Navas, H.
Dias, A.S.M.E.
Morgado, Teresa
Abreu, A.
Anes, V.

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Improvement of acquisition processes for highly perishable products by using lean, TRIZ and *Kano* model

Navas, H.[1,4*], Dias, A.S.M.E.[1,2], Morgado, T.[1,2,3,4], Abreu, A.[2,5], Anes, V.[2,6]

[1] UNIDEMI, Department of Mechanical and Industrial Engineering, NOVA School of Science and Technology, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal
hvgn@fct.unl.pt

[2] DEM-ISEL, Department of Mechanical Engineering of Superior Institute of Engineering of Lisbon,
Polytechnic Institute of Lisbon, 1959-007, Lisbon, Portugal
ana.dias@isel.pt

[3] CINAV – Navy Research Center, 2810-001, Almada, Portugal
teresa.morgado@isel.pt

[4] LASI - Intelligent Systems Associate Laboratory, 4800-058, Guimarães, Portugal

[5] Center of Technology and Systems (UNINOVA-CTS) and Associated Lab of Intelligent Systems (LASI), 2829-516, Caparica, Portugal
ajfa@dem.isel.ipl.pt

[6] IDMEC, Instituto Superior Técnico, University of Lisbon, 1049-001, Lisbon, Portugal
vitor.anes@isel.pt

* Corresponding author.

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Abstract. The high competitiveness of the fishing sector, combined with the economic and environmental crises, together with the search for customer satisfaction and for increasing the efficiency and effectiveness of internal processes, makes companies constantly try to implement continuous improvement processes, to guarantee their survival in the sectors in which they operate. The present study was developed in a company of fresh fish processing and freezing industry, aiming to improve the fish acquisition process and to reduce the loss of freshness quality throughout it. Several instances for improvement were identified, analyzed, and prioritized whilst several proposals for improvement were also developed and implemented. For this purpose, TRIZ analytical tools were used to resolve contradictions that arose in the search for opportunities to implement improvements in situations highlighted by customer complaints, the *Kano* Model was used to assess the necessary requirements to implement such improvements, and finally several support tools to the Lean philosophy were used to carry out the implementation of the necessary improvements. A standard operating procedure for the evaluation of the freshness quality was developed together with the introduction of a rigorous traceability method, and complaints concerning the discrepancy in freshness quality levels, between the place of purchase and the factory decreased in number from 8 to 3 in 10 daily receptions. Consequently, the number of batches produced at the same purchased quality was increased by 62.5%. The waiting time to initiate production after reception was reduced from one hour to twenty minutes resulting in a 67% improvement of this process. Moreover, the number of calls made between buyers and the factory decreased, from 5 to 3 daily calls per purchase, improving by 40%. The full implementation of the proposals will allow the company to improve processes, increase employee motivation whilst reducing waiting and setup times.

Keywords: Continuous improvement; Fish freshness; Lean; TRIZ; *Kano* model.

1. Introduction

This article presents as an innovative point, the use of management tools: Theory of Inventive Problem Solving (TRIZ); *Kano* Model; *Gemba* walk; brainstorming; 5 Whys and Value Stream Mapping (VSM), to improve processes for acquiring fresh fish, which is a highly perishable product, and therefore, needs particularly special

care to reach the final customer in good consumption conditions. It is extremely important to ensure good management of the fishing sector and its logistic processes, to guarantee that fish and its derived products continue to prevail with high quality and value, in a sustainable way. This study aims to improve the sardines and white horse mackerel acquisition process in a fish processing and deep-freezing company, since this is the first event to occur in the sequential order of intern events, and all the other following processes depend on it. A case study was carried out in a fishing and fish sales company, called Docapesca – Portos e Lotas, S.A., located in the south of Portugal, whose main functions are to carry out, in Portugal, the service of the first sale of fish at auction, as well as the control and management of fishing ports. The research methodology is based on the use of tools that support the Lean philosophy to: firstly, detect the problems inherent to the loss of fish quality, in situations evidenced by complaints from the company's customers, in all processes that range from gauging the demand for sardines and white horse mackerel to the sale of fish-food processing companies; secondly, find solutions to solve contradictions that arose from the process of detecting opportunities to implement improvements, using the TRIZ methodology; thirdly, establish which improvements to implement, based on the assessment of the requirements they need, using the *Kano* Model; and fourthly, proceed with the implementation of such improvements, through the use of various tools that support the Lean philosophy.

2. Quality of Fish in Fishing and Deep-Freezing Processes

The fishing sector goes from the work of the fishing managing company directly with local fishermen in collaboration and cooperation, aiming to reduce losses and add value to the fish, supplying the market on a regular basis and focusing on exports. Thus, a large part of the fish that had no sale at auction, due to the lack of an interested market, is purchased by fish processing companies, which must have a high storage capacity. When fresh fish is sold under contracts, normally after being caught, it is packed in containers. This type of container can have a variable capacity between 200kg to 500kg [1]. In these cases, fish transportation containers are delivered to the buyer who is then responsible for returning them clean and undamaged. Thus, when it is anticipated that there will be no outflow of fish caught by auction, or even when the auction sale value is lower than that established in the contract, these situations become both favorable for ship owners as well as for the company that processes and needs fresh fish daily [2]. The freshness quality is divided into three freshness categories: the Extra; the A; and the B, assuming only the universe of fishery products for human consumption. The Extra category stands out for being considered the freshness category of fish of excellence, where all the organoleptic characteristics of the fish are practically intact, and where the absence of visible parasites is also essential.

On the other side, B category, within the scale of the three categories, is the one in which the fish presents the lowest level of freshness, but which is still considered acceptable for the purpose of human consumption [3]. Fresh fish is a very sensitive type of food and tends to deteriorate quickly, especially when it is not consumed within a few hours after being caught, or when it is not properly refrigerated and treated. In this way, it is essential to guarantee a great durability of the fish with high freshness quality, adopting good conservation and processing methods, as well as the freezing through the process of deep freezing [4]. So, the existence of an excellent communication and interconnection net between all stakeholders involved in the supply chain, from upstream to downstream, is extremely important. In this way, the loss of freshness quality of fish along the supply chain becomes minimal [4, 5]. However, it is important to note that the freezing method does not improve the freshness quality of the fish, this method only guarantees that the quality that the fish had at the time it started to be frozen is not lost until the time of defrost for consumption, assuming that all processing, storage, and distribution steps are performed correctly [5, 6].

3. Case Study

The case under study was developed by an internal multidisciplinary team of Docapesca, as the regulatory entity for the act of purchasing fresh fish. The main focuses of this case study were the process of acquiring fresh fish and understanding the problems associated with it, throughout the year of 2022. For that, some initial techniques were applied such as direct observations, *Gemba* walks and brainstorming, reaching the conclusion that the main problem laid in the fact that all the fish that arrived at the fish processing company (factory), was mostly received with reduced or almost unacceptable quality. At this point, the 5 Whys Analysis tool was implemented on the problem "Category B fresh fish is the most used" (Figure 1).

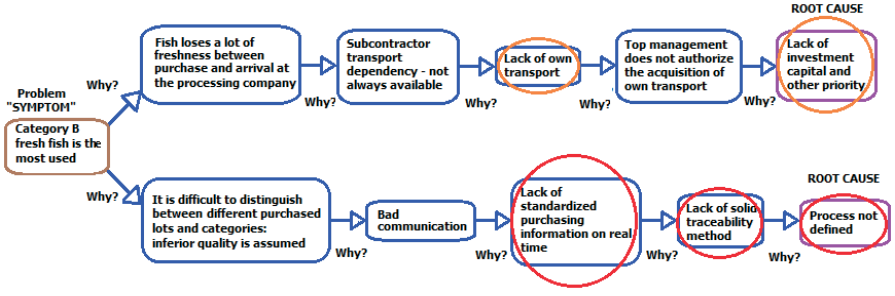

Figure 1. Analysis of the 5 Whys to the problem raised and its pertinent causes.

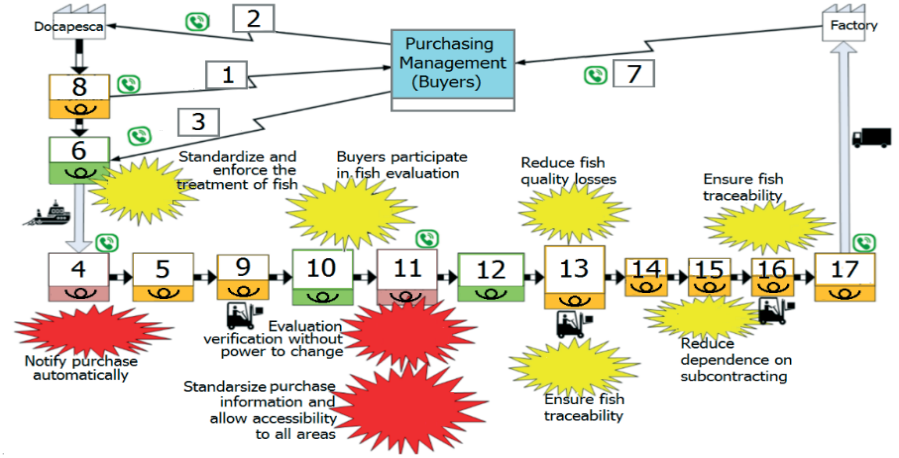

Figure 2. VSM of the initial state of the fish acquisition process.

Circles marked in red are considered possible causes to mitigate based on decisions in the field, and those marked in orange are causes that can only be mitigated by top management decisions, for which confidentiality has been requested. Thus, the root cause "Process not defined" had to be the main mitigation focus of this study. To obtain a more general and clearer picture of what was happening in the process, it was decided to apply the VSM tool. It was considered that, first, for the mapping it was expected that the purchase would be guaranteed, and then that the beginning of the process occurred with the communication of the capture made by the ship owners to the company's buyers. The end of this process occurred with the notice of buyers from the company to the factory about the estimated time of arrival of the fish purchased. All process steps and activities were numbered, as shown in Figure 2.

In Table 1, it is possible to consult the activities of the process where opportunities for improvement were identified and suggested, based on the interaction between the company's operation and customer complaints, regarding failures in quality inherent to the freshness of the fish supplied.

Table 1. Opportunities to improve the purchasing process.

Nr	Value	Activity
4	Buyers communicate with the factory by WhatsApp or individual Short Message Service (SMS)	Notify purchase automatically
6	The fish caught is packed in containers and treated according to practices of the crew	Standardize and enforce the correct treatment of the fish
10	Attribution of freshness assessment quality of the fish caught by a qualified representative of the vessels	Buyers participate in the assignment of the assessment
11	Buyers check the fish discharge and communicate to the factory according to their critical analysis (by WhatsApp or individual SMS) with photo support	Assessment verification with power to chance and standardize purchase information and accessibility to all areas of the company
13	Docapesca employees kindly stack the fish containers purchased by the factory, on that day, in an accessible place to load the transport truck	Reduce fish quality losses Ensure the traceability of fish
14	Buyers request transportation, for the day, according to the purchases made. If such request is impossible to attend, the buyers rent a smaller refrigerated trucks and drive them to the factory	Reduce dependence on subcontracting
16	Docapesca employees load the truck with the containers purchased in random order	Ensure the traceability of fish

To respond to these needs, the matrix of contradictions regarding the TRIZ methodology was used, where the element to be improved was the freshness of the fish and the elements that would have to be modified to achieve this objective were the form and time associated with packing the fish in the containers. For this purpose, the Innovation Work Bench®3.2 IWB (2005) TRIZ software was used, with the previously mentioned aspects being the inputs of the matrix of contradictions, whose guidelines for the solutions pointed out by using the mentioned software were discussed in several brainstorming sessions, that took place among company employees, more directly linked to the quality inherent in the freshness of the fish caught. As a result, the following list of proposed improvement measures was generated:

P1. Process documentation and mapping.

P2. Standard Operating Procedure (SOP) to evaluate fish freshness category.

P3. More rigorous traceability method using a specific pen.

P4. Standardized purchase communication by submission of an online form.

With proposal 1, it is possible to close the existing gap in terms of internal documentation of the fresh fish acquisition process, by developing an internal document coding and specifically related to the processes regarding these 8 topics: Process objectives; Field of application; Abbreviations and Acronyms; Process Flowchart; Sub-processes or Procedures; Risk Analysis; Responsibilities and Revision History.

Proposal 2 allows any buyer and company representative to be properly informed of the existing freshness levels and how to classify them. For that, a SOP document was developed for the process in issue, based on regulation CE No 2406-96.

Proposal 3 intends to use a more rigorous and less fallible traceability method, which consists of assigning an Internal Identification Number (NII), which allows different purchases to be distinguished throughout the day. This code is automatically generated by completing an online form (proposal 4), created to record all purchases made. The code is written by the buyer, with a specific pen, on each of the containers belonging to the same purchase lot. The pen tested and chosen to be applied in the traceability method was the Artline Wetrite Marker EK-47, widely used in the food industry [7].

Proposal 4 avoids exchanging information in an unorganized way. To this, an online form was created to be filled in after each purchase. In this way, it is intended to ensure that the information on each purchase is shared with all areas of the organization in a standardized, clear, and timely manner. By consulting this form, it is possible to see which the last code was assigned during that day and assign the next code, respecting the sequential order and not repeating codes already assigned. After that, the properly identified containers are packed in the transport truck, and when received at the factory, they can be easily distinguished.

4. Results and Discussion

First, after the suggested improvement proposals and knowing which ones would be effectively accepted and implemented, the future state VSM diagram was constructed, allowing to illustrate in a very intuitive way where these proposals were applied throughout the described process (Figure 3 and Table 1).

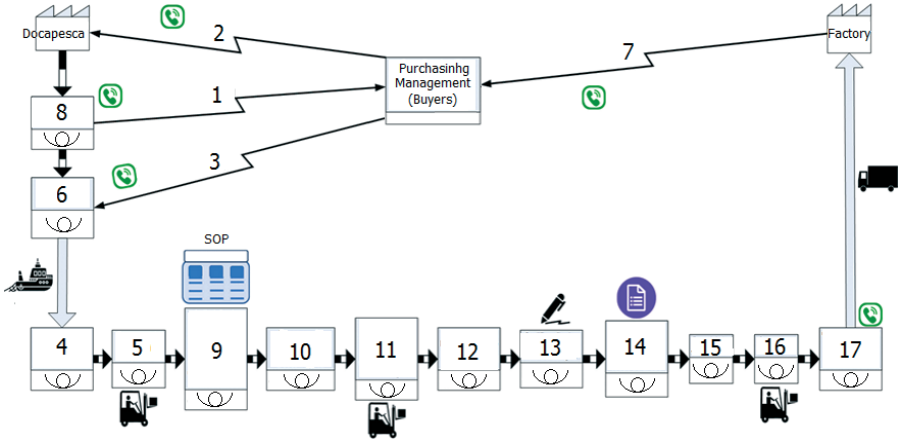

Figure 3. VSM of the future state of the fish acquisition process.

It is possible to verify that, at the beginning of the process, some of the communications and information exchanges that already took place were maintained through telephone calls, text messages, images, and multimedia via WhatsApp. This is justified, because initially it is necessary to define direct instructions to specific employees, and because it deals with negotiations between the company's buyers and the ship owners. In this way, by comparing both VSM, it is possible to verify that it demonstrates a reduction in activities that do not add value to the process in question, and that this ensures a more rigorous traceability method, as intended. After the implementation of the proposals for improvement and execution of the process as mapped and documented, *Kano*'s survey was carried out on the last three proposals presented, since the first related to the documentation and mapping of the process was obligatory, but the others had the need to infer whether they had been well accepted by the employees who put them into practice on a day-to-day basis, and whether they would or would not have continuation in the organization.

The *Kano* survey was carried out with as many employees as possible from five of the company's work areas directly involved with the inherent quality of fish freshness: 1) separation of freshly caught fish species - sardines and white horse mackerel; 2) packing the fish in containers; 3) loading of fish container trucks; 4) fish quality control at the fish processing factory and 5) operations management. An average of twenty employees were surveyed for each of these five work areas of the company.

For the *Kano* survey, the following requirements were established:

- Requirement 1 – SOP - laminated A5 sheet - to carry out or contradict the attribution of the fish freshness assessment.

- Requirement 2 – Specific pen for application in fish containers, to identify the different purchase batches, traceability method.
- Requirement 3 – Submission of online forms per purchase batch, which contains all the necessary information relating to them, and which allows access to this standardized information to all areas of the company in real time.

The caption for the types of requirements considered in this type of survey is also presented [8]:

O – Obligatory; A – Attractive; U – Unidimensional; N – Neutral; R – Reverse; Q - Questionable.

And the coefficients of satisfaction and dissatisfaction are calculated as shown below, through Eq. (1) and Eq. (2) [9, 10]:

$$CS = \frac{A\% + U\%}{A\% + U\% + O\% + N\%} \quad (1)$$

Where: *CS* - Coefficient of Satisfaction; *A*% - Percentage of attractive requirements; *U*% - Percentage of unidimensional requirements; *O*% - Percentage of must be requirements; *N*% - Percentage of neutral requirements.

$$CI = \frac{O\% + U\%}{A\% + U\% + O\% + N\%} \times (-1) \quad (2)$$

Where *CI* - Coefficient of Dissatisfaction.

The analysis of the responses obtained from the *Kano* surveys, allowed: to rate each requirement obtained for the 3 proposals under study with the corresponding types of requirements from the *Kano* model (Figure 4); and to calculate the percentages of responses obtained by type of requirement regarding the 3 proposals, as well as their respective satisfaction and dissatisfaction coefficients (Figure 5).

Ranking List:

Inquired group	*Kano* Ratings		
	Proposal 1	Proposal 2	Proposal 3
1	U	Q	U
2	O	U	U
3	U	Q	A
4	A	A	N
5	A	U	O

Figure 4. Ratings of the Kano Survey applied to implemented improvement proposals.

Final Classification:

Kano Requirements	O	A	U	N	R	Q	Total	Classification	CS	CI
Proposal 1	20.0%	40.0%	40.0%	0.0%	0.0%	0.0%	100.0%	U	0.8	-0.6
Proposal 2	0.0%	20.0%	40.0%	0.0%	0.0%	40.0%	100.0%	U	1.0	-0.7
Proposal 3	20.0%	20.0%	40.0%	20.0%	0.0%	0.0%	100.0%	U	0.6	-0.6

Figure 5. Requirement results along with Kano coefficients applied to implemented improvement proposals.

Figure 6, graphically illustrates the relationship between the obtained satisfaction and dissatisfaction coefficients (*CS* and *CI*), and the type of *Kano* model requirement to which they correspond.

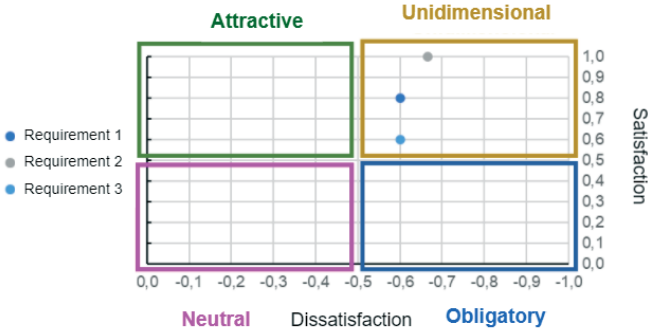

Figure 6. Diagram of the satisfaction and dissatisfaction coefficients of the present Kano.

Through the *Kano* survey it was observed that all proposals were considered as unidimensional requirements. That is, the execution of these requirements does not raise any kind of positive surprise effect on the respondents, which assume that the requirements under analysis should already be given as guaranteed acquisitions for the process in case. However, the failure to comply with these requirements ends up causing a lot of dissatisfaction among the people surveyed. It should also be noted that, based on the calculated satisfaction and dissatisfaction coefficients, the most rigorous traceability method using a specific pen, is clearly the one that has a greater level of satisfaction, but also has the greatest influence on the respondents' dissatisfaction. The online submission of forms, although also considered a unidimensional requirement, is the closest to becoming an obligatory requirement, so it means that this proposal is the most important of all.

5. Conclusions

Throughout this study, proposals supported by various Lean thinking tools for improving the fresh fish acquisition process, were suggested, and implemented. After that, the number of complaints related to the loss of quality of fresh fish received at the fish processing factory, made by those responsible for the areas of quality and production to the company's buyers, decreased. That is, with an average of 10 daily receptions of fresh fish at the factory, in high season periods, there was a reduction from 8 to 3 daily complaints per reception. This means that, the number of purchased batches processed according to the quality of freshness at which they were purchased, increased and the devaluation of the fish was reduced, since the quality of freshness inferred at the time of purchase was maintained until receipt at the factory. Currently, it is possible to guarantee about 70% of purchase batches to the same purchased freshness quality, so an improvement of 62.5% was achieved. The waiting time to start fish processing, after the factory receive the fish, was also reduced from 1 hour to 20 minutes, on average, representing an improvement of about 67%. It was also possible to verify the reduction in the number of phone calls made between the company's buyers and the various people in the factory, going from an average of 5 to 3 calls per daily purchase, representing a 40% improvement. Traceability methods of process conditions and product quality were also implemented, namely, the coding incorporated in fish transport containers or sales tickets printed by Quick Response (QR), bars code or using Radio Frequency Identification (RFID) technology, or even, through standardizing the type of container used for placing fish in all sectors or at least for ship owners and catching vessels, reducing waiting and setup times. As future work, it is recommended the possibility to carry out a financial feasibility analysis regarding the implementation of the methods applied in this study not only at the branch of Docapesca approached, but also to the other subsidiaries of this company that exist in Portugal.

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