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Loss in Perishable Food Supply Chain: An Optimization Approach Literature Review

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Abstract - In recent years, food loss becomes the problem of the world and researches indicate that 20 to 60 percent from the total production is lost in the food supply chain. Hence, researcher and practitioners give more attention to maximize the availability of food products for the society. As a result researchers use different operation research tools to optimize the food supply chain and to support decision making process. The aim of this paper is to present a literature review of the perishable supply chain management modeling and optimization approach focusing on loss minimization along the supply chain. We focus particularly on perishable foods and the papers are analyzed based on the objectives, models used and solution approach in the selected researches. Through our analysis of the research, we identify future research options for studying perishable food supply chain to minimize loss along the supply chain.

Index Terms - Food loss, Perishable food, Supply chain, Operation research, Modeling Optimization

1 Introduction

Supply Chain Management (SCM), currently a popular topic in research literature, breaches the boundaries of many academic disciplines. Supply chain management has been defined in a number of ways from different perspectives, but the general and arguable definition of SCM is the management of information, finance and physical flows in all stages of the supply chain to provide customer value and profit for all members of the chain [1]. Supply Chain Management is a broad topic and has been examined by researchers from different angles in the last decades.

Over the years, the definitions have changed and broadened the scope of SCM, but, these definitions are still limited to manufactured products and services with little attention being paid to agricultural products or food sector. Food supply chains (FSC) are distinct from other product supply chains. The fundamental difference between FSC and other supply chains is the continuous and significant change in the quality of food products throughout the entire supply chain until the points of final consumption [2] [3]. In addition, FSC is complex as compared to other supply chains due to the perishable nature of the produce, high fluctuations in demand and prices, increasing consumer concerns for food safety [4] [5] [6] [7] and dependence on climate conditions [7].

The high perishability of agricultural food products has resulted in immense food loss, further stressing FSCs and the associated quality, profitability and food sustainability. Some post-harvest food wastage and losses are inevitable in FSC network links [8] [9] [10]. Murthy et al, 2009, reported that a huge amount of food is wasted in various stages of the FSC [11]. According to FAO report, the amount of post-harvest loss ranges from 20 to 60 percent of the total production across countries and roughly one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year [12].

There is an increased food demand in the globe, so increasing food production is one way to fulfill the need, in addition, waste reduction at every stage of the food supply chain can be also an option to get advantage from the increased production. Major operational causes of waste are inefficiencies in production, storage, handling, and transportation [11]. In addition, lack of proper planning and management practices in food supply chain can be the major operational cause in different countries. In developing countries farmers are small land holders and share croppers and have little knowledge of technology, market demand, and financial incentives also considered as the cause [13].

Many approaches are used by researchers and practitioners to reduce food loss and waste. To reduce the food loss it's important to study and give appropriate action for the entire food supply chain. Most countries at government level use different approaches to minimize loss, for example, at the production stage government supports farmers to improve availability of agricultural extension services, to have market access and to improve harvesting techniques. In addition, improving access for handling and storage, improving processing and packaging technologies, conducting consumer education campaigns, etc. are suggested and used in different areas [14].

This review gives an assessment of researches on perishable food loss and optimization approach used to minimize loss in FSC in the last decade by considering different aspects.

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The paper is organized as follows: the next section presents review objective and methodology. Section 3 provides background of food losses in FSC. Section 4 reviews methods and optimization approaches used to minimize food losses. Finally, section 5 presents discussion and suggest future research agenda for the field of FSC.

2 Objective and Research Methodology

The objective of the paper is to review FSC researches which is related to perishable food losses specific with tools/methods used to optimize and sustain the food supply chain. The review highlights the following points to satisfy the main objective: segmentation of research papers, product type used, optimization approach used in for perishable products and identification of gaps that need further investigation.

The sources of the reviewed papers are from different scientific journals (i.e. emerald insight, Elsevier, IEEE publishers) that are related to the main heading of the paper. The following key words are used to search the research papers: food supply chain, food supply chain loss, post-harvest loss and food supply chain optimization and relevant papers were selected seeing the title and the abstract of the paper for further study. Several optimization approaches are used for modeling and optimizing the food supply chain. In this review we focus on perishable food supply chain because of the product limited shelf life and main source of food loss in addition there are few modeling and optimization researches in the area of perishable FSC.

3 Background

The current world population of 7.2 billion is projected to increase by 1 billion over the next 12 years and reach 9.6 billion by 2050, according to a United Nations report, 2013. Though, the existence and availability of resources around the globe becoming challenging for the people, hence, we should create a way to maximize the availability of resources at higher rate comparing with the population growth [15]. The situation which is seen in reality and from different literatures, countries are working to create opportunities to fulfill their population needs. Now a days from the needs "food", becomes more scares than ever, in addition the way of processing or manufacturing also challenging. In any ways countries should give special attention to produce and feed their people sustainably.

Rather than population or climate change, food loss along the food chain also contributes a huge effect on food security. According to FAO report in 2011, up to 50% of food grown or produced for consumption is lost and wasted along the supply chain "from field to fork". Food losses and wastage occur at all levels of the FSC system, from farming, processing, and wholesaling, through to consumers – in both developed and developing countries. In developed countries, losses along the entire value chain of food products range from a few percent to as high as 40% to 50% from this 42% of total food waste occur at retail and consumer levels [12]. In developing countries, losses along the entire value chain of food products are estimated to be 30% to 50%, and 40% of the losses occur at post-harvest and processing level. In Sub-Saharan African countries consumers are only responsible for approximately 3.5% of overall food waste, with the majority being generated during the pre-consumer stages of the FSC [12].

Carlos M., et al. point out that wasting food while millions of people around the world suffer from hunger raises moral questions [16] [17] and could lead to a future food crisis [18], environmental impacts associated with the inefficient use of natural resources, such as, water, energy and land [19] [20], disposal of waste to landfill causes pollution and produces methane, which is a powerful greenhouse gas and there is an economic impact of throwing food away which ultimately affects all the organizations and individuals involved in the supply chain, including the final consumer [21]. Hence, food loss is become a significant global problem and attracts the attention of governments, non-governmental organizations and sectors involved food supply chain [22].

Although, food loss and waste can occur at each stage of FSC, i.e. during production or harvest in the form of grain, fruit left behind by poor harvesting equipment, discarded fish due to fail to meet quality standards; during handling and storage in the form of food degraded by pests, fungus, and disease; during processing and packaging in the form of spilled milk, damaged fish, and fruit unsuitable for processing; during distribution and marketing in the form of edible food discarded because it is non-compliant with aesthetic quality; during consumption in the form of food purchased by consumers, restaurants, and caterers but not eaten [14].

The stages of supply chain in which loss occurs and the causes are different for developed and developing countries. In developed countries the largest portion of loss is occur at the final stage of the supply chain. The causes are due to difficulty in interpreting food labeling, mistake in purchasing plan, and food not being preserved appropriately. In developing countries the largest portion occur at the first part of the food supply chain, due to limits in technology and infrastructure (like in transportation and storage), lack of expertise in the area, and techniques for land preparation, sowing, cultivating, harvesting, processing and storage [22] [23].

Literatures provide different strategies and opportunities for the reduction of food loss in FSC. These are consumer education [24] [14], post-harvest technologies [25], increase waste disposal cost, develop private and public sector partnerships to jointly reduce food waste and share responsibility etc. [26] [27] [28]. In addition literatures provides modeling and optimization approach to support the strategies. Supply chain modeling and optimization for analyzing several factors are proposed, such as: stock management, processing costs, scheduling and distribution strategies, and customer-specific demand, among others because structuring supply chain network is a complex decision making process. Supply chain losses, supply and demand variability/uncertainty, etc. in the supply chain network must be optimized and react to serve the customer accordingly [29] [30].

FSC modeling and optimization must balance traceability with the ability to realistically capture the essential elements of food supply chains. Mathematical optimization is the most common method of modeling the food production stage of food supply chain. Like the design of general supply chain network, food supply chain determines the number, location, capacity and type of processing plants and distribution centers, as well as the amount of materials and items to consume, produce, and ship from suppliers to customers. For the agri-food supply chain problem, the logistics should be carefully considered, especially for perishable agricultural goods. As for the supply chain problems, the models and solution methods for industrial products are relatively abundant.

The mixed integer programming model is used in most researches (e.g, [29] [30] [31] [32]) for supply chain network design is very popular. Due to the NP-hardness of supply chain network design problems and the large sized problems in the real world, meta-heuristics such as Evolutionary Algorithm (EA) [33] [34] [35] [36] [37] have been widely used. The following section presents the application of these modeling and optimization approaches used in researches.

4 METHODS AND OPTIMIZATION APPROACH

This section reviews research's focusing on the perishable food loss and optimization techniques and we structure the review papers based on the following categories;

i. Research segmentation, i.e., publication category by year, journal and country
ii. Product type used for analysis,
iii. Optimization approach used in perishable products and solution approaches

4.1 Research Segmentation

i. Category by journal

Papers addressing the issue of perishable food loss and optimization are reviewed. For the selection, from different journals we used food supply chain, post-harvest loss and supply chain and logistic optimization as a main key word and we collect 85 related papers and the journals are categorized into six categories (see table 1): management science, production economics, operation and production management, mathematical modeling and simulation, supply chain and logistics management and food science and engineering.

The papers are presented in fig. 1 by year of publication and the numbers of articles are clearly increasing during the period (1997-2014), this indicates the area is crucial for securing food in the world so that researchers are gives more attention and the area is under expansion.

Considering the geographic diversity of scholars as shown in fig. 2, it is relevant to note that European and North American researchers take the leadership. The research area is very relevant for developing countries (like African countries) due to the food security problem, however, scholars in this field from developing countries is still low as shown in the table.

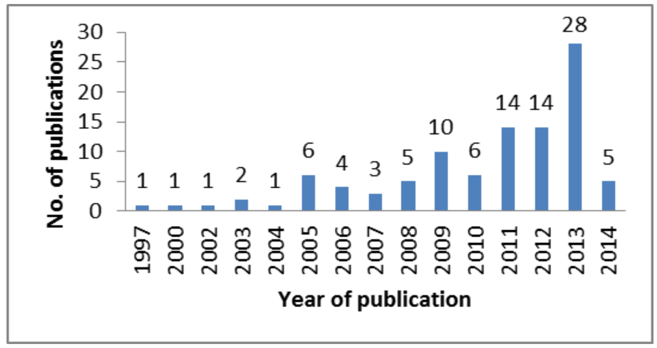

Fig. 1 number of publication by year

We give more emphasis and closely reviewed 52 papers out of 85 based on the objective of the review. As illustrated in table 1 the following journals contribute the major number of articles for the analysis: *International Journal of Production Economics, International Journal of Computer and Electronics in Agriculture, Journal of Fuzzy Sets and Systems, Journal of Advanced Engineering Informatics, Journal of Simulation Practice and Theory, Supply Chain Management: An International Journal, International Journal of Physical Distribution and Logistics Management, Journal of Food Engineering, International Journal of Food Control and Journal of Food Science and Technology.*

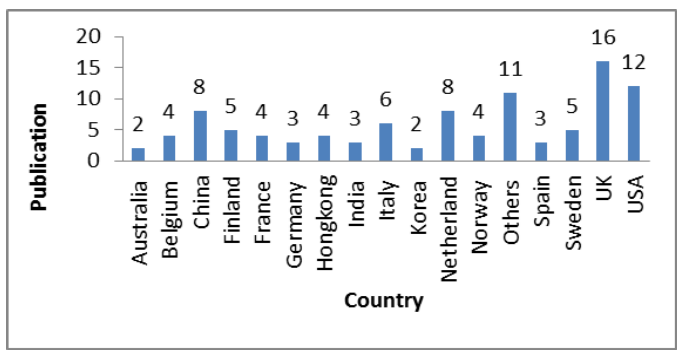

Fig. 2 geographic diversity of publications

TABLE 1 NUMBER OF PUBLICATIONS BY JOURNAL

Category	Journal title	publication by journal	Publications by category
Management science	Int. J. of management science	3	12
	J. of Waste Management	3	

	Int. J. of management and social science research	1	
	J. of resource, conservation and recycling	2	
	European journal of operation research	3	
Production economics	Int. J. of production economics	8	10
	J. of business and industrial marketing	2	
Operations and production management	J. of production planning and control	1	5
	Int. J. of operations and production management	1	
	J. of cleaner production	3	
Mathematical modeling and simulation	Int. J. of computer and electronics in agriculture	5	21
	J. of applied mathematical modeling	2	
	J. of fuzzy sets and systems	4	
	J. of advanced engineering informatics	6	
	J. of simulation practice and theory	4	
SC and Logistic management	Int. J. of logistic management	3	12
	Supply Chain Management: An International Journal	5	
	Int. J. of physical distribution and logistics management	4	
Food science and engineering	British food journal	3	23
	J. of food engineering	4	
	J. of food research international	2	
	Int. J. of food control	7	
	Int. J. of food science	2	
	J. of food science and technology	4	
Others			19

ii. ***Category by strategy***

Scholar's in the area of supply chain management analyze different supply chain strategies to balance and support the decision making problem with a set of appropriate measures for the development and exploitation of logistic competitive capabilities and improvement potentials of supply chain management in order to achieve different logistics and supply chain objectives. The objectives can be the determination of number, location and capacity of warehouses and manufacturing plants and the flow of material through the logistics network, inventory management policies, supply contracts, distribution strategies, supply chain integration, outsourcing and procurement strategies, product design, decision support systems and information technology [38] with a focus of cost, flexibility, quality, delivery and additionally collaboration, coordination and transformability.

The strategic approach used in different supply chain researches are unique and captures most of the above strategic supply chain management decision problems. In this review we present strategic approaches used in food supply chain and we analyze the papers by considering the quantitative decision support tools they used. From all papers presented above those works dealing with modeling and optimization for food supply chain are selected and 31 papers are identified for analysis. The complete list of the research papers are presented in table 2 The table presents the authors, the publication year, the general objective of the paper, modeling tools and its application in real world. Most of the papers presented in the table use different modeling tools and the models are tested by using appropriate case studies and it is presented in the table by Y/N (yes/no). In the rest of the section we analyze the modeling approaches used considering the review objective.

TABLE 2 DESCRIPTIONS OF SELECTED PUBLICATIONS

Author	Objective of the research	Modelling approach	Application
Xiaojun W. et al. (2012)	Food waste reduction and maximize food retailers profit	Dynamic pricing approach	Y
Xiaojun W. et al. (2011)	Performing structured risk assessment and establishing an aggregative food safety risk	Fuzzy set theory	Y
M.F. Stringer et al. (2006)	Integrate food supply chain by breaking the chain into component parts	Hierarchical generic model	Y
Xia Zhao et al. (2011)	Optimization of agri-food supply chain network design to reduce the sum of cost	Hybrid particle swarm optimization	Y
Teimoury E. et al. (2013)	Determine the impact of supply, demand and price interaction for fruits and vegetable supply chain	System dynamics	Y
Paksoy T. et al. (2010)	Optimization of commodity transportation and distribution of supply chain network	Mixed integer linear programming	N
Qinglin D. et al. (2013)	Supply chain inventory management for highly perishable	Simulation optimization	Y

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	products		
Chun-Wei R. et al. (2000)	Optimizing the expected quick response alliance profit for supply and distribution of food	Linear programming, Genetic algorithm	N
Patroklos G. et al. (2005)	Presents the strategic modeling of single and multi-echelon supply chains	System dynamics modeling	Y
Aiying R. et al. (2011)	Integrate food quality in decision-making on production and distribution of food supply chain	Mixed-integer linear programming model	Y
Turan P. et al. (2012)	To minimize the total transportation costs in supply chain network of an edible vegetable oils manufacturer	Fuzzy multi-objective linear programming model	Y
Simone Z. et al. (2012)	Modelling and optimizing the food supply chain in consideration of economy, energy and quality of products over time	Analytical modeling	Y
Min Yu et al. (2013)	Development of network-based food supply chain model under oligopolistic competition and perishability	Network oligopoly model	Y
Dabbene F. et al. (2008)	Modeling of fresh-food supply chain network and performance improvement for preserving food quality using case study	Linear and analytical modeling	Y
Soysal M. et al. (2013)	Develops a model for generic beef logistics network problem with the objective of) minimizing total logistics cost	Multi-objective linear programming	Y
Venus V. et al. (2013)	Determination of deterioration in tomato quality during transport	Simulation model	Y
Vorst V. et al. (2009)	Proposes new integrated approach towards logistics, sustainability and food quality	Simulation modeling	Y
Ali M. et al. (2012)	Develop a supply chain model for analyzing product quality and customer satisfaction	Mixed-integer linear programming	N
Qin Li et al. (2006)	Development of food supply chain quality management system and implementation algorithm	Game theory	N
Fabrizio D. et al. (2011)	Introduces criteria and methodologies for measuring and optimizing the performance of a traceability system	Mixed integer linear programming	N
Jinyou H. et al. (2013)	Development of methodology for the implementation of vegetable supply chain traceability	Unified Modeling Language	Y
J.K. Gigler et al. (2002)	Optimization of agri-food chain with consideration of appearance and quality of products	Dynamic programming	Y
Omar A. et al. (2011)	Presents an operational model that generates short term planning decisions for the fresh produce industry	Mixed integer programming	Y
Jing Shi et al. (2010)	Develop a decision-making model for distribution strategies in cold chain network with the real-time flow and quality information of perishable foods	Radio frequency identification (RFiD)	Y
Qian Tao et al. (2013)	Optimization of green agri-food supply chain network to reduce the total transportation cost for efficient and effective supply chain management	Chaotic particle swarm optimization	Y
Fabrizio D. et al. (2005)	Presents a novel approach for the optimization of fresh food supply chain	Hybrid model	Y
Widodo K.H. et al (2006)	Constructs a basic model of agricultural fresh products by formulating the plant growing process and the loss process of fresh products	Analytical modeling	N
Leutscher K.J. (1999)	Development of operational decision-making to analyze pot plant production	Simulation and Regression meta-modelling analysis	N

Takeshi I. et al. (2003)	Proposes a model of crop planning with uncertain (stochastic) values to support decision making of agricultural farms	Linear programming	N
Kouki C. et al. (2013)	Investigates the impact of product perishability on the inventory review policy and the benefits of using Time Temperature integrator technology on inventory management	Inventory model	N
Herbon A. et al. (2014)	Development of inventory management system for perishable products, to maximize the retailer's profit and customer satisfaction	Non-linear mixed integer programing and Simulation	N

i. Category by product type

Different products are used to test the modeling and optimization techniques. From the wide range of perishable product types fresh vegetable and fruit are considered in many literatures under study. The table presents the authors with the product type used in the research.

TABLE 3 PRODUCT TYPE USED IN RESEARCHES

Author	Product type
Xiaojun W. et al. 2012, Xiaojun W. et al. 2011, Dabbene F. et al. 2008	Meat
M.F. Stringer et al. 2006, Chun-Wei R. et al. NA, Min Yu et al. 2013, Jing Shi et al. 2010, Qian Tao et al. 2013	General
Xia Zhao et al. 2011	General (Agri-food)
E. Teimoury et al. 2013, Aiying R. et al. 2011, Simone Z. et al. 2012, Venus V. et al. 2013, Mattias E. et al. 2012, Manthou V. et al. 2005, Jinyou H. et al. 2013, Omar A. et al. 2011	Fruit, Vegetable
Patroklos G. et al. 2005	Fast food
Turan P. et al. 2012	Edible vegetable oil
Riikka K. et al. 2012, Anton N. et al. 2013, Qinglin D. et al. 2013)	milk, fresh fish, fresh poultry
Adrie J.M. et al. 2013	Egg

4.2 Modeling approaches for perishable products

Due to the growing need of food (especially in the last decade) the number of studies on food related issue is increasing and food supply chain management researches recently covers highest share. Studies use different tools to support decision making in food supply chain management problems with a common objective of to improve supply chain performance. Hence, for these reason scholars proposes various types of modeling tools, like Linear Programming (LP), Mixed Integer Programing (MIP), Goal Programing (GP), Dynamic Programming (DP), Analytical and Simulation Models and recently Evolutionary Algorithm is used.

In optimization approach in supply chain management can be classified as deterministic or stochastic, according to the parameters used [51]. Researcher's uses different mathematical tools, like LP, DP, MIP, GP, etc. are used for the case of deterministic modeling and Stochastic Programming (SP), Stochastic Dynamic Programming (SDP), Stochastic Simulation (SIM), etc. are used for stochastic modeling approach.

Over the years, there is a significant increase in research on modeling and optimization of food supply chain system. In this review we consider papers addressing modeling and optimization techniques for perishable products focusing on operational issues causing perishable food loss or waste. In most research, loss is occurs at high rate in the production, transportation and inventory activities throughout the food supply chain. Hence, we specify our modeling and optimization technique review looking up on these three operational issues for food supply chain loss.

4.2.1 Production decision

Due to the rise in demand of food products decision techniques related to production of food are at increasing over time. Researchers have presented several models for farm location, crop plantation, and harvesting analysis. Farm planning, demand planning, production and distribution of fresh produce, etc are presented in several reviews related to production issues [39]. In this production issue different decision approaches are used to minimize losses or waste at the production stage. Traditionally, decisions are made based on expertise experience on the area but today this traditional approach is replaced by operation research tools or mathematical models to assist to optimize the food supply chain [40].

Widodo K. et al. (2006) propose and test a basic model of agricultural fresh produce by formulating the plant growing process and the loss process of fresh products in mathematical forms. The model is sub-divided into two considering flowering-harvesting and harvesting-delivery through the introduction of plant maturity curve and loss function to express the growing process and the decaying process of fresh products and the model is tested by using numerical example [9]. Quality loss function is used in Ferrer J.C. et al. (2007) research to represent wine quality reduction at farm [41].

Plant production under uncertainty is analyzed with respect to crop growth and price formation by means of simulation and regression meta-modelling in the Leutscher K. (1998) paper. In Jacxsens L. et al. (2009) paper simulation modeling is used to monitor and prevent microbiological food safety risk during in all phases of food production and supply. Simulation of climate change scenarios and logistic chain of fresh produce with the help of mathematical models is used to optimize the system to maintain quality and safety of fresh produce [69]. Most of the reviewed papers, operational decisions regarding production are used for making long term profit [42].

It is evident from the review; the majority of the papers have focused on supply fluctuations, farm labor productivity, production technologies, harvesting scheduling and farm locations [39] [13] [43] [44] [45] [41] [46] and LP, MIP, SIM, DP, SP are used as optimization tool, giving a little attention on loss/waste at the production stage. From the review most of the papers main objective is maximization of revenue as a main objective not loss reduction and the studies are limited in developed countries rather than giving attention for developing countries with high loss at the production (harvesting) stage.

4.2.2 *Transportation decision*

Transportation provides the foundation for the linking of economic activities for a sustainable supply chain. Without transportation products cannot be shipped to different stages of the supply chain. In the food supply chain of perishable product, transportation is a critical function and it can affect the quality of the product. Hence, optimizing transportation in food supply chain is critical for sustaining and securing food.

The most popular modeling approach for the optimization of transportation has been LP. The popularity of LP can be explained by the simplicity of use and the flexibility of LP models to capture a large variety of decisions, such as scheduling, capacity and location of distribution centers, selection of location, investment for transportation, etc. [68].

Most reviewed papers on transportation modeling and optimization approach are focuses on minimizing the transportation cost in the food supply chain [47] [31] [48] [47] [49] [50]. Few papers focuses on loses or waste issues in relation to the transportation and logistics activities in food supply chain [51] [52]. According to Murthy et al., 2009, loss or waste in transportation is one of the highest in the food supply chain management. This is due to handling and deterioration of the product in the transportation activity [11]. Hence, vehicle routing decisions are of high important in relation to time windows for perishable food products so that to satisfy customer demand with minimum time, distance traveled and vehicle used. Modeling of this kind of problem is more complex and becomes gained more attention from researches [40].

Many literatures in food supply chain management uses different types of modeling approaches for the optimization of transportation, for example, LP, MIP, DP, NLP, SD are used. Omar, et al., (2009), Rong, et al., (2011) and Apaiah, et al. (2005) are applies a mixed integer linear programming; Gigler J. et al. (2002) use dynamic programming for agri-food supply chain; Chen et al. (2009) applies non-linear programming model for distribution of food products and transportation cost and maximization of revenue are considered as a main objective.

In addition to the traditional optimization approach scholars uses the state of the art optimization techniques like neural network, fuzzy optimization, genetic algorithm and particle swarm optimization approaches for the design and analysis of different supply chain systems. In the research of Paksoy T. et al. (2012) fuzzy optimization technique is used for the same objective of transportation cost minimization and hybrid particle swarm optimization approach is used in Xia Z. et al (2011) research to optimize production and transportation cost of agri-food supply chain.

From this review it is observed that most of the researches in transportation and distribution system are not focused directly towards minimization of loss but the researches might give a way for scholars as an input for the optimization of loss. Very few research papers have addressed the issues of fresh produce, especially the loss due to transportation and handling, in addition it is found that time is a critical factor due to strict delivery window of the customers and continuous deterioration of fresh produce. In general, loss should be considered while modeling or optimizing transportation in the supply chain of perishable products because in the other way it maximize revenue and it can increase the availability of food.

4.2.3 *Inventory decision*

In most inventory systems, it is assumed that stock items can be stored indefinitely to meet future demands. However, the effects of perishability cannot be ignored for certain types of inventories, which may become partially or entirely unsuitable for consumption as time passes. Due to this, the economic impact of managing perishable products becomes a serious challenge [53]. Perishable products are sensitive to temperature conditions in which they are handled and require special storage conditions in order to preserve their freshness. Once an item lost its freshness, it is considered to be lost (no longer safe for use). Hence, perishable inventory has been intensively studied and a large number of models have been proposed by researchers. Nahmias (1982), Raafat (1991), Karaesmen et al. (2011) and Bakker et al. (2012) reviewed inventory theories on perishable products [53] [55].

Different research categorizes models depending on the product characteristics; based on that inventory models are classified into three categories: (1) models for inventory with a fixed lifetime; (2) models for inventory with a random lifetime; and (3) models for inventory, which decays corresponding to a proportional inventory decrease in terms of its utility or physical quantity [54]. Models related to the third type of inventory issue are analyzed, which is the perishable food inventory decays in terms of its quality (shelf-life).

Xiaojun W. et al. (2012), uses dynamic pricing model to reduce food spoilage waste and maximize profit through pricing approach using the shelf life of the product. The kinetic model approach is used to predict the shelf life of the product.

A simulation optimization framework is proposed in the work of Quinglin D. et al. (2013) for supply chain inventory management of highly perishable products. The optimization considers a class of order-up-to policy for

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handling high perishable products (fresh vegetable/fruit, dairy/meat, blood, etc) in a single-vendor multi-buyer supply chain. The research tests the formulated mathematical model by using a case of regional blood center. Furthermore, studies by Kopach et al., (2008); Broekmeulen and Von Donselaar, (2009) assumed that products such as blood platelets and packaged food expire rather than decay after a certain period of time [55] [56].

Patroklos G. et al. (2004), applies system dynamics approach as a modeling and analysis tool to tackle strategic issues of food supply chain for single and multi-echelon supply chain. The paper examines capacity planning policies with transient flows due to market parameters or constraints and examined by using a multi-echelon network of fast food chain.

J.K. Gigler et al (2002) propose a dynamic programming methodology for optimizing agri chain supply chain taking product appearance and product quality into account. Optimization is done by constructing routes defining by considering distribution and storage to archive minimum supply costs. The deterioration rate is the most important factor in the inventory models for perishable products. Most of the studies considered the inventory model by assuming deterioration rate constant. A few authors have considered the exponential deterioration rate and the pattern is as Weibull distribution [13].

From the review it is found that most of the studies address the operational decisions of the inventory system considering demand, transportation lead time, storage capacity and inventory policies as a factor. Similarly loss reduction decisions are not considered in the literatures. Thus, this should be the main questions for researchers and practitioners for further study.

5 Discussion and Future Research Agenda

This paper presents the modeling and optimization approaches used in perishable food supply chain literatures. The focus of the review is not only the perishability of products but also the waste and loss assessment in food supply chain. The modeling and optimization tools are used in many areas to support decisions and to have a better advantage from it. Now a day's decision regarding supply chain issues are becoming very difficult due to the increased complexity of the system.

In the review, the first approach we used is structuring the papers according to the publication year and country. From these we observed that about 55% of the papers are published in the last two years including 2014. This trend indicates that researchers and practitioners are gives attention due to the scarcity of food and related products around the globe. In addition to these there is lack of research's related to modeling and optimization approaches in the perishable food supply chain management area. Due to the formulation of new state of the art optimization approaches, researchers practice the tools in their own research interest is the other factor for the increased size of recent publications.

According to the countries, almost all the research papers are found from developed countries addressing different issues regarding food and supply chain management, but in reality loss of food is the problem of all. Therefore, in future researchers in developing countries should focus and optimize loss to increase the availability of food.

In the review, the literatures are also classified according to the strategy they used to support decisions in the management of food in the supply chain. In most of the research LP models are used to optimize the food supply chain, in addition few recent papers apply the state of the art optimization technique like evolutionary optimization approach and most papers uses case studies to test the model. This indicates using state of the art modeling techniques is in maturity stage and needs further study in the area of perishable food products.

This paper considers production, transportation and inventory as the main issues due to loss is high at these stages of agricultural supply chain. From the review we observed that many researches focused on maximizing revenue in the supply chain. Researches indicate that there is a huge loss of food along the food supply chain, however, there is a limited attention given for minimizing food loss. This is an opportunity for researchers or practitioners to use optimization tools for reducing food loss for perishable food supply chain.

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