

Building of the Knowledge Base for the Elaboration of Processes of Food Raw Materials and Food Product Transportation by Means of Tractors and Road Vehicles

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Abstract: Food raw materials and food products represent one of the most important and at the same time challenging cargoes, and this specifies the variety of technological processes and technical facilities used in transportation. In Russia and abroad, intense research and development are taking place, that are aimed at improvement of technological processes and technical facilities for food raw material and/or food products transportation by means of tractor, road, rail and water transport. Of special importance are tractor and road transports, which require the development of patentable technological and technical solutions in order to increase their competitiveness. This resulted in the knowledge base building for the elaboration of processes of tractor and road transportation of food raw materials and food products on the basis of scientific and technical and patent search. Based on the analysis and knowledge building, the areas of improvement of food raw materials and food product transportation processes by means of tractor and road transport were identified.

Keywords: road vehicles, knowledge base, logistics, patent, food raw materials, food products, tractor transport, transportation.

JEL Classification Code: Q18

I. INTRODUCTION

Food raw materials and food products are one of the most important and challenging cargoes, which is attributed to the need to preserve the functional qualities of food raw materials and food products, including perishable ones. This leads to a wide variety of logistics chains, technological processes, technical facilities and combinations of these processes, means and their combinations used in their transportation (for example,

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tractors + cars, cars + rail transport, cars + water transport + cars). Attention to the justification of logistics in the transportation of various types of food raw materials and food products is determined by the urgent need to solve the problem of providing the population with quality food, and the fact that its transportation is an essential part of the transportation system in Russia and worldwide.

Reducing the final price of food supplied to the population can be achieved by reducing transport costs in the total final cost of the supplied products. This explains the current importance of the problem related to the organization of rational logistics chains of food raw materials and food products transportation, as well as the use of scientifically sound technical facilities for this purpose. To date, this problem has not been fully addressed and requires closer consideration.

In the greater part of the studies related to the problem of food products transportation, researchers analyzed the formation of the general theory and methodology of logistics in the framework of cross-cutting technologies of preparation, transportation and processing of food raw materials and production of functional foods. Certain technology and certain types of transport used in the implementation of these logistics chains were also studied.

The article by Magomedov (2005) examines the transportation and storage of vegetables as a part of the unified system of the food program. At the same time, it was shown that low-cost technologies of a controlled atmosphere (gas environment) should be used to preserve the supplied vegetable products. The studies made by Zavodnov (2004) observe the large losses of fruits and vegetables (potatoes) occurring during transportation owing to mechanical damage during cargo-handling and transport operations. According to the research made by Klepikov (2006), the organization of effective transportation is important for the industrial complex of modern Russia, and improvement of the processes of international food products transportation is important for the state and industrial enterprises. Oleinikova in her work (2016) considers the main areas of development of perishable food products transportation in multi-modal transport hubs.



Bogatyriov and Mikhailova (2009) focus on the need to improve cargoes transportation through the possibility of reducing the final price of food by reducing transport costs, which can amount from 20 to 40 % of the final cost of the production.

The presented variety of types of food products transportation, requirements for special heat-treatment, climatic and hygienic conditions result in additional restrictions in the formation of logistic technological operations and transport facilities for the effective transportation of food raw materials and/or food products.

The chain of technological processes, related to the need for transport support of the Northern regions population with functional food products containing the necessary amount of trace elements, includes: food transportation from the places of cultivation to intermediate warehouses, where a certain amount of products is accumulated and stored; distribution of food products by regions; process of food enrichment with the necessary trace elements, as well as the delivery from enrichment points to the end consumers of enriched functional agricultural products.

In research and development, that currently are carrying out in Russia and abroad, tractors and road vehicles occupy a special place among other types of transport. Transportation of food raw materials and food products by tractors and road vehicles has its own features and details. At present, food transportation by means of road vehicles is the most accessible at close and long distances, and food raw materials transportation by means of tractors is necessary at the first stage of its transportation from the place of preparation to the transfer point, primary or final processing points. To improve the competitiveness of road and tractor transportation of food raw materials and food products and corresponding transport facilities, it is necessary to develop patentable technological and technical solutions.

This led to the building of knowledge base for improving the processes of tractor and road transportation of food raw materials and food products on the basis of scientific, technical and patent search.

II. LITERATURE REVIEW

Food raw materials and food products transportation is carried out in case of supply to foreign and domestic markets, as well as to the places of food products preliminary or final processing. In this regard, it is necessary to pay attention to the research of the Doctor of Economics Butakova (2016), that proves the need to improve international transportation.

If to examine food transportation in detail, there are two categories of transported food products: perishable and non-perishable.

Paquette and colleagues in their work (2017) developed a 3D model, simulating heat transfer in a multilayer box for insulation of food products during non-refrigerated transportation. The simulation showed the critical role of heat transfer due to radiation inside the box in addition to conduction. It was found that the equipment of the internal surface of the box with aluminum foil reduced the food temperature increase by more than 10% from the original temperature increase during the first 30

hours of storage by reducing the radiation. The placement of the initially frozen gel packs at the center of the box significantly delayed melting and doubled the time of preservation of the food products quality. As a sensitivity analysis showed, the thermal conductivity of the box walls and the emissivity of the internal surface of the box and the use of gel packs are the most important input parameters affecting the result, while the convection heat transfer coefficient is less significant.

Lohithaksha and Thakkar in their work (2017) proposed a combined tactical and operational two-stage model of food grain transportation with a linear formulation at the first stage and a mixed integer nonlinear problem (MINLP) at the second stage on the example of India. Transport cost is minimized at both stages to meet deterministic demand. The first and second stages correspond to the transportation of food grains between state warehouses and central level warehouses, respectively. Authors proposed a new method for handling constraints based on the k-parameter. In addition, a two-stage MINLP formulation newly incorporates vehicle capacity limitations and provides a generic metric to measure vehicle utilization. The first stage is solved by means of CPLEX, and the second stage uses two methods of random search based on population: optimization of particle clot – particle swarm optimization-composite particle (PSOCP) and PSO. Experimentations on 10 different sets of problems show that PSOCP performs slightly better than PSO with less standard deviation of global fitness and better solution quality with slightly higher CPU time. Later, sensitivity analysis is carried out on all ten problem sets, and a decision support system is proposed to assist potential stakeholders.

As shown in the study made by Tanner (2016), the global transformation of food transportation methods in recent decades largely stems from the introduction of modern refrigeration methods using refrigeration equipment for transportation and storage of food products. In previous years, logistics of the trade in perishable food products was limited to the use of “local” products (grown in the regions of their consumption) due to limited storage life or due to the use of only traditional methods of food preservation (for example, using brine), which significantly changed the sensory properties of perishable products. The development of the refrigeration system in transportation and storage has significantly revolutionized the transportation and storage of food and has made it possible to maintain the quality of food for much longer periods of time, over longer distances. Today, refrigerated vehicles and vessels using modern equipment are used to transport perishable products such as frozen foods, fruits and vegetables, as well as temperature-sensitive chemicals throughout the globe.

The study of foreign experience shows that manufacturers, suppliers and consumers of food products in various countries of Europe and America use mainly road transport for the transportation of perishable food products. At the same time, food products are transported by special thermally insulated or refrigeration containers mounted on the basis of truck trailers,



as well as large-capacity refrigeration containers. Railroad insulated refrigerated cars are used less frequently. There are also technologies that combine the transportation of refrigeration containers by road and rail (water) transport into a single technological process. In Russia, road transport accounts for 45% of the transportation of perishable food products (Naumenko S. N., 2006).

S. A. Sidorov (2011), who studied the suitability of refrigerated vehicles for the perishable goods transportation, proposed four intervals of severity of operating conditions of refrigerated vehicles and emphasized the need to improve the efficiency of road transportation through research and development aimed at improving the suitability of refrigerated vehicles, considered as an element of the space-time system.

In the study made by Kondratiev (2007), as a result of the analysis of the current state in the field of road transport supply of perishable food products, the author noted the logistics costs reaching up to 50% in the structure of the final cost of these products, the need to improve the quality of logistics services, the regulatory framework of transportation, as well as the system of transport control and accounting.

Doctor of Technical Sciences Chetvertakov (1994) emphasizes the insufficient level of mechanization of fruits transportation and processing in the existing basic technological processes. Sheikhov and Imashova(2008) studied the system of preparation, storage, transportation, processing and disposal of vegetables in the farms of Dagestan. The need for more efficient technology of transportation, storage and processing of vegetables is emphasized.

III. MATERIALS AND METHODS

The aim of the study was to build a knowledge base in order to improve the competitiveness of road and tractor transportation of food raw materials and food products by elaborating the technological processes and technical facilities of this area. The research is conducted in order to overcome certain difficulties in the process of learning new phenomena, to explain previously unknown facts or to reveal the incompleteness of old methods of explaining known facts. These difficulties are most distinct in the so-called problem situations, when the existing scientific knowledge is insufficient for addressing new tasks of knowledge.

For this purpose, there were conducted collection and subsequent analysis of the results of research and development of Russian and foreign scientists, developers, and inventors. The collection of materials was based on the fact that the active search for methods of technical modernization of the agro-industrial complex and the food industry, equipping them with modern machines, mechanisms, mastering progressive processes is carried out by numerous scientific, research and development organizations, universities and enterprises.

The tasks of intensive exchange of knowledge and competencies, building of new knowledge and competencies require large-scale access to scientific and technical information databases and, in particular, to Russian and foreign patents databases. Since it is the

Federal Institute for Industrial Property (FIPS) that issues the documents confirming copyright and registers intellectual property in Russia, and since its database contains the most complete and reliable information, the FIPS information retrieval system was used during the patent search among documents of law enforcement nature registered in Russia. The database of the European Patent Office was used during the patent search for foreign patents.

The research is based on the methodology of scientific, technical and patent search and scientific analysis of the information database. During the search, there was awareness of its completeness and quality completely being depended on the correctness of the search terms (keywords, scope of use, authors and patent holders, classification symbols, etc.), due to which the correct formulation of the search problem and careful study of its regulations is a very important stage in this work. The analysis of scientific publications was focused on identifying their promising areas of research in the field of transportation of food raw materials and food products by tractors and road vehicles.

Particular attention is paid to the analysis of patentable technological and technical solutions, as they are tested for scientific novelty during patenting and successfully reflect the state and development trends of improved or newly created objects of technology in various areas of the economy.

IV. RESULTS AND DISCUSSION

Kuftinova (2011), who was engaged in optimization and logistics of food products transportation, highlighted the problem of management and planning of transportation of finished products and proposed to improve its efficiency through the creation of methods, algorithms and software simulating tools for automation using the simulation modelling process.

The studies of Tyurin (2010) emphasize the need for aligning transport, production and warehouse cycles in order to minimize the logistics costs of product promotion and reduce the stock levels in the supply chain stages. Other works of the author feature the peculiarities of functioning of the enterprises of the food industry and their transport service.

Napkhonenko (1984) considered the issues of transportation of perishable food products from the economic perspective and noted the special role of road transport, highlighting the problems associated with perishable products transportation. To solve the problem, the author proposed to improve the efficiency and quality of road transportation of vegetables on the basis of a systematic approach to improving the technology and organization of transport management and the development of appropriate techniques.

Gutte in his work (1999) proposed the improvement of technological process of biomass yield transportation to a stationary threshing station, as well as the definition of an efficient frontier of industrial and combine technology application for its rational combination.



Marinin's studies (1992) highlighted the problem of crop (grain) loss at all stages of its production, especially during the harvesting. Basing on the analysis, the author proposed to improve the efficiency of harvesting grain crops with its stationary threshing on the basis of improving the transportation process and the use of heavy self-loading stack-mover.

The work of Rakhatov (1992) observed the problems related to the rice cultivation, harvesting, transportation and purification of crops (60% of total costs), the problem is exacerbated by the limited biological maturing term of rice and high degree of lodging. The author proposed to increase the efficiency of rice harvesting by optimizing the entire technological process, including selection, transportation to threshing-floor, as well as purification and transportation to the grain elevator. Similar issues were examined in the work of Makulova and Mukhametzhanova (2012), where the economic and mathematical model of food products transportation in the production complex "field – preparation – processing – market" is presented.

Yesina's studies (2016), in order to improve the efficiency of the use of road vehicles in the grain transportation, proposed the optimization of the road vehicles' combination, capacity and reduce their harmful environmental impact.

Many studies addressed the issues of preserving the quality of milk and its transportation. In particular, the problem of preserving the quality of raw milk, which depends on the conditions of primary treatment, on the cooling method, conditions and duration of storage and transportation, is highlighted in the work of Ponikarova (1983). The author proposed to develop an optimal scheme for storage and transportation depending on the radius of delivery and milk quality parameters.

The problems of logistics system of grain transportation are considered in the work of Delz (2012). It indicated that the infrastructure restrictions and logistics costs, the lack of guarantees on delivery time restrain the implementation of the export grain potential of the country. Based on the analysis, the author proposed to increase the availability of production, consumption and export of grain by means of modern facilities for its storage and transshipment, as well as to increase the capacity of the logistics chain through the construction, reconstruction and technical re-equipment of agricultural and port elevators – terminals.

The study of Zhang, Sun and Li (1994) was focused on a method for the rapid determination of the overall heat transfer coefficient K of refrigerated and insulated vehicles. Having calculated the temperature distribution in the insulation wall using the finitedifference method, the following parameters were obtained: the heat inertness coefficient and the conversion ratio. Based on these parameters, a new formula for calculating the K -value was developed. The results show that the time required for the new method is less than the time required by other fast methods, whereas the precision is much higher. Compared to the steady-state method, the error is within a limit of 5%. This new method is particularly suitable for vehicles quality control in production runs.

Transportation of perishable goods is crucial and poses a number of challenges in the refrigeration supply

chain and logistics operations. A specific task that has to be solved is the strict control over the transportation conditions. Here we should consider the models of logistics decision-making related to the refrigeration supply chain of perishable products. The decision-making process is performed in the cloud by using temporary virtual machines (VMs) related to each shipment or series of shipments. VMs make operational decisions based on an assessment of the actual conditions of transportation and location of the shipped products in compliance with the requirements and original geographical location of the wholesale warehouses. The physical part of the logistics cyber-physical monitoring and management system is represented by integrated RFID-WSN sensors attached to the goods and readers checkpoints distributed along the transportation routes. Models proposed by S. Mejjouli and R. F. Babiceanu consider two types of decisions: stopping of transportation and / or cargo rerouting to a closer location. The implementation of optimization models for an actual case study, which observes the supply of fresh products across the continental United States, shows significant savings obtained in case if producers or third-party logistics companies adopt this methodology (Mejjouli, & Babiceanu, 2018).

As shown in the work of Tassou, De-Lille and Ge(2009) during the transportation of food products, refrigerating is at the forefront, because it provides: a) maintaining the temperature integrity of the transported products; b) impact on energy consumption; c) impact on CO₂ emissions. Emissions of greenhouse gas from conventionaldiesel engine driven vapor compression refrigeration systems can reach 40 % of the greenhouse gas emissions from the vehicle's engine. For articulated vehicles with a capacity of more than 33 tons, which account for more than 80% of refrigerated food transportation in the UK, the amount of reject heat generated by the engine is sufficient to drive sorption refrigeration systems and meet most of the vehicle refrigeration requirements. For CO₂ emissions reduction, more perspective isthe refrigeration system with an air cycle or hybrid systems in which conventional refrigeration technologiesare integrated with the thermal energy storage. In multi-compartment vehicles, the refrigeration space is divided into compartments with individual temperature values. Different temperature in each compartment is achieved by means of a distributed evaporation coil powered by a single condenser.

Refrigerated transport, that for a long time was considered a weak link in the chain, has shown its ability to bind all elements of the refrigeration chain. The fleet with more than four million refrigerators, trailers and vans is constantly growing and improving, facing challenging of performance, sustainability and continuity. But even having the best equipment, users play an important role in the overall performance of the refrigeration chain. Their first requirement is to choose the right equipment for the right purpose. Then they need to maintain it for optimal performance, and finally they need to follow best practice when using their equipment to ensure a safe and efficient refrigeration chain for the consumer (Cavalier G., 2017).



In the work of Novaes and colleagues (2015) it is shown that the temperature of the refrigerated products in the distribution process must be maintained within close limits to ensure an optimal level of food safety and high quality of the product. Temperature variability correlates with the time it takes for the refrigeration unit to recover from cargo unloading due to cargo discharging process. A method of vehicles routing optimization used in the traditional problems of goods distribution, as a rule, is based on Travelling Salesman Problem aimed at minimizing travelled distance or time. The thermal quality of routing alternatives is assessed in this analysis using process capability indices (PCI). The authors have developed an algorithm in order to obtain the optimal solution, which looks for the minimum travelling distance of the vehicle, but respecting level of quality expressed by the required minimum value of PCI.

In work made by Ge, Tassou and Chaer (2009), the model of ammonia-water absorption refrigeration system is proposed. The model was validated with experimental results over a range of the chilled water flow temperature and the ambient temperature. Together with the heat input to generator, these are the main parameters affecting the performance of the system. Some significant results can be obtained by simulation using a validated model, which can help to better understand the performance of the absorption system.

When using road vehicles for transportation, there is a need to ensure that vehicle transporting food was not previously used for the transportation of chemicals and other non-food substances. A sanitary card is required for a vehicle used food transportation, it should be updated at least every 6 months. The driver must have a sanitary book, which contains information about the medical examination. The driver must perform a complete vehicle body wash and disinfection in compliance with standards of water temperature and cleaning agents used (before and after transportation). It is necessary to meet special temperature requirements during the transportation. Upon completion of the food loading, the body doors must be sealed. At the same time, it is impossible to ignore the issue of increasing epidemiological safety in cities through compliance with the existing requirements of sanitary treatment of vans for food transportation. In the work of Rybin (2010), a methodology for determining the number of units in sanitation zones and a computer version of this methodology was proposed.

The authors consider it necessary to note that road transportation of food raw materials and food products is preceded by tractor transportation of agricultural products. At the same time, the present state of the transport and technological support of agricultural production requires immediate modernization (Zagarin et al., 2015), that predetermines the need for search and developing promising methods for this modernization.

During the patent information search using patent databases of the Federal Institute for Industrial Property (FIPS), by key phrase "agricultural transport" as at 31.12.2018 was found 83 patents, 23 patent of these are dated from 01.01.2015. Attention should be paid to the one developed by Far Eastern State Agrarian University (DalGAU) titled "Weight transfer unit for steerable axle of wheeled tractor of "MTZ" (patent RU2547323) that

provides increased passability, resistance to rollover, reducing slipping and increasing safety of tractor operation. Far Eastern State Agrarian University (DalGAU) has also proposed an auxiliary device for agricultural tractor – Hydraulic loader of a semi-tractor (patent RU2658753), to increase passability, reduces slipping when operating on slippery roads, off-road and on soils with low bearing capacity. Another invention proposed by DalGAU is a tractor loading clamp of the semi-frame installation (patent RU2655990), ensuring the redistribution of the coupling weight between axles of a wheeled tractor. DalGAU proposed own variant of regulator of trailing weight of semi-framed tractor (patent RU2547294), ensuring, where applicable, increase in tractor passability by the redistribution of the coupling weight from the front axle and semi-frame to rear axle and semi-frame.

Another direction of development of DalGAU is the creation of an auxiliary device of an agricultural tractor – correction and adjustment of the coupling weight of a wheeled tractor of a semi-frame type. For example, corrector of adhesion weight of wheeled tractor of semi-frame type (patent RU2563306). A limiter of vertical movement of the steering axle of a wheeled tractor by DalGAU (patent RU155844) is an auxiliary device installed to limit the vertical movement of the axle in order to increase its floating, speed while performing work, reduce the "bulldozer" falling wheel effect in motion, energy losses and hysteresis changes in the soil layer.

Among the inventions of DalGAU, it is necessary to mention a device for increasing the passability of a wheeled tractor with an additional controlled engine (patent RU155535). This solution increases the passability and speed of the wheeled tractor while reducing its environmental impact on the cultivated soil.

Saratov State Agrarian University named after Vavilov proposed a technical solution for the creation of a radio-controlled electrified transportation unit for agriculture use (patent RU2657156), which contains a wheeled rectangular platform.

Belgorod State Agricultural University named after Gorin suggested hauling-loading device for the trailer (patent RU2559660). Voronezh State Agrarian University named after Emperor Peter the Great (Voronezh GAU) also proposed a hauling-loading device for the trailer in order to improve the towing properties of the tractor when it moves forward or backward (patent RU2632560).

It should be noted that when using the patent base of the Federal Institute for Industrial Property with by key phrase "rural transport" as at 31.12.2018, 113 patents were found, 10 patents of which are dated from 01.01.2015, and only two address the problems associated with the transportation of agricultural products. Among them there is the invention of the Ural Federal University named after the First President of Russia B. N. Yeltsin on the construction related to cargo-handling equipment, cargo transport, preferably for use in agriculture, for example, for transportation of potatoes, vegetables and other cargo in bulk (patent RU158477).

During the period starting from 01.01.2015



to 12.11.2018 no patents by the phrase “grain transportation” were found. But by the key phrase “grain transportation” we found the invention of Novosibirsk State Agrarian University (patent RU158744) – a soft container for the collection and transportation of grain, which allows to improve the performance characteristics through opening of the pneumatic feed inlet and its mechanized closing, as well as maintaining by pneumatic elements of the geometric shape of the container when loaded from the combine in the field. The container has inflatable lifting loops that are sewn to the guide channels, extending along the edge of the loading opening, into which loop cables are inserted, forming lifting loops of a smaller size in the open feed opening. The proposed device of lifting loops provides mechanized closing of the feed opening when loading the container on the vehicle. This method of loading and transportation of the soft container can significantly reduce the dwell time of the vehicle under loading and eliminate dwell time of combines waiting for transport.

When using the patent base of the Federal Institute for Industrial Property with the phrase “transportation of potatoes” as at 31.12.2018, three patents were found. Among them is the above-mentioned design of cargo-handling equipment, preferably for use in agriculture (patent RU158477); block-modular horse-drawn vehicle invented by The All-Russian Scientific Research Institute for Horse Breeding(VNIHK) (patent RU183640) and cargo wagon for transportation of agricultural products (patent RU2048331).

When using the key phrases “transport of agricultural raw materials”, “hauling of agricultural raw materials”, “hauling of vegetables”, “hauling of fruits”, “hauling of fruit railway transport”, “hauling of grain railway transport”, “transportation of fruits”, “grain railway”, “vegetables railway”, “fruit railway” as at 31.12.2018 in the FIPS patent database no patents were found.

Searching in the FIPS patent base, using the key phrase “grain railway” no patents related to the problem were identified.

Using the key phrase “transportation rural” in the FIPS patent base as at 31.12.2018, we found only 40 patents, 9 patents of which starting from 01.01.2015, where two of these nine patents (patent RU154532; patent RU2618306) are related to trailer vehicles used for transportation of animals, and one related to the waterborne wheel-ski trailer-shelter of general purpose (patent RU177382U1), which were patented by private holders. Among them was one patent – “Method of container transportation, drying and storage of seeds and complex for its implementation” (patent RU2644596C1) – patented by OOO “RosAgroTrade”, according to which, during the container transportation to a stationary station for drying, a heap of seeds is actively ventilated with air to ensure the smooth exit of the ventilating air from the container. Other nine patents are not related to methods and devices for transporting agricultural products from fields to stationary stations.

The use of high-production combines at the present time, and, consequently, the reduction of harvesting time requires to dry the seeds and transfer them to a long-term storage warehouse in a fairly short time frame and with minimal losses. Therefore, this area is advanced enough

and develops technological solutions presented in the method of container grain drying with stirring for drying of seeds of premium varieties (patent RU2558663); the method and device for container drying seeds (patent RU2589972); method of container transportation, drying and storage of seeds, mainly from the breeding stations, and device for its implementation (patent RU2558663) patented by Federal Scientific Institution All-Russian Research Institute for Mechanization of Agriculture (VNIIMSKh). In our opinion, these solutions are evolutionary in nature and indicate a sufficient level of a successful solution to the problem of seeds transportation in containers from fields to stationary stations with active air ventilation.

In addition to the considered technological and technical solutions, the solutions patented and corresponding to the key phrase “rural transportation” from 2010 to 01.01.2015 were considered. There were identified 16 such solutions, including the one proposed by Novosibirsk State Agrarian University related to the supporting device of the semitrailer (patent RU128595) for application under the scheme of the negotiable transportation when in the field there is a need to change a trailer in the towing vehicle and the one proposed by VNIIMSKh presented as vehicle for transportation of containers during seeds transportation from the breeding combiners (patent RU119696).

OOO “Belavtomash” developed transport and technological machine for use in agriculture as a tractor or basic agricultural chassis (patent RU136411), that can be used when performing various agricultural and transport works on various soils, particularly on that with low load-bearing capacity, providing the possibility of attaching equipment for sowing, plough, cultivation etc.

Saveliev and Rybinin their study (2016) described the design of the device for the sanitary treatment of road vans with a small-space cargo compartment for the food products transportation, and provided structural diagrams of the device and calculations of its basic geometric dimensions and developed the technological process of sanitation of vans using this device.

As the experience of operation of vehicles in Northern Russia shows, one of the problems faced with a freezing temperature is the spontaneous blocking of the truck wheels due to the freezing of the brake shoe to the brake drums/disks or due to the accidental activation of the brake mechanism of one of the wheels. As a result, there are cases of tires fire. The authors of the article proposed a method for detecting wheel blocking, including the determination of wheel speed by sensors, comparison of wheel speed in the control unit and adding of signal indicator on the control signal of the unit. Rotation speed sensors are installed on the wheels, the average speed of the wheels not including the speed of the individual controlled wheel is calculated in the control unit, their rotation speed is compared with the average speed of the other wheels. A control signal is given from the control unit to activate the signal indicator with respect to the rotation speed of one of the controlled wheels to the average rotation speed of other controlled wheels, equal to the ratio of the radius of the vehicle's



trajectory to the radius of the trajectory of the vehicle's outside wheel when it moves with turning radius that is the minimum acceptable by design and less than this ratio (Shegelman et al., 2018).

The analysis showed that many scientists were focused on the issues of transportation, cargo-handling, processing and disinfection of containers, various requirements for vehicles and their drivers. Special requirements for rolling stock transporting perishable food by road were also developed. At the same time, the optimal volume and delivery time of perishable food products were determined using mathematical modeling methods. The solution to this problem is very important due to the limited time of delivery of perishable food and food raw materials.

The analysis showed that the formation of logistics chains of technological processes and operations in the field of transportation of food raw materials and food products is largely determined by the need to provide the population of country's Northern regions with functional food containing the necessary amount of micronutrients and vitamins for quality nutrition. These chains of technological processes and operations consist of operations of food raw materials transportation from places of cultivation to intermediate warehouses, where a certain amount of food is accumulated and stored, operations of distribution and the organization of deliveries of food raw materials to regions and productions, operations of enrichment with the necessary trace elements and vitamins, as well as delivery from enrichment points to the end consumers of enriched functional agricultural products.

The authors believe, that in the cross-cutting technology, transportation operations are a key element not only in agro-industrial complexes and food production, but also in forest industries, as was revealed during the research (Voronin, 2012; Sushkov, Burmistrova, & Pilnik 2015; Shegelman, 2013).

The common feature is the presence of multi-level geographically-distributed transport and production systems that function effectively with a scientifically-based combination of technological operations and the use of machines and equipment complexes in cross-cutting technologies. This problem is particularly urgent for the Northern regions of Russia, where transport operates on large areas, with geographically-distributed producers and consumers of production. This results in the formation of models, methods and algorithms of integrated planning and management of material flows in the agro-industrial complex and the forest industry, some of which are presented in the works of A. V. Voronin, O. N. Burmistrova, S. I. Sushkova, I. R. Shegelman.

The processes of formation of import-substituting cross-cutting technologies of preparation, transportation of agricultural raw materials and subsequent use for production at enterprises located in the Northern Russia, competitive in foreign and domestic markets of functional food products along with the development of agro-industrial complex in the regions of the European North are the most important factors for improvement of food security of the population living in these regions and are essential for providing this population with the required amount of high-quality functional food products

(Shegelman, Vasiliev, & Shchukin, 2018a; 2018b). Land transport with use of road vehicles and tractors plays an important role in the operations of these cross-cutting technologies. Knowledge building is essential for improvement of processes of transportation of food raw materials and food products by tractors and road vehicles. The knowledge base built upon the mentioned researches can be used for the choice and synthesis of new solutions focused on improvement of processes of tractors and vehicles transportation of food raw materials and food products.

V. CONCLUSION

The problem of ensuring effective management of the system of transportation of agricultural products is of great importance and requires scientific understanding and practical solutions. Modern agriculture is one of the richest sectors of transportation in the economy. The operation of agricultural transport has distinctive characteristics owing to strong seasonal fluctuations in scope of work, large amount of loads and safety requirements, the need for processing and storage of agricultural products, the distribution of transport, challenging route conditions, terms close to the main agricultural work. In the transportation of agricultural products, the main means of transportation is a car, which accounts for up to 85 % of the transportation load. Share of tractor equipment in the transportation of goods is about 13 %. Despite a large number of cars, there is a huge loss of products.

The food raw materials transportation from the cultivation areas is implemented largely by road vehicles, as other types of transport are not available. Thereafter, the food products and food raw materials are accumulated in special storage areas that meet the relevant storage standards and requirements. These storage areas are commonly located near rail loading facilities where food products and food raw materials are loaded to wagons and delivered either to the enrichment points or to the end consumer. From the above it follows that railway transport is the main means of food raw materials transportation, which has its own deficiencies described above.

It was revealed, that in the cross-cutting technology, transportation operations are a key element not only in agro-industrial complexes and food production, but also in forest industries. The common feature is the presence of multi-level geographically-distributed transport and production systems that function effectively with a scientifically-based combination of technological operations and the use of machines and equipment complexes in cross-cutting technologies. This problem is particularly urgent for the Northern regions of Russia, where transport operates on large areas, with geographically-distributed producers and consumers of production, whereas the quality of transport network of these areas, reasonable selection of transport facilities and use of simulation and optimization tools for the control over the transportation flows play a key role.

On the basis of the analysis and knowledge



building it can be stated that the following avenues of improvement in the field of processes of food raw materials and food products transportation by means of tractors and road vehicles can be distinguished:

- improvement of technological processes and technical means for transportation of food raw materials and food products to foreign and domestic markets, including technological operations, machinery and equipment for transportation of perishable food products by tractors and road vehicles;
- justification of optimal logistics of cross-cutting supply of perishable and non-perishable products for geographically-distributed producers and consumers of food raw materials and food products;
- improvement of special thermally insulated or refrigeration containers mounted on the basis of truck trailers and large-capacity refrigeration containers, as well as technologies that combine the transportation of refrigeration containers by road and railway (water) transport into a single technological process;
- development of recommendations for reducing transport costs for the transportation of food raw materials and food products by tractors and road vehicles;
- formation of cross-cutting technological processes of preparation, transportation and processing of food raw materials to provide the population of the Northern regions with functional food products;
- reduction of food raw materials and food products losses during transportation, as well as the elimination of spoilage of perishable products and their mechanical damage during handling and transport operations;
- the improvement of tractors and their technology use in food raw materials haul to increase passability, resistance to rollover, reducing slipping and increasing the safety of operating tractors, the redistribution of the coupling weight from the front axle and semi-frame to rear axle and semi-frame, correction and adjustment of the coupling weight of a wheeled tractor of a semi-frame type;
- improvement of container transportation, drying and storage of seeds, mainly from the breeding stations;
- formation of models, methods and algorithms of integrated planning and management of cross-cutting material flows of food raw materials and food products in the multi-level geographically-distributed transport and production systems;
- improvement of all elements of the refrigeration chain of refrigerated road vehicles;
- elimination of spontaneous blocking of the truck wheels due to the freezing of the brake shoe to the brake drums/disks during the winter period or as a result accidental activation of the brake mechanism of one of the wheels caused by the failure of the brake control or failure of the wheel hub bearing.

The knowledge base built upon the conducted researches can further be developed on the methodical approach stated in work and can be used for the choice and synthesis of new solutions related to improvement of processes and objects of equipment for transportation of food raw materials and food products by tractors and road vehicles. This knowledge base is of high importance both

for agro-industrial complexes, food production and for timber industries.

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