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MODELING OF SUPPLY PROCESSES FOR PERISHABLE FOODSTUFFS

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Abstract. Contemporary experience has proved the necessity of ensuring unity in the transport and logistics systems of food supplies.

This is particularly relevant for perishable goods, the acceleration of delivery dates directly impacts their safety and quality.

The article considers the problem of creating an effective transport process for perishable food supply chains. The analysis of influencing the efficiency of perishable food supply chains and the main principles and approaches to improve the transport support of perishable food products have been substantiated.

The constructed theoretical model of a technological transportation system for perishable food goods considers compatibility (adaptability) of transport machines with agricultural machinery; technological parameters of technical systems; adaptability of technical systems to environmental conditions and technological properties of perishable food cargoes; transport and technological cycles parameters.

Key words: efficiency, supply chain, delivery time, temperature control, perishable food goods.

Introduction

The transportation of perishable food products occupies a specific position in the list of transportation services. Such cargo is characterized by limited shelf life and particular climatic conditions for storage and transportation to ensure the longest possible shelf life of the foodstuffs. Product expiry date restrictions also affect the logistics processes, so the lower the expiration date, the more often the product is manufactured and shipped.

Formulation of problem

Modern experience indicates the need for unity in the transport and logistics systems of food supplies. This is especially true for perishable goods, acceleration of delivery terms, which directly influences their safety and quality.

Analysis of recent research results

Therefore, a rational assessment of supply chain efficiency allows us to determine optimal solutions for improvement and heighten commercial advantage. This is especially true for transportation processes because it is difficult to describe the transportation system accurately only by analytical methods due to the high number of parameters and influencing factors.

Moreover, external factors, input process parameters, and system characteristics have a probabilistic origin. Contemporary scientists R. Ballou [3], L.Hee-Yong, S. Young-Joon, J. Din-woodie [6], V. Lukinskiy, V. Dragomirov pay a lot of attention to the study of certain logistics problems [8].

The situation is more complicated because referring to the transport operations related to the carriage of perishable foodstuffs, the uncertainty of the transportation process involves additional limitations related to delivery time and conditions. These aspects are the focus of R. Badia-Melis, U. Mc Carthy, L. Ruiz-Garcia, J. Garcia-Hierro, J.I. Robla Villalba [2], A. Chaudhuri, I. Dukovska-Popovska, N. Subramanian, H. Chan, R. Bai, [4], J. Dai, W. Che, J.J. Lim, Y. Shou [5], N. Ndraha, H. Hsiao, J. Vlajic, M. Yang, Victor Lin Hong-Ting [10], A. Ratul, F.Z. Megat, S. Nazmus [11], O. Zagurskiy et al. [21, 13], O. Zagurskiy, T. Zhurakovska [14].

However, concerning a substantial amount of developments, it is necessary to determine that a holistic approach to building an effective transport process in the supply chain of perishable food products needs to be expanded and upgraded.

Purpose of research

The purpose of the article is to analyze factors impacting the effectiveness of supply chains of perishable food products and build a theoretical model of a technological transportation system of perishable food cargo.

Research results

The category of perishable goods includes food products with a limited shelf life that require the necessary temperature and humidity conditions for their maintenance. Different literature uses a range of terms such as perishable food cargo, food product, or perishable product to describe them. However, we are going to use the term: perishable foods, in other words, foods that become unfit for their intended use within a short period without special measures (e.g., refrigeration). These include meat and meat products, seafood, dairy products, fruits, and vegetables.

Steven Nahmias divides all perishable foods based on their expiration dates into two groups:

1) products with a fixed expiration date, which have a set expiration date;

2) products with an arbitrary shelf life for which no expiration date is specified [9].

The limited shelf life of the first group of perishable foodstuffs is particularly challenging and requires consideration in inventory and supply management policies decisions.

Therefore, overproduction and excessive storage of these products are not advisable because they can be used only within their expiration date. It is not advisable to use the product beyond its expiration date, and it must be disposed of.

Given this, speed and delivery conditions are often the determining factors in transportation choice methods for perishable food products. Their preservation affects not only the income of all participants in transport and logistics systems, but also human health, so transparency of perishable food products origin is a prerequisite for supply chain management of such products. Food retailers make up to 40% of their profits from selling perishable food products, but losses caused by disruptions in transportation and logistics systems sometimes reach 65% or more in this category [7]. It is possible to reduce the proportion of perishable goods losses by reducing the delivery time of products and continuing their lifecycle on the store shelf. Modern digital technologies are successfully used to control the supply lines of many types of everyday goods (clothing, electronics, home appliances, etc.), but these technologies don't allow the same effective management of transport and logistics systems for the supply of perishable foodstuffs. Thus, according to A.T. Kearney consulting firm (Fig. 1), freshness is the top factor in choosing perishable food products for 93 percent of surveyed consumers. It far outpaces the highest quality attribute, which was chosen by 58% of consumers.

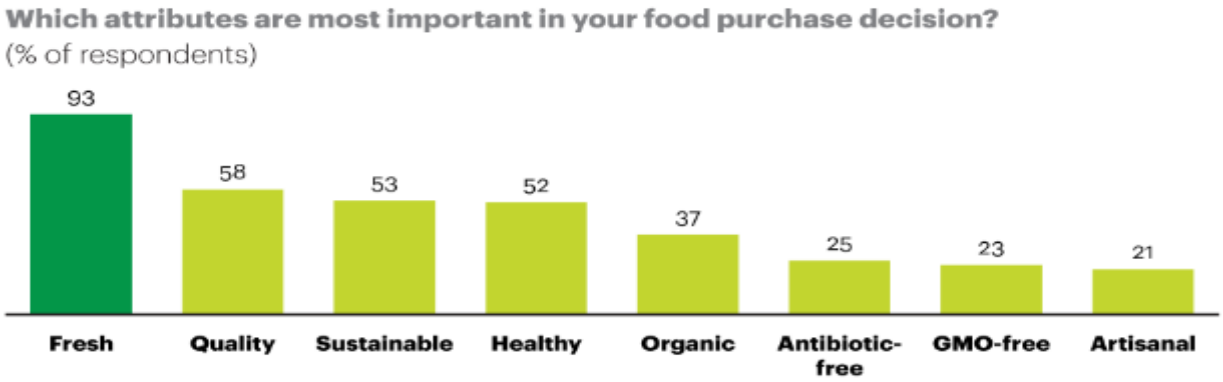

Fig. 1. Factors that influence the consumer's choice in purchasing perishable food products.

Source: A fresh look: perishable supply chains go digital. Kearney. URL: https://www.de.kearney.com/operations-performance-transformation/article?/a/a-fresh-look-perishable-supply-chains-go-digital

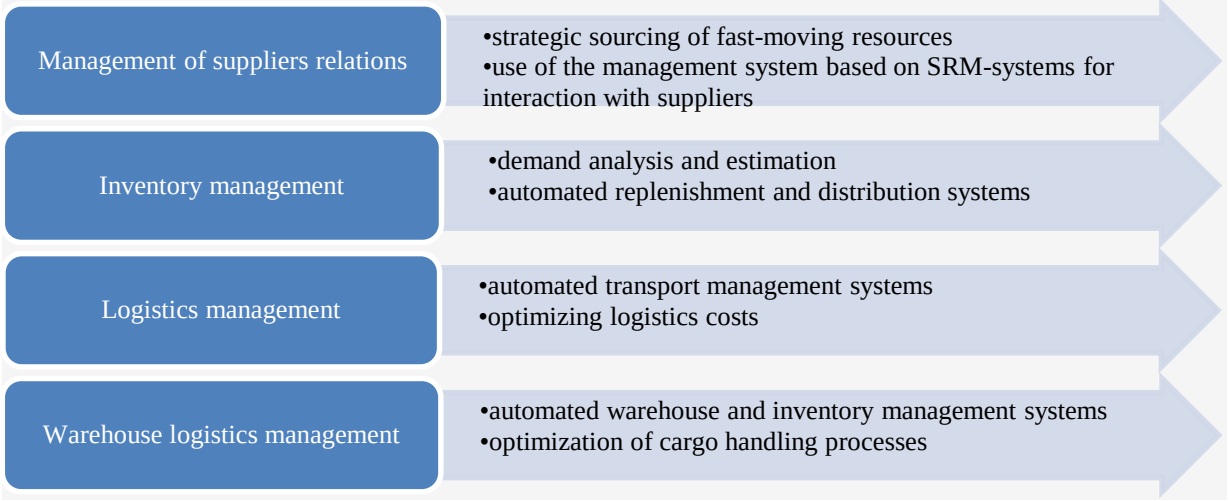

Fig. 2. Tools used for manage perishable food supply chains

Source: Hagen C. A fresh look: perishable supply chain go digital. A.T. Kearney. URL: https://www.atkearney.com/operations-performance-transformation/article?/a/a-fresh-look-perishable-supply-chains-go-digital

To analyze the inequalities of passengers at The availability of accurate information about the origin of goods is an equally important factor in the choice of products for buyers, increases the requirements for systems of transparency and tracking the movement of goods in the transport and logistics systems.

Hence, there is no single ready-made universal solution for managing the supply chain of perishable food products today, but this mechanism is demanded by the market and all supply chain participants, so commercial companies offer some technological tools aimed at managing the individual stages of perishable food supply (Fig. 2).

The complexity of supply chains organization of perishable food products is caused, on the one hand, by the participation of numerous links in the chain, and on the other by the peculiarities of perishable cargo, namely:

– dispersion of production locations for perishable food products;

– seasonality of cargo flows;

– complexity of coordinating loading and unloading processes on the interacting modes of transport;

– nondeterministic rolling stock arrivals at transfer points (transportation hubs);

– nondeterministic delivery of perishable goods to wholesale collection points;

– necessity of the empty rolling stock return mileage;

– the necessity of phytosanitary and veterinary control at border crossings delays cargo at departure and destination terminals, frequently not adapted for the storage of the perishable product.

The solution of indicated problems of organizing the supply of goods to consumers prompted the inclusion in the transport and logistics system of intermediaries of transport and freight forwarding companies (FFC). Although the services of freight forwarders increase product delivery costs under market economics, they are presented in the food market, carving out a certain niche. Furthermore, several forwarding firms are constantly growing in number with the development of intermodal transportation and mass containerization and bagging.

The solution of indicated problems of organizing the supply of goods to consumers prompted intermediaries of transport and freight forwarding companies (FFC) inclusion in transport and logistics systems. Although the services of freight forwarders increase product delivery costs under market economics, they are presented in the food market, carving out a certain niche. Furthermore, several forwarding firms are constantly growing with the development of intermodal transportation and mass containerization, and bagging:

1. The assistance in performing customs clearance procedure (about 200 documents are processed for international shipments at present) - 78%,

2. Observance of delivery time 70%,

3. Cargo preservation during transportation, and storage - 69%,

4. Lowest delivery costs - 65%,

5. Additional services - 55%,

6. Transporter's high image - 52%,

7. Payment flexibility - 40% [1].

Consequently, the process of supplying perishable food products can be presented as a system described by the internal construction and interacts with the external environment. It is necessary to use logistics to build the internal organization of this process with the best result on the principle of optimizing the distribution of all kinds of resources to achieve the necessary level of customer service while reducing costs, which enables a competitive advantage. Thus, the implementation of supply processes for perishable food cargo based on the principles of transport logistics allows:

– to consider the nature of interaction and relationship of producers, warehouses, transport;

– to determine optimal conditions for packaging, storage and transportation of perishable goods;

– to find "bottlenecks" that prevent the movement of cargo flow from producer to consumer;

– to organize scientifically substantiated transport and technological processes, taking into account the needs of individual links of the logistics chain and the system as a whole;

– to improve the management structure, legal, informational, and documentary assistance necessary for the optimal flow of processes in transport and logistics systems;

– to carry out measures to automate the management system of perishable goods deliveries.

The technological lines, as a rule, constitute the technical basis of transport and production processes. Transportation is the connecting link of the technological line, substantially determining the mode of its operation.

In the case of perishable goods, the economic feasibility and technical ability to ensure that the cargo is transported on time and without losses are important criteria for the choice of a particular mode of transport. Meanwhile, various transport modes are interchangeable, so everything is up to the owner's choice.

Considering the main technologies of transportation of perishable food products, one should note that no matter whether it is transported within the country or it is an international supplier, a set of factors and conditions is approximately equal:

– temperature range

– shelf life or period of delivery

– packaging and labeling according to the type of cargo

– secure mechanical fixation using pallets, straps, film, etc.

However, guaranteeing full compliance with shipping conditions along the way is a much more difficult task than maintaining the same conditions in the middle of conventional storage facilities.

Consequently, there is a need for high-quality organization of transportation, providing for unforeseen circumstances and protection cargo from devastating effects. Thus, competent use of specific technologies for each group of cargo and the use of technical equipment, understanding of the peculiarities of their work, including those arising during the movement.

In the complex transport and logistics system, there is a production system, which is called a transport process. It

consists of a certain technological system of transportation, with its specifics for perishable food cargo.

Figure 3 shows a graphical model of this system. Technical systems of assembly (SM) or distribution (RM) and transport machines (TM), interacting with each other to maintain the necessary climatic regime, are involved there. They have their technological parameters: according to K (k1, k2, ... kn), C (c1, c2, ... cn), A (a_1, a_2, ... a_n). The suitability or conformity of these machines is characterized by the indicator S against one another. Technical systems are affected by the environment P (t) - weather conditions, D (t) - road conditions, etc.

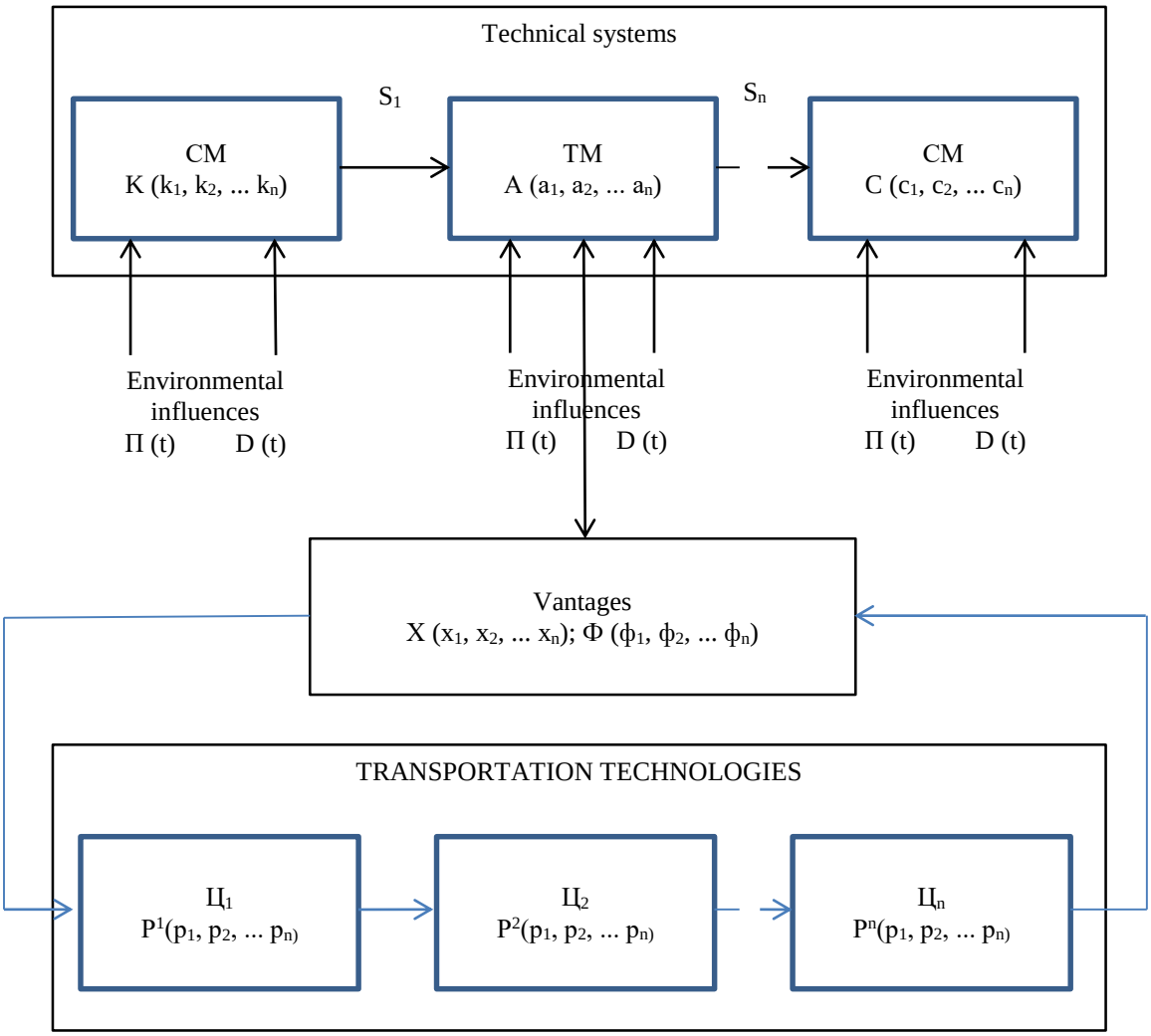

Fig. 3. Graphical building model of a technological system for perishable food cargo transportation
Source: compiled by the author

Cargo list X (x1, x2, ... xn) with their technological properties Φ (ϕ_1, ϕ_2, ... ϕ_n) presented as an operation argument, with the process of transportation changing not only their location in space but their properties and technologies applied to them.

Moreover, the transportation technology process comprises a set of transportation cycles Ts (Ts1, Ts2 ... tsn), all of which are a function of its parameters. This technological transportation system for perishable foodstuffs can be described by a mathematical model:

$$\begin{cases} S = f(K, A, C); \\ Y_M = f\left[K(k_1, k_2, ..., k_n), A(a_1, a_2, ..., a_n), C(c_1, c_2, ..., c_n)\right]; \\ \Pi_K = f\left[M(t), D(t)\right], \Pi_A = f\left[M(t), D(t)\right], \Pi_C = \left[M(t), D(t)\right]; \\ \Pi_A = f\left[X(x_1, x_2, ..., x_n), \Phi(\phi_1, \phi_2, ..., \phi_n)\right]; \\ Y_{TП} = \sum Ц_i(p_j). \end{cases}$$

This model accounts for:

– compatibility (adaptability) of transport machines (TM) with agricultural machines (CM, SM) is the first equation;

– technological parameters of technical systems are the second equation;

– adaptability (adaptability) of technical systems to environmental conditions and technological properties of perishable food cargoes are the third and fourth equations;

– transport-technology cycle parameters are the fifth equation.

So, all the most important technological factors are taken into account in the model. To carry out the transport process in the complex of transport and logistics system of perishable food products, in addition to moving the cargo must not only load it at the right place in the process chain but also unload it at the destination point observing certain parameters of temperature, humidity, etc.

So, a complete technological transportation cycle consists of submitting a vehicle for handling, movement of cargo (transportation) as well as unloading. External, internal, and environmental factors must be analyzed and taken into account to improve transport support for the delivery of perishable food cargo (Fig. 4).

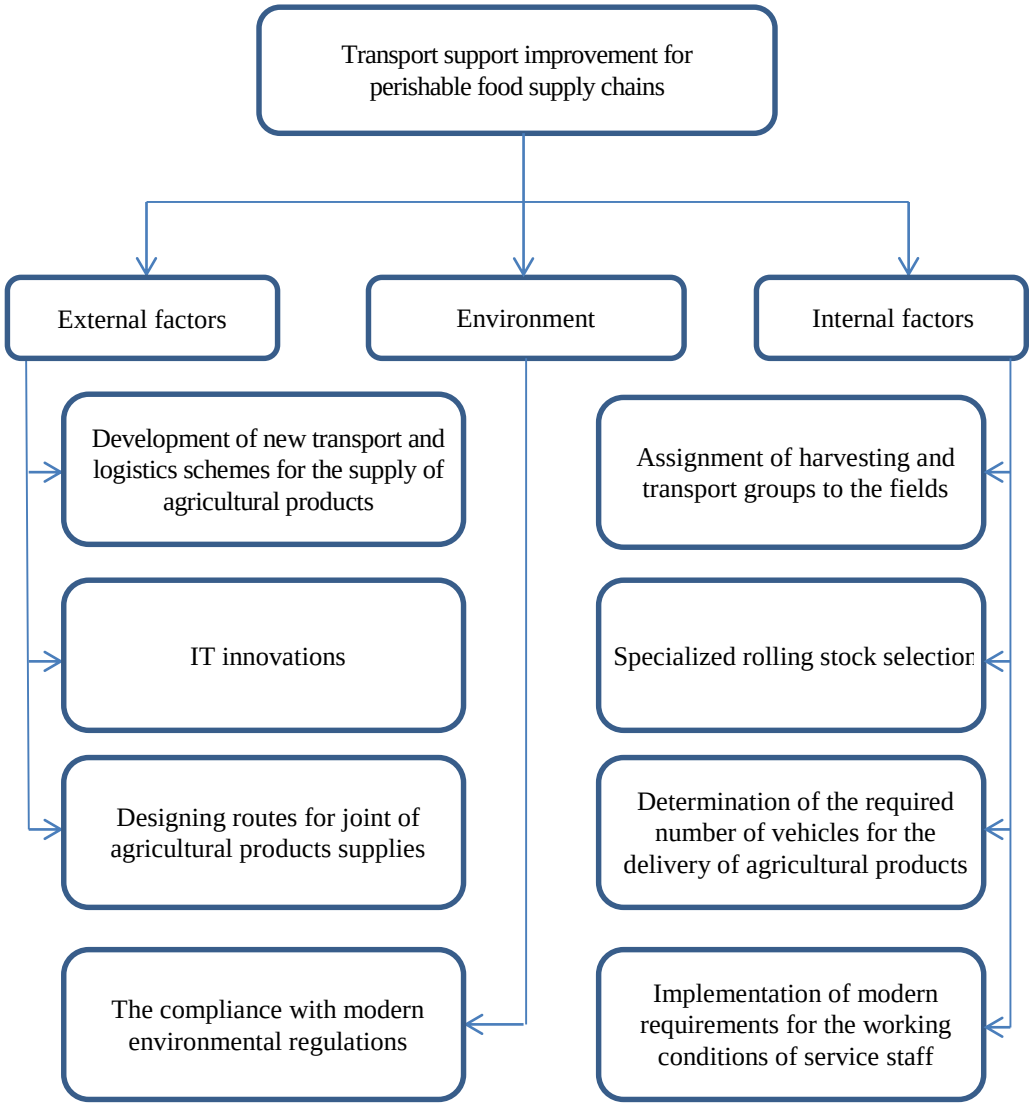

Fig. 4. Improving means of perishable food transportation
Source: compiled by the author

Implementation of certain means in the organization of transport and logistics systems for perishable food supplies will minimize the mutual influence of the environment and cargo on each other and contribute to preserving more products of the required quality for consumers and customers of the agro-industrial complex.

If we separate transportation processing for perishable foodstuffs from shipping, it will also have some specific features related to the usage of specialized rolling stock, as well as technological means of transportation, that are used during shipment to reduce the probability of product damage during transportation and reduce the impact of cargo and the shipping process on the environment.

In this regard, it should be noted that transportation of perishable food products occupies a special position in the list of transportation services. Indeed, (underline again) their main difference from other types of cargo is a limited shelf life, as well as special climatic conditions of storage and transportation required to ensure the longest possible shelf life of this type of cargo. All perishable food products require certain storage conditions. While some are sufficient to maintain a temperature of 5-18 °C (fresh berries, fruits, vegetables, dairy products in tetra pack), others require minus values (frozen semi-finished products, fish, seafood, etc.).

Conclusions

1. In the analysis of the optimization of route schemes of urban public transport, the interests of all participants in the urban transport system were considered and the efficiency indicators of the system as a whole were formulated. The classical problem of transport routing, its varieties and methods of solution are considered. As an optimization criterion for the urban public transport system, it is proposed to use the density of passenger traffic on a certain section of the road. Analysis of methods for

solving problems of transport routing showed that the most promising today are the methods of game modeling.

2. As a result of the performed work by methods of game modeling the technique of search of optimum routes on Pareto criterion is developed. Optimization game model of the process of passenger transportation on the route №9 in Pryluky showed results that take into account the interests of all stakeholders.

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МОДЕЛЮВАННЯ ПРОЦЕСУ ПОСТАЧАННЯ ШВИДКОПСУВНИХ ХАРЧОВИХ ПРОДУКТІВ

О. М. Загурський

Анотація. Сучасний досвід свідчить про необхідність забезпечення єдності в транспортно-логістичних системах постачань продуктів харчування. Особливо це стосується швидкопсувних вантажів, прискорення термінів постачання яких безпосередньо впливає на їх збереженість та якість.

В статті розглянуто проблему побудови ефективного транспортного процесу в ланцюгах постачань швидкопсувних харчових продуктів. Здійснено аналіз факторів, що впливають на ефективність ланцюгів постачань швидкопсувних продуктів харчування та обгрунтувано основні принципи і підходи щодо покращення транспортного забезпечення швидкопсувних харчових продуктів. Побудовано теоретичну модель технологічної системи перевезень швидкопсувних харчових вантажів, яка враховує: сумісність (пристосованість) транспортних машин з сільськогосподарськими машинами; технологічні параметри технічних систем; пристосованість (адаптивність) технічних систем до умов середовища та технологічних властивостей швидкопсувних харчових вантажів; параметри транспортно-технологічних циклів

Ключові слова: ефектвність, ланцюг постачань, терміни постачань, температурний режим, швидкопсувні харчові вантажі.

МОДЕЛИРОВАНИЕ ПРОЦЕССА ПОСТАВОК СКОРОПОРТЯЩИХСЯ ПИЩЕВЫХ ПРОДУКТОВ

О. Н. Загурский

Аннотация. Современный опыт свидетельствует о необходимости обеспечения единства в транспортно-логистических системах поставок продуктов питания. Особенно это касается скоропортящихся грузов, ускорения сроков поставки которых непосредственно влияет на их сохранность и качество.

В статье рассмотрена проблема построения эффективного транспортного процесса в цепях поставок скоропортящихся пищевых продуктов. Осуществлен анализ факторов, влияющих на эффективность цепей поставок скоропортящихся продуктов питания и обоснованы основные принципы и подходы по улучшению транспортного обеспечения скоропортящихся пищевых продуктов. Построена теоретическая модель технологической системы перевозок скоропортящихся пищевых грузов, которая учитывает: совместимость (приспособленность) транспортных машин с сельскохозяйственными машинами; технологические параметры технических систем; приспособленность (адаптивность) технических систем к условиям среды и технологических свойств скоропортящихся пищевых грузов; параметры транспортно-технологических циклов

Ключевые слова: ефектвность, цепь поставок, сроки поставок, температурный режим, скоропортящиеся пищевые грузы.

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