Artículos de investigación

Methods and models to address logistics problems in the agrifood supply chain

Métodos y modelos para abordar problemas logísticos en la cadena de suministro agroalimentaria

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Abstract: The growing demand for food, preserving food quality, and food safety are some of the challenges the agrifood supply chain faces today. This article shows a review of some of the contributions made by various authors, based on processes and logistics activities, to identify techniques and tools proposed specifically for the agrifood supply chain, covering aspects from production support operations to environmental implications. This analysis allows to knowing which are the logistics processes accounting for the greatest contributions, highlighting the importance of logistics as a key element in the operations of the agrifood supply chain.

Keywords: logistics, agrifood supply chain, logistics processes, agrifood tools.

Resumen: La creciente demanda de alimentos, la preservación de la calidad y la inocuidad de los alimentos son algunos de los desafíos que enfrenta la cadena de suministro agroalimentario en la actualidad. Este artículo muestra una revisión de algunas de las contribuciones realizadas por varios autores, basadas en procesos y actividades logísticas, para identificar técnicas y herramientas propuestas específicamente para la cadena de suministro agroalimentaria, que cubre aspectos desde las operaciones de apoyo a la producción hasta las implicaciones ambientales. Este análisis permite identificar cuáles son los procesos logísticos que representan las mayores contribuciones, destacando la importancia de la logística como elemento clave en las operaciones de la cadena de suministro agroalimentaria.

Palabras clave: logística, cadena de suministro agroalimentaria, procesos logísticos, herramientas agroalimentarias.

1. Introduction

The agrifood industry significantly contributes to the economy of many nations, specifically in developing countries, creating one of the main resources for the population located in rural regions (McCullough et al., 2008). Recent studies indicate that the global food demand will increase between 70% to 100%, mainly due to the population growth, since it is projected that population will grow between 7 to 9 billion people by 2050. Thus, the challenge for the agrifood industry and specifically for the agrifood supply chain in the coming decades will be to respond to the growing demand by improving the quality and reducing food waste (Condratchi, 2014), in addition, to focus on improving aspects such as sustainability and traceability.

In general, an agrifood supply chain is mainly characterized by the limited lifetime of food products, such that quality can change significantly from the first supplier to the end consumer. A variety of risks is present during the processes of supply, manufacturing, processing, and distribution, making this unique and quite different from any other supply chain. In this way, as a result of the globalization of food markets, it has generated the need to develop better transportation systems and methods for managing and preserving the quality. For example, harvesting food is usually centralized in certain regions, but the consumption is distributed nationally or internationally, which clearly promotes the development of logistics along the agrifood supply chain. It is particularly evident in the case of perishable products where limited lifetime requires careful planning of distribution, transportation, inventory and material handling in order to reduce damage and preserve their value.

Logistics is being increasingly used to manage the agrifood supply chain (Van der Vorst et al, 2007), involving processes such as customer service, transportation, warehousing, inventory control, order processing, distribution, procurement, material handling, and demand forecasting. This research begins by explaining the research methodology, where a number of scientific articles were analyzed, and the approach used for the search is indicated. The techniques and tools proposed by various authors were classified according to the logistics processes addressed along the agrifood supply chain. Finally, the conclusions of this analysis are presented.

2. Methodology

"Inconsistent research output makes critical literature reviews crucial tools for assessing and developing the knowledge base within a research field. Literature reviews in the field of supply chain management (SCM) are often considerably less stringently presented than other empirical research" Seuring and Gold, (2012).

This article is aimed to outline the disperse knowledge about the agrifood supply chain. The main objective is to identify important information about the areas where significant research efforts are conducted for increasing this area of knowledge. Logistics in the agrifood supply chain is studied by identifying techniques and tools proposed by various authors. The analysis identifies research gaps in the literature to facilitate further study, and research directions; it addresses the production support processes, transportation and distribution, warehousing and inventory management, order processing, quality management, and traceability and environment.

The literature review was performed by searching in databases of recognized scientific publications, i.e. Elsevier, Emerald, and EBSCO. In these databases, 67 articles were consulted and analyzed, whose contributions focused on agrifood supply chains and were published between 1994 and 2018. For the search, the following keywords were used: agrifood supply chain, logistics processes - agrifood supply chain, agri logistics processes, agri food logistics tools, agrifood supply chain logistics, and agrifood supply chain logistics design. It is important to note that although there is a considerable number of scientific publications about supply chains in general, recent studies such as that conducted by Mahajan et al. (2017),Sanabria-Coronado et al. (2017) and Badole et al. (2012) show that the number of articles concerning agrifood supply chains and logistics is significantly lower compared to publications regarding supply chains for industrial or specialized manufacturing sectors.

2.1. Background

2.1.1 Agrifood Supply Chain

An agrifood supply chain (AFSC) is one that produces and distributes products in the food sector, according to Aramyan et al. (2006), this chain is formed by a network of companies in which food is moved from production to the consumer, with the characteristic that these products take part of a commodities market, basically competing on price and availability. Overall, in the AFSC two types of products can be distinguished: fresh products (perishable) as vegetables, flowers or fruit, and processed products (nonperishable) such as canned goods. These products have a limited lifespan, quality and safety, and high variability in demand and price, which makes this supply chain more complex and difficult to manage than any other (Aramyan et al., 2006;Ahumada and Villalobos, 2009). For example, the lifetime constraints of the raw material and the perishable nature of the products require special conditions of transportation and storage, to preserve physical aspects such as taste, odor, appearance, color, and size (Tsolakis et al., 2014). In addition, the production is made in complex networks (Fritz and Schiefer, 2008), involving business infrastructure at regional, national and international levels, with vertical and horizontal interrelationships. Another feature of an AFSC is that some of its products are transformed from commodities to differentiated food brands (Salin, 1998), while others are only packed, retaining its physical properties.

The AFSC also consists of a number of stakeholders (farmers, processors, distributors and retailers) that perform one or more of the activities of handling, processing, transportation and storage, in order to alter the appearance and quality condition of a product (Granillo et al., 2017). Another feature is the asymmetric distribution of bargaining power in favor of large distribution companies (Abatekassa and Peterson, 2011; Pulina and Timpanaro, 2012). Here, each party tries to buy as cheap as possible and to sell at the highest possible price, such that profits from the sale of finished food products are unevenly distributed along the chain, where processors and distributors usually receive the greatest benefits.

2.1.2 Logistics in the AFSC

In an industrial context, logistics as the art to obtain, produce and distribute materials and products in the right place at the right amount. On the other hand, Christopher (1998) describes it as the process of strategically managing supply, movement and storage of materials, parts and finished goods inventory, through the organization and its trading channels, such that current and future profit is maximized through the fulfillment of orders. In the focus of AFSC, logistics also includes planning activities of food production, physical collection of primary production from the crop fields and greenhouses (Vanecek and Kalab, 2003), with an emphasis on packaging and processing according to the characteristics of food products moving along this chain. Logistics processes in an AFSC involve the management of products flow along the supply chain with the aim of providing superior customer value (Tsolakis et al, 2014), seeking to minimize the total cost, optimize operational efficiency and maintaining the stability of the supply chain according to the demand (Van der Vorst et al., 2007;Soysal et al., 2012;Haoran et al. 2013).

In particular, in logistics, different processes and activities that support the design and operation of the AFSC are involved. From the perspective of the supply chain, according to Christopher (2005) the logistics processes can be classified into: production support, transportation, and distribution, warehousing and inventory management, order processing, traceability, quality, and environment management, and these, in turn, are integrated by different activities as shown in Table 1.

TABLE 1:
Table 1: Logistics processes and activities.

Process	Activities
Production support	Primary production planning Procurement for production Harvesting Production and materials scheduling
Transportation and distribution	Planning of distribution tasks Planning of distribution networks Transportation management Selection of transportation modes/materials Monitoring and traceability of the product Routing and scheduling of transports
Warehousing and inventory management	Warehouse location Selection of storage facilities Inventory management Inventory control Demand forecasting
Order processing	Infrastructure management Picking planning Orders packing Shipping management Product returns management
Traceability and quality management	Quality control Total quality management Quality of services Monitoring and traceability
Environment	Packaging materials handling Gas emissions / pollutants generation Energy consumption

3. Logistics processes in the AFSC

The design and operation of logistics processes for an AFSC are mainly based on techniques and tools focused on reducing cost and time, keeping quality, reduction of waste, and improvement of traceability and sustainability. The products circulating along the AFSC are time sensitive, making quality change because they are exposed to various risks during production, transportation, warehousing, and material handling. Some authors (Gigler et al., 2002; Verdouw and Beulens, 2010; Boudahri et al., 2011) have proposed various techniques applied to these logistics activities such as distribution networks planning, where the main factor to consider is quality during post-harvest transport. Specially, for perishable goods, it is necessary to reduce spoilage to retain their value (Ahumada and Villalobos, 2009), as well as minimizing the flow time towards the end customer (Haoran et al., 2013; Tsolakis et al., 2014). In developing countries, product losses due to logistical aspects, where transportation is included, are estimated above 40% of total production in the case of perishable products (Vigneault et al., 2009; Gustavsson et al., 2011; Bosona and Gebresenbet, 2013).

3.1. Production Support

The design and planning of the production support process for the AFSC, addresses activities related to harvesting practices, vertical integration and horizontal cooperation (Tsolakis et al., 2014). Table 2 presents the articles related to the logistics process of the production support, which integrates activities of: planning of primary production, procurement for production, harvesting, scheduling and planning of production and materials.

TABLE 2:
Table 2: Production support

Activities	Tool / technique	Reference	Product / Application
Planning of primary production	Business reference model	(Verdouw and Beulens, 2010)	Flower industry
	Supply chain performance model	(Jie et al., 2016)	Meat
Procurement for production	CPFR	(Xiao Fang et al., 2009)	Walnuts
		(Mason et al., 2015)	Horticultural products
Harvesting	Linear programming	(Mason et al., 2015)	Horticultural products
		(Ahumada and Villalobos, 2011)	Tomato
		(Xiao Fang et al., 2009)	Walnuts
Planning and scheduling of production and materials	CPFR	(Ahumada and Villalobos, 2011; Ahumada and Villalobos, 2009)	Tomato
Production planning	Mixed-integer programming	(Burer et al., 2008)	Seeds
	Stochastic model	(Boundeth et al., 2011)	Maize
	Business reference model	(Verdouw and Beulens, 2010)	Fruit industry
		(Esteso et al., 2017)	Unspecified

Verdouw and Beulens (2010) present a reference model for perishable product planning. Other authors (Ahumada and Villalobos, 2009; Xiao Fang et al., 2009; Verdouw and Beulens, 2010; Boundeth et al., 2011; Esteso et al., 2017; Jie et al., 2016) suggest the use of techniques for harvest planning based on the application of mathematical optimization models, including stochastic programming, linear programming, and dynamic programming. Some of them also propose the use of tools for strategic cooperation, mathematical programming and the agent-based model driven decision support system in the AFSC.

3.2. Transportation and distribution

Agrifood production is done in integrated complex networks by multinational companies, as well as small and medium enterprises. These networks are generally characterized by one or two levels of distribution, where the main factor affecting the behavior of quality is the temperature and time (Fritz and Schiefer, 2008; Stragas et al., 2011). Hence a poor transportation infrastructure increases the price of inputs while reduces the price of products (McCullough et al., 2008). In this logistics process, the work of Boudahri et al., (2011) focused on the application of techniques for optimization, in the proposed Capacited Centred Clustering Problem (CCCP). Lanfranchi et al. (2018) present the Organized Large-Scale Retail Distribution, aimed at consumers, to reach the goal of reducing food waste. Gigler et al. (2002) and Higgins (2006) propose dynamic programming for planning and optimization of distribution networks. Haoran et al. (2013) propose a model for optimizing distribution networks using non-linear integer programming. Other works about the AFSC are focused on transportation planning, applying mixed integer linear programming (MILP), vehicle routing scheduling (VRS) and transportation management systems (TMS). Other authors such as Vigneault et al. (2009) discuss a method where physical and structural characteristics are included for the management of transport vehicle systems. Transport operations in the AFSC have determined qualities in different parts of the chain (Ljungberg and Gebresenbet, 2004). These are characterized by seasonal factors and patterns dependent on production climate, geographically dispersed collection in areas of rural production, and traceability requirements. A key factor in transportation operations is the monitoring and traceability of products, so Regattieri et al. (2007), Suprem et al. (2013) conducted a review of the tools for automated monitoring as radio frequency identification (RFID) and geographic information systems (GIS). Ghezavati et al. (2017) present a periodical planning mathematical model for the distribution of fresh agri-food after qualitative segregating. Table 3 organizes such works according to the logistics activities for transportation and distribution.

TABLE 3:
Table 3: Transportation and distribution.

Activities	Tool/technique	Reference	Product / Application
Planning of distribution tasks	Optimization of CCCP	(Boudahri et al., 2011)	Chicken meat
Planning of distribution networks	Dynamic programming	(Gigler et al., 2002)	Seed / biomass
		(Boudahri et al., 2011)	Chicken meat
	Nonlinear integer programming	(Haoran et al., 2013)	Fresh agricultural products
	MILP	(Ghezavati et al., 2017)	Tomato
		(Granillo-Macias et al., 2018)	Barley
	Retail distribution model	(Lanfranchi et al., 2018)	Tomato
Transportation management	MILP	(Adame al., 2011)	Fresh palm oil bunches
		(Agustina et al., 2014)	Unspecified
	Discrete simulation	(Iannoni and Morabito, 2006)	Sugarcane
	Quantitative operations management approaches	(Akkerman et al., 2010)	Unspecified
	Optimization, modelling and simulation	(Gebresenbet et al., 2011)	Unspecified
		(Gebresenbet and Oodally, 2005)	
	Discrete/continuous-time mixed integer programming model	(Kopanos et al., 2012)	Dairy industry
Selection of transportation modes/materials	RFID	(Jedermann et al., 2009;	Fruits and vegetables
	Transport systems	(Vigneault et al., 2009)	Horticultural products
Monitoring and traceability of the product	RFID	(Regattieri et al., 2007)	Unspecified
		(Gan et al., 2011)	Horticultural products
	Information systems	(Opara, 2003)	Fruits and vegetables
		(Suprem et al., 2013)	Fruits and vegetables
Routing and scheduling of transportations	Mixed-integer programming / VRS	(Higgins, 2006)	Sugarcane
	Load rate analysis / TMS	(Ljungberg and Gebresenbet, 2004)	Unspecified
	Discrete/continuous-time mixed integer programming model	(Kopanos et al., 2012)	Dairy industry

3.3. Warehousing and inventory management

Table 4 shows the works related to logistics activities such as locating warehouses or distribution centers. Pulina and Timpanaro (2012) point out the need in the AFSC to have tools focused on location theory that help to explain the concentration of specific production activities in certain territories, which is a characteristic of this supply chain.

TABLE 4.
Table 4. Warehousing and inventory management

Activities	Tool/technique	Reference	Product/application
Location of warehouse or distribution center	Corporate Social Responsibility (CSR)	(Pulina and Timpanaro, 2012)	Unspecified
Selection of warehousing facilities	Planning Models	(Ahumada and Villalobos, 2009)	Unspecified
	Operational performance	(Manikas and Terry, 2010)	Fruits and vegetables
Inventory management	EOQ	(Pehlivanova, 2011)	Unspecified
Inventory control (monitoring)	Simulation model	(Beshara et al. 2012)	Fruits and vegetables
Demand forecasting	Collaborative forecasting	(Eksoz et al., 2014)	Unspecified
	Machine learning	(Sujjaviriyasup and Pitiruek, 2013)	Shrimp
	Business Reference Model	(Taylor, 2006a)	Unspecified
	CPFR	(Xiao Fang et al., 2009)	Walnuts

In this context, other authors like Manikas and Terry (2010) focus on measuring the operating performance of distribution centers (DC) for perishable agricultural commodities in terms of space utilization and flow of work and information. Ahumada and Villalobos (2009) conducted a review of the main contributions in the area of planning and distribution of production. Pehlivanova (2011) proposes the use of models for optimizing inventory based on techniques such as economic order quantity (EOQ). On the other hand, Beshara et al. (2012) implement a simulation applied to the maximization of profits. In the logistics activity of demand forecasting, other authors provide an evaluation centered on collaborative forecasts, machine learning, and the CPFR approach, as shown in Table 4.

3.4. Order processing

Processing and packaging orders are two important stages in the operations of the AFSC (Mahalik and Nambiar, 2010). This because there are a high diversification and specialization of processes to maintain the quality and lifetime of the products. The main causes of physical deterioration of perishable products occur during the post-harvest processes since the most significant losses occur when especially vulnerable products, like vegetables and fruits, are exposed to mechanical damage after harvest. Through discrete simulation, Iannoni and Morabito (2006) analyze the planning of picking, while works by Van der Vorst et al. (2009), Mahalik and Nambiar (2010), Condratchi (2014) show a focus on the activities of packaging orders and management of shipments and returns. According to the literature in Table 5, these authors note that packaging is one of the constraints in the logistics systems, mainly for small production units (farmers/producers) moving from subsistence to commercial agriculture.

TABLE 5:
Table 5: Order processing.

Activities	Tools/technique	Reference	Product/application
Planning of picking	Discrete simulation	(Iannoni and Morabito, 2006)	Sugarcane
Order packing	Implementation of technologies	(Mahalik and Nambiar, 2010)	Unspecified
Shipments management	Technological indicators	(Vanecek and Kalab, 2003)	Fruits and vegetables
Returns management	Simulation	(Van der Vorst et al., 2009)	Fruits and vegetables

3.5. Traceability and quality management

Quality management and assurance are tools that have important relevance to supply chain management. In particular, the AFSC involves a high risk to the safety and quality of food (Schiefer 2004), mainly because of the continuous and significant change in the quality of agrifood products that move along the chain up to the final consumer (Schiefer, 2004; Van der Vorst et al., 2007). With globalization, this supply chain has intensified the processes for control and improvement of quality, food security, monitoring, traceability and the environmental consequences of these operations. For example, Van der Vorst et al. (2009) suggest product quality analysis in the logistics processes as a tool for modeling the AFSC, besides applying simulation tools a support for the analysis of the quality of food. Koutsoumanis et al. (2005) propose a security monitoring and assurance system (SMAS). Other authors such Trienekens et al. (2011) evaluate the quality of service, collaborative practices and the implementation of quality and safety standards.

In this context, and according to Table 6, other authors focus their work on traceability systems in the AFSC by using radio frequency identification (RFID) and geographic information systems (GIS). Lehmann et al. (2012) report the use of information and communication technology as a key factor for traceability in the agrifood sector. Traceability has become a method to ensure the security of supplies, particularly in the food sector where it is essential to have traceability systems to help to monitor the distribution of products and at the same time to reduce the damage and to improve the reliability in the delivery (Krissoff et al., 2004).

TABLE 6:
Table 6: Traceability and quality management.

Activities	Tool/technique	Reference	Product/application
Quality control	Simulation	(Van der Vorst et al., 2009)	Fruits and vegetables
	SMAS	(Koutsoumanis et al., 2005)	Frozen food
Quality of service	Information exchange	(Trienekens et al., 2011)	Unspecified
Traceability and monitoring of production and material handling	Food traceability technology	(Bosona and Gebresenbet, 2013)	Unspecified
		(Lehmann et al., 2012)	
	RFID	(Regattieri et al., 2007)	Unspecified
		(Gandino et al., 2007)	
	Information systems	(Krissoff et al., 2004) (Manzini and Accorsi, 2013)	Fruits and vegetables Dairy products

3.6. Environment

The effect of continued population growth has increased demand of planting areas, water, energy, and necessary biological resources for an adequate supply of food, while on the other hand, it also seeks to maintain and preserve ecosystems (Roy, 2009). For example, in conventional agriculture, large amounts of fertilizers and pesticides for food production are used, jeopardizing the preservation of the environment.

From an environmental perspective, Table 7 presents the references of authors like Mahalik and Nambiar (2010) and Meneses et al. (2012), who analyze packaging selection as a tool for environmental assessment in the AFSC. The package produces an environmental impact since it contributes to pollution when discarded. Thus, innovations in packaging are intended to extend the shelf life of food products but also seek to preserve the environment through proper disposal management. Taylor (2006a), Massoud et al. (2010), Bosco et al. (2011), Folinas et al. (2013) and Banaeian et al. (2018), explored the use of lean thinking approaches, Environmental Management Systems (EMS) and environmental technologies applied to minimize the risks of producing noxious waste and the incorporation of environmental criteria into the conventional supplier selection practices.

TABLE 7:
Table 7: Environment

Activities	Tool/technique	References	Product/application
Packaging materials handling	Life Cycle Assessment	(Meneses et al., 2012)	Milk
	Package selection	(Petersen et al., 1999)	Unspecified
	Implementation of technologies	(Mahalik and Nambiar, 2010)	Unspecified
Gas emission / pollutants production	Lean techniques	(Folinas et al., 2013)	Fruits and vegetables
		(Taylor, 2006b)	Pork
	EMS	(Massoud et al., 2010)	Unspecified
	Life Cycle Assessment	(Bosco et al., 2011)	Wine
	Fuzzy Set Theory	(Banaeian et al., 2018)	Unspecified
Energy consumption management	Sustainable food system	(Fritz and Schiefer, 2008) (Alfonso-Lizarazo et al., 2013)	Unspecified Palm oil

4. Discussion

According to the literature review, the tools applied in logistics processes for the AFSC consider, on the one hand, quantitative models for harvest planning, optimization of inventory levels with constraints on quantity and quality, the design of the distribution routes considering the decline in quality and the geographical dispersion of farmers/producers, and transportation and technologies for monitoring and traceability of agrifood mainly considering restrictions on processing time, temperature and uncertainty in the demand and supply.

On the other hand, other authors also propose qualitative models such as operations management approaches based on proposed frameworks for planning and performance in the AFSC, and models of collaborative practices to integrate the different actors in this supply chain. In this study, the tools based on quantitative models represent the largest contribution, a number of papers, to logistics in AFSC, even considering that in recent years. There is a remarkable growth in the proposals for the study of the AFSC.

Figure 1 reveals some interesting implications. Clearly there is higher interest from the scientific community towards the study and development of more efficient and responsive agrifood supply chains. The first studies focused more on qualitative rather than quantitative approaches. However, the relationship turned over and recently quantitative methodologies prevail over quantitative approaches. Furthermore, and the incipient gap is growing between both aforementioned approaches.

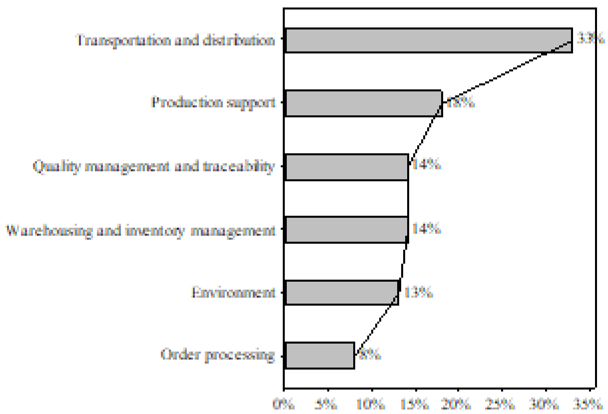

FIGURE 1:
Figure 1: Contributions by logistics process.

The logistics processes of transportation and distribution concentrate the largest number of proposals for implementation of analytical methods for optimization, simulation, and heuristics, which mainly consider the decay in quality, temperature constraints, monitoring, and traceability in distribution routes, in order to minimize delivery time to the customer and the costs associated with these operations in the AFSC. In fact, in the review, it was found that the largest contribution in the area of agrifood chains, under the focus of logistics, is for the process of transport and distribution. A total of 33% of the published work focuses on transport and distribution, followed by the process of production support, covering both fundamental aspects such as the appropriate selection of crops, production planning, and the distribution networks necessary to ensure supply. All the logistics processes represent research stream opportunities, but maybe the higher potential is for barely studied logistics processes such as order processing, environmental issues, warehousing and inventory management, production support, and transportation and distribution.

This study also confirms that because of an increasing integration of tools and techniques applied to perishable products. The current emphasis and importance of logistics are a key factor to preserve the quality of agrifood products. In this way, perishability is a very important area of opportunity, as evidenced by Badole et al. (2012),Sanabria-Coronado et al. (2017) in a similar study in which they identify future research areas for supply chain modeling.

5. Conclusions

The agrifood supply chain and the products that delivers to the food sector are certainly of significant relevance because it is in this supply chain where the food for daily consumption is produced, processed, distributed, and traded, representing a major source of income for those countries where the prevailing economic activities occur in rural areas. It is important also to note that this supply chain is unique and different from others mainly because of the limited lifetime of their products moving from the supplier to the end consumer, which makes it more difficult to handle than other supply chain. In this regard, logistics as a process that moves this whole supply chain is a key factor to minimize the risks of deterioration of quality to which the food products are exposed along time, from harvest to the distribution in the different local and international markets. It is estimated that the loss of food products by logistics aspects can reach more than one third of the total production. In an agrifood supply chain, the main objective will be to preserve the food quality and food safety, so it is necessary to have particular tools and techniques for this supply chain, which ensure covering these aspects and at the same time the increasing demand requirements for food worldwide.

The analysis in this work provides an overview of some of the tools and techniques particularly used in the agrifood supply chain. Through this study, contributions by several authors focused on logistics processes and activities were analyzed, covering aspects from operations for production support to those related to the environment. In general, the major contributions of logistics in the agrifood supply chain, are applied to transportation and distribution processes, where the main interest of the authors is to improve the planning of transportation and the distribution networks, as one of the main activities that create value in logistics. Logistics in the agrifood supply chain, as mentioned by many authors, represents a key element to improving the performance of this supply chain. Because of its own complexity and the conditions under which the different stakeholders (farmers/producers, processors, distributors and retailers) operate, there exist inefficient processes that require of tools and techniques to integrate information flows and materials in a timely manner, and to provide support to face important challenges. These challenges and research opportunities are the lifetime of products, long processing time, storage capacities and inventory management, high product differentiation, seasonality in harvesting and production operations, variability in the quality and quantity of supplies, and the need to develop specific attributes such as traceability and visibility.

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Referencias

Abatekassa, G., & Peterson, H.C., 2011. Market access for local food through the conventional food supply chain. International Food and Agribusiness Management Review, 14: 63-82.

Adame, J., Fontanilla ,W. D., & Arango, M.D., 2011. Some Optimization logistics models for transportation of fresh palm oil bunches, Colombia.Ciencia e Ingenieria Neogranadin, 21: 89-114.

Agustina, D., Lee, C.K.M., & Piplani, R., 2014. Vehicle scheduling and routing at a cross docking center for food supply chains.Int. J. Production Economics, 152: 29-41.

Ahumada, O., & Villalobos, R., 2011. Operational model for planning the harvest and distribution of perishable agricultural products.Int. J. Production Economics, 133: 677-687.

Ahumada, O., & Villalobos, R., 2009. Application of planning models in the agri-food supply chain. A review.European Journal of Operational Research, 195: 1-20.

Akkerman, R., Farahani, P., & Grunow, M., 2010. Quality, safety and sustainability in food distribution: a review of quantitative operations management approaches and challenges.Or Spectrum, 32: 863-904.

Alfonso-Lizarazo, E., Montoya-Torres, H. J. R., & Gutiérrez-Franco, E., 2013. Modeling reverse logistics process in the agro-industrial sector: The case of the palm oil supply chain.Applied Mathematical Modelling, 23: 9652-9664.

Aramyan, C., Onderstejin, O., Van Kooten, O., & Lansink, A.O., 2006. Performance indicators in agri-food production chains. In: Quantifying the Agri-Food Supply Chain. Springer.

Badole, C.M., Jain, R., Rathore, A.P.S., & Nepal, B., 2012. Research and Opportunities in Supply Chain Modeling: A Review. Int. J. Sup. Chain. Mgt, 13: 63-86.

Banaeian, N., Mobli, H., Fahimnia, B., Nielsen, I. E., & Omid, M., 2018. Green supplier selection using fuzzy group decision making methods: A case study from the agri-food industry. Computers & Operations Research, 89: 337–347.

Beshara S., El-Kilany, K.S., & Galal, N. M., 2012. Simulation of Agri-Food Supply Chains.World Academy of Science, Engineering and Technology, 2: 388-393.

Bosco S., Di Bene, C., Galli, M., Remorini, D., Massai, R., & Bonari, E., 2011. Greenhouse gas emissions in the agricultural phase of wine production in the Maremma rural district in Tuscany, Italy.Italian Journal of Agronomy, 6: 1-15.

Bosona T., & Gebresenbet, G., 2013. Food traceability as an integral part of logistics management in food and agricultural supply chain.Food Control, 32-48.

Boudahri F., Sari, Z., Maliki, F., & Bennehrouf, M., 2011. Communications, Design and optimization of the supply chain of agri-food: Application distribution network of chicken meat. International Conference on Computing and Control Applications. Hammamet IEEE: 1-6.

Boundeth S., Teruaki, N., & Shigeyoshi, T., 2011. Analysis of maize supply chain in Northern Laos. Research Journal of International Studies, 20: 140-153.

Burer, S., Jones, P. C., & Lowe, T. J., 2008. Coordinating the supply chain in the agricultural seed industry. European Journal of Operational Research, 185: 354-377.

Christopher, M., 2005. Logistics and Supply Chain Management.Edit. Prentice Hall, London.

Christopher, M., 1998. Logistics and Supply Chain Management: Strategies for reducing cost and improving service. Financial Times Pitman Publishing.

Condratchi, L., 2014. Supply chains in agriculture and food production. Methods, 14: 81-88.

Eksoz, C., Mansouri, S. A., & Bourlakis, M., 2014. Collaborative forecasting in the food supply chain: A conceptual framework.Int. J. Production Economics, 49: 121-133.

Esteso, A., Alemany, M. M. E., & Ortiz, A., 2017. Deterministic and Uncertain Methods and Models for Managing Agri-Food Supply Chain. Direccion y Organizacion, 62: 41–46.

Folinas, D., Aidonis, D., Triantafillou, D., & Malindretos, G., 2013. Exploring the greening of the food supply chain with lean thinking techniques.Procedia Technology: 416-424.

Fritz, M., & Schiefer, G., 2008. Food chain management for sustainable food system development: a European research agenda. Agribusiness, 24: 440-452.

Gan, W., Zhun, Y., & Zhang, T. (2011). On RFID Application in the Tracking and Tracing System of Agricultural Product Logistics. In Computer and Computing Technologies in Agriculture Iv, Springer, Heidelberg, Berlin: 400-407.

Gandino, F., Montrucchio, B., Rebaudengo, M., &. Sanchez, E.R., 2007. Analysis of an RFID-based information system for tracking and tracing in an agri-food chain.In RFID Eurasia. IEEE: 1-6.

Ghezavati, V. R., Hooshyar, S., & Tavakkoli-Moghaddam, R., 2017. A Benders' decomposition algorithm for optimizing distribution of perishable products considering postharvest biological behavior in agri-food supply chain: a case study of tomato. Central European Journal of Operations Research, 25: 29–54.

Gebresenbet, G., Bosona, T.G., Ljungberg, D., & Aradom, S., 2011. Optimisation analysis of large and small-scale abattoirs in relation to animal transport and meat distribution.Australian journal of agricultural engineering, 2: 31-39.

Gebresenbet, G., & Oodally, G., 2005. Review and analysis of rural agricultural transport and logistics in developing countries: Technical Guidelines Report. Switzerland: University of Agricultural Sciences.

Gigler, J.K., Hendrix, E.M.T., Heesen, R.A.,Van den Hazelkamp, V.G.W., & Meerdink, G., 2002. On optimisation of agri chains by dynamic programming. European Journal of Operational Research: 613-625.

Granillo-Macías R.; Olivares, B. E.; Martínez, F. J. L. y Caballero, M. S. O. 2017. Gestión de operaciones en una cadena de suministro agroalimentaria. Ciencias Holguin. 23(4):1-17.

Granillo-Macías, R., Olivares-Benítez, E., Martínez-Flores, J y Caballero-Morales, S., 2018. Analysis of logistics cost in contract agriculture: the case of barley supply chain in Hidalgo, Mexico. Custos e agronegocio on line. 164-183.

Gustavsson, J,. Cederberg, C., Sonesson, U., Van Otterdijk, R., & Meybeck, A., 2011.Global food losses and food waste: Extent, Causes and Prevention. Rome: Food and Agriculture Organization of the United Nations.

Haoran, S., Wen, D., & Ling, Z., 2013. Optimization model for fresh agricultural products supply chain network based on nonlinear integer programming. Advances in Information Sciences and Service Sciences, 5: 107-115.

Higgins, A., 2006. Scheduling of road vehicles in sugarcane transport: a case study at an Australian sugar mill. European Journal of Operational Research,170: 987-1000.

Iannoni, A.P., & Morabito, R., 2006. A discrete simulation analysis of a logistics supply system. Transportation Research Part E, 42: 191-210.

Jedermann, R., Ruiz-Garcia, L., & Lang, W., 2009. Spatial temperature profiling by semi-passive RFID loggers for perishable food transportation. Computers and Electronics in Agriculture, 65: 145-154.

Jie, F., Parton, K. A., & Mustafid., 2016. Supply chain performance flexibility in the Australian beef industry. International Journal of Logistics-Research and Applications, 19: 300–317.

Kopanos, G.M., Puigjaner, L, & Georgiadis, M.C., 2012. Simultaneous production and logistics operations planning in semicontinuous food industries. Omega, 40: 634-650.

Koutsoumanis, K., Taoukis, P.S., & Nychas, G.J.E., 2005. Development of a safety monitoring and assurance system for chilled food products. International journal of food microbiology, 100: 253-260.

Krissoff, B., Kuchler, F., Calvin, L., Nelson, K., & Price, G., 2004.Traceability in the US food supply: economic theory and industry studies. Washington. DC: Department of Agriculture. Economic Research Service.

Lanfranchi, M., Falco, N. D., Santagada, R., Sippelli, S., & Giannetto, C. , 2018. Analysis and Models for the Reduction of Waste in Organized Large-Scale Retail Distribution: ``The Tomato{''}. Quality-Access to Success, 19: 130–133.

Lehmann, R.J., Reiche, R., & Schiefer, G., 2012. Future internet and the agri-food sector: State-of-the-art in literature and research. Computers and Elecctronics in Agriculture, 89: 158-174.

Ljungberg, D., & Gebresenbet, G., 2004. Mapping out the potential for coordinated goods distribution in city centres: The case of Uppsala. International Journal of Transport Management, 2: 161-172.

Mahalik N.P., & Nambiar, A.N., 2010. Trends in food packaging and manufacturing systems and technology. Trends in food science & technology, 21: 117-128.

Manikas I., & Terry, L., 2010. A case study assessment of the operational performance of a multiple fresh produce distribution centre in the UK.British Food Journal, 112: 653-667.

Mahajan, R., Garg, S., & Sharma, P. B., 2017. Processed food supply chain: a framework for literature review. Journal of advances in management research, 14(1), 91–109.

Manzini, R., & Accorsi, R., 2013. The new conceptual framework for food supply chain assessment. Journal of Food Engineering, 115: 251-263.

Mason, N., Flores, H., Villalobos, R., & Ahumada, O., 2015. Planning the Planting, Harvest, and Distribution of Fresh Horticultural Products. En Handbook of Operations Research in Agriculture and the Agri-Food Industry, de Lluis Plá-Aragonés, 19-54. New York: Springer.

Massoud, M. A., Fayad, R., El-Fadel, M., & Kamleh, R., 2010. Drivers, barriers and incentives to implementing environmental management systems in the food industry: A case of Lebanon. Journal of Cleaner Production, 18: 2000-2009.

McCullough, E.B., Pingali, P.L., & Stamoulis, K.G., 2008. Small farms and the transformation of food systems: An Overview. In The transformation of agri-food systems: globalization, supply chains and smallholder farmers, de E.B. McCullough., P.L Pingali., y K.G. Stamoulis, 50-62. London: Food & Agriculture Org FAO.

Meneses, M., Pasqualino, J., & Castells, F., 2012. Environmental assessment of the milk life cycle: The effect of packaging selection and the variability of milk production data. Journal of Environmental Management, 107: 76-83.

Opara, L.U. (2003). Traceability in agriculture and food supply chain: a review of basic concepts, technological implications, and future prospects. Journal of Food Agriculture and Environment, 1: 101-106.

Pehlivanova, T., 2011. Optimization of management of logistic systems in agriculture. Trakia Journal of Sciences, 3: 16-19.

Petersen, K. (1999). Potential of biobased materials for food packaging. Trends in Food Science & Technology, 10: 52-68.

Pulina, P. & Timpanaro, G., 2012. Ethics, sustainability and logistics in agricultural and agri-food economics research. Italian Journal of Agronomy, 7: 237-246.

Regattieri, A., Gamberi, M., & Manzini, R., 2007. Traceability of food products: General framework and experimental evidence. Journal of Food Engineering, 81: 347-356.

Roy, P., 2009. A review of life cycle assessment (LCA) on some food products. Journal of Food Engineering, 90: 1-10.

Sanabria Coronado, L. A., Peralta Lozano, A. M., & Orjuela Castro, J. A. ,2017. Facility Location Models in Perishable Agri-Food Chains: a Review. Ingenieria, 22: 23–45.

Salin, V., 1998. Information technology in agri-food supply chains.» International Food and Agribusiness Management Review, 1: 329-334.

Seuring, S, & Gold, S., 2012. Conducting content-analysis based literature reviews in supply chain management. Supply Chain Management. 17: 544-555.

Schiefer, G., 2004. New technologies and their impact on the agri-food sector: an economists view. Computers and electronics in agriculture, 43: 163-172.

Soysal, M., Bloemhof-Ruwaard, J.M., Meuwissen, M., & Van der Vorst, J.G. 2012. A review on quantitative models for sustainable food logistics management. International Journal on Food System Dynamics, 3, 136-155.

Stragas N., Zeimpekis, V., Bourlakis, M., & Vlachos, I. 2011. Basic Principles for Effective Warehousing and Distribution of Perishable Goods in the Urban Environment: Current Status, Advanced Technologies and Future Trends. En Intelligent Agrifood Chains and Networks, 39-65. Wiley-Blackwell.

Sujjaviriyasup, T., & Pitiruek, K., 2013. Agricultural Product Forecasting Using Machine Learning Approach.Int. Journal of Math. Analysis, 7: 1869-1875.

Suprem, A., Mahalik, N., &. Kim, K., 2013. A review on application of technology systems, standards and interfaces for agriculture and food sector. Computer Standards & Interfaces, 35: 355-364.

Taylor, D. H, 2006a. Demand management in agri-food supply chains. An analysis of the characteristics and problems and a framework for improvement. The International Journal of Logistics Management, 17: 163-186.

Taylor, D. H., 2006b. Strategic considerations in the development of lean agri-food supply chains: a case study of the UK pork sector. Supply Chain Management: An International Journal, 11: 271-280.

Trienekens, J.H., Wognum, P.M., Beulens, A.J.M.., & Van der Vorst, J.G.A.J., 2011. Transparency in complex dynamic food supply chains.Adv. Engineering Informatics, 26: 55-65.

Tsolakis, N. K., Keramydas, C. A., Toka, A. K., Aidonis, D. A., & Iakovou, E. T, 2014. Agrifood supply chain management: A comprehensive hierarchical decision-making framework and a critical taxonomy.Operations Management in Bio-production Systems 120: 47-64.

Van der Vorst, J., Da Silva, C. A., & Trienekens, J. H., 2007. Agro-industrial supply chain management: concepts and applications. Rome: Food and Agriculture Organization of the United Nations.

Van der Vorst, J., Tromp, S., & Van der Zee, D.J., 2009. Simulation modelling for food supply chain redesign; Integrated decision making on product quality, sustainability and logistics.International Journal of Production Research: 6611-6631.

Vanecek, D., & Kalab, D., 2003. Logistics in agricultural production.» Agri. Econ.- Czech: 439-443.

Verdouw, C.N, & Beulens, A.J.M., 2010. Process modelling in demand-drive supply chains: A reference model for the fruit industry.Comp. and Electr. In Agr , 73: 174-187.

Vigneault, C., Thompson, J., Wu, S., Hui, K.C.., & LeBlanc, D.L., 2009. Transportation of fresh horticultural produce.Postharvest technologies for horticultural, 2: 1-24.

Xiao Fang, D., Stephen, L., Zhang Jin Long C.H., & Lai K.K., 2009. Procurement of agricultural products using the CPFR approach.Supply Chain Management : An International Journal, 14: 253-258.