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# IMPROVING THE METHOD OF OPTIMIZING THE DISTRIBUTION OF PRODUCTION RESOURCES IN CONFECTIONERY PRODUCTION

***The object of the research*** *is the processes of production planning and utilization of production resources in confectionery production under conditions of limited production and technological capacities and variability of the product assortment.* ***The subject of the research*** *is methods and mathematical models for optimizing the allocation of material, energy, and production resources aimed at improving the efficiency of enterprise operation.* ***The purpose of the research*** *is to improve the method and mathematical model for optimizing the allocation of production resources of an enterprise, ensuring profit maximization under given production and technological conditions, resource constraints, and product assortment structure, as well as enhancing the effectiveness of managerial decision-making in production planning. To achieve the stated purpose, the following* ***objectives*** *are addressed in the study: analysis of modern methods and approaches to resource allocation in the confectionery industry; identification of key factors influencing the efficiency of material, energy, and production resource utilization; improvement of the mathematical model for enterprise profit formation; formulation of an optimization objective function considering economic and technological constraints; improvement of the method for solving the optimization problem to determine rational resource allocation parameters. The research employs the following* ***methods****: system analysis and generalization of scientific sources; linear and nonlinear programming methods; economic and mathematical modeling; discrete-analytical optimization methods; methods of algorithm design and software implementation. The main* ***results*** *of the study consist in improving the mathematical model of profit optimization by considering the interrelationships between technological production parameters, resource constraints, and product assortment structure. An optimization objective function has been formulated, and the method for solving it has been improved, enabling the generation, evaluation, and selection of the optimal resource allocation alternative. The proposed approach has been implemented in the form of a software and algorithmic tool suitable for integration into production management information systems. In the* ***conclusions****, it is established that the implementation of the improved method enhances the efficiency of production planning, rationalizes resource utilization, and increases the profitability of a confectionery enterprise, confirming its practical feasibility and effectiveness.*

***Keywords:*** *optimization; resources; production; profit; modeling; algorithm; planning; automation; system; enterprise.*

## 1. Introduction

Confectionery enterprises operate in the conditions of high competition, unstable demand, rising costs of raw materials and energy resources, as well as increased requirements for the efficient use of production resources in the confectionery area. In view of this, the rational allocation of material, labor, and production resources becomes one of the key factors in ensuring the profitability and sustainable development of an enterprise [1]. Inefficient production planning leads to overuse of raw materials, equipment downtime, and a decline in economic performance.

In practice, a significant number of confectionery enterprises use traditional approaches to planning and resource allocation based on normative methods, static planning models, or expert assessments [2]. Such approaches do not provide sufficient flexibility in conditions of changing demand, seasonal fluctuations in product range, and limited resources. As noted in works on operational management, the use of static models reduces the adaptability of production systems and does not allow for a quick response to changes in external and internal factors [3].

The development of mathematical modeling and optimization methods has created the conditions for the application of formalized approaches to resource allocation problems in the food industry [4]. Linear and nonlinear programming methods, heuristic and metaheuristic algorithms, as well as hybrid optimization approaches have been widely implemented in scientific research [5]. However, universal optimization models often do not take into account the specifics of confectionery production, in particular, complex recipe dependencies, multi-stage technological processes, and equipment limitations [6].

Particular attention in modern research is paid to the integration of optimization methods into production management information systems [7]. Such systems provide automation of information collection, formation of production plans, and support for management decision-making. At the same time, existing software

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solutions are often expensive or require significant adaptation to the specific conditions of the enterprise, which limits their practical use, especially in medium-sized enterprises [8].

In this regard, there is a pressing scientific and practical need to improve methods for allocating production resources at confectionery enterprises in the confectionery industry by developing mathematical models of profit and optimization algorithms capable of taking into account the dynamics of the production process and the variability of resource constraints. Solving this task contributes to improving the accuracy of planning, the efficiency of resource use, and the growth of the enterprise's profitability, which determines its importance from both a scientific and practical point of view.

## 2. Analysis of literature sources and formulation of the research issue

The problem of rational distribution of production resources is one of the key issues in the theory and practice of production management, particularly in the food and confectionery industries. In scientific research, resources are considered as a combination of material, labor, energy, and production factors, the effective use of which directly affects the cost of production, output volumes, and financial results of the enterprise [9]. In conditions of growing competition and market instability, the relevance of optimal resource planning tasks is significantly increasing.

In classical works on operations management, the main focus is on production planning methods based on deterministic models that use normative indicators and average parameter values [10]. Such approaches ensure formal simplicity and transparency of calculations, but they have limited flexibility and do not take into account the dynamics of demand changes, seasonality of the product range, and variability of resource constraints that are characteristic of confectionery enterprises.

A significant body of scientific research is devoted to the application of mathematical programming methods to resource allocation problems. In particular, linear programming is widely used to maximize profit or minimize costs when resources are limited [11]. Within such models, the objective function is usually formed on the basis of marginal income, and the variables are the production volumes of individual types of products. However, linear models do not always adequately reproduce complex technological dependencies and the nonlinear nature of production processes in the food industry.

Today, there are models that allow for the discreteness of production decisions, equipment constraints, and interrelationships between operations [12]. Works devoted to production optimization in the food area emphasize the effectiveness of such approaches for assortment planning and capacity utilization tasks. At the same time, the complexity of implementation and high computational costs often complicate their practical application.

A separate group of studies consists of heuristic and metaheuristic methods, in particular genetic algorithms, particle swarm algorithms, and ant algorithms [13]. They demonstrate a high ability to find optimal solutions in complex multidimensional problems. However, the results of such methods can be unstable, they depend on the choice of parameters and do not always provide the necessary interpretability of management decisions, which is important for production managers [14].

Modern research is increasingly focused on integrating optimization models into production management information systems. Such systems combine the functions of information gathering, production process modeling, and decision support [15]. The works emphasize that the use of information systems makes it possible to increase the accuracy of planning and reduce the influence of the human factor. However, universal software solutions often do not take into account the specific features of confectionery production, which reduces their effectiveness without additional adaptation [16].

An analysis of the literature shows that most of the existing resource allocation methods are based on static profit models that do not take into account the variability of technological parameters, seasonal fluctuations in demand, and the possibility of operational adjustments to the production program [17]. For confectionery enterprises, which are characterized by a wide range of products and limited resources, such simplification of models is a significant drawback.

Therefore, despite a significant number of scientific works in the field of production optimization, the issue of improving resource allocation methods, taking into account the peculiarities of the confectionery area and the possibilities of their practical implementation in information systems, remains insufficiently researched [18]. This necessitates the development of mathematical profit models that combine economic and technological

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parameters, as well as the improvement of algorithms for solving optimization problems with a focus on real production conditions [19].

In view of the above, the research problem lies in improving the method of distributing production resources of a confectionery enterprise by developing a mathematical model and algorithmic support, which will increase the efficiency of resource use and create conditions for maximum profit under given production constraints.

## 3. Research objectives and tasks

The purpose of the study is to improve the method and mathematical model for optimizing the distribution of enterprise production resources, which ensures profit maximization under given production and technological conditions, resource constraints, and product range structure. The outlined goal is aimed at improving the effectiveness of management decisions in the process of production planning and resource utilization.

To achieve this goal, the following tasks must be performed: analyze current methods and approaches to resource allocation in the confectionery area; identify key factors affecting the efficiency of the use of material, energy, and production resources; improve the mathematical model of enterprise profit formation; determine the target optimization functions, taking into account economic and technological constraints; improve the method of solving the optimization problem to find the optimal parameters for resource allocation.

## 4. Materials and methods of the study

This study uses a combination of theoretical, formalized, and experimental methods aimed at substantiating and verifying the effectiveness of an improved method for optimizing the distribution of production resources at a confectionery enterprise. The methodological basis of the work is a systematic approach that allows us to consider the process of resource allocation as a complex multifactorial system with close interrelationships between economic and technological parameters [20].

System analysis methods were used to analyze the subject area and identify key factors affecting the efficiency of resource use. This made it possible to structure production processes, determine the role of raw material, energy, time, and capacity constraints, and assess their impact on the formation of the enterprise's profit [21]. The identified dependencies were formalized using mathematical modeling methods, in particular, the construction of an analytical profit model that takes into account the cost of production, technological coefficients, resource consumption standards, and production constraints.

To solve the problem of profit maximization, optimization methods were applied, based on a discrete-analytical approach to finding acceptable alternatives [22]. This approach involves the discretization of variables, the generation of a set of possible production programs, the verification of each of them for compliance with the specified constraints, and the calculation of the value of the objective function. A comparative analysis was introduced to evaluate the effectiveness of the improved method in relation to traditional production planning approaches used in the confectionery area [23].

The developed algorithm for the distribution of production resources was implemented using software engineering methods [24]. Based on them, a software and algorithmic complex was created that automates the processes of preparing input indicators, forming a mathematical model, performing optimization calculations, and presenting the results in a form convenient for analysis. To verify the performance of the model and method, as well as to confirm the theoretical propositions, experimental studies were conducted on sets of realistic production indicators that simulate the operating conditions of a typical confectionery enterprise.

The experimental results made it possible to justify the feasibility of applying the improved method in production management practice and confirmed its effectiveness in increasing profitability and rational use of production resources.

## 5. Research results

The study analyzes modern methods of planning and optimizing the distribution of production resources used in food industry enterprises, particularly in the confectionery area. It has been established that the vast majority of enterprises use a traditional deterministic approach based on linear programming, normative planning, or expert assessment. This approach makes it possible to formally determine optimal production volumes, but it has a number of significant drawbacks. In particular, it does not take into account the dynamic nature of the production environment, seasonal

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fluctuations in demand, changes in raw material prices, and the limited flexibility of technological processes.

Production management at enterprises involves ensuring maximum efficiency of resource use while maintaining stable product quality and regular output. To this end, a mathematical model has been developed that makes it possible to determine the optimal output of different types of products, taking into account the limited resources of the enterprise, and to obtain profit from their sale [25].

The profit model is defined as the difference between the price of sales and the total cost of production:

$$P=(b_1-c_1)\cdot x_1+(b_2-c_2)\cdot x_2+\ldots+(b_i-c_i)\cdot x_i+\ldots+(b_n-c_n)\cdot x_n, \quad (1)$$

where $b_i$ – selling price per unit of the $i$-th type of product; $c_i$ – production cost per unit of the $i$-th type of product; $x_i$ – quantity of manufactured products.

The indicators determine the economic impact of each type of product on the total profit of the enterprise. The main idea is that each product brings the enterprise a certain marginal income $(b_i-c_i)$. The production of each unit of output consumes certain resources, which forms a system of constraints.

The main goal of optimization is to find such values $x_i$, under which profits are maximized and restrictions are not violated.

Marginal income is a key criterion that allows determining the feasibility of producing a certain type of product.

If:

$$(b_i-c_i)>0, \quad (2)$$

production is profitable, and provided that

$$(b_i-c_i)<0 \quad (3)$$

production causes losses.

Effective management of production processes in the confectionery area is impossible without purposeful consideration of external market environment factors. One of the most influential factors is seasonality, which determines changes in purchasing activity and affects the demand for various groups of confectionery products. Therefore, the optimization model must include parameters that reproduce these patterns.

To improve the optimization model, two types of adjustment parameters have been introduced, namely: the sales coefficient $k_i$ and seasonality coefficient is $s_i$.

Coefficient $k_i$ – Sales coefficient, the share of production volume that is actually sold. It takes into account specific market conditions, consumer behavior, and the competitive advantages of the enterprise (brand recognition, market share, product quality, etc).

Seasonality coefficient $s_i$ – adjusting demand depending on the season.

This helps to take into account changes in purchasing activity: $s_i>1$ – season of increased demand (winter, holidays); $s_i=1$ – average annual demand, $s_i<1$ – season of reduced demand (summer, vacations).

Such coefficients enable the optimization model to respond adequately to real market dynamics.

Taking into account the implemented coefficients, the model of maximized profit of the enterprise is defined as

$$maxP=(b_1-c_1)\cdot x_1\cdot k_1\cdot s_1+(b_2-c_2)\cdot x_2\cdot k_2\cdot s_2+\ldots+(b_i-c_i)\cdot x_i\cdot k_i\cdot s_i+\ldots+(b_n-c_n)\cdot x_n\cdot k_n\cdot s_n. \quad (4)$$

The mathematical optimization model should include a system of constraints that take into account the availability of resources, production capacity, and actual demand.

Constraints on the use of resources (raw materials, materials):

$$\sum_{i=1}^{n} a_{ij}\cdot x_i \le R_j,\ j=1,2,\ldots,m, \quad (5)$$

where $x_i$ – production volume of the $i$-th type of product, kg; $a_{ij}$ – consumption of the $j$-th type of raw material per unit of the $i$-th type of product, kg/kg; $R_j$ – available amount of $j$-th type raw material; $n$ – number of product types; $m$ – number of raw material types.

Production capacity rconstraints:

$$\sum_{i=1}^{n} t_i\cdot x_i \le T, \quad (6)$$

where $t_i$ – labor intensity of production of 1 kg of the $i$-th type of product, man-hours/kg; $T$ – available working time fund, man-hours; $x_i$ – volume of production of the $i$-th type of product, kg; $n$ – number of product types; $i=1,2,\ldots,n$ – product type index.

Demand constraints due to seasonality:

$$x_i \le D_i\cdot k_i\cdot s_i, i=1,2,\ldots,n, \quad (7)$$

where $D_i$ – projected demand for the $i$-th type of product, kg; $k_i$ – sales coefficient; $s_i$ – seasonality coefficient.

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This helps to avoid overproduction during periods of low demand and maximize profits during peak seasons.

The optimization of production processes in the confectionery industry is aimed at achieving maximum economic effect through the rational use of resources, improving product quality, and reducing raw material costs. The main task is to determine the optimal ratio between the costs of raw materials, labor, and energy resources while ensuring the necessary level of production productivity.

Among the key methods of production optimization are classical linear programming methods, which allow determining the optimal output volumes with limited resources of raw materials, energy, and capacity.

In the practice of managing the production activities of enterprises in the food area, and in particular the confectionery area, the classical method of resource allocation optimization based on economic and mathematical modeling and linear programming methods has become widely used [25]. This approach is aimed at determining the production volumes that ensure maximum economic results under conditions of limited resources and compliance with technological standards. This approach makes it possible to formally determine optimal production volumes, but it has a number of significant drawbacks, in particular, it does not take into account the dynamic nature of the production environment, seasonal fluctuations in demand, volatility in raw material prices, and limited flexibility of technological processes.

The current method is based on the assumption of relative stability of production conditions, the deterministic nature of input indicators, and the possibility of formalizing production processes in the form of a system of linear dependencies.

The method is implemented as a sequence of interrelated stages.

**Stage 1.** Formation of an information base. At this stage, the following information is collected: product cost; cost of raw materials and energy; production standards; planned demand volumes; available production capacity. This information forms the basis for parameterizing the model.

**Stage 2.** Construction of the profit target function according to expression (4).

**Stage 3.** Formation of a system of constraints (for example, the amount of flour, cocoa products, sugar, fat components, equipment operating time, workshop capacity, labor resources, etc.).

**Stage 4.** Normalization of indicators and verification of correctness. The purpose of this stage is to identify illogical information, eliminate anomalies, and verify compliance with production standards.

**Stage 5.** Solving the optimization problem. To do this, use: the simplex method, the branch and bound method, gradient methods, weighted optimization methods (in the case of multi-objective problems).

**Stage 6.** Analysis of the results achieved. Based on the solution, the following are determined: optimal production volumes, expected profit, product range structure, and economic effects of applying the model.

**Stage 7.** Testing the model in production conditions.

The described method is basic and is widely implemented in production planning and resource management systems. It serves as a theoretical and methodological basis for further improvements that take into account dynamic factors, seasonal fluctuations in demand, and changes in resource constraints in the current conditions of confectionery enterprises.

This task can be accomplished using an improved method that allows for a quick response to changes in demand, resource base, and economic parameters, ensuring stable growth in the company's profitability. This method is based on the principle of profit maximization, taking into account relevant technological and market factors. To implement the improved method, a target function has been formed that integrates: the selling price of products, production cost, seasonal demand coefficient, demand adjustment coefficient, and production volume. The purpose of implementing the method is to find the following production volume values $x_1, x_2, ..., x_i, ..., x_n$, which maximize efficiency within the limits of available resources. An improved method for determining the rational allocation of resources in the production system of a confectionery enterprise is based on the use of an economic-mathematical model of profit maximization $(P)$.

The method involves step-by-step execution of operations to process input parameters, form an acceptable solution space, calculate the optimality criterion, and select the best option for resource allocation.

**Stage 1.** Collection and formalization of necessary information. At the first stage, it is necessary to collect, verify, and structure all the necessary parameters. They form the initial basis for further calculations using the profit maximization formula. In a structured form, we obtain the following groups of parameters: economic indicators, technological standards,

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resource constraints, and demand forecasts. All this information forms a parametric set that is used in the following stages.

**Stage 2.** Formation of a set of acceptable production volume options.

*Step 1.* Construction of a space of possible options. Based on the defined variables $x_1, x_2, ..., x_i, ..., x_n$, denoting the production volumes of each product type, the initial space of options is formed. This space can be specified in the following ways: by searching through discrete values of variables or by generating solutions according to a specific algorithm (grid search, stochastic generation, etc). This forms the initial set of possible combinations of production volumes.

*Step 2.* Checking combinations of options for compliance with the system of constraints. Each formed combination of quantities $x_1, x_2, ..., x_i, ..., x_n$. It is necessary to check for compliance with the set of model constraints. It is determined whether the available values exceed the demand for raw materials, labor resources, equipment capacity, and energy. It is important to take into account the conditions for compliance with recipes, ingredient proportions, the duration of technological operations, and the maximum permissible production volumes. It is necessary to control the compliance of budget expenditures with cost constraints and other economic parameters established by the model.

*Step 3.* Formation of a set of feasible solutions. Combinations that fully satisfy all constraints must be included in the set of feasible solutions.

This set contains all variants of the production program that do not violate resource limits, meet technological requirements, are economically feasible, and can be implemented at the enterprise.

**Stage 3.** Calculation of profit for each production option. For each feasible set of production volumes, it is necessary to calculate the value of the optimization criterion – the enterprise's profit. The following are taken into account in the calculation process: adjustment of the demand value using coefficients $k_i$; seasonal fluctuations in demand, indicated by coefficients $s_i$; the quantity of each type of product that can be manufactured within the specified limits.

**Stage 4.** If the solution meets all criteria, it is considered optimal and the implementation of the method is completed. If inconsistencies or instability are found, it is necessary to return to the previous stages to adjust the input parameters.

The optimal solution found should be implemented in specific recommendations for planning the production activities of the enterprise. In accordance with the selected set $x_1, x_2, ..., x_i, ..., x_n$. The following are formed: an optimal production plan that determines the volume of production of each type of product, the rational distribution of resources between technological operations and production lines, recommendations for equipment schedules, in particular with load adjustment, elimination of downtime, and optimization of the sequence of operations, automatic updating of production program parameters if there are changes in prices, costs, seasonal coefficients, or the volume of available resources.

Traditionally, the task of allocating production resources in food industry enterprises is solved using the linear programming method, which involves the formation of a profit objective function and a system of linear constraints, followed by a search for the optimal solution using the simplex method or its modifications. This approach is effective in the case of a linear model, continuous variables, and the absence of complex technological dependencies.

At the same time, in the practical conditions of confectionery production, discrete constraints, nonlinear technological relationships, recipe ratios, and combinatorial dependencies often arise, which significantly complicate the application of classical linear programming methods.

Unlike the basic approach, the improved optimization method is based on the formation of a set of acceptable production volume options with their subsequent selection according to the criterion of profit maximization. At the second stage of the method, a space of possible combinations of variables that determine the production volumes of individual types of products is constructed.

This space can be formed by discrete enumeration or algorithmic generation of options, which allows the integer nature of production decisions to be taken into account directly.

Each generated combination must be checked for compliance with resource, technological, and economic constraints. This approach ensures strict adherence to real production conditions along with restrictions on raw materials, equipment, recipes, and acceptable production volumes. Only those options that fully satisfy all constraints are included in the set of feasible solutions, from which the optimal one is selected. Thus, the key difference between the improved method and classical linear programming is the transition from analytical search for extremes to discrete-analytical analysis of a set of feasible alternatives. This makes it possible to increase the flexibility of the model, ensure that complex technological constraints are correctly taken into account, and form economically sound production programs in the conditions of real confectionery production.

The improved method ensures greater accuracy in determining the rational distribution of resources; takes into account seasonal and market fluctuations in production; and increases planning flexibility thanks to dynamic coefficients $s_i$ and $k_i$; the ability to adapt the production program in case of changes in available resources or restrictions; the formation of economically sound decisions on the distribution of resources between competitive areas of production. The result of the method is an optimal production program that determines the rational and balanced distribution of resources between product types in order to achieve the highest possible target value. The method can be implemented as

1) a separate module (or subsystem) within the production management information system,

2) an element of the ERP system. The IS helps to automatically solve the optimization problem of resource allocation, providing the user with a ready-made set of management decisions.

This method and model enable the rapid updating of the production plan and adaptive response to market changes. The advantages of using the improved method for production are: reduction of total production costs; increased equipment utilization; and ensuring sustainable production planning taking into account seasonal factors. To demonstrate the modularity of the system and the clear division of responsibilities between its components, a class diagram of the resource allocation optimization task was developed (Fig. 1).

The UML class diagram is an element of modeling the architecture of the software and algorithmic complex that implements the method and model of resource allocation optimization within the enterprise production management information system.

The construction of a class diagram is necessary for several reasons. It reproduces the static structure of the software, i.e., it shows which entities (classes) are involved in the implementation of the method, what attributes they contain, and what operations they perform. This makes it possible to formalize the internal logic of the software-algorithmic complex (SAC) and to unambiguously interpret the structure of the program code. A class diagram provides logical order to the components, which helps to structure, for example, a Java project in such a way that each module performs a clearly defined function: storage and processing of production parameters; implementation of a mathematical model; access to a database (DB); logic for selecting the optimal option; integration with other components of the enterprise IS.

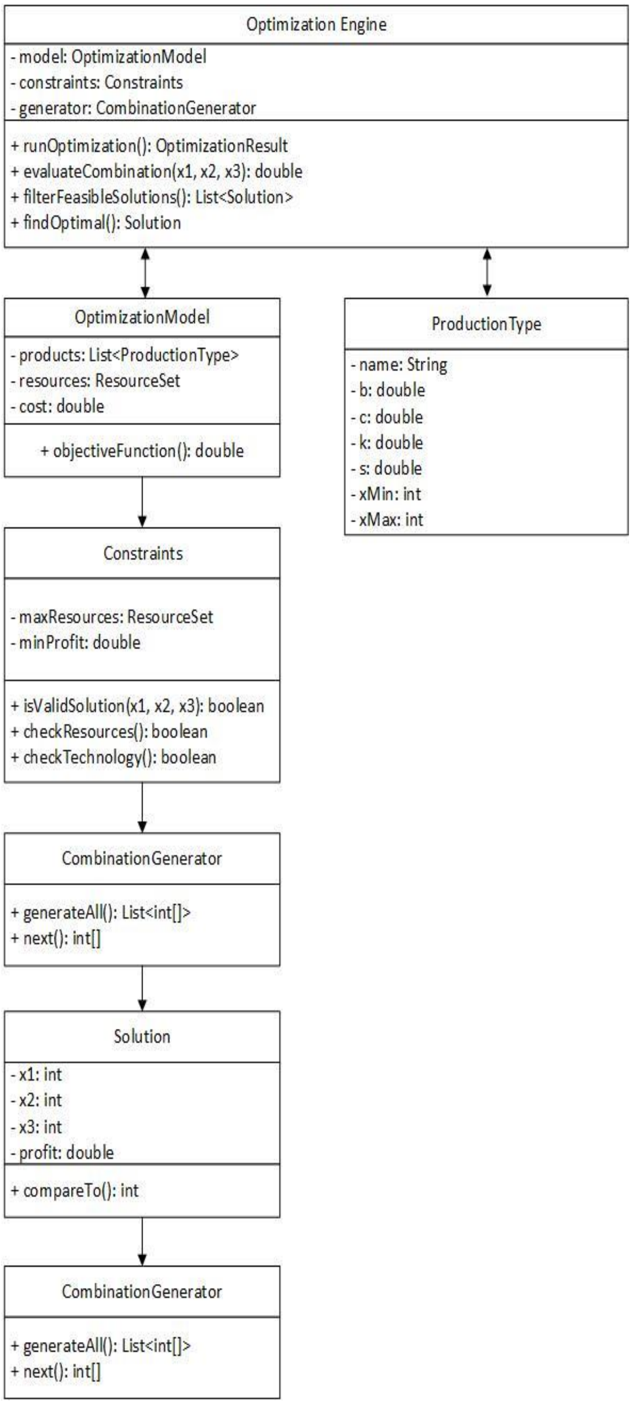


**Fig. 1.** Class diagram of the resource allocation optimization problem

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The class diagram performs a number of important functions: it structures the program logic; formalizes the implementation of the method; defines the architecture of the modules; documents architectural decisions; serves as the basis for further implementation, maintenance, and development of the PAC; ensures transparency and reproducibility of the resource allocation optimization process.

This structure shows: dependencies between the model, constraints, and optimizer; separation of combination generation from evaluation logic; presence of an information access layer (*Data Access Object*, DAO) for storing parameters and results.

The proposed method of optimizing resource allocation at a confectionery enterprise is being implemented in practice through the integration of a mathematical model, algorithmic procedures, and software. The developed model and method for optimizing resource allocation take into account a combination of factors: the cost of production of individual types of products, the level of sales prices, the efficiency of resource use (coefficients and), the availability of raw materials and warehouse stocks, the throughput capacity of equipment, and planned production restrictions. This creates a universal tool that can be integrated into any enterprise management system, from traditional ERP to highly specialized MES solutions.

Fig. 2 shows a diagram of the application of the resource allocation optimization method in the production processes of a confectionery enterprise. The diagram demonstrates the step-by-step implementation of the method, which begins with the collection of actual production indicators.

These include: raw material consumption rates per unit of a particular product type; price parameters – purchase prices and projected sales prices; production constraints in the form of available equipment and labor; seasonal fluctuations in demand and production line utilization schedules. The information collection and validation stage ensures the accuracy of the initial parameters, which is a key prerequisite for the implementation of the model. After that, a resource matrix is formed – a centralized structured data set that contains available resources and possible options for their distribution among product types.

Table 1 presents a comparative description of the existing and improved methods of resource allocation.

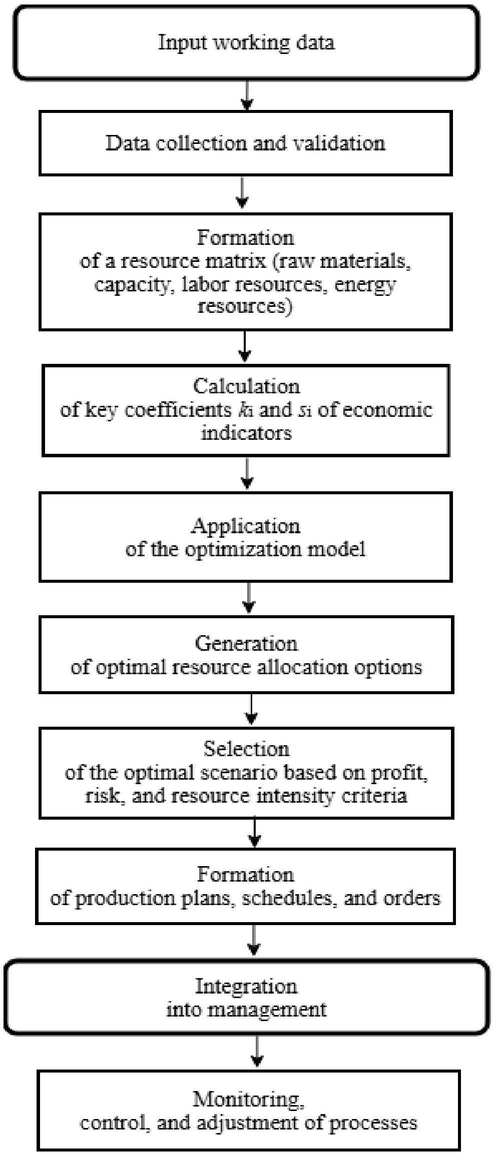


**Fig. 2.** Scheme for implementing the resource allocation method

A comparative analysis shows that the existing method is effective under stable production and economic conditions, but has limited flexibility and does not take market dynamics into account. The improved method eliminates these shortcomings through the use of adaptive parameters, expansion of the mathematical model, and improvement of the optimization algorithm, which increases the accuracy and practical applicability of the solutions obtained. To implement the improved method, a software module has been developed using the *Java* programming language, which ensures reliability, platform independence, an object-oriented approach, and the possibility of integration with existing modules of the enterprise information system. Listing 1 shows a fragment of *Java* code that implements the functional basis of the IS optimization module.

**Table 1.** *Comparative characteristics of existing and improved methods of resource allocation*

| Comparison criterion | Existing (basic) method | Improved method |
|---|---|---|
| Optimization goal | profit maximization under fixed resource constraints | profit maximization taking into account dynamic economic and technological factors |
| Type of mathematical model | linear profit model | improved economic-mathematical model of profit with adaptive parameters |
| Type of input data | static, deterministic | partially dynamic taking into account seasonal and market fluctuations |
| Demand | fixed or average | variable, with the possibility of adjusting the production program |
| Resource constraints | rigidly defined, unchanging | flexible, with the possibility of adaptation in case of changing conditions |
| Technological coefficients | constant normative values | Dynamic coefficients |
| Seasonality | not taken into account or taken into account indirectly | and, reflecting real production conditions |
| Model scalability | limited with an increase in the number of variables | taken into account directly in the model parameters |
| Planning flexibility | low, requires a complete recalculation | ensures operation with a large number of interrelated parameters |
| Optimization result | optimal production volumes under given conditions | high, with the possibility of operational adjustment of plans |
| Practical application | limited by stable production conditions | optimal production program with adaptation to changes in the environment |
| Economic effect | moderate | effective in a changing market |

**Listing 1.** *Java code of the optimization module (OptimizationModel.java)*

```
public class OptimizationModel {
  private List<ProductionType> products;
  private ResourceSet resources;

  public OptimizationModel(List<ProductionType> products, ResourceSet resources) {
    this.products = products;
    this.resources = resources;
  }

  public double calculateProfit(int x1, int x2, int x3) {
    return products.get(0).profit(x1) +
        products.get(1).profit(x2) +
        products.get(2).profit(x3);

  public List<ProductionType> getProducts() {
    return products;
  }
}
```

The proposed *Java* code ensures: correct execution of the mathematical model; verification of technological and resource constraints; complete enumeration of permissible combinations; determination of the optimal resource allocation option. The proposed method for optimizing the distribution of production resources at a confectionery enterprise is implemented by combining a mathematical model, algorithmic procedures, and software implementation as part of a production management information system. The improved method is integrated into a software and algorithmic complex that provides automated collection and processing of input information, formation of acceptable production alternatives, calculation of the target function, and selection of the optimal solution.

At the practical level, the method is implemented in the form of a separate optimization module that interacts with modules for collecting production indicators,

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forming input parameters, and supporting management decision-making.

The input information for the optimization module is data on available resources (raw materials, production capacity, labor resources), economic indicators (cost price, sales prices, marginal income), as well as demand parameters taking into account seasonal and market coefficients.

This information is processed automatically, which minimizes the human factor and increases the accuracy of planning. To demonstrate the feasibility and practical significance of the method, we consider an example of its implementation for a confectionery enterprise that manufactures three types of products. Within the example, a space of possible production programs is formed by discretely enumerating the production volumes of each type of product. All combinations are checked for compliance with resource, technological, and economic constraints, after which the acceptable options are evaluated according to the criterion of profit maximization. The result of the implementation is an optimal production program that determines the rational distribution of resources between product types, the level of equipment utilization, and the expected economic effect. The results can be used to quickly adjust production plans, adapt the product range to changes in demand, and make economically sound management decisions.

Units: $x_i$ – kg (in the table).

Accepted coefficients:

$$b_1 - c_1 = 40; k_1 = 1{,}10; s_1 = 0{,}90 \Rightarrow multiplier\ f_1 = 40 \cdot 1{,}10 \cdot 0{,}90 = 39{,}6\left(UAH/kg\right);$$

$$b_2 - c_2 = 40; k_1 = 0{,}95; s_1 = 0{,}85 \Rightarrow multiplier\ f_2 = 40 \cdot 0{,}95 \cdot 0{,}85 = 32{,}3\left(UAH/kg\right);$$

$$b_3 - c_3 = 50; k_3 = 1{,}20; s_3 = 1{,}00 \Rightarrow multiplier\ f_3 = 50 \cdot 1{,}20 \cdot 1{,}00 = 60{,}0\left(UAH/kg\right).$$

Discretization step: $\Delta x = 500\ kg$ (technologically justified minimum batch). Target function for specific numbers:

$$P = 39.6 \cdot x_1 + 32.3 \cdot x_2 + 60 \cdot x_3, \qquad (8)$$

where $P$ – profit, UAH; $x_i$ – volumes in kg.

Table 2 shows examples of combinations $x_1, x_2, x_3$ and profit $P$ calculations.

**Table 2.** *Examples of combinations $x_1, x_2, x_3$ and profit $P$ calculations*

| № | $(x_1)$ (кг) | $(x_2)$ (кг) | $(x_3)$ (кг) | $P$ calculations (UAH) | $P$ (UAH) |
|---|---|---|---|---|---|
| 1 | 1000 | 800 | 600 | 39.6 · 1000 + 32.3 · 800 + 60 · 600 | 101440 |
| 2 | 1500 | 800 | 600 | 39.6·1500+32.3·800+60·600 | 121240 |
| 3 | 2000 | 600 | 400 | 39.6·2000+32.3·600+60·400 | 122580 |
| 4 | 2500 | 0 | 500 | 39.6·2000+32.3·600+60·400 | 129000 |
| 5 | 0 | 1800 | 1500 | 39.6·0+32.3·1800+60·1500 | 148140 |
| 6 | 500 | 500 | 500 | 39.6·500+32.3·500+60·500 | 65950 |
| 7 | 2500 | 1800 | 1500 | 39.6·500+32.3·500+60·500 | 247140 |
| 8 | 2000 | 1000 | 1000 | 39.6·2500+32.3·1800+60·1500 | 171500 |
| 9 | 1500 | 1800 | 0 | 39.6·2000+32.3·1000+60·1000 | 117540 |
| 10 | 1000 | 0 | 1500 | 39.6·1000+32.3·0+60·1500 | 129600 |

The right column shows the total profit $P$ for each combination (rounded to UAH). Combination No. 7 (maximum values for each type) gives the maximum $P$ in this sample (247,140 UAH), but before the final selection, it must be checked for compliance with all resource constraints (raw materials, total equipment operating time, logistics, etc.). If the combination violates one of the constraints, it must be filtered out.

Thus, the results achieved confirm the implementation of the developed complex as an element of a modern information system for managing confectionery production. Practical results show that the use of the improved method makes it possible to increase the accuracy of determining the rational distribution of resources, reduce the share of inefficiently used resources, and increase the value of the objective function compared to basic planning methods. On average, the increase in profit as a result of optimization ranged from 5 to 12%, depending on the scenario and product range structure. A particularly significant effect was achieved in conditions of resource scarcity or unstable demand, which confirms the practical feasibility of implementing the improved approach.

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The results achieved confirm that the improved method is an effective tool for supporting management decisions in the field of production planning. Its application contributes to increasing the economic stability of the enterprise and reducing the risks associated with the irrational use of resources.

## 6. Discussion of research results

The results achieved demonstrate the feasibility and effectiveness of the improved method and mathematical model for optimizing the distribution of production resources. Unlike most previous studies in this area, which are dominated by static linear programming models or normative-planning approaches, this work implements a more flexible discrete-analytical approach focused on the real conditions of production systems.

A distinctive feature of the results achieved is the comprehensive consideration of both economic and technological factors within a single objective function. Previous studies have tended to focus either on economic indicators (profit, cost) or on technological constraints, which has led to a simplification of the model and a reduction in the accuracy of the results. The improved model proposed in this work makes it possible to combine these aspects and ensure a more adequate reproduction of the real production process. Compared to existing planning methods, the results of implementing the improved method demonstrate a number of significant advantages. First, it ensures greater accuracy in determining the rational allocation of resources by reviewing acceptable alternatives and rejecting ineffective options at the early stages of the method. Second, the use of dynamic coefficients makes it possible to take into account seasonal and market fluctuations, which is practically not implemented in traditional approaches. Third, the method provides high planning flexibility and the ability to quickly adapt the production program in case of changes in constraints or available resources.

An important advantage of the results achieved is their practical orientation. Unlike purely theoretical models, the improved method is implemented in the form of a software and algorithmic complex, which creates the prerequisites for its practical implementation in production management information systems. At the same time, the results achieved have certain limitations that must be taken into account in practical application. In particular, the discrete-analytical approach to generating alternatives can lead to an increase in the computational complexity of the task if there is a significant increase in the number of product types or model parameters. This limits the application of the method to very large production systems without additional procedures for reducing the search space or parallel computations.

In addition, the accuracy of the results largely depends on the quality of the input information. Inaccurate or outdated information on cost, equipment productivity, or raw material availability can negatively affect the adequacy of the decisions made. Therefore, the effective application of the method requires a well-established system for collecting and updating production and economic information.

## 7. Conclusions and directions for further research

The study analyzed modern approaches to the allocation of production resources in the confectionery area and identified their limitations related to the use of static models and insufficient attention to the dynamics of production conditions. Key factors affecting the efficiency of resource use were identified, namely: the structure of production processes, equipment limitations, availability of raw materials, and economic properties of products.

The mathematical model of enterprise profit was improved by detailing the relationships between technological parameters and economic indicators. The objective function of optimization has been formulated taking into account production, resource, and time constraints. The method of solving the optimization problem has been improved, ensuring the search for a rational distribution of resources based on the generation and evaluation of acceptable alternatives.

During the testing of the improved method on the example of a typical enterprise in the confectionery area, its effectiveness and economic feasibility were confirmed. In general, the set research goal has been achieved, and its results can be used to support management decision-making in production information systems.

Prospects for further research on this issue are related to expanding the functionality of the proposed method and model. In particular, it is advisable to include stochastic factors, which will allow for the uncertainty of demand and raw material prices to be taken into account. Another promising direction is the integration of the improved method with ERP and MES systems to ensure automated planning in real time.

In further research, it is advisable to pay special attention to the application of intelligent methods, in particular elements of machine learning, for forecasting the input parameters of the model.

The implementation of these areas will contribute to increasing the practical value of the results achieved and expanding their scope of application in the context of the digital transformation of food industry enterprises.

## Conflict of interest

The authors declare that they have no conflict of interest with respect to this research, including financial, personal, authorship, or other conflicts that could influence the research and its results presented in this article.

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## Data availability

The manuscript has no associated data.

## Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technology in the creation of this work.

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# МЕТОД РОЗПОДІЛУ ВИРОБНИЧИХ РЕСУРСІВ У КОНДИТЕРСЬКІЙ ПРОМИСЛОВОСТІ

***Об'єктом дослідження*** *є процеси планування виробництва й використання промислових ресурсів у кондитерській діяльності в умовах обмежених виробничо-технологічних можливостей і варіативності асортименту продукції.* ***Предмет вивчення*** *– методи й математичні моделі оптимізації розподілу матеріальних, енергетичних і виробничих ресурсів підприємства з метою підвищення ефективності його функціювання.* ***Метою дослідження*** *є вдосконалення методу й математичної моделі оптимізації розподілу виробничих ресурсів підприємства, що забезпечує максимізацію прибутку відповідно до заданих виробничо-технологічних умов, обмежень на ресурси й структури асортименту продукції,* *а також підвищує ефективність управлінських рішень у процесі планування виробництва. Для досягнення окресленої мети в роботі визначено такі* ***завдання****: аналіз сучасних методів і підходів до розподілу ресурсів у кондитерській галузі; визначення ключових факторів, що впливають на ефективність використання матеріальних, енергетичних і виробничих ресурсів; удосконалення математичної моделі формування прибутку підприємства; побудова цільової функції оптимізації з огляду на економічні й технологічні обмеження; удосконалення методу розв'язання задачі оптимізації для знаходження раціональних параметрів розподілу ресурсів. У дослідженні застосовано такі* ***методи****: системний аналіз і узагальнення наукових джерел; лінійного й нелінійного програмування; економіко-математичне моделювання; дискретно-аналітичні методи оптимізації; алгоритмізації та програмної реалізації. Основні* ***результати*** *дослідження полягають в удосконаленні математичної моделі оптимізації прибутку способом урахування взаємозв'язків між технологічними параметрами виробництва, ресурсними обмеженнями й структурою асортименту продукції. Сформульовано цільову функцію оптимізації та вдосконалено метод її розв'язання, який забезпечує формування, оцінювання й вибір оптимального варіанта розподілу ресурсів. Запропонований підхід реалізовано у вигляді програмно-алгоритмічного інструментарію для застосування в інформаційних системах управління виробництвом.* ***Висновки:*** *впровадження вдосконаленого методу сприяє підвищенню ефективності планування виробництва, раціоналізації використання ресурсів і зростанню прибутковості кондитерського підприємства, що підтверджує його практичну доцільність та ефективність.*

***Ключові слова:*** *оптимізація; ресурси; виробництво; прибуток; моделювання; алгоритм; планування; автоматизація; система; підприємство.*

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