities during their working day because of the direct involvement with attending the customer, this causes disinfections to be carried out more repeatedly. Meanwhile, manufacturing enterprises had more cautious controls because of regulations they had before, the effect on them was on a smaller scale. Repercussions were seen on the time needed to complete orders, in most cases, extra hours were needed.

As Dora & Gellynck mentioned applying easy-to-use practices motivate these types of companies to enroll in the Lean Six Sigma thinking. The proposed tools and techniques can accomplish changes that can have a significant impact on mitigating the effects caused by COVID-19 biosafety measures. Since these activities cannot be eliminated, the mitigation actions are essential to ensure an adding-value product to the customer.

5. LIMITATIONS AND RECOMMENDATIONS

Time constraints limited the study to complete all the phases of DMAIC due to this the improvement and control phase were not developed. Also, a face-to-face data collection could not

be performed because of the risks of contagion. A culture of collecting data from production and customer satisfaction should be implemented in these companies to get a better image of the performance. For future research, an investigation should be executed about the effects of using personal protective equipment (PPE) that slow down the pace of people working.

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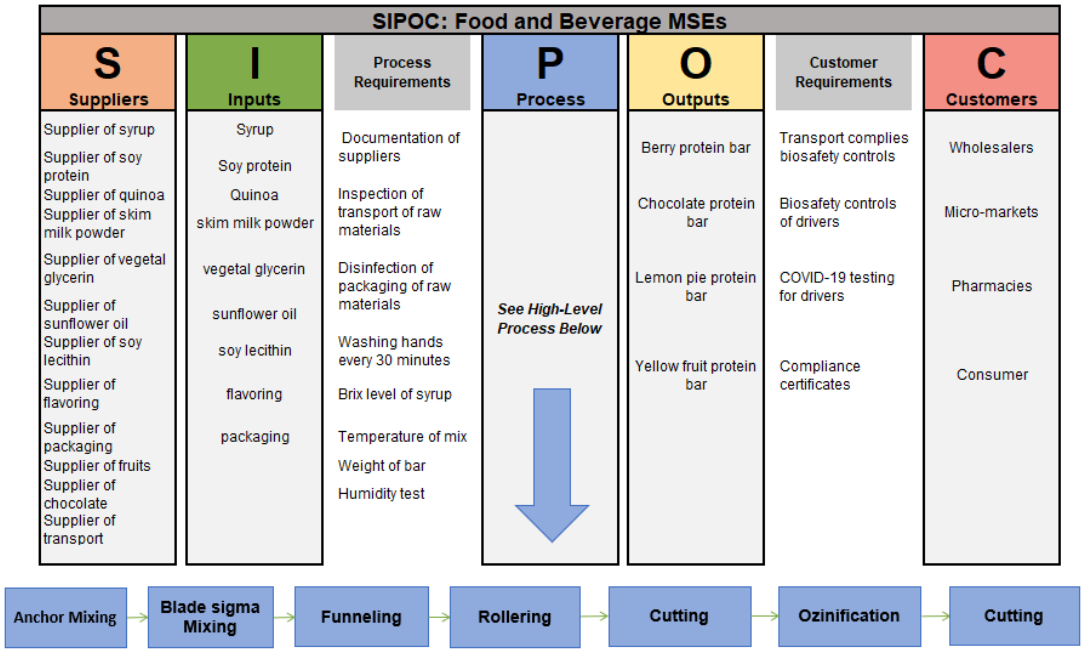
APPENDIX A: SIPOC FOR COMPANY M1



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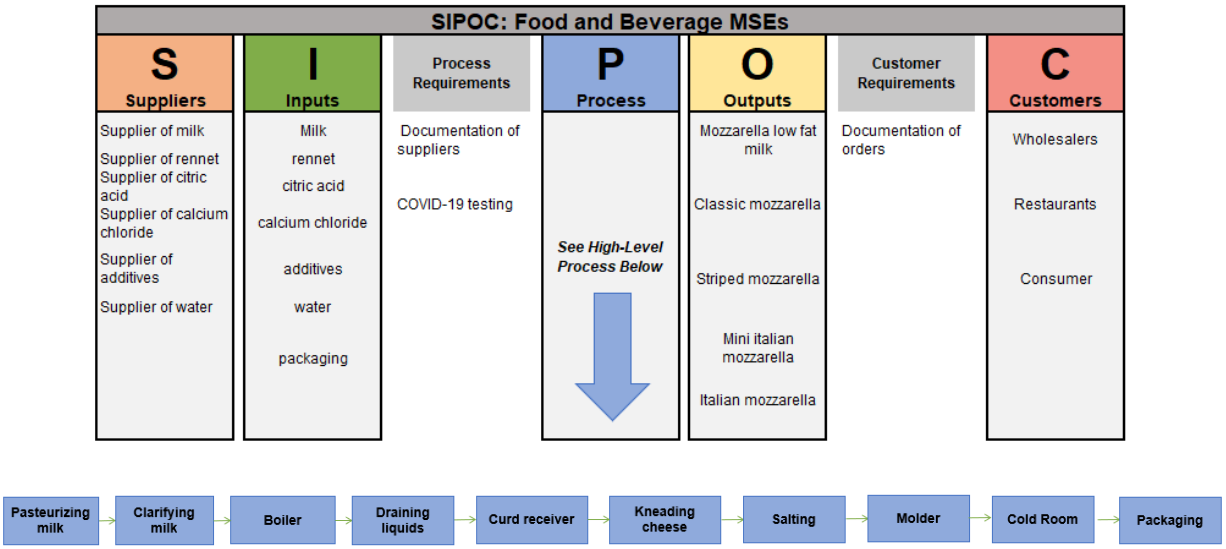
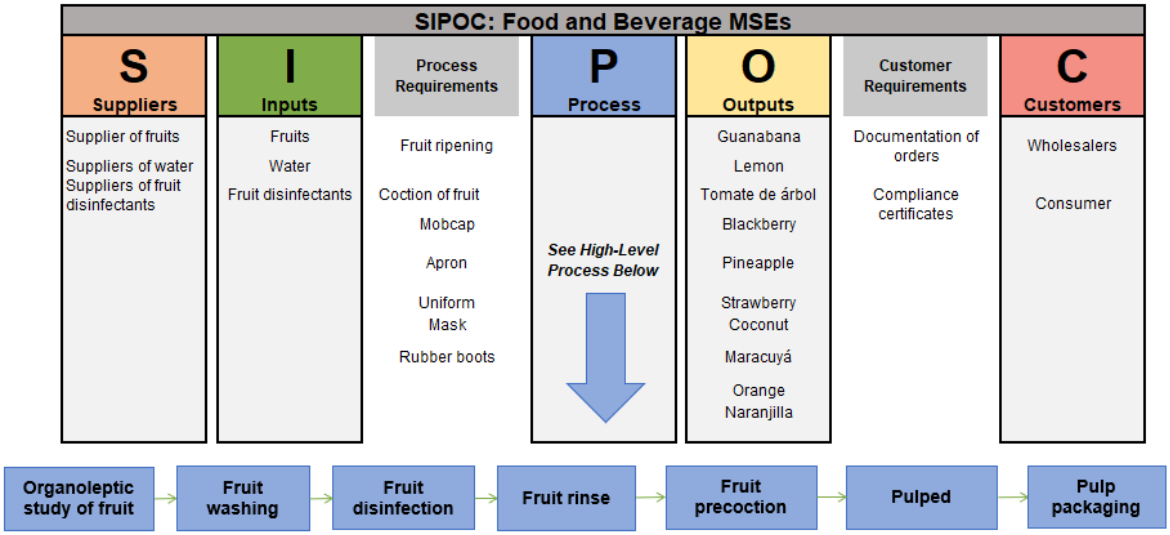
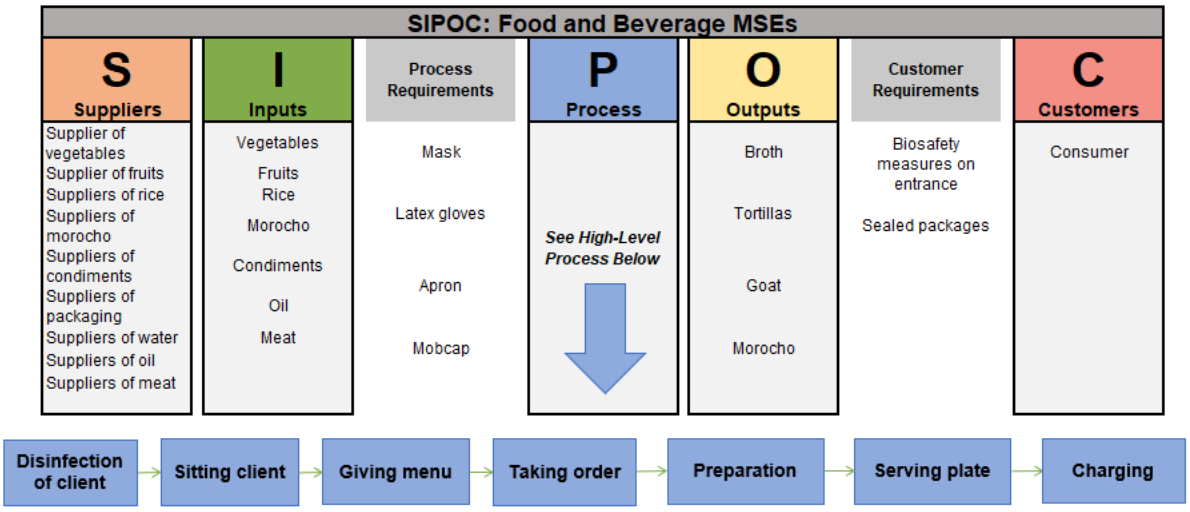


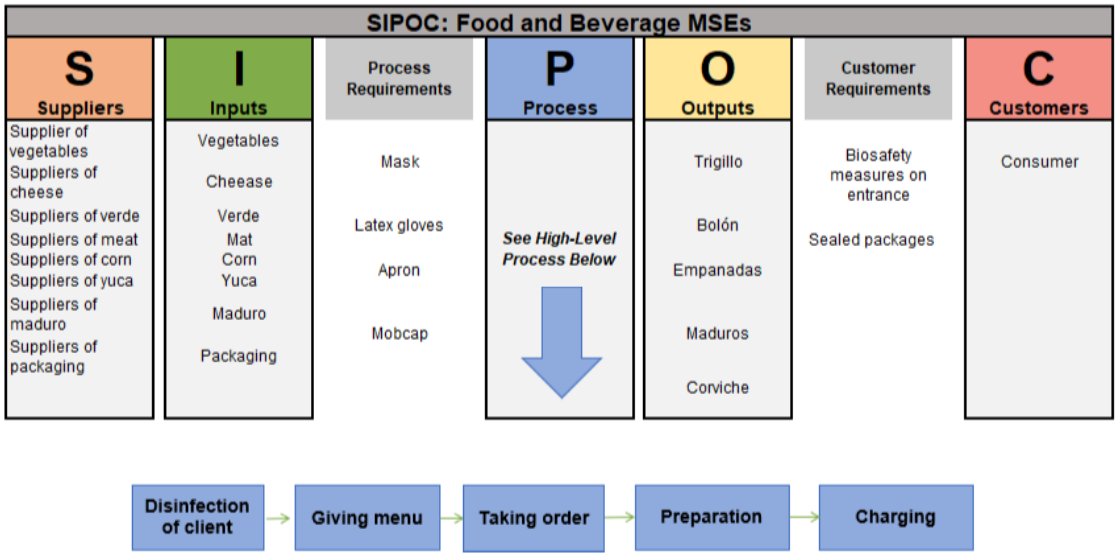
APPENDIX C: SIPOC FOR COMPANY M3



APPENDIX D: SIPOC FOR COMPANY S1



APPENDIX E: SIPOC FOR COMPANY S2



APPENDIX F: SIPOC FOR COMPANY S3