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Optimization Methods Applied for Fresh Food Supply Chain Planning: a Review

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Abstract: Fresh food supply chains are different from other product supply chains due to continuous and significant change in the quality of food products throughout the entire supply chain until the points of final consumption. Resources used to produce the fresh foods are wasted if food that has already been produced ends up not being consumed. This results in less profit of the producers, negative impacts on the environment, and shortage of food. These challenges generate a need for management efficiency and the use of modern optimization decision methods at different levels of the supply chain. Thus, one of the aspects that may be the subject of considerable decisions is the planning activities performed along the supply chains of fresh foods. In this paper, we review some of the optimization methods applied for fresh food supply chain planning. We attempt to gain a better understanding of the optimization methods used in the reviewed papers oriented towards problem solving. Through our review of the current state of the research, we diagnose some of the future requirements for planning the supply chain of fresh-foods**.**

Keywords: Fresh Food, Decision method, Optimization, Planning, Supply Chain

1. Introduction

Food supply chains are different from other product supply chains. The fundamental difference between food supply chains 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 [1], [2]. Clearly, many consumers prefer the freshest produce at a fair price but, the high perishability of food products has resulted in immense food waste/loss. The Food and Agriculture Organization of the United Nations [3]assumes that roughly one-third of the food produced globally for human consumption, or about 1.3 billion tons per year, is lost or wasted. At the same time, around 925 million people are suffering from hunger and malnutrition according to the FAO.

Throughout the food supply chain (production, harvesting, processing, distribution, retailing, and consumption), stakeholders draw upon natural resources and consume considerable amounts of them. These resources are wasted if food that has already been produced ends up not being consumed. This results in less profit of the producers, negative impacts on the environment, and hunger and famine of the society.

Such challenges have underlined the need for the efficient management of food supply chains, which is critical to profitability [4].Therefore, in recent years a renewed interest on the application of planning tools on different decision levels for rapidly deteriorating perishable foods, such as fruits, vegetables, meat, yoghurt and fresh milk has emerged. Due to perishability phenomenon of these foods (usually less than one-month time span) integrating operational level of supply chain stages should be taken into consideration in order to be optimized simultaneously. Therefore, if proper management of the foods supplies chain activities is not in place these perishable items may get lost before their final use. This makes the stakeholders to incur on avoidable costs [5].

In this paper the researchers reviewed papers which focus primarily on planning models used in the different aspects of the supply chain of fresh food products in an attempting to gain a better understanding of the optimization methods in fresh agricultural products. To achieve this the researchers have used reviewing and analyzing criterias.Fig.1 belowshows the criteria's used to classify and organize this review. Future directions are pointed out to provide a basis for future research options through extensive research of published papers. Therefore, we propose to do that by:

- Reviewing the existing literature on fresh food supply chain planning models,
- Categorizing the existing literature using different criteria,
- Outlining the fresh food supply chain planning perspectives in the future.

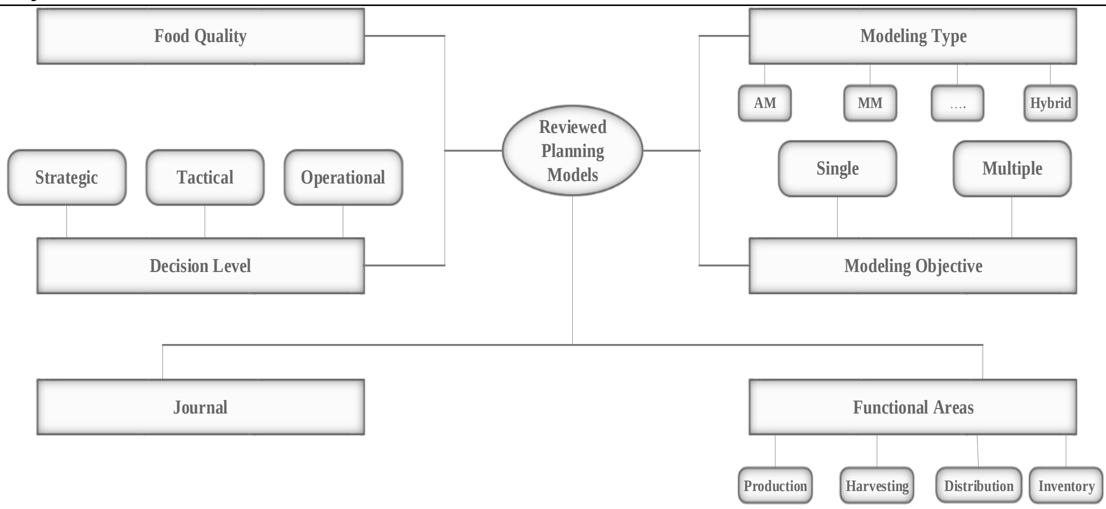

Fig.1. Classification criteria's of reviewed paper

1.1. Research Organization

In view of two previous literature reviews in areas related to the topic of planning models of food supply chains; the earliest was done by [1], and the latest by [6]. Synthesis of both papers has been done including additional criteria used to classify and present this review. The researcher's intention in this paper is to expand the previous works by identifying the works that either were not covered or were published after these reviews. Another objective is to frame the literature in the context of supply chain planning. So that the proposed organization in this paper considers the following classification criteria's as shown in fig1.above:

- *Food quality*: Product quality is one of the essential food product characteristics to be considered throughout the supply chain in relation to developing modeling approaches. Keeping food quality which reduces due to environmental conditions of storage and transportation facilities [7] is of vital importance for supply chain performance. Apart from being a performance measure of its own, food quality is directly related to other food attributes such as integrity, safety, and shelf life.
- *Food Supply chain functional areas*: The structure of the FSC can Vary regarding the different decision activities involved ranging from farming (i.e. land cultivation, fruit production and harvesting), processing, packaging, warehousing, transportation and distribution to marketing. Focusing on the agricultural food supply chain[1]have identified four main functional areas: production, harvest, storage, and distribution.
- *Decision level*: in the area of supply chain management to balance and support the decision making problem many scholars have been analyzing different strategies. From the perspective of the decision level; we classify the papers into strategic, tactical, and operational planning corresponding to long, medium and short time horizon respectively.
- *Modeling Objective*: In real world, supply chains operate in a somehow uncertain environment with different objectives of each stakeholder. Uncertainty may be associated with target values of objectives, external supply, supply deliveries along the SC, customer demand etc. objective functions used throughout the papers either they aimed at mono-criterion (revenue, profit, cost, time, distance, etc.) or multi criteria approach are reviewed focusing on economic aspect of the supply chain and freshness value of items.
- *Modeling approach*: From the perspective of modeling approaches used to model and solve the planning problem within the context of fresh food supply chain; we divide the models into Analytical, mathematical programming, hybrid, heuristic and simulation based on the [8].
- *Segmentation by journal*: to understand the motivation of the research and the multidisciplinary approach papers addressing the issue of planning fresh food supply chain and optimization methods are reviewed.

1.2. Objective and Review Methodology

The main objective of the paper attempts to gain a better understanding of optimization methods related to fresh food supply chain planning and to identify gaps so that to recommend future research works through a comprehensive search of related articles from last 10 years. To achieve the main objective the following issues are considered: food quality, optimization approaches, decision levels, supply chain stages and identification of gaps that need further investigation for planning the supply chain of fresh-foods.30 papers which are published at different international journal publishers (i.e. Elsevier, Hindawi, Springer &etc.) are reviewed using keywords such as: fresh food , food supply chain ,planning, optimization(see table III).In the end ;through an examination of paper by paper and by looking in title and abstract the final decision for selection of relevant papers is reached.

In The remainder of the paper we first present a background about fresh food supply chain (section II); food supply chain planning and optimization according to the selection criteria's (see section I) is presented in (section. III); and finally our conclusion and references we used are presented in section IV and section V respectively.

2. BACKGROUND OF THE FRESH FOOD SUPPLY CHAIN

The term food supply chains (FSC) has been defined to describe the activities from production to distribution that bring products from the farm to the table formed by the organizations in charge at the entire supply chain [1].Due to increasing competitions in today's global market and the heightened expectations of customers; food industries have forced to recognize and use supply chain management as a tool for their competitiveness during the last 10 years [9].Thus; taking in to account that perishability of foods through the whole supply chain development of optimization models to tackle the challenge becomes hot issue for both academician's and practitioner's. For instance; [6] performed one of the latest reviews about perishable food supply chain management modeling and optimization approach focusing on loss minimization was evidence. There is also a review performed in [10] that is only concentrated in production planning and inventory management. However, this review is different from ours because no classification criteria are used to present the review and expand the existing literature. Similarly a review conducted by [11] addresses models applied for the agri-food business for both perishable and non-perishable products by concentrating only on procurement and harvesting planning of crops, mostly vegetables.

The structure of the FSC can vary regarding the decisions taking part in the different activities involved ranging from farming (i.e. land cultivation, fruit production and harvesting), processing, packaging, warehousing, transportation and distribution to marketing. Focusing on the agricultural food supply chains [11] has identified four main functional areas: production, harvest, storage, and distribution. Decisions need to be made during production; harvesting, storage and distribution are summarized below in table 1.
Based on the table 1 presented below review of the papers is conducted on subsequent sections.

Table 1:Decisions Corresponding To Functional Areas of Food Supply Chain Planning

Functional area	**Decisions**	**Example(author)**
Production	• the amount of land to allocate to each crop, • timing of sowing, and • the determination of resources required for growing the crops	• (AiyingRong et al.,2011) • (P. Amorim et al.,2012) • (X. Wang et al.,2009)
Harvesting	▪ the timing for collecting the products from the fields, ▪ amount of product to harvest per period and ▪ the determination of the level of resources needed to perform this activity	▪ (Arnaout and maaturana,2010) ▪ (Bohle,c. et al.,2010) ▪ (Ferrer.J. et al.,2007)
Storage	• when the products need to be stored before or during their distribution • the amount to store and sell in each planning period and • how to position the inventory along the supply chain	• (KanchanaKanchanasuntorn et al.,2006) • (F. Dabbene et al.,2008) • (Ana Osvald and LidijaZadnik Stirn,2008)
Distribution	▪ selecting the transportation mode, ▪ the routes to use and ▪ the shipping schedule to deliver the product	▪ (Aby K Abraham et al,2012 ▪ (Ana Osvald and LidijaZadnik Stirn,2008) ▪ (S. M. Seyedhosseini et al.,2014)

In the context of supply chain characteristics, the typical decisions taken in general supply chains are divided into strategic, tactical and operational which linked to long, mid-term and short time horizon respectively [9]. Hence, Examples of decisions related to the respective decision level are presented in table 2. The papers under this review are categorized based on the decision variable they used as shown in table 2.

Table 2: Decision Level Considered in Terms of Decision Variables

Decision level	Time horizon	Decision variables	Example(author)
Strategic	Long term	▪ financial planning, ▪ network design, ▪ storage and distribution locations	▪ (Nurgul&Umut , 2012) ▪ (Marlies , et al., 2012)
Tactical	Medium term	• crop selection and scheduling (what to sow, when to sow it, and • what potential markets to target	• (Bohle,c. et al.,2010) • (Ahumada& Villalobos,2011)
Operational	Short term	▪ Timing of harvesting, ▪ scheduling of production activities, ▪ storing, packing and shipping	▪ (Ahumada& Villalobos, 2011) ▪ (Ferrer.J. et al. ,2007)

3. Fresh Food Supply Chain Planning

Planning is an activity that supports decision-making by identifying potential alternatives and making the best decisions according to the objectives of planners. According to the classification criteria's presented in section 1.1 of this paper a summarized review of 30 Papers is presented in table 3 below.Selection of papers is performed based on the methodology presented in section1.2.

Table 3:Summary of All the Reviewed Papers Dealing with Fresh Food Supply Chain Planning

Author	year	Title
KanchanaKanchanasuntorn et al.	2006	An approximate periodic model for fixed-life perishable products in a two-echelon inventory–distribution system
C.A. Soman et al.	2007	Capacitated planning and scheduling for combined make-to-order and make-to-stock production in the food industry: An illustrative case study
Ferrer.J. Et al.	2007	An optimization approach for scheduling wine grape harvest operations
Stephen C.H. Leung and Wan-lung Ng	2007	A goal programming model for production planning of perishable products with postponement
Ana Osvald and LidijaZadnikStirn	2008	A vehicle routing algorithm for the distribution of fresh vegetables and similar perishable food
cittadini, E., et al.	2008	Exploring options for farm-level strategic and tactical decision-making in fruit production systems of Patagonia, Argentina
F. Dabbene et al.	2008	Optimization of fresh-food supply chains in uncertain environments, Part I: Background and methodology
Huey-Kuo Chen et al.	2009	Production scheduling and vehicle routing with time windows for perishable food products
X. Wang et al.	2009	Optimization of traceability and operations planning: an integrated model for perishable food production
Arnaout and maaturana	2010	Optimization of quality and operational costs through improved scheduling of harvest operations
B. Bilgen and H.-O. Günther	2010	Integrated production and distribution planning in the fast moving consumer goods industry: a block planning application
Bohle,c. et al.	2010	A robust optimization approach to wine grape harvesting scheduling
AiyingRong et al.	2011	An optimization approach for managing fresh food quality throughout the supply chain
Omar Ahumada and J. Rene Villalobos	2011	A tactical model for planning the production and distribution of fresh produce
Omar Ahumada and J. Rene Villalobos	2011	Operational model for planning the harvest and distribution of perishable agricultural products
Pedro Amorim et al.	2011	Multi-Objective Lot-Sizing and Scheduling Dealing with Perishability Issues
Aby K Abraham et al	2012	The Pickup And Delivery Vehicle Routing Problem For Perishable Goods In Air-Cargo Industry

Marlies de Keizer et al.	2012	Hybrid Simulation and Optimization Approach to Design and Control Fresh Product Networks
NurgulDemirtas and Umut R.	2012	Strategic planning of layout of the distribution center: an approach for fruits and vegetables hall
P. Amorim et al.	2012	Multi-objective integrated production and distribution planning of perishable products
Bilge Bilgen and YeldaÇelebi	2013	Integrated production scheduling and distribution planning in dairy supply chain by hybrid modeling
Min Yu and Anna Nagurney	2013	Competitive food supply chain networks with application to fresh produce
P. Amorim et al.	2013	Lot sizing versus batching in the production and distribution planning of perishable goods
XiaoqiangCaietal.	2013	Fresh-product supply chain management with logistics outsourcing
OleksandrVelychko	2014	Integrated modeling of solutions in the system of distributing logistics of a fruit and vegetable cooperative
Open Darnius and Herman Mawengkang	2014	An Optimization Model for A Supply Chain Decision Problem of Fish Processed Products Considering Inventory and Routing
S. M. Seyedhosseini and S. M. Ghoreyshi	2014	An Integrated Model for Production and Distribution Planning of Perishable Products with Inventory and Routing Considerations
HoutianGe et al.	2015	Agricultural supply chain optimization and complexity: A comparison of analytic vs simulated solutions and policies
MarekBoryga et al.	2015	Trajectory planning with obstacles on the example of tomato harvest

3.1. Quality of Food Products

Food Quality can be seen resulting from the combined action of several quality attributes, each based on its own biological or physical product property. These product properties generally change over time, as part of the normal metabolism of the product[12]. When developing food supply chain planning models, a considerable number of different approaches could be considered.Taking into account the estimated remaining shelf life of the product, and matching it to the requirements of the subsequent stage of the supply chain, value can be added by optimizing the supply chain planning systems. This contribution focuses on how quality changes and remaining shelf life estimating model approaches can be combined in optimizing the planning system of the whole supply chain.

In fact, many problems in agro industry are multi-objective in nature that is several conflicting-objectives have to be optimized simultaneously, as indicated by[5]. Out of the reviewed papers presented in table 3above only the work by[5] considers the remaining shelf life of both fixed and random life time products as an objective to be maximized simultaneously with the total system cost that should be minimized. And the work by [13] , and [7] develops a quality based production/harvesting planning model, where maximizing the system profit and minimizing total system cost, the most important objectives, which is optimized andthe quality requirement of the products/ shelf life are considered in the restrictions.

3.2. Functional areas of food supply chain planning

Regarding the integrated supply chain planning, many authors have shown the economic advantages of using an integrated decision models over a decoupled approach. For example the work by [14] on multi objective integrated production and distribution planning of perishable products shown that the pareto front of the integrated approach strongly dominates the pareto front of the decoupled one for perishable products and they reach around 42% of savings for mean remaining shelf life of fixed shelf life products.

Integration of two functional areas is one of the lines of research mentioned by [15] when they discussed the growing needs in the perishable agricultural products planning efforts. Related work by [16] resulted in a scheduling model that integrated grape harvesting decisions and wine production processes. [17] Studied optimization of quality and operational costs by comparison of two heuristics to decrease the computational time of the execution of the harvesting and production processes presented by [16].

Considering the decision variables throughout the models the different food supply chain functional areas are verified. Among the papers reviewed only 6 papers consider the decision variables associated/related with Harvesting which is lesser relative to production and distribution (see table 4) below. Furthermore, only two considers integrated planning. but in real world growers of fresh food (agricultural products), often faces complex planning problems such as timing of harvesting, management of labor cost, and using efficient transport system at the stage of harvesting[15]. Thus, more attention should be given to this area to overcome the planning problems.

Table 4: Classification of Reviewed Papers According Decision Variables

Author	Decision variables related to:			
	Production	**harvesting**	**storage**	**distribution**
Aby K Abraham et al.				*
AiyingRong et al.	*		*	*
Ana Osvald and LidijaZadnikStirn				*
Arnaout and maaturana		*		
B. Bilgen and H.-O. Günther	*			*
Bilge Bilgen and YeldaÇelebi	*			*
Bohle,c. et al.		*		
C.A. Soman et al.	*			
cittadini, E., et al.	*	*		
F. Dabbene et al.	*		*	*
Ferrer.J. et al.		*		
HoutianGe et al.				
Huey-Kuo Chen et al.	*			*
KanchanaKanchanasuntorn et al.			*	*
MarekBoryga et al.		*		
Marlies de Keizer et al.				
Min Yu and Anna Nagurney	*		*	*
NurgulDemirtas and Umut R.				*
OleksandrVelychko				*
Omar Ahumada and J. Rene Villalobos	*			*
Omar Ahumada and J. Rene Villalobos		*		*
Open Darnius and Herman Mawengkang			*	*
P. Amorim et al.	*			*
P. Amorim et al.	*			*
Pedro Amorim et al.	*			
S. M. Seyedhosseini and S. M. Ghoreyshi	*		*	*
X. Wang et al.	*		*	
XiaoqiangCaietal.	*			*
Stephen C.H. Leung and Wan-lung Ng	*			

3.3. Decision level

Based on the category of decision level classification of reviewed papers is presented in table V below. Out of the 30 total reviewed papers 9, 9, and 4 papers focused on operational, tactical and strategic decision levels respectively. Regarding the combined decision levels 3 papers address the tactical and strategic decision levels and 4 papers address about the operational and tactical.

Among the operational decisions made by the fresh food producers, mentioned in table 2 are some of the essential. Of these decisions, storage and harvesting are particularly important given the limited shelf life of these products [11].since many agricultural activities remain labor intensive, another factor that needs to be considered in the operational planning of perishable crops is the use of labor [15].

The work by Ferrer et al. (2007) can be considered a good representative of the papers dealing with operational planning given by harvesting models,

Which include decisions such as the amount of product to harvest per period, the transportation of the harvested product to the packing site, and the scheduling of packing and processing plants.

Other examples of operational models in the literature include those related to production–distribution, such as the work of [7], who presents an integrate food quality in decision-making on production and distribution in a food supply chain. They provide a methodology to model food quality degradation in such a way that it can be integrated in a mixed-integer linear programming model used for production and distribution planning. The resulting model was applied in an illustrative case study, and can be used to design and operate food distribution systems, using both food quality and cost criteria.

Table 5: classification of reviewed papers according decision

	Decision variables related to:		
Author	**Strategic**	**Tactical**	**operational**
Aby K Abraham et al	*	*	
AiyingRong et al.			*
Ana Osvald and LidijaZadnikStirn		*	
Arnaout and maaturana		*	*
B. Bilgen and H.-O. Günther			*
Bilge Bilgen and YeldaÇelebi		*	
Bohle,c. et al.		*	*
C.A. Soman et al.	*	*	
cittadini, E., et al.	*	*	
F. Dabbene et al.	*		
Ferrer.J. et al.		*	*
HoutianGe et al.		*	*
Huey-Kuo Chen et al.			*
KanchanaKanchanasuntorn et al.			*
MarekBoryga et al.		*	
Marlies de Keizer et al.	*		
Min Yu and Anna Nagurney	*		
NurgulDemirtas and Umut R.	*		
OleksandrVelychko			*
Omar Ahumada and J. Rene Villalobos		*	
Omar Ahumada and J. Rene Villalobos			*
Open Darnius and Herman Mawengkang		*	
P. Amorim et al.(2013)			*
P. Amorim et al.(2012)			*
Pedro Amorim et al.(2011)		*	
S. M. Seyedhosseini and S. M. Ghoreyshi		*	
X. Wang et al.			
XiaoqiangCaietal.			*
Stephen C.H. Leung and Wan-lung Ng		*	

A finding that can be drawn from the literature reviews consulted [6], [11] is that planning models dealing with perishable products very often fail to incorporate shelf life and stochastic features in the different functional areas of the food supply chain. From the existing literature consulted we conclude that although the food supply chain is an area that is attracting a growing interest, there is a limited number of models addressing operational planning models which combine the shelf life of products.

3.4. Modeling Objective

Objective is a single measure by which the goodness of any solution to a decision problem can be measured. There are many possible objectives arising from different fields of application but some of the most commonly arising relate at the highest level to cost, profit, time, distance, performance of a system, quality and safety considerations. A decision problem which has one target to be achieved is referred to as a single objective whereas a decision problem with more than one objective is therefore referred to as a multi-objective decision making problem.

In fact, regarding to the harvesting and distribution planning of perishable foods, few authors have shown the economic advantages of using an integrated decision models. But, the existing research works in perishable foods have been using single objective. For example [5]developed an Operational model for planning the harvest and distribution of perishable agricultural products using mixed integer problem (MIP) whichhelps the growers to maximize their revenue. [18] Also Proposed a nonlinear mathematical model to consider production scheduling and vehicle routing with time windows for perishable food products expected total profit of the supplier. Similarly, [19]develop an integrated production–distribution model for a deteriorating item in a two- echelon supply chain. Their objective is to minimize the total system cost. In real world, supply chains operate in a somehow uncertain environment with different objectives of each stakeholder Thus, the use of a single objective function would hinder the important trade-off between conflicting objectives.

Table 6: classification of reviewed papers based on modeling objective and approach

author	Modeling objective		Modeling and solution	
	single	multiple	type	approach
Aby K Abraham et al	*		MM	GA and heuristic rationing rules
AiyingRong et al.	*		MM	MILP
Ana Osvald et al.	*		MM	Tabu search
Arnaout et al			MM	ILP
B. Bilgen et al.	*		MM	MILP
Bilge Bilgen et al	*		MM &SM	MILP
Bohle,c. et al.	*		MM	ILP
C.A. Soman et al.	*		AM +Hybrid	heuristic
cittadini, E., et al.	*		MM	MOLP
F. Dabbene et al.	*		MM	SPSA optimization algorithm
Ferrer.J. et al.	*		MM	MILP
HoutianGe et al.	*		AM&SM	
Huey-Kuo Chen et al.	*		MM	NLP and a heuristic
Kanchana K. et al.	*		MM&SM	MS(Matta and Sinha)model +EOQ
MarekBoryga et al.	*		MM&SM	PR-APT method
Marlies de Keizer et al.		*	hybrid model	simulation and optimization
NurgulDemirtas	*			NLP+ MIP+ Heuristic
OleksandrVelychko		*	MM	LP
Omar Ahumada	*		MM	MIP
Omar Ahumada	*		MM	MIP
P. Amorim et al.(2013)	*		MM	MIP +vehicle routing
P. Amorim et al.(2012)		*	MM	MOMILP and MOMINLP
p. Amorim et al.(2011)		*	MM	MOLP with genetic algorithm
Seyedhosseini et al.	*		MM &Hybrid	MILP+particle swarm heuristic
X. Wang et al.	*		MM&SM	MILP
XiaoqiangCaietal.	*		MM	MOLP+heuristic
Stephen C.H. et al.		*	MM	Preemptive GP

NB: MM=Mathematical Modeling, AM= Analytical Modeling, SM=Simulation Modeling, SP= Stochastic programming, GA=Genetic Algorithm, MILP=Mixed integer linear programming, ILP=Integer Linear Programming, MOLP=Multi Objective Linear Programming, PR-APT=Planning Rectilinear-Arc Polynomial Trajector, LP=Linear Programming, EOQ=Economic Order Quantity, GP= Goal Programming

The performance of a supply chain should usually be measured by multiple criteria. In fact, many problems in agro industry are multi-objective in nature that is several conflicting-objectives have to be optimized simultaneously, as indicated by[5] . Despite a few researchers have also applied multi-objective models in their projects, for instance [20] apply one of the techniques of multi objective programming (goal programming) in a Brazilian forest problem concern of the farm managers with increasing the diversity of flora and fauna, increasing environmental protection conditions and maintaining employees in the farm.

The work by [21]address production, distribution and capacity planning of global supply chains considering cost, responsiveness and customer service level simultaneously.in this multi objective mixed-integer linear programming (MILP) approach is developed with total cost, total flow time and total lost sales as key objectives. Similarly [22] developed A preemptive goal programming model to solve aggregate production planning for perishable products is developed, in which three objectives are optimized hierarchically. A set of Hong Kong data has been used to test the effectiveness and the efficiency of the proposed model. Results demonstrate that the decision-makers can find the flexibility and robustness of the proposed model by adjusting the goal priorities with respect to the importance of each objective and the aspiration level with respect to desired target values. The objectives were Operating cost goal, Inventory cost goal, and Hiring and layoff goal.

Furthermore, the drawback of the existing research works in multi-objective optimization is that they are only dedicated to economic advantage (such as cost and profit). So to tackle the perishability phenomenon in planning tasks, such as production, harvesting, storage and distribution it is necessary to employ another multi objective planning method to understand the complementary effects of supply chain costs and product perish-ability.

3.5. Optimization Models and Solution Approaches of FSC Planning

Taking in to account that perishability of foods through the whole supply chain development of optimization models to tackle the challenge becomes hot issue for both academicians and practitioners (see table 6 above). From the perspective of modeling approaches used to model the planning problem within the context supply chain planning are classified as; Analytical models, Mathematical programming models, simulation model, Heuristic method and hybrid models[8]as summarized in table 7below.

Table 7 Classification of Optimization Models and Solution Approaches of FSC Planning

Model type	**Model technique**	**Solution approach**
Analytical, heuristics, hybrid, mathematical programming, simulation	Artificial intelligence, business game, discrete-event simulation (DES), game theory, meta-heuristics, multi-criteria decision making, multi objective, simple heuristics, single objective, spreadsheet calculation, system dynamics, systemic models	Analytic hierarchy process/analytic network process (AHP/ANP), dynamic programming, fuzzy logic, genetic algorithm, goal programming, input–output-analysis (IOA), life cycle analysis (LCA), linear programming/mixed integer linear programming (LP/MILP), neural networks, nonlinear programming, petri net, particle swarm optimization, queuing, rough set, simulated annealing, variation inequality

Many of the decisions taken in fresh food supply chain planning involve multiple objectives. Thus, as discussed earlier in section 3.4, less attention is given to multi objective decisions in the area of food supply chain planning. Though, there are few studies; which consider multi objective; only one paper used goal programming model as a solution approach from the reviewed papers (see table 6). Goal programming is part of multi criteria decision analysis which used in optimization of multiple objective goals by minimizing the deviation for each of the objectives from the desired target. Solving planning problems with multiple objective using goal programming has the advantage of reaching all the objectives as closest as possible of the ideal, since usually is impossible to find an optimum solution when all the objectives were considered simultaneously [20], [22].therefore, future studies should be conducted considering multi objective planning problems and the advantage of Goal programming for such situations can be used.

3.6. Research Segmentation by Journal

Papers addressing the issue of food supply chain planning are reviewed.For the selection of papers, from different journals we used and decide key words as mentioned in section I to be fresh food, food supply chain, planning, optimization and decision methods. Here the food supply chain planning models with respect to the journal they published is presented in table to understandthe motivation of the research and the multidisciplinary approach papers.

Table 8: Reviewed Papers Based On the Journal Category

Model	Journal
Aby K Abraham et al. [23]	International Journal of Emerging Technology and Advanced Engineering
AiyingRong et al. [7]	Int. J. Production Economics
Ana Osvald and LidijaZadnikStirn [24]	Journal of Food Engineering
Arnaout and maaturana	
B. Bilgen and H.-O. Günther [25]	OR Spectrum
Bilge Bilgen and YeldaÇelebi [26]	Ann Oper Res
Bohle,c. et al. [27]	European Journal of Operational Research
C.A. Soman et al. [28]	Int. J. Production Economics
cittadini, E., et al. [29]	Agricultural Systems
F. Dabbene et al. [30]	Bio systems Engineering
Ferrer.J. et al. [31]	International Journal of Production Economics
HoutianGe et al. [32]	Int. J. Production Economics
Huey-Kuo Chen et al. [33]	Computers & Operations Research
KanchanaKanchanasuntorn et al. [34]	Int. J. Production Economics
MarekBoryga et al. [35]	Agriculture and Agricultural Science Procedia
Marlies de Keizer et al. [36]	Winter Simulation Conference
Min Yu and Anna Nagurney [37]	European Journal of Operational Research
NurgulDemirtas and Umut R. [38]	Procedia - Social and Behavioral Sciences
OleksandrVelychko [39]	Business: Theory and practice
Omar Ahumada and J. Rene Villalobos [13]	Int.J. Production Economics
Omar Ahumada and J. Rene Villalobos [40]	Ann Oper Res
Open Darnius and Herman Mawengkang	
P. Amorim et al. [41]	Int. J. Production Economics
P. Amorim et al. [5]	Int. J. Production Economics
Pedro Amorim et al. [42]	Ind. Eng. Chem. Res
S. M. Seyedhosseini and S. M. Ghoreyshi [43]	Mathematical Problems in Engineering
X. Wang et al. [44]	International Journal of Production Research
XiaoqiangCaietal. [45]	Omega
Stephen C.H. Leung and Wan-lung Ng [22]	Computers & Industrial Engineering

4. Conclusions And Directions For Future Research

In this paper we have reviewed some of the optimization methods related to solve decision problems related to fresh food supply chain planning.The review attempt to gain a better understanding of the optimization methods used in the paperstowards problem solving. From the review we can conclude that a less attention is given to strategic decision problems compared to tactical and operational decisions. Mathematical type of modeling food supply chain planning is the dominant and most of the models used MILP as a solution approach.

A recent study done by[5], on the integrated production and distribution planning of perishable foods, shows that the economic importance of integrating different functional areas of fresh food supply chain during planning. Among the models reviewed in this paper only 5 of them considers multiple criteria's as an objective function. But, only the work by [5]considers food product perishability as a modeling objective. After the study is verified using an illustrative case study it showed study a potential savings of using an integrated approach over a decoupledonearesavings can ascend up to 42%. Taking into account this,considering estimated remaining shelf life of the product, and matching it to the requirements of the integrated functional areas of the supply chain, value can be added by optimizing the supply chain planning systems. Thus, future researches could focus on:

- How quality changes and remaining shelf life estimating model approaches can be combined in optimizing the planning system of the whole supply chain?

- How to develop a multi objective optimization model considering product shelf life as an objective?
- Take into consideration strategic decisions consider the location of several customers and depots, storage and distribution locations,financial levels, and inventory levels setting are needed for more complete dynamic scenarios.

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