Technological-logistic models of the integrated production structure

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Abstract. The article is devoted to the formation of a technological-logistic model of the integrated structure of food production. The main goal of corporate structure management is the integration of all its constituent units for the fulfillment of the mission, which ensures achievement of the set goals. The main purpose of modeling is to show how the intermediate links-enterprises are logically formed the target object. A mathematical formulation of the problem of choosing optimal capacities and rational location of enterprises, as well as minimum costs for transportation of raw materials, is proposed. A complex mathematical model for planning the production of agricultural raw materials and processing it into ready-made food products in the system "agricultural sector - provision / primary processing - food industry enterprises" was formed. Models of the logistic organization of integrated food production are based on the principles of rational organization of the technological chain and are characterized by: complexity, universality, differentiation of the approach; specialization. The developed mathematical models allow planning and programming of the development processes of the integrated food production system, assessing the impact of changes in the parameters of the system, and adjusting plans. With the help of Statgraphics, Statistica, Excel software and having as a basis an array of enterprise data, it is possible to plan and program the development processes of an integrated food production system, assess the impact of changes in system parameters, make adjustments to plans. The models make it possible to specify the technological complex of work and the need for raw materials, provide an opportunity to establish boundaries between complexes of works of individual companies and, in general, the responsibility of the entire corporate structure.

Keywords: logistic model, food industry, agrarian sector, integrated production, economic-mathematical modeling

1. Introduction

Enterprises of the food industry are the basis for the development of the Ukrainian economy. The food industry is one of the few branches of the national economy, which is in the stage of steady development. However, the raw material base of food production – the agricultural sector of Ukraine today is in a crisis condition, characterized by a decline in the material and technical base, high costs of production, shortage of working capital. The problem of price discrepancies between the agrarian and processing sectors of the food-processing industry remains unresolved. Not least role in shaping this situation is played by the severance of industrial and economic ties between agrarian and processing industries. The low level of organization of the industry leads to the fact that there is no clear mechanism of interaction between the technological links of production, between suppliers and consumers. In conditions of underdevelopment of market infrastructure, the companies independently find partners, links with which, as a rule, are not stable, which leads to the spontaneity of the processes of supply of raw materials, semi-finished products and sales of finished products.

The organizational and technological system of the food industry needs to be formed consciously, differentiating approached to the volumes and quality of raw materials of plant and animal origin in order to achieve the harmony of the raw material base with the existing processing industry, in view of its further development. The development strategy should be aimed at the formation of a single, dynamically developing complex, which will provide today and in the future the production of competitive products in the natural, climatic and geographical conditions of Ukraine.

Objective laws of economic development necessitate the interconnected development of the food industry and the raw material base on the basis of strengthening the economic ties between industrial and agricultural enterprises on the basis of their industrial integration, the formation of new organizational forms of integration that will increase the overall efficiency of the production chain and decrease costs at all stages of the technological chain.

The main ideas in developing the strategic vision and mission of the future food industry and its raw material base are defined as the cooperation of production for the joint use of production capacities, joint research, the exchange and harmonization of technological processes, the promotion of products market created by joint efforts. Such formations will achieve a synergistic effect, strengthen the combined capabilities of all branches of production in the creation of competitive technologies and entry into commodity markets inside and outside the country. This vision also defines the mission of future production.

At the same time, the main pressure should be on: the revival or the creation of insufficient parts of the torn technological chains (vertical integration); the formation of a flexible assortment policy (diversification); support and expansion of investment activity.

Measures to implement integrated development strategy should be scientifically sound and rely on mathematical models of processes that will take place in a new production system.

Technological peculiarities of the production of agrarian products, as well as the complexity of the processes of its harvesting, accumulation and, if necessary, primary processing, processing into finished products, make a relevant mathematical modeling of the planning of production of raw materials, taking into account possible changes in production volumes. The purpose of the article is to study the technological and logistical side of the rational organization of the integrated complex of enterprises "agriculture - procurement organizations - enterprises of the food industry". The objectives of the paper are: the identification of production, economic and transport factors of the interaction of production in the technological chain of food production and the mathematical formulation of the task of choosing the optimal capacities and rational allocation of the integrated production complex enterprises, as well as the minimum costs for the transportation of raw materials.

2. Related works

It should be noted that the issue of the placement of specialized agricultural enterprises and the transportation of products produced by agrarian enterprises has been given attention in the literature since the 60s of the last century [1]. Since the Soviet times, calculations of the indicators of plans for the placement of agricultural crops, as well as the justification of the most profitable types of specialization for each farm are known. In works by A. A. Alimov [2], Mikhalevich VS [3], Sitnik V.F. [4] explores the issues of optimization of technological processes, production placement, transport of production stages. However, in the works of the above authors, only the methodological basis for the study of technological and logistic chains of food production is laid. Today it is necessary to rethink these principles in the light of the realities of a market economy.

In later works, such as the works of Butnik O.M. [5] and Chepurko V.V. [6], developed a model of processes of agrarian and processing industries, taking into account their specificity, which was manifested in the era of market transformation of the economy. Their work has still not lost its relevance, however, the food industry in its development has even departed from the planned model. Inter-farm relations were reformed, which significantly influenced the adequacy of previously developed models.

The issue of solving problems of optimization of processes in agrarian and processing sectors of the economy of Ukraine and today are at the center of attention.

So in the works of Brodsky Yu.B. [7], Babenko V.O. and Vitlinsky V.V. [8, 9], Nakonechny SI [10] shows the economic and mathematical functioning of agrarian enterprises, in particular models of production structure, innovation processes, technical and economic processes. These models have a high level of reliability, however, they cover only the primary link in the technological and logistic chain of food production.

Separately allocated works related to the simulation and optimization of logistics processes in the industry, such as scientific works Borbot Y. [11] and Naumova L.M. [12].

It should be emphasized that market requirements today require the formation of a complex integrated system of agro-industrial food production, which will enable to realize the reserves of competitiveness of the industry. Consequently, it is necessary to approach the modeling of technological and logistic processes in a complex way, as is noted in the work of Grishovoyi I.Yu. [13] and Naumovoyi LM [14].

The necessity of mathematical modeling of the planning of the enterprises of the food industry and its raw material base is caused first of all by the possibility in this case of more rational use of available resources and optimization of commodity-cash flows [15].

Taking into account that the question of modeling the optimal development of the food production complex remains open, we will try to propose an own view on its solution in this paper.

3. Research methods

The tasks of logistic management of commodity flows in order to minimize costs and maximize profits in the food production system is a complex methodological task, as the technological chain of food production involves a large number of actors that enter into interaction. Consequently, it is necessary to take into account the whole set of participants in production and to coordinate their numerous interactions, taking into account their functional features of their organization and the technology of the work. The main criteria and factors that determine the effectiveness of management of the technological and logistic system of food production are: technical and technological parameters, the state of equipment, qualitative indices of raw materials, qualitative indicators of technological processes, the level of organization of production, etc.

To solve this problem we used the instrumental apparatus of mathematical modeling, namely - setting up an optimization problem Z-type with a system of constraints, which allows the most adequately describe the investigated technological and logistic system. Two mathematical models were developed during the study:

1.The model of the vertical integrated association, which aims to find the best option for a combination of productions in terms of capacity and assortment. The criterion for the model is the size of profit in the integrated food production system. Model constraints: raw materials; production capacity; coherence of capacities; specific conditions of production technology.

2. Model of optimization of capacities of production units and minimization of expenses for transportation of raw materials. Limitations of the model are the volumes of raw material production, the quantities of raw materials delivered between the stages of the technological process and the volume of raw materials transported between all the links of the production-technological chain.

Since the main objective of the food production system is to generate profits, the initial methodological position of the simulation is the requirement for the exact reaction of the system to managerial influence. That is, at all stages of the technological chain must meet the requirement of optimizing the ratio of cost / profit. The system should strive to get close to the ideal state of operation, which will ensure the economy of resources and maximize returns.

For the practical use of models, the formation of an appropriate information environment is required by monitoring and accumulating the statistical base of parameters that characterize the use of resources, costs, production and logistics and transport and logistics flows.

4. Results of the research and their discussion

When forming the strategy, all stages of corporate structure management are considered, taking into account the limiting parameters. The main objective of the corporate structure management is the integration of all units of the structure to fulfill the mission, which ensures achievement of the set goals. The main purpose of simulation is to show how intermediate links-enterprises logically build up, forming a target object.

The specificity of integrated food production is the existence of direct economic ties between suppliers of agrarian raw materials and consumers at the subsequent technological stages of its processing. This provides the opportunity for the agrarian sector to develop as the weakest link in the technological chain of food production in accordance with the parameters given by food businesses.

The internal structure of integrated production depends on the level of development of enterprises involved in the complex, their revenues and volumes of production. These relationships reflect the relationships between the complex and the interests of the industries that are part of its operating system, which in the future can determine the path of development in a joint activity or transformation into other organizational structures.

In order to assess the reserves and opportunities for the development of integrated organizational structures, it is necessary to scrutinize the internal and external economic relations according to the components:

I. Production of agricultural raw materials of plant and animal origin. These connections are due to the territorial location and specificity of the land as an object of management. Agrarian production determines rational ways of using agricultural land as the main means of labor, which is reflected in the development of the system of crop rotation, in the specialization of agricultural processes, in the decision to integrate on a partnership basis.

At the initial stage, agrarian units can create territorial (regional) agro-industrial complexes "agriculture - harvesting and primary processing". Inter-regional links in the technological chain will be conditioned by the objective process of the technology of food production of a particular type.

At the next stages, opportunities for wider geographic expansion are being sought. It occurs in a logical sequence, that is, "state level – international level". The size of the integrated production system and its sphere of influence can be determined by the external and internal factors created: competition, lack of resources, inappropriate market development, and others.

II. Harvesting, primary processing and sale of raw materials. Links on harvesting, storage, primary processing and sale of raw materials, as well as waste processing can be established at the level of the region or neighboring regions, which reduces transport costs. The proximity of suppliers and consumers provides a quick response that allows you to achieve high quality raw materials. Improvement of territorial-production relations between suppliers and consumers of raw materials will target agrarian producers of all forms of ownership to increase production volumes. Preparatory organizations should not engage in plant growing, feed production and animal fattening, their task is to form a portfolio of orders from raw materials to final processing.

III. Food production. These connections are caused by the specifics of food production and are formed depending on the volumes of production and the range of products. Nutrition companies have a complex economic and production structure that consumes a large number of raw materials, capital and labor resources, and markets many types of products on the consumer markets. The wide assortment of these products determines the necessity of creating a network of connections for production and sales.

IV. Transport service, repair base, power, water, heat supply, sewage treatment, etc. The industrial base of agrarian production is being formed, the development of processing in agrarian enterprises expands the capacity of agricultural units, which is associated with the development of infrastructure of a new form of production organization.

All elements of the infrastructure must be formed in accordance with the needs and capabilities of the main production. The same principle should be used when creating service farms.

In general, integrated production should be such that the connections that provide it enable the fullest use of all consolidated capacities. To optimize the structure of an integrated production system, it is necessary to express in a quantitative mathematical formulation a certain criterion of optimality. This criterion can serve as a profit indicator. Moreover, subject to the existing restrictions, total profit should not be maximally possible, but sufficient for the stable functioning of the whole system in the long run. The model provides for the optimal plan for production output by enterprises incorporated in the integrated association.

The rhythmically working association should have the combined (coordinated) capacity of the enterprises that are part of it and the agreed range of output. To ensure development, it is necessary to generate a sufficient profit. Consequently, for the implementation of the model of the vertical integrated association, the solution of the problem of the following type is required at different variants of the combination of production by capacity and assortment:

$$\sum_{i=1}\sum_{j=1} C_{ij} * O_{ij} * x_{ij} \to \max , \quad \sum_{j=1}^{M_i} x_{ij} \le 1 ; \quad x_{ij} \in \{0,1\} , \qquad (1)$$

where xij - coefficient of correction of the intensity of j-th technological production of i-type products;

Cij - cost per unit of production i in j-variant combination of production;

Oij - j-version of production of i-products with restrictions:

I. In agrarian organizations:

$$\sum_{j=1}^{m} O_{ij1} * x_{ij} - \sum_{i=2}^{m}\sum_{j=1}^{mi} Hp_{ij1} * O_{ij1} * x_{ij} \ge S_{\min} , \qquad (2)$$

where Oij1 - j-variant of production of agricultural raw materials;

Hpij1 - the norm of expenses for the development of a unit of agricultural raw materials (fertilizers, sowing material, feed and other types of expenses);

Smin is the minimum compensation stock.

II. In procurement organizations and enterprises of primary processing of raw materials:

$$\sum_{i=1}^{k}\sum_{j=1}^{Ni} E_{j2} * O_{i\,j2} * x_{i\,j} - \sum_{i=1}^{k}\sum_{j=1}^{Ni} P_{j2} * O_{i\,j2} * x_{i\,j} \geq S_{\min} \quad , \qquad (3)$$

where Ej2 - output of processed raw materials per unit of raw material;

Pj2 - norm of consumption of raw materials per unit of processed raw materials;

Oij2 - j-version of primary processing of raw materials.

III In the food industry

$$\sum_{i=1}^{n}\sum_{j=1}^{Mi} E_{j3} * O_{i\,j3} * x_{i\,j} - \sum_{i=1}^{n}\sum_{j=1}^{Mi} P_{j3} * O_{i\,j3} * x_{i\,j} \geq S_{\min} \quad :, \qquad (4)$$

where Ej3 - output of finished products per unit of raw material, which has undergone primary processing;

Pj3 - the rate of consumption of raw materials that has undergone primary processing, per unit of finished products.

$$\sum_{i=1}^{n}\sum_{j=1}^{Mi} k_{ij} * O_{i\,j} * x_{i\,j} \leq K \quad , \qquad (5)$$

where kij - capital investments or expenses of other resources per unit of i-type products in the j-version;

Oij - total production of and-finished products in the j-version;

K - total volume of capital investments of the whole integrated system.

This model considers the whole interconnected set of productions - from growing primary raw materials to the production of finished products. Similar tasks belong to the class of tasks of linear integer programming [16].

However, this model can not fully characterize an integrated system due to a number of restrictions on its use. These restrictions arise from the impossibility of obtaining reliable data for the calculation in the current economic conditions. The following model, which is a logical continuation of the previous one, does not have such restrictions.

When optimizing the structure of integrated production it is necessary to take into account the limitations:

- on the use of natural resources (crops, pasture, forage lands, labor resources, fertilizers, etc.);
- for feed resources in livestock production;
- on the use of specific capacities of raw material processing, procurement and storage;
- in the system of providing a proportional relationship between production;
- specific conditions of plant growing, livestock breeding, storage, primary processing and food production;
- information (a single level of processing and analysis of production and financial and economic indicators is necessary).

The solution of the task of linking production in the complex involves the development and analysis of numerous variants of technological methods of production and their economic provision.

As you know, the main technological chain of food production is as follows: agricultural production → harvesting and primary processing → enterprise of the food industry. In the complex of integrated production, a number of small agricultural enterprises, several harvesting organizations and / or primary processing enterprises, one or several enterprises of the food industry are connected. All of them are, as a rule, geographically located in one region or neighboring regions of Ukraine - in the zone of growing of raw materials.

Since each enterprise of the next stage is a consumer of raw materials or semi-finished products produced by enterprises of the previous stages, the desired quantities can be represented in homogeneous units of measurement by means of conversion into a single conditional product.

To construct a mathematical model for planning the production and processing of raw materials, we introduce the following notation:

k is one of the plurality (1,2,3, ..., k, ..., l) of agricultural enterprises producing agrarian raw materials and supplying it to procurement organizations and / or primary processing enterprises;

j is one of the plural (1,2,3, ..., j, ..., n) type of raw material produced by the kth agricultural enterprise;

i is one of the plurality (1,2,3, ..., i, ..., r) of procurement organizations and / or primary processing enterprises;

m is one of the plural (1,2,3, ..., m, ..., p) enterprises of the food industry, which produces the final product;

τ - one of the plural (1,2,3, ..., τ, ..., t) years of the planned period of development of food production;

Cjk - production costs of the unit of raw material of the j-th species in the k-th agricultural enterprise;

C * jk - costs related to the expansion of the sown area / livestock to obtain an additional unit of raw material of the j-th species in the k-th agricultural enterprise;

Cjki - expenses for processing of the unit of volume of raw material of the j type, received from the k-th agricultural enterprise at the i-th enterprise of primary processing;

Sjki - transportation costs per unit of raw material of j-th type from k-th agricultural enterprise to i-th enterprise of primary processing and / or procurement organization;

Sjim - transportation costs per unit of raw material j-th type from the i-th primary processing enterprise and / or procurement organization to the m-e enterprise of the food industry;

νj - the largest volume of raw materials of the j-th type, which should be developed by all l agricultural enterprises;

Vj - the largest volume of j-th type raw material, which can be taken for processing from all l agricultural enterprises all r of the enterprise of primary processing;

Wj - the largest volume of j-th type raw material, which can be taken for processing by all r of procurement organizations and / or enterprises of primary processing all p enterprises of the food industry;

xjk - the desired amount of raw material of the j-th species, which should be developed in the k-th agricultural enterprise;

x * jk - the required additional amount of j-th type raw material to be produced in the k-th agricultural enterprise;

xjki is the desired amount of j-th type raw material delivered from the k-th agricultural enterprise to the i-th primary processing enterprise and / or procurement organization;

xjim - the required volume of j-th type raw material, delivered from the i-th enterprise of primary processing and / or procurement organization to the m-th enterprise of the food-processing industry;

Gojk - quantity (in units of measurement) of j-th type raw material at k-th agricultural enterprise;

Gnji - the need (in units of measurement) of j-th type raw material at the i-th enterprise of primary processing and / or stockpiling organization;

Goji - the quantity (in units of measurement) of j-th type raw material at the i-th enterprise of primary processing and / or procurement organization;

Gnjm - demand (in units of measurement) of raw material of the j-th type at the m-th enterprise of the food-processing industry;

The mathematical model of the optimal development of the food production complex consists of the objective function F (x), which expresses the general minimum expected costs of growing the raw material, its harvesting and primary processing and transportation of products:

$$F(x)=\sum_{j=1}^{n}\sum_{k=1}^{l}C_{jk}x_{jk}+\sum_{j=1}^{n}\sum_{k=1}^{l}C^{*}_{jk}x^{*}_{jk}+\sum_{j=1}^{n}\sum_{k=1}^{l}\sum_{i=1}^{r}S_{jki}x_{jki}+\sum_{j=1}^{n}\sum_{k=1}^{l}\sum_{i=1}^{r}C_{jki}x_{jki}+\sum_{j=1}^{n}\sum_{i=1}^{r}\sum_{m=1}^{p}S_{jim}x_{jim}$$

$\rightarrow$min, (6)

with restrictions:

1. The gross output of j-type raw material by all l agricultural enterprises must be agreed in advance with all enterprises of primary processing and / or procurement organizations:

$$\sum_{k=1}^{l}(x_{jk}+x^{*}_{jk})\le v_j; \qquad (7)$$

2. The total volume of deliveries of raw materials of the j-th type to all l agricultural enterprises should not exaggerate the possibilities of its processing by all enterprises of primary processing:

$$\sum_{k=1}^{l}\sum_{i=1}^{r}x_{jki}\le V_j; \qquad (8)$$

3. The total volume of supplies of j-type raw materials by all enterprises of primary processing and / or procurement organizations should not exaggerate the possibilities for its processing by all enterprises of the food industry:

$$\sum_{i=1}^{r}\sum_{m=1}^{p}x_{jim}\le W_j; \qquad (9)$$

In this case, to perform compatibility of the conditions of the problem, it is necessary that there are fair inequalities:

$$\nu_j \le V_j \le W_j. \qquad (10)$$

In the set task the criterion of optimality is taken the minimum of production and transport costs. With the closed model of the transport task to the specified restrictions, the following is added:

4. The gross volume of j-type consignments shipped from all l agricultural enterprises should correspond to the total demand for these cargoes at the destination points of each of the r enterprises of primary processing and / or procurement organizations:

$$\sum_{j=1}^{n}\sum_{i=1}^{r} x_{jki} = G^{o}{}_{jk}; \qquad (11)$$

$$\sum_{j=1}^{n}\sum_{k=1}^{l} x_{jki} = G^{н}{}_{ji}; \qquad (12)$$

$$\sum_{k=1}^{l} G^{o}{}_{jk} = \sum_{i=1}^{r} G^{н}{}_{ji}. \qquad (13)$$

The same value should occur when sending materials to the food industry:

$$\sum_{j=1}^{n}\sum_{m=1}^{p} x_{jim} = G^{o}{}_{ji}; \qquad (14)$$

$$\sum_{j=1}^{n}\sum_{i=1}^{r} x_{jim} = G^{н}{}_{jm}; \qquad (15)$$

$$\sum_{i=1}^{r} G^{o}{}_{ji} = \sum_{m=1}^{p} G^{н}{}_{jm}. \qquad (16)$$

If the problem under consideration is to be formulated in a dynamic statement, then the mathematical model to be derived should be classified in a particular year, which we accept for the first (τ = 1) in the planned period t. In this case, the target function Z (x, τ) takes the form:

$$Z(x,\tau) = \sum_{\tau=1}^{t} F_{\tau}(x) \rightarrow \min, \qquad (17)$$

where Fτ (x) means that the parameter τ is present as an additional index for all parameters and variables of the function F (x).

Since the dynamical model implies the need to increase the production plan with each passing year, the relationship must be fulfilled:

$$0 \le x_{jk\tau} \le x_{jk(\tau+1)},$$
$$0 \le x_{jki\tau} \le x_{jki(\tau+1)},$$
$$0 \le x_{jim\tau} \le x_{jim(\tau+1)}. \qquad (18)$$

The offered mathematical model allows to carry out planning and programming of processes of development of the new integrated food production system, to estimate influence of changes in system parameters and to make adjustments of plans. Since the study of the management of integrated food production only on the basis of the cost index and the process of its inconsistency does not allow to fully assess the applicability of the proposed model of management, it is also necessary to estimate the link of cost deviations and the effect of reducing the inconsistency.

The output data for calculating the optimal amount of raw materials for production and processing are given in the table 1.

Table 1. The output data for calculating the optimal amount of raw materials

The raw material base								
Farms	**Area under crops, ha**	**Crop capacity, t/ha**	**Available amount of raw materials, t**	**Distribution of raw materials (G_{0jk}), t**		**Unit production costs (C_{jk}), uah/t**	**Transportation costs (S_{jki}), UAH/t**	
				Kherson	**Nash Product**		**Kherson**	**Nash Product**
1. Chaika	10	70	700	700	-	7000	30	35
2. Lotos	27	60	1620	800	-	6000	25	30
3. Ukraine	20	55	1100	500	-	5000	20	25
4. Druhba	50	40	2000	-	2000	5000	30	24
5. Ahrkom	35	30	1050	-	1000	4000	20	15

Primary processing				
Processing enterprises	**Need for raw materials (G_{Hjk}), t**	**Output products, t**	**Unit production costs (C_{ji}), UAH/t**	**Costs of transportation to the food business (S_{jim}), UAH/t**
1. Kherson	2000	350	11000	15
2. Nash product	3000	500	10000	25

Production of finished products				
Enterprises	**Volume of consumed raw materials (G_{Hjm}), t**	**Unit production costs ((C_{jim}), UAHt**	**Price of the finished product, UAH/t**	**Total cost F(x), UAH**
1. Pani Kritina	850	5000	40000	39431750

A real system of production of tomato raw materials (tomatoes → tomato paste → ketchup), localized on the territory of Belozersky district of the Kherson region, was selected to test the model.

The system consists of three production steps. The first stage is the raw material base, which is represented by farms (F) “Chaika”, “Lotos”, “Ukraine”, “Druzhba” and “Ahrokom”, which grow tomatoes. The second stage is the primary processing, which is represented by processing enterprises LLC Fruit and Vegetable Plant “Kherson” and PE “Nash Product”, which produce tomato paste. The third stage is the enterprise of the food industry of PICF "Pani Kristina", which produces the final product - ketchup under the trademark "Holiday".

The calculation of the model was made using the SAS Model Manager software. Results of optimization of the model are presented in the table 2.

Table 2. Calculating the optimal amount of raw materials

The raw material base								
Farms	**Area under crops, ha**	**Crop capacity, t/ha**	**Available amount of raw materials, t**	**Distribution of raw materials (G_{0jk}), t**		**Unit production costs (C_{jk}), uah/t**	**Transportation costs (S_{jki}), uah/t**	
				Kherson	**Nash Product**		**Kherson**	**Nash Product**
1. Chaika	10	70	700	-	-	7000	30	35
2. Lotos	27	60	1620	850	-	6000	25	30
3. Ukraine	20	55	1100	1100	-	5000	20	25
4. Druzhba	50	40	2000	50	1950	5000	30	24
5. Ahrokom	35	30	1050	-	1050	4000	20	15

Primary processing				
Processing enterprises	**Need for raw materials ($G_{нjk}$), t**	**Output products, t**	**Unit production costs (C_{ji}), UAH/t**	**Costs of transportation to the food business (S_{jim}), UAH/t**
1. Kherson	2000	350	11000	15
2. Nash Product	3000	500	10000	25

Production of finished products				
Enterprises	**Volume of consumed raw materials ($G_{нjm}$), t**	**Unit production costs ((C_{jim}), UAH/t**	**Price of the finished product, UAH/t**	**Total cost F(x), UAH**
1. Pani Kristina	850	5000	40000	38025050

According to the results of the calculation, optimal volumes of production and supply of raw materials and semi-finished products in the technological chain of production and processing of tomatoes were determined.

In the basic, actually existing (non-optimal) version of production, the total amount of expenses is 39431750 UAH, the optimal amount of expenditures F(x)= 38025050.

The obtained data allow to reduce expenses for production and transportation of products, increase production efficiency. In particular, the cost saving is 1406700 UAH.

According to the results of the calculation, it is possible to recommend "Chaika" to refuse to produce raw materials in favor of other types of products, due to economic impracticability. It is recommended to reduce volumes of tomato crop area for Lotus, and it is advisable to revise programs for the supply of raw materials to processing plants. In particular, the part of raw materials from "Druzhba" should be sent to the processing plant LLC Fruit and Vegetable Complex "Kherson".

5. Conclusions and Outlook

The construction of a cost management system in integrated food production should be based on the principle of feedback, that is, on the needs of food industry enterprises, which are conditioned by the market conditions. The resource management cycle, like the whole system of control of the technological chain, should cover all stages of product creation. The most developed and well-established element of the resource management system is its subsystem at the production stage, where it is possible to clearly establish the conditions for the supply of raw materials, ensuring technological transitions and output products. Compliance with the resource saving regime in the management system involves constant regulation, that is, maintaining them at a certain level in order to reduce the high costs.

The offered models of the technological-logistic integrated structure of food production should be used in practice in the activity of the enterprise of the food sector.

With the help of Statgraphics, Statistica, Excel software, and based on the enterprise data array, it is possible to plan and program the development processes of the integrated food production system, to evaluate the impact of changes in the parameters of the system, to make adjustments to the plans.

These programs are most user-friendly for beginners due to the lack of targeting a specific subject area, a wide range of statistical techniques, and a user-friendly interface. They are more accessible to practice and can be used by a wide range of specialists of different profiles.

Using the proposed models will significantly reduce the need for raw materials in the enterprise. In addition, a significant reduction in the likelihood of errors when making managerial decisions.

The presented models allow to specify the technological complex of works and the need for raw materials, provide an opportunity to establish boundaries between the complex of works, for which the producers-executors are responsible and, in general, the responsibility of the entire corporate structure.

The current approach to the management of the technological and logistic system of integrated food production meets the basic principles of rational organization of technology and is characterized by the following properties:

- versatility - participants in integrated food production are characterized by significant differences in functional purpose, type and technology of production, level of specialization, level of organization of technology, level of management. However, the proposed models offset significant differences and take into account the same production and management functions of enterprises that are part of the integrated food production system. They aimed at achieving the common goals of the operation of this complex technological and logistics system.

- differentiation - models take into account the section of the technological chain of food production to separate functional stages: agrarian sector, harvesting and primary processing, food industry. This takes into account the specifics of each stage.

- specialization - the formation of integrated production systems is based on the principle of deepening the technological specialization of its participants, which forms the prerequisites for the high efficiency of the functioning of each level and the structure as a whole.
- complexity - the models cover all the key stages of the technological and logistic process of food production, which provides a comprehensive character of the modeling.

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