The Impact of Asparagus Supply Chain Quality Management: An Empirical Research from Peru

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Abstract— The objective of the article is to show how quality tools help the management of the supply chain in the agricultural sector, in this way quality management of the supply chain will improve operating results in companies that produce asparagus. The company is located in Trujillo, Peru; where the managers of each area were interviewed to determine the practices that will be used in the agribusiness sector. Through the review of the literature, the practices that will be used are supplier relationship management, operations management, and human resources management, the right design and application of these practices will achieve improvements in operational results. The proposed model, Supply Chain Quality Management, is an innovative method that will have a positive impact on the agribusiness supply chain. In addition, quality management in the supply chain is an unusual topic to find in research. Finally, asparagus is a high consumption vegetable and this study provides a great value in increasing economic indicators and competitiveness within the industry

Keywords—Asparagus, Quality management, Supply chain management, Agribusiness, Supply Chain Quality Mnagement.

1. Introduction

Peru achieved the first place among the five main export countries of green asparagus, producing 390 million tons of asparagus. Agriculture represents 5.8% of Peruvian exports and 24.2% of the active population is employed in that sector, making Peru an important country worldwide for the production of agricultural products [1]. Our research will conduct a study on the main waste that exists along the food supply chain to propose various improvements that help optimize operational and logistical results [2].

The food supply chain of fresh products has special characteristics, especially in the quality of the product, such as fruits or vegetables, due to the continuous deterioration over time [8], [51]. The objective is to mitigate the waste to increase competitiveness with the help of quality tools, for which an innovative model of SCQM in the asparagus industry is proposed.

2. Research Methodology

The research methodology is integrated in five steps; in which they explain the individual steps of the research process. To ensure validity and reliability, a proposed process model used for similar research objectives [9], is shown in the following figure:

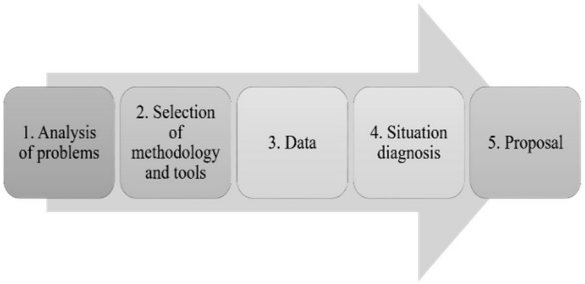


Figure 1. Research Methodology,
Source: Adapted from [29], [56]

3. Literature review

In total, 74 articles have been found for this research. The publications are dated from 2012 until 2018. Based on the literature review, it has been established that the search string body of the text should contain the word “quality”, “supply chain management”.

It was determined that the researches were going to be carried out on the following bases: Emerald Insight, Taylor & Francis, Science Direct, Inderscience, Springer, Wiley, Scopus, Elsevier, Proquest, IEEE, among others. As is showed in the figure 2.

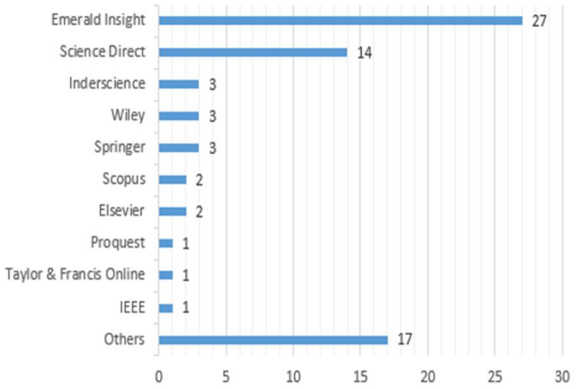


Figure 2. Amount of Publications per Database, Source: Based on Own Study

Regarding the journals, the articles have been published in Journal of Cleaner Production, International Journal of Quality & Reliability Management, The TQM Journal, Supply Chain Management: An International Journal, among others. Table 1 shows the magazines used and their abbreviations in descending order and in figure 3 the number of publications per journal.

Table 1. Top journals used for the research Literature Review, Source: Adapted from [17], [57], [58]

Journal	*Abbreviation*
Journal of Cleaner Production	JCP
International Journal of Quality & Reliability Management	IJQRM
The TQM Journal	The TQM Journal
Supply Chain Management: An International Journal	SCM: An International Journal
International Journal of Production Economics	IJPE
International Journal of Physical Distribution & Logistics Management	International Journal of PD & LM
International Journal of Operations & Production Management	International Journal of O & PM
International Journal of Lean Six Sigma	International Journal of LSS
Food Quality and Preference	Food Quality and Preference
British Food Journal	British Food Journal
International Journal of Quality and Innovation	International Journal of Q&I
International Journal of Postharvest Technology and Innovation	International Journal of PTI
Agribusiness	Agribusiness
International Journal of Supply Chain Management	International Journal of SCM
Journal of Supply Chain Management	Journal of SCM

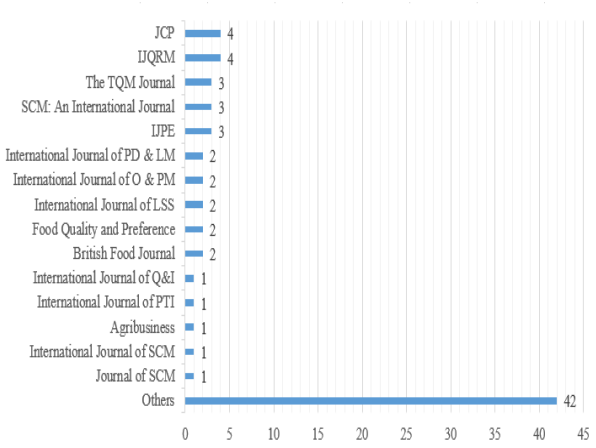


Figure 3. Amount of Publications per Journal**,** Source: Based on Own Study

The review of the literature was carried out to define the theoretical framework of SCQM, showed in figure 4, and, therefore, to use it in companies producing asparagus. The concepts that were used to review the literature are presented below. It starts from the management of the supply chain to the integration with the strategies of quality management [54].

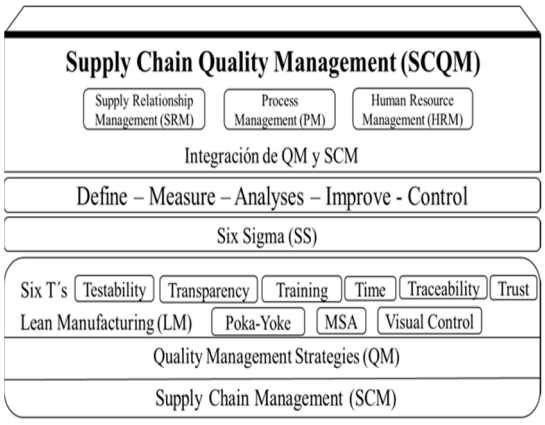


Figure 4. Theorical Framework of SCQM, Source: Adapted from [17], [57], [58].

Quality Management Strategies (QM)

Three main quality management strategies were chosen because they improve logistics and operational processes and reduce errors [21]; they also focus on waste disposal and implement techniques and tools to improve processes to achieve customer satisfaction [13], which are: Lean Manufacturing (LM), Six Sigma (SS) and Total Quality Management (TQM) [28].

3.1.1 Lean Manufacturing (LM)

It is considered one of the most widespread production systems. It was developed for the first time at Toyota, where the production was very repetitive [3]. It is responsible for reducing waste and variability in processes, adding more value to customers and providing improvements in operational performance [4]. In addition, three pillars of Lean Manufacturing practices were identified, which are: the participation of suppliers and their impact on the company, quality, cost and delivery goal and internal problems of the company that includes continuous flow, just in time (pull), preventive maintenance [5].

On the other hand, to correct the waste in the processes, techniques and tools were created that are currently used in all companies [6].

In a general approach see Table 2, LM practices and principles aimed at reducing waste and variability in processes, adding more value to customers and providing improvements in operational performance [7].

a) Poka-Yoke

Poka-yoke is a mechanism to detect errors and defects, which inspects 100% of the pieces, by using processes or design features to avoid errors or the negative impact of errors [8].

The Poka-yoke goal is to create a concept that allows a process without failure. It focuses on processes that are controlled by human work, because it is considered to have high potential for fails [9], [10].

b) Control Visual

Visual control [11] is a support for performance, organization of the workplace and continuous improvement. One type of research that takes visual control is the use of a method or tool such as; color coding, various production control boards or the extensive role of visual control in the design of cellular production systems [12].

On the other hand, it is mentioned that visual control is a device of communication to use in the work environment that tells us at a glance how work should be done [13].

c) 5s

The tool is based on the integral maintenance of the company, which aims to help improve the work area environment by eliminating everything that does not generate value [10]. The steps are the following [14]:

- Seiri: separate objects that are necessary in the right place. In order to increase the productivity of workers.
- Seiton: organize the work environment, so that each object has a unique and exclusive place where it should be after using it.
- Seiso: assign responsibility to each worker in their place of work, take care of tools and machinery, to avoid duplication of activities, losses and damages of materials and products.
- Seiketsu: Maintain the environment and clean machinery in order to avoid damage to the health of workers.
- Shitsuke: Continue the improvements with each S constantly, provided that each worker knows their function.

Table 2. Lean tools applied, Source: Adapted from [3], [11], [15]

Authors	**Lean Tools**		
	Poka-Yoke	***Visual Control***	***5s***
Kattman et. al (2012) [12]	X	X	
Marcineková et. al (2015) [14]		X	X
Pötters et. al (2018) [10]	X		X
Saurin et. al (2012) [8]	X		
Zhou (2016) [15]	X	X	X

3.1.2 Six Sigma (SS)

The Six Sigma methodology [16] is considered as one of the most important for improvement both for quality and process management [17]. In addition, the focus is on the client and their needs, thanks to its structured and systematic methodology known as DMAIC [18]. On the other hand, the variability of

measurement systems (R & R studies) is one of the most addressed tools in Six Sigma [19].

a) DMAIC:

- Define: the team is defined, the role of the members, the scope and the limit of the research, as well as the expectations and requirements of the client.
- Measure: measurement factors that want to improve. It is possible to map the process, collect data and determine the capacity of the process.
- Analyze: the causes of the problem are determined, in this way you can compare and prioritize the causes with the greatest opportunity for correction.
- Implement: techniques and tools are used to improve the quantity of quality problems.
- Control: establish controls to improve quality standards, monitor performance and improve the continuity of the process.

b) R&R Gage:

It is helpful and easy for the level of work to apply the method because the R & R measurement is well known in quality assurance [20], and the study is included in various conventional statistical software such as Minitab [21]. On the other hand, this measurement statistically isolates different types of variation in the measurement process [22], such as:

- Repeatability: equipment variation.
- Reproducibility: variation of the evaluator, one may tend to interpret a caliber differently than others.
- Can be applied to any type of measurements: attribute or variables, indeterminate or determined.

3.1.3 Total Quality Management (TQM)

Total Quality Management is a methodology used in the industry to increase competitiveness [12]. Likewise, it can be defined as an integrated effort to achieve and maintain high quality products based on the maintenance of continuous processes [39]. In addition, the improvement and prevention of errors, in all levels and functions of the organization, with the aim of reaching and even exceeding the client's expectations [59].

Several case studies and investigations have provided evidence that supports the success of TQM in terms of financial results, operational performance, and customer and worker satisfaction [14].

According to the table 3. The two most important best practices for TQM are SRM and HRM.

Table 3. TQM practices, Source: Adapted from [3], [11], [15].

Authors	TQM Practices				
	SRM	***HRM***	***CRM***	***PM***	***QMC***
Bastas (2018) [23]	X	X	X		
Bisalyaputra (2018) [24]	X		X		
Bouranta (2018) [25]	X	X		X	X
Quang (2016) [26]	X	X			X
Psomas (2014) [27]	X	X	X	X	
Seow (2012) [28]	X		X		
Yogesh (2015) [9]		X		X	
Young (2014) [29]	X	X			
Total	**7**	**6**	**4**	**3**	**2**

3.2 The Six T´s in food supply chain quality management

The concept of 6Ts was adopted by Roth [30] which are associated with the quality of the product in order to achieve the best practices for the supply chain management [31]. Each of the T's are related to the phases of the DMAIC as described below:

- Traceability: the ability to trace a product through identification along the supply chain, which is directly related to the definition phase as an input and in the improvement phase [32],[33].
- Transparency: to assure responsible practice in companies and protect responsibility throughout the supply chain. The transparency of procedures and regulations is essential for the analysis, improvement and control phase [34].
- Testability: ability to detect an attribute of a product, must be a result, because the tests must be implemented to allow measurement at each necessary point in the supply chain. It refers to the measurement and improvement phase [35].
- Time: working with food products, their quality is time dependent, having a correct control is

essential. Because of this, this point refers to the control phase [36].

- Trust: It is facilitated when the farmer and the markets share similar objectives [37].
- Training: process of developing knowledge, skills and attitudes with respect to international standards of quality, safety and best practices. The team must be trained to develop the research so the training is an output of the definition phase and it is essential in the control phase [38].

3.3 Integration of quality management with the supply chain

3.3.1 Supply Chain Management (SCM)

The supply chain facilitates the integration between the customer base, the distribution network and the internal activities of the companies [32]. Therefore, supply chain practices influence the performance of the organization, the performance of sustainability and the way in which the parties related to the companies perceive it. In addition, the correct management of the supply chain generates a series of competitive advantages, since it covers: the management of suppliers, the management of customers, the management of inventories, distribution, development and design of a new product, among others [26], [27]. In addition to direct customers influencing changes in the supply chain, there are also new announcements on sustainability [23].

By incorporating the practices, higher levels of customer satisfaction can be achieved through improved collaboration within the network and higher performance processes [23].

3.3.2 Supply Chain Quality Management (SCQM)

Supply Chain Quality Management is an emerging research area, which integrates the practices of Supply Chain Management and Quality Management [71], to achieve higher levels of customer satisfaction through better collaboration within the companies of the network, processes of higher performance and information flow to organizations, for higher quality products and services [26], [20]. According to the SCQM theory, see Table 4, the internal dimension comes from Quality Management; while the external comes from the context of the management of the supply chain [38].

Supply Chain Quality Management is a system based in the approach of performance improvement [39] that integrates supply chain partners with a creating value and achieving satisfaction for intermediate and final customers.

Table 4. SCQM comparative table, Source: Adapted from [26],[13],[72]

SCQM	
Autor	***Description***
Bastas et. al (2018) [23]	Integration of quality and supply chain management were established including performance improvements and integration increasing the effect of both methodologies.
Huo et. al (2014) [40]	Consists of internal, supplier, and customer integration for quality improvement, and develop a model that specifies the relationships
Manzini et. al (2014) [41]	Apply an original assessment of quality, safety and environmental effects due to the international distribution of food products via different container solutions.
Siddh et. al (2017) [42]	Issues related to supply chain quality as well as performance measurement (with respect to entity of analysis, level of analysis and element of exchange).

4. Case study

4.1 Current situation

The company is an agricultural producer, is located in Trujillo, Peru, and has 130 hectares, of which 35 are used for the production of green asparagus. The company has 25 farmers, which vary according to the season they are in. The company has a production volume of 490,000 kg. According to the interview, the main customer is Damper, which is one of the main exporters of Peru and local markets.

4.2 Scope of the research

According to the models of supply chain mapping, the scope of the research starts from the end supplier to end customer, however, due to the limit of the information obtained by the company, it was decided to reduce the chain's reach to direct interaction with suppliers and their main customers, see Figure 5.

This research is focused on analyzing the process from the supply of inputs to the distribution of the products to the main client. The processing of the products, the marketing to the retailers and the relationship with the customers will be detailed at a macro level to generate the context. With this scope, it

is expected to comply with the integration of quality management practices throughout the supply chain.

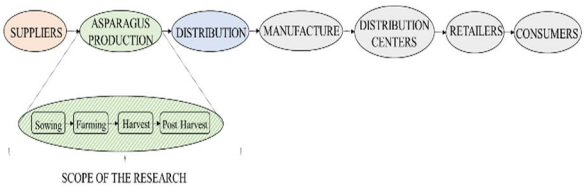


Figure 5. Scope of the research, Source: Adapted from [9], [60].

4.2.1 Supply Chain mapping

There are five stages in the food supply chain consisting of the farmer, supplier, processor, distributor and retailer [43], these are conceptualized and formulated to prove the relationship between stages. The results affirmed that value addition these stages are positively related [44]. The following illustration shows the supply chain of green asparagus production. This also includes the traceability of the waste generated throughout the SC, in order to identify them easily. As shown in the following Figure 6, the main entities in the asparagus supply chain are:

a) Source: The supply chain starts from tier 1 suppliers with seed, agrochemicals, fertilizer, insecticides, irrigation system, water, crates, pumps and harvest tools which are all needed to start asparagus production which takes place in tier 2 suppliers. The inputs that are stored are seeds, agrochemicals, insecticides and fertilizers.

b) Asparagus production: There are 35 hectares for asparagus production. The production begins with the sowing process. During the sowing, the study of the soils and the preparation of the land is carried out, and then the amount of seeds that are estimated to be planted is removed from the store. The sowing usually lasts a year, since in parallel the land is fertilized and protected to make way for the farming. During this process, the asparagus are in full development, so it is necessary to use the irrigation system, fertilizers and agrochemicals to not affect their quality and finally prepare for the harvest. This process is the most significant, so it generates value to the final product. During the harvest, the farmers cut the turions and place them in plastic boxes to be taken to the storage area, where they are weighed. The harvest is done twice a day for about a month and a half. Finally, the post-harvest is carried out, it is the stage of healing those asparagus that are growing crooked and were not harvested.

c) Distribution: The distribution of asparagus in boxes occurs through the collection trucks that arrive at the field twice a day. This is due to the fact that they are perishable products and there is a risk of malfunctions, shoot growth, among other consequences. The main customer is Damper with 87% distribution and local markets with 13% distribution. The main exporter of Peru is responsible for processing asparagus for export to different countries, such as the United States, Spain, the Netherlands, among others. These are responsible for distributing to retailers and markets to reach the final consumer.

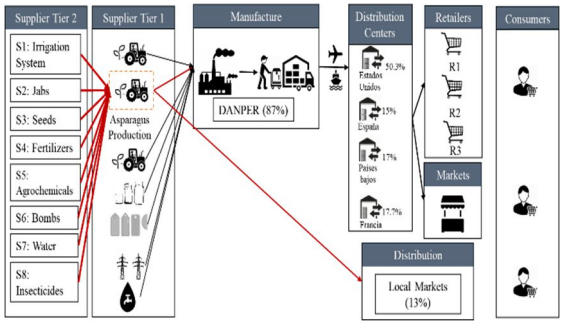


Figure 6. Asparagus supply chain , Source:Adapted from [61], [62].

The quality of food products depends on both harvesting and processing, as well as logistics, transport and packaging processes [41].

A study by the Food and Agriculture Organization of the United Nations (FAO) estimated the waste of various agricultural food products. The percentages in fruits and vegetables are presented in Table 5.

Table 5. Percentage of estimated waste for each group in each process, Source:Adapted from [63].

	Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption
Cereals	6%	4%	7%	4%	10%
Roots & Tubers	14%	14%	12%	3%	4%
Fruits & Vegetables	20%	10%	20%	12%	10%
Meat	5.3%	1.1%	5%	5%	6%
Fish & Seafood	5.7%	5%	9%	10%	4%

4.3 Model of SCQM

With respect to the review of the literature, the theoretical model of SCQM refers to quality integration in supply chain management [6]. When integrating quality, different tools were considered that are suitable for companies that have all their integrated processes in order to reach all the actors involved [29].

On the side of supply chain management, the relationship with suppliers (SRM) is based on the establishment of selections, controls and follow-ups that guarantee a good relationship with each supplier [45], operations management (OM) provides the traceability of each of the suppliers, processes and evaluates options for improvement and human resources management (HRM) for the alignment of the personnel with the new structure of the company.

On the other hand, the Quality provides the methodology of the 6T's supported by DMAIC of Six Sigma (SS) and Lean Manufacturing Tools (LM) with the aim of having an integrated process, mapped, instructed and correctly controlled as shown in the next figure.

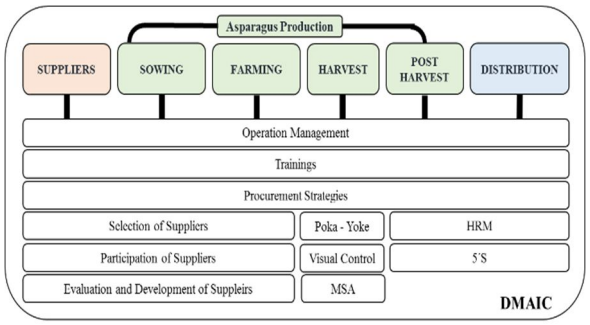


Figure 7. Proposal of a SCQM Model for Companies Producing Asparagus, Source: Adapted from [17], [26], [64].

4.3.1 The Internal Integration

Throughout the trips that were made to the hectares and in cooperation with the farmers, each of the processes of the supply chain was mapped, in each of them the different causes that generate the waste in the chain were identified. These causes are related to supply, labor, methodology and control, for example, infected seeds and asparagus, failure to comply with the requirements related to the size and thickness of the asparagus, uncured asparagus, beaten asparagus and poor management by farmers. As shown, these causes are directly related to the management of the processes, the quality of the asparagus and the management of the human factor. Therefore, the following practices were considered: SRM, OM and HRM.

Table 6. Tools/techniques results, Source: Based on Own Study.

Authors	*Tools / Practices*	*Results*
[45],[46],[47],[20]	SRM	• Increase in the satisfaction of services and purchases of goods. • Increase in satisfaction among suppliers. • Decrease in costs to serve customers.
[10],[8], [9], [48], [49]	Poka-Yoke	• Decrease in reprocessing (52.3%). • Decrease in delivery time (62.4%).
[13], [11], [12]	Visual Control	• Saved 9 operators for the operation of waste management, saving 23% of labor. • Reduction of 12 routes: 28 routes to 16 routes.
[20],[22], [50]	R&R Gage	• The capacity of the measurement system satisfies the required criteria, as well as the confidence interval. • It is adequate to monitor the process, according to the criteria Cg, Cgk, PTR and DR.
[51], [52], [53]	HRM	• The indicators are acceptable. Therefore, the model is accepted. • The time of foundation of the companies was controlled, since a long stay in the company can lead to a high SCI. • HRM / SCI exhibits different patterns in different countries and industries.

4.3.2 Supply Relationship Management (SRM)

It is an important factor that influences the development of quality, so that companies interact with suppliers to mutually improve their organizational processes, such as asset management, purchasing, material handling, inventory management, among others [45], [56].
Most organizations rely on supplier participation in the development of a new product to increase their innovative capabilities and quality products [52].

Figure 8. Process of Implementation of Supplier Relationship Management for Asparagus, Source: Based on Own Study.

a) **Purchasing Strategies:** An analysis is carried out to determine the classification of the products to be able to carry out the

strategies, giving priority to the key products.

b) **Supplier Selection:** Implies the following criteria: commitment to quality, price / sensitivity negotiation, ease of delivery and order flexibility. These criteria will establish the choice of suppliers that contribute to efficiently manage the procurement of inputs. Also, analyze the business, financial, technical, security and environmental aspects implemented.

c) **Collaboration with Suppliers:** The internal participation of suppliers is the basis for the relationship between the supplier and the company and thus form an alliance where both must obtain benefits; Therefore, functions and benefits should be cooperated through a method where suppliers can help improve some processes, increase the quality of processes, reduce costs and delivery times. In addition, include specific clauses that the provider must comply with.

d) **Evaluation and development of suppliers:** For this point, procedures are established for the evaluation of the selected suppliers according to the strategic products obtained in the analysis of the first stage. The evaluation determines if the suppliers that entered the process can continue fulfilling the function of providing inputs to the company.

4.3.3 Operations Management

a) **Process Coordination:** It consists in the identification of mutual synchronization between the different processes of the defined scope. You can visualize which are the critical processes and the capacity base to prevent problems.

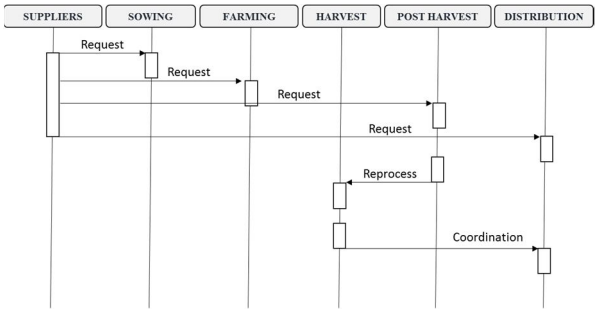


Figure 9. Process Coordination for the Supply Chain, Source: Adapted from [5].

As shown in the figure 10, the process of implementing the Poka Yoke tool consists of four stages.

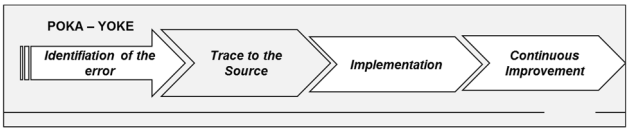


Figure 10. Poka Yoke Tool Implementation Process, Source: Adapted from [9].

Identification of the Error: This stage is to identify which is the error that the product or service owns throughout the process.

Trace to the source of error: evaluate ideas on different simple and low budget solutions to avoid this error.

Implementation: We proceed to test the error-proof tool for a certain time to evaluate its performance. At this stage it is necessary to carry out training on the use of the tool for farmers.

Continuous improvement: we proceed to work with the PDCA method. The cycle is repeated when the error is found and solution options are proposed, then the best option is selected. The data of the processes are collected with the tool and finally analyzed to find improvements.

b) **Visual Control:** According to [22], visual control is any communication device used in the work environment that tells us at a glance how work should be done. Visual control limits guide human response in terms of height, size, volume, weight, width and length. The Poka Yoke tool has been made integrating the visual control as support for the measurement.

c) **Measure system analyses (msa):** According to [66] the measurement analysis system aims to ensure that the measured values are correct and relevant to the process in which they are used. Within this system, you will find the Gage R & R Xbar-R tool. R & R Xbar-R: This method estimates the repeatability, that is, the variation of measurement and reproducibility, which refers to the variation of the operator. To develop this method, it is necessary to follow the following process. For implementation, the following phases are followed [55].

Figure 11. Implementation of R&R, Source: Adapted from [50].

Collet Data: In this phase it refers to the data collection that is taken according to the size of the bakery sample. Transparency in information is a fundamental part in the collection of these.

Get Variables: Having defined the data, we proceed to obtain the average of the measurements as the range of these. In the case of repeatability, farmers are taken as the base. On the other hand, for the reproducibility the product is taken as a basis.

Get Control Limits: With the support of statistical tables A2, D2 and D4, the formulas for variability for both repeatability and producibility are used to obtain the limits for the control chart.

Graph: With the control limits defined correctly, the corresponding graph for R is made for both repeatability and reproducibility.

Analyze: Finally, the graphs were analyzed to evaluate the measurement system in practice.

4.3.4 Human Resources Management (HRM)

According to [36] it will allow the skills and motivation of employees to develop through training and will result in greater productivity and improve the level of communication among all workers in the company [24]. HRM seeks the integration of farmers to improve the process by training them in relation to the Poka Yoke error-proof tool [4]. As shown in Figure 12, training and development of farmers is carried out.

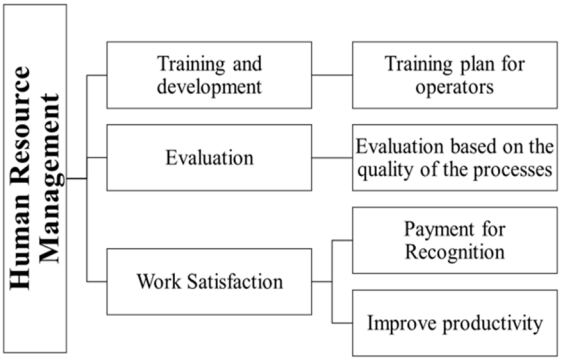


Figure 12. System of Human Resources Management for Asparagus, Source: Adapted from [53], [51].

Subsequently, we proceed to evaluate the performance of each one of them to finally recognize their work and incentivize them economically, in this way productivity will increase.

The 5s tool, serves as support for staff training and thus solve the cause of lack of training for the development of their functions. The implementation will be carried out in the following manner in the company, see the Figure 13 below:

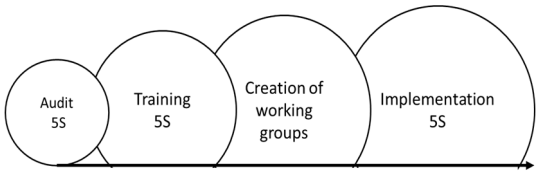


Figure 13. Process of implementation of 5S for Asparagus, Source: Adapted from [14],[56].

Audit 5S: Quantitative aspects all those involved are informed about the results of the inspections carried out in the company with the purpose of informing the current state of the company.

Training and information on 5S tool: Training will be given to the workers on the 5S tools, their application, benefits and importance for the improvement of the company.

Creation of working groups and definition of schedules responsibilities and functions: Work teams will be created for a better development of the processes, as well as defining the responsibilities of

each worker according to the functions and tools that they use. Finally, timetables will be made for a better organization.

Implementation: it proceeds to classify and discard the work tools that serve and those that do not, then they are organized according to a selection and classification already established.

The work environment, machinery and tools that are used are cleaned. Hygiene and visualization is important to keep the 3s running daily. Finally, with discipline and commitment, workers are expected to comply with the procedures and thus commit themselves.

5. Numerical Results

The validation was carried out through the MSA R & R analysis in the Minitab 18 program and a simulation modeled in the Arena Simulation Software - Version 14.70.00 System Requirement program through an HP Elite book 840 G3 computer.

Through a statistical analysis of both the current situation and the situation in which it applies to improvement with the support of the Minitab program. In a sample of 20 shoots Warehouse of asparagus, with data obtained 2 months prior to the run, the correct cut by the farmers was evident, since all the shoots were within 18 and 23 centimeters respectively, which represents the compliance with the quality standards required by the client. This measurement system is directly related to harvesting and distribution.

With respect to the simulation, the processes of the scope, supply, sowing, cultivation, harvest, post-harvest and distribution were established. In each stage, the number of farmers participating and the average time in minutes with constant distribution were determined. The unit of measurement was made based on the bags of seeds that enter the production process, as it passes through the different stages of the process the percentage of waste they have was established to finally place a counter of the asparagus produced. The model was run for an amount of ten months.

Figure 14 shows the results obtained from the simulation carried out in the Arena Simulation

Figure 15. Results for the Research of Waste, Source: ı, Based on [3], [44]. :s

refer to the percentage amount (%) of the waste along the supply chain. It should be noted that the types of waste have been unified by having a criterion to the process of the chain to which they belong, as shown in Figure 12, the results are positive, since they reflect the reduction of waste in each of the processes.

In the supply stage, it was reduced to 8.9%, thanks to the good relationship and selection of suppliers. In the warehouse the waste was reduced to 0.25% due to the implementation of the 5S in the company. On the other hand, the waste generated in the crop was reduced to 0.08% and the waste in the harvest was 6.56% due to the new measurement system and the quality control in the collection. Finally, the amount of waste generated in the post-harvest and distribution stage respectively was reduced to 0.01% and 1.87%.

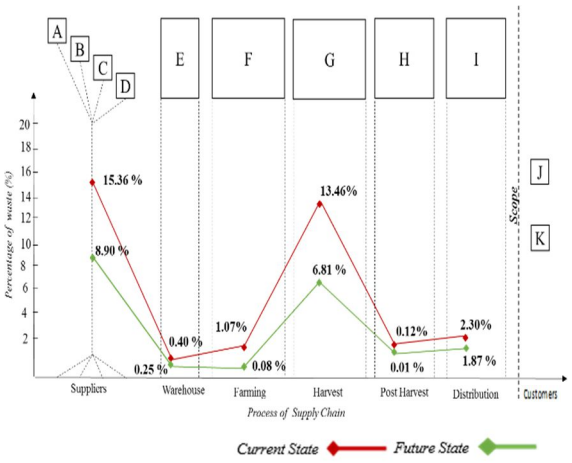
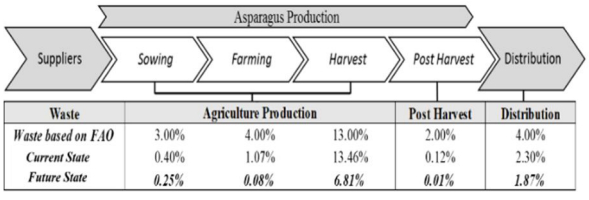


Figure 14. Percentage Results of Waste along the Supply Chain, Source: Adapted from [65]

According the Figure 15, when comparing the results with the average of waste collected by the FAO in South America, there is evidence of improvement. Even the results in current state are improved, it is necessary monitoring the new system proposed, in order to consider other variables not studied, or influence from other elements no managed directly; sourcing or external environment.



Waste	Agriculture Production			Post Harvest	Distribution
Waste based on FAO	3.00%	4.00%	13.00%	2.00%	4.00%
Current State	0.40%	1.07%	13.46%	0.12%	2.30%
Future State	***0.25%***	***0.08%***	***6.81%***	***0.01%***	***1.87%***

As is showed in Figure 16, within a more specific point, the total production of asparagus is 14% higher than that of 2017. This is because the total waste was reduced by 8%, which guarantees the increase of production.

Factor	Fulfillment Order	Production (in Kg)	Waste (in Kg)	Income (in USD)
Current State	65%	311,000	53,000	619,200
Future State	82%	360,000	32,040	787,104
Variations (+)	***17%***	***14%***	***8%***	***21%***

Figure 16. General Results, Source: Adapted from [43]

In addition, there is evidence of improvements in order fulfillment, which increase to 82% compared to 65% compliance in 2017. These improvements result in an increase in the company's profitability by 21%.

6. Conclusions

A harmony between the three practices is proposed in the SCQM model in the asparagus supply chain in Trujillo Region, La Libertad. The methodological framework is based on three best practices applicable to the stakeholders of the conflicting objectives. Between them; Supplier Relationship Management (SRM), Operations Management (OM) and Human Resources Management (HRM). The correct management of suppliers contribute efficiently and effectively to the optimal development of the company [54].

The results show improvements in the relationship and selection of suppliers, the generation of waste in the sowing, cultivation, harvest and post-harvest processes; the preparation of farmers, fulfillment of orders, compliance with quality requirements and the profitability of the company. In addition, it is essential to understand that customer satisfaction is the key to success [55].

7. Limitations

Our present study has some limitations. However, these are considered for future directions in a new investigation.

This case study has optimized the production of asparagus focusing on the relationship with suppliers and the reduction of waste along the chain. However, there are factors that are far from the scope of the research because they cannot be developed with the tools under study. Example, climatic changes, soil fertility, insect pests and sudden changes in temperature.

8. Future research

The present case study has the potential to generate a positive impact in the asparagus sector, for the supply, sowing, harvesting, post-harvest and distribution processes. However, the entire supply chain was not investigated, so for future research it is planned to cover the processing of products, distribution to retailers and final customers.

For future research the option of using the cold chain will be evaluated in order to have a better control and an optimal follow-up along the supply chain.

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