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Diagnosis of the logistics supply system of the fishing industry of Sancti Spiritus

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Abstract

Fishing industries are part of complex supply chains, due to the limited life cycle of fish, high variability in the availability, quality and quantity of raw materials; also for the changes experienced by the quality of the product in the different processes. The research shows the main results of the application of a procedure for the diagnosis of supply logistics to the fishing industry, through a case study in an enterprise of the Cuban province of Sancti Spíritus. For this, tools such as the influences diagram were used; failure mode and effects analysis; variant mode and effect analysis and the scenario matrix. Disturbances were identified, as well as the impact of vulnerabilities in the supply chain to strengthen its performance. With the design of indicators, attributes were proposed to evaluate the quality of the raw material, based on the quality index method.

Keywords: fishery supply chain; quality improvement; vulnerability.

Diagnóstico del Sistema logístico de aprovisionamiento de la industria pesquera en Sancti Spíritus

Resumen

Las industrias pesqueras forman parte de cadenas de suministros complejas, por el limitado ciclo de vida del pescado, la alta variabilidad en la disponibilidad, calidad y cantidad de las materias primas; además, por los cambios que experimenta la calidad del producto en los diferentes procesos. El trabajo muestra los principales resultados de la aplicación de un procedimiento para el diagnóstico de la logística de aprovisionamiento a la industria pesquera, mediante un caso de estudio en una empresa de la provincia de Sancti Spíritus en Cuba. Para ello, se emplearon herramientas como el diagrama de influencias: análisis modal de fallos y efectos, análisis modal de variaciones y efecto y la matriz de escenarios. Se identificaron las perturbaciones e impacto de vulnerabilidades en la cadena de suministro, para robustecer su desempeño. Con el diseño de indicadores, se propusieron atributos para evaluar la calidad de la materia primar, a partir del método de índice de calidad.

Palabras Clave: cadena de suministro pesquera; mejora de la calidad; vulnerabilidad.

Introduction

Supply chain management facilitates integration between the customers, the distribution network, internal enterprise activities and the supply [1]. This has a predominant role in the competitiveness of companies in terms of quality, efficiency, productivity and costs. Consequently, there is a prevailing need to eliminate operations that do not add value in processes, in order to minimize cycle time, to increase productivity and minimize inventory levels throughout the supply chain, and at the same time improve product quality, and customer satisfaction as high as possible. As a result, supply chains are very vulnerable to disturbances, due to unforeseen events in each process [2]. Consistent with this approach Van der Vorst et al. [2-4] refer that food supply chains have specific characteristics that make them much more vulnerable, as they are products with a limited life cycle, and high variability in availability, quality and quantity of raw materials, and also the fact that the quality of the product can change as it is transformed through the different processes. These vulnerabilities make the management of food supply chains more complex when it comes to strengthening their performance.

In general, the vulnerability of supply chains is reflected in their performance, which is quantified using key performance indicators (KPIs). The performance of supply chains generates post-harvest losses that affect product quality, productivity and costs, among others [2].

In today's competitive business environment, supply chain performance is one of the most critical issues in various industries [5]. Supply chains are complex in themselves, each component that is part of them involves details that are essential to take into account in decision-making, with the most up-to-date and accurate information from all members of the chain [6].

A supply chain is a network of enterprises that produce, sell, and deliver a product or service to a predetermined market segment. It not only includes producers and suppliers, but also carriers, storage, retailers and own customers, among others [7]. According to Yared Lemma and Gatew [8] supply chains are composed by four logistics systems: supply, production, merchandising and inverse logistics. In perishable food supply chains, the supply logistic system is where the greatest losses occur, and their causes are different from developed and developing countries; in the later, approximately 64% of the losses occur in the supply logistics system, due to the difficulties of technology and infrastructure (such as transportation and storage), and techniques for harvesting, transportation and storage.

In developed countries, losses along the entire value chain of food products range between 40% and 50% of this 42% come of total food waste and in developing countries, losses can be as high as 30% to 50%, and 40% of that losses occur at the post-harvest and processing level [9].

Now a days Cuba is immersed in a process of transformations of its economy, to lay the foundations for the economic development that allows to perfect its socialist social system. This process is taking place within the framework of an international economic, financial, alimentary, energetic and environmental crisis; in an increasingly globalized environment. At the beginning of these transformations, certain symptoms are manifested that reflect the incongruities between the previous concept, and the new concept of economy functioning that is beginning to be instituted. At present the individual management of each enterprise do not result in high competitiveness, for that reason it is necessary to integrate the management of the supply chain [10].

The research integrates various tools that allow identifying the noise factors that influence the performance of the supply logistics to the fishery and aquaculture industry, their application permits to strengthen the process and the quality index method is proposed as an indicator of system management and reliability.

Materials and methods

The procedure depicted in Figure 1, allowed to carry out a diagnosis of the supply logistics to the fishing industry of Sancti Spíritus province. Tools are applied in the different stages such as Failure Mode and Effects Analysis (FMEA); and Variant Mode and Effects Analysis (VMEA) that allow to identify and to classify the disturbances in the chain and the proposed indicators also the use of the quality index method (QIM), as well as the definition of stages.

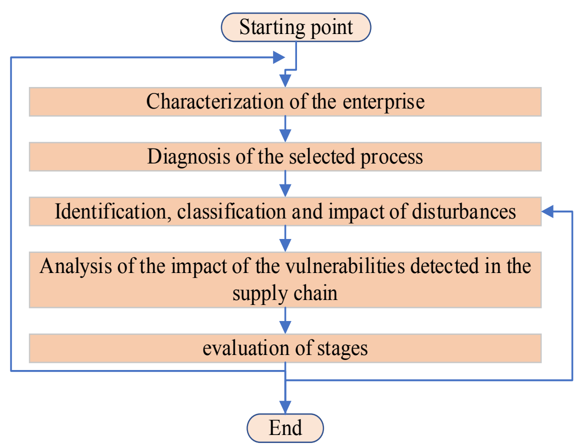

Figure 1. Procedure for the diagnosis of supply logistics to the fishing industry of Sancti Spíritus province [11].

Characterization of the enterprise

A description of the enterprise under study and the supply chain was made, followed by the creation of specialists work team with knowledge about the supply chain and the different logistics systems that comprise it, to lead the implementation of the proposed procedure, regarding the organization and the contribution of criteria with experts providing assessments and recommendations with maximum competence [12, 13]. This made it possible to carry out a general characterization of the supply chain and a graphic representation where each of the processes, suppliers and clients involved in the chain are identified, as well as to select the logistics system to study.

Diagnosis of the selected logistics system

Through Brainstorming, information is obtained from the experts on the main causes of the problems that the logistics system presents. A cause-effect diagram was carried out, a tool that allows with increasing details, graphically to show the possible causes related to a problem or condition.

Identification, classification and impact of disturbances

With the graphic analysis of the process and the assessment of the cause and effect relationships of the problems detected in the diagnosis, disturbances are identified and classified, to evaluate the impact of each disturbance in the selected logistics system through FMEA [14, 15].

The analysis continues with the development of VMEA, as a tool to determine the magnitude of the disturbance, in terms of the variability that appears in the process performance.

Impact analysis of vulnerabilities detected in the supply chain

For the identification of the selected logistics system processes, an influence diagram was drawn up, which made it possible to detect the existing relationships among each of the aforementioned processes. Indicators defined to measure disturbances are represented in the diagram. The causes taken into account are those identified in the FMEA and the objective is defined in the VMEA to minimize variability of the quality characteristics.

For the design of the quality indicators, the QIM is proposed, which is based on significant sensory quality parameters, external appearance attributes for raw fish, with a system of score for demerits on a scale of 0 to 3 [16, 17].

Definition of vulnerability stages

The stages were defined, and the indicators of time, quantity and quality that characterize them are declared, in correspondence with the results of the failures identified in the FMEA, and of the variability analysis with the VMEA, for the fish supply chain as perishable food.

Results and discussion

The supply chain for the fishing company is shown in Figure 2, the description of the systems involved in its operation are described as follows:

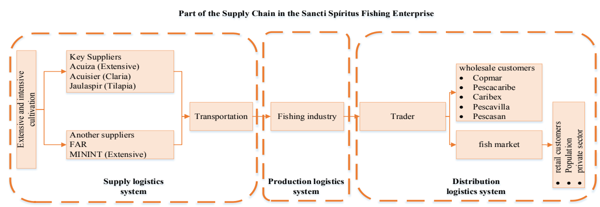

Figure 2. Representation of the supply chain

Next, with the opinion of the experts, the degrees of relationship between the logistics systems are obtained. Determining that the system to study is the logistics supply system.

Diagnostics of the selected system

The supply logistics system in the enterprise begins at the moment of capture and ends with the delivery of raw material to the industry. In the investigation with the experts, the deficiencies that affect the operation of this system were analyzed, they are shown in Figure 3

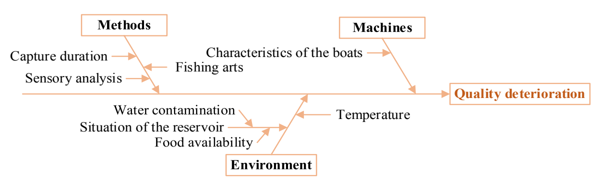

Figure 3. Deficiencies detected in the selected system.

Disturbances identification, classification and impact

For the disturbances identification, classification and impact, the FMEA was used, which allowed to analyze the quality, safety and / or reliability of the operation in each of the studied processes. An experts teamwork was carried out, where the potential failures were identified, evaluating their severity, occurrence and detection, allowing to calculate the risk priority number (RPN), to prioritize the causes, in order to avoid the occurrence of such failure modes. Table 1 shows the main processes with the highest RPN identified.

The results of VMEA show the relative contribution of each sub -KPC and each NF in a Pareto diagram (Figures 4 and 5). These graphical representations show that microbial growth (sub-KPC) and temperature (NF) are the ones that contribute the most to the variability in the fish quality characteristics. Secondly, there is the variability of the reservoir situation (sub -KPC), in correspondence with water contamination and food availability (NF). It is for these reasons that improvement efforts are focused on these areas. It can be seen that there are others sub -KPCs

Table 1. Failures mode and effects analysis results.

Process steps	Failure mode	Effects of the ruling	Causes of failure	Current control	RPN	Corrective actions
Capture	Deterioration of quality characteristics	Microbiological contamination of raw material	High temperatures	Visual analysis	**504**	Compliance with freeze and cold storage regulations based on ambient temperature
Reception at the fishery gathering point	Deterioration of quality characteristics	Microbiological contamination of raw material	High temperatures	Sensory evaluation (quality index method)	**846**	Compliance with freeze and cold storage regulations based on ambient temperature
Transfer to industry	Raw material transportation problems	Microbiological contamination of raw material	Environmental contamination	Sensory evaluation (quality index method)	**486**	Check that the transfer of raw material complies with the established freeze and cold storage standards.
			High temperatures		**846**	Use of insulated fish holder, boxes and proper refrigeration mode

Table 2. Results of Variant Mode and Effect Analysis application.

Key Product Characteristics KPC	Sub-KPC	Sensitivity	NF	Sensitivity	size variation (NF)	RPNV (NF)	RPNV (Sub-KPC)
Fish quality	Location of the reservoir	9	Water contamination	8	3	216	306
			Food availability	5	2	90	
	Capture methods	7	Duration of captures	10	5	350	574
			Weather condition	8	4	224	
	Microbial growth	10	Temperature	9	8	720	720
	Boats	5	Characteristics of the boats	6	5	150	150

NF: noise factor; RPNV: risk priority number variation

To define the factors that influence the variability of the process, the VMEA was used. Brainstorming was also applied to identify key product characteristics (KPC) and sub KPCs. Fish quality is selected as KPC taking into account the needs of the industry. The description of each sub KPC is shown in Table 2 and allows us to understand the characteristics that most contribute to KPC variations.

and NFs that their relative contribution to KPCs was not significant, but they have a direct and unfavorable impact on the consumption rates of fruit and vegetable products; therefore, in the efficiency of the process, hence the VMEA study was carried out, taking fish quality as KPC.

In this way, the situation presented by the reservoir is visualized due to the contamination of the existing water and food availability, which also generates variability. Therefore, it is necessary to work on them to improve the quality assurance of the enterprise supply logistics.

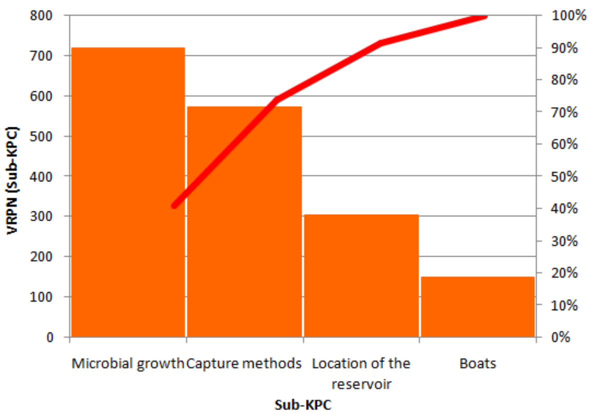

Figure 4. Relative contribution of Sub-KPC to fish quality.

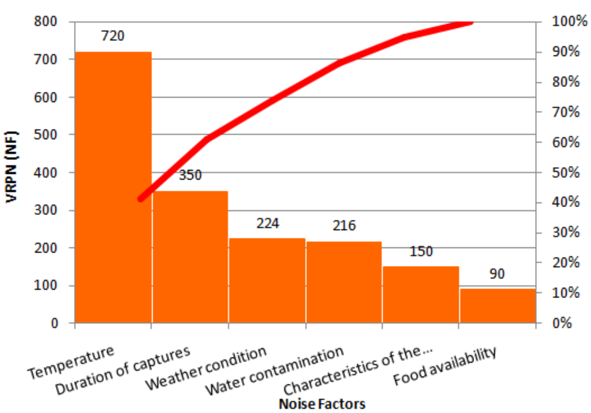

Figure 5. Relative contribution of NF to fish quality.

Impact Analysis of vulnerabilities detected in the supply chain

For the impact analysis of vulnerabilities, a flowchart is drawn through the influence diagram as shown in Figure 6, where the following is revealed: the causes of the disturbances, the relationship of each one of them with the indicators defined, and the direct relationship with their quality indicator. In this way, the type of relationship of the variables with the system is visualized, and the improvement actions that correspond to the quantification of these relationships are established, to minimize the quality characteristics variability.

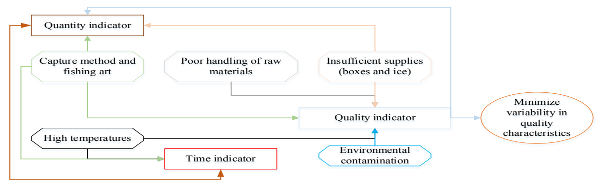

Figure 6. Influence diagram depicting the relationships of NF and Sub-KPC with the system to minimize the quality characteristics variability.

For the impact analysis of vulnerabilities in the supply chain, detected during the VMEA, a proposal of indicators for time, magnitude and quality is made, as shown in Table 3.

The defined attributes were considered the most important parameters to perform the sensory analysis through the QIM, to determine the freshness of the fish, with scores ranging from 0 to 3 (odor) and 0-2 (other attributes), depending on the score of each characteristics. The total sum ranges from 0 (total freshness) to 16 (total loss of freshness).

Scenario evaluation

The scenarios behavior evaluation is carried out qualitatively through the failures identified in the FMEA and the variability provided by the VMEA, it is represented in Table 5, which allows to show these disturbances effect and in what work regimen they are classified.

Time is taken as a reference to locate the scenarios in the matrix, according to NF determined in the current months since the tendency is to obtain high volumes of fish and increase temperatures as NF.

In the capture process, failures in the methods were identified, that bring mechanical damage, if the duration of the capture is prolonged and the boats do not have the necessary conditions for fishery freeze and cold storage and when exposed to high temperatures, it increases microbial contamination. These disturbances are located in scenario E6 in an altered regime, with preventive and reduced response.

The reception process at the fishery gathering point is located in scenario E5, under an altered regime,

Table 3. Proposed indicators for time, quantity and quality

Process	Calculation method	Evaluation	Legend
Reception at the fishery gathering point	$IC=\frac{CLNMIC}{TL}$	Good: IC = 0 Bad: IC > 0	Quantity indicator (IC) Number of lots that do not meet the quality index (CLNMIC) Total lots (TL)
Collection point	$IT=\frac{CLNTDCD}{TL}$	Good: IT = 0 Bad: IT > 0	Time indicator (IT) Number of lots that fail to comply with the time defined in the deterioration curve (CLNTDCD) Total lots (TL)
Collection point	$IQ=\frac{CPCIQ}{CTC}$	Good: IQ = 0 Bad: IQ > 0	Quality indicator (IQ) Quantity of fish that do not meet the quality index (CPCIQ) Total amount caught (CTC)
Reception in the industry	$IQ=\frac{CPCIQ}{CTR}$	Good: IQ = 0 Bad: IQ > 0	Quality indicator (IQ) Quantity of fish that do not meet the quality index (CPCIQ) Total amount received (CTR)
Reception in the industry	$IT=\frac{CLNTDCD}{TL}$	Good: IT = 0 Bad: IT > 0	Time indicator (IT) Number of lots that fail to comply with the time defined in the deterioration curve (CLNTDCD) Total lots (TL)

The attributes to be considered as product quality indicators for the quality index method (QIM) use are shown in Table 4.

Table 4. Quality attributes to measure quality indicator.

Quality parameters		Scores
General appearance	Color	0 - 2
	Odor	0 - 3
	Skin	0 - 2
	Scales	0 - 2
Eyes	Shape	0 - 1
	Pupil	0 - 2
	Cornea	0 - 2
Gills	Color	0 - 2
Quality index		0 - 16

since the average time is taken and the quantity levels are high, and the fishing art used must also be analyzed. To guarantee the quality of the raw material at that point in the process, the necessary inputs supplies such as plastic boxes and ice for cold storage must be guaranteed. The transfer to the industry is located in the E1, E3 scenarios, under a normal regime, with reduced response, with

Table 5. Relationship matrix between time and quantity indicators

Time indicators	Low (Quality indicators)	Medium (Quality indicators)	High (Quality indicators)
Low	**E0** **Ideal regime robustness zone**	**E1** **Normal regime robustness zone**	**E4** **Regime interruption Reduced response**
Medium	E3 Normal regime Preventive response	E1, E3 Transfer to industry Normal regime Reduced response (T,I,M)	E5 Fishery gathering point reception Altered regime Reduced response (MCU,T,I,M)
High	E3 Altered regime Preventive response	E2, E6 Altered regime Preventive response	E6 Capture process Altered regime Preventive and reduced response (MCU,T,I,M)

medium time and quantity, to guarantee the quality of the raw material, an adequate handling must also be guaranteed, as well as the ice supplies and plastic boxes, to maintain the proper temperature. The scenarios may vary under a given situation at a given time, such as weather conditions, high capture volumes, and the necessary of not available inputs.

Conclusions

As the research emphasizes, supply chain managers need to be better equipped with the methods of measuring and managing vulnerability. The designed procedure allowed the integration of scientific tools in order to help assess the levels of vulnerability in the supply chain and proactively manage the response to be considered for each type of scenario. The procedure studied the supply chain vulnerabilities depending on the amount captures exposure time to high temperatures and their impact on the quality characteristics, evaluated through sensory analysis, achieving a direct relationship in the management of the different processes. In this way, top management obtained more reliable information on the enterprise "health" and could assess whether the supply chain is managed effectively and efficiently, with a philosophy of continuous quality improvement.

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