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Abstract. The study substantiates the need to apply methods of economic and mathematical modelling of optimization of the production process of enterprises of the agrarian complex. The key elements of the various stages of development and construction of an economic and mathematical model of agricultural enterprises' production resources that optimizes resource reserves for resource identification, judicious resource use, and enhancement of economic activity efficiency are taken into consideration. The proposed model may be used to analyze and discover resource potential reserves for businesses with any kind of ownership, as well as to identify elements of strategies to increase the economic activity of both the business as a whole and its individual units. The findings confirm that the employment of economic and mathematical approaches is efficient in evaluating agricultural firms' resource potential as well as the optimization of raw materials, output, and sales. The process of modelling the activities of agricultural enterprises makes it possible to respond quickly to changes in demand for marketable products and make scientifically sound management decisions regarding the planning of production of its various types in order to maximize profits. Confirmation of the result is that the use of economic and mathematical methods is effective in assessing not only the resource potential of agricultural enterprises, but also the optimization of raw materials, production and sales. The process of modelling the activities of agricultural enterprises makes it possible to respond quickly to changes in demand for marketable products and make scientifically sound management decisions regarding the planning of production of its various types in order to maximize profits.

1. Introduction

The defining condition of modern management is the realization that the production potential of domestic agricultural enterprises should be used rationally and taking into account the limited amount of available resources. This is due to the fact that the efficiency of production resources in many agricultural enterprises is low, the cost of agricultural products increases and its level of profitability decreases, which leads to a decrease in the competitiveness of domestic producers [1]. The experience

of many successful enterprises of developed industrial countries shows that in conditions of fierce competition, the planning of production and economic activities of enterprises is the most important condition for their survival and economic growth [2].

Modern economic conditions require scientifically sound approaches to the formation of a plan of production and sales through the use of new effective approaches in the management using economic and mathematical modeling of production and technological processes. The most effective means of planning, which allows to organize production with maximum profit from sales and at the same time meet consumer demand, is the formation of a production program that will increase product competitiveness, efficient use of resources and expand sales [3].

Applied approbation of mathematical calculations of optimization of production structure taking into account production and market restrictions was carried out by PJSC "Oril-leader" of the Dnepropetrovsk region. The proposed model may be used to analyze and discover resource potential reserves for businesses with any kind of ownership, as well as to identify elements of strategies to increase the economic activity of both the business as a whole and its individual units. One of the Microsoft Office Excel spreadsheet package's office applications was used to process the analysis's findings.

2. Research methods

In the economic literature there is a significant number of publications that reflect the problems of formation and optimization of production parameters of agricultural enterprises. In particular, attention is paid to methodological approaches based on the use of trend analysis and economic-mathematical modeling [4-5], modeling the management of the production program of the enterprise, which is based on optimizing net income from sales taking into account the planned level of profit [6], economic indicators of the enterprise and the impact of external and internal factors on optimal production volumes [7]. Scientists have developed a number of economic and mathematical models that allow to determine the optimal volume of production taking into account the level of market demand and supply of products by competitors [8]. Works [9-11] are devoted to the problem of resource substantiation of the production program and development of the concept of economic and mathematical modeling. The mechanism of planning the production program of the enterprise on the basis of dependence of probability of realization of production on volume and sources of financing is improved [12]. Investigating aspects of production planning under conditions of fuzzy input information, a set of models for forming an optimal production program based on the theory of fuzzy sets has been developed [13-15]. However, the challenges of simulating production optimization within the context of optimizing firm profitability are still understudied and call for more research.

Today, linear and mathematical programming is the main methods of making production and economic decisions. The use of linear programming methods in the planning of agricultural production has significant advantages: linear programming takes into account all possible options for the plan and chooses the best - the best; linear programming tasks are easily automated, which makes it possible to take into account a significant number and conditions of production; the quality of the developed plans increases.

To solve the problem by programming, the situation described in it must meet five basic conditions: 1. It was associated with limited resources (workers, equipment, finances, materials, etc.). 2. Had a clearly defined goal (profit maximization or cost minimization). 3. Described by linear formulas. 4. Was homogeneous. 5. Low divisibility, because the method of linear programming is based on the assumption that the results and resources can be divided into parts. If such a division is not possible, it is better for analysts to use a special modification of linear programming - discrete programming [1].

For poultry farms, it is important to create an optimal production plan to maximize profits, taking into account production and market constraints. On the one hand, there are certain advantages to different ways of processing poultry meat depending on the weight of its carcass. For example, it is more rational to send the bird with the lowest weight, which has a low yield of meat, for deep

processing; a medium-weight bird is in demand when selling the whole carcass, and the largest bird is better processed in parts. In addition, different types of poultry carcass processing involve different production costs. On the other hand, an important factor in the production process is the real demand for different types of poultry products (minced meat, whole carcass, processed carcass), which differ in the periods of time of sale (weekdays or weekends and holidays).

To form an optimal production plan, it is important to make timely management decisions, depending on what period and what weight group of birds should be sent to a particular type of processing. To solve this production problem, we propose to use the methods of mathematical modeling in the context of the basic concepts of operations research and methods for optimizing management decisions [16].

Our proposed method of planning poultry production based on the method of linear programming includes eight stages: grouping of poultry by weight categories; calculation of yield in slaughter weight; determination of the number of finished products by species depending on the option of processing poultry meat; determination of cost poultry meat processing; determination of the price of manufactured products; calculation of profit from sales of all products; determination of demand coefficients for different types of products; drawing up an optimal plan for processing poultry meat.

The model of optimization of production and sale of poultry meat includes different processing options: whole carcass, processed carcass (thigh, leg, quarter back, wing and fillet), soup products (goulash, bone residue, stomach, liver, heart, neck, head, paws) and minced meat. At the same time, all broiler carcasses of different weight categories grown at the enterprise are used for the production of different types of products. For the purpose of processing chicken meat, carcasses in the first and second weight categories can be separated into the four categories. It is quite expedient to direct the non-standard to the production of soup products and minced meat.

To build an economic-mathematical model, it is necessary to introduce the notation of variables and justify the criterion of optimality. Because it best captures the effectiveness of the enterprise's production and marketing operations, we choose maximum profit as a criterion for the optimality of the production plan.

Denote x_{iq} – the amount of primary raw materials of the q category for the i variant of processing, and $x_{iq} \geq 0$, i=1,..,4, q=1,2 (for the first and second weight categories), $x_{13}=0$, $x_{23}=0$, $x_{33} \geq 0$, $x_{43} \geq 0$ (for non-standard category).

Let us take R_q as the stock of primary raw materials of the q-th category, q = 1, .., 3. Then the restrictions on the cost of raw materials describe the inequalities:

$$\sum_{i=1}^{4} x_{iq} \leq R_q, q = 1,...,3. \quad (1)$$

As a result of four options for processing broiler meat, namely: whole carcass, processed carcass, soups and minced meat, the following types of products are obtained: 1) whole carcass; 2) thigh; 3) shin; 4) goulash; 5) the back quarter; 6) wing; 7) fillets; 8) bone residue; 9) stomach; 10) the liver; 11) heart; 12) neck; 13) minced meat; 14) heads; 15) paws.

Let us take Y_k as the total number of k types of products, where k are the types of products (k = 1,…., 15). Let us denote the volume of raw materials processed by the i variant as:

$$X_i = \sum_{q=1}^{3} x_{iq}, i = 1,...,4. \quad (2)$$

The technological requirement for the total output S is set in the form:

$$\sum_{i=1}^{4} e_i X_i \le S, \tag{3}$$

where e_i - is the rate of total consumption of primary raw materials in the i variant of processing.

Processing of poultry meat requires consideration of labor constraints ($b1$) and equipment ($b2$). If a_{ij} - the rate of consumption of the j resource in the i (i=1,2,3,4) variant of processing, we obtain the ratio:

$$\sum_{i=1}^{4} a_{ij} X_i \le b_j, j = 1,2. \tag{4}$$

If we denote by u_{ki} the yield of the k type of product in the i variant of processing, the number of products of the k type of the i category will be:

$$Y_{kq} = \sum_{i=1}^{4} u_{ki} x_{iq}, k = 1,....,15, q = 1,...,3. \tag{5}$$

The total number of products of the k type will be:

$$Y_k = \sum_{q=1}^{3} Y_{kq}, k = 1,...,15. \tag{6}$$

and must be consistent with the demand S_k for it, i.e.

$$Y_k \ge S_k, k = 1,...,15.$$

Operating profit will be defined as the difference between sales revenue (B) and cost (C).

Let us take p_k as the base price for the k type of product, i.e. k = 1,…, 15, which corresponds to the data in table. 3. The coefficient of price correction depending on the category q is denoted as w_q, q = 1, .. 3. Then

$$B = \sum_{k=1}^{15} p_k \sum_{q=1}^{3} w_q Y_{kq} \tag{7}$$

For the non-standard category $w_3=1,05$, the second weight category $w_2=1,08$, the third weight category $w_1=1,12$.

The cost, which depends on costs, the cost of resources used and primary raw materials is as follows:

$$C = \sum_{q=1}^{3} c_q \sum_{i=1}^{4} x_{iq} + \sum_{j=1}^{2} d_j \sum_{i=1}^{4} a_{ij} X_i \tag{8}$$

where c_q - is the cost of primary raw materials of the q-th category, i.e. q = 1, .., 3, d_j - is the unit cost of the j resource, i.e. j = 1,2.

Finally, the obtained model requires the search for unknowns $x_{iq}\ge 0$, i.e. i=1,…,4, q=1,2, $x_{13}=0$, $x_{23}=0$, $x_{33}\ge 0$, $x_{43}\ge 0$, which satisfy the constraints:

$$\begin{cases} \sum_{i=1}^{4} x_{iq} \le R_q, \ q = 1,..,3 \\ X_i = \sum_{q=1}^{3} x_{iq}, \ i = 1,..,4 \\ \sum_{i=1}^{4} e_i X_i \le S \\ \sum_{i=1}^{4} a_{ij} X_i \le b_j, \ j = 1,2 \\ Y_k = \sum_{q=1}^{3} Y_{kq}, \ k = 1,....,15 \\ Y_k \ge S_k, \ k = 1,....,15 \end{cases} \quad (9)$$

and maximize the criterion:

$$П = \sum_{k=1}^{15} p_k \sum_{q=1}^{3} w_q Y_{kq} - (\sum_{q=1}^{3} c_q \sum_{i=1}^{4} x_{iq} + \sum_{j=1}^{2} d_j \sum_{i=1}^{4} a_{ij} X_i) \to max \quad (10)$$

3. Results and discussion

Our research was based on the materials of the State Statistics Service of Ukraine for 2000-2021 - Statistical Yearbook "Agriculture of Ukraine" and Statistical Yearbook "Labor of Ukraine", the data of which were used directly or for analysis and calculation of necessary economic indicators, as well as production reports of PJSC "Oril-leader".

In the described model of optimizing the parameters of production and sale of poultry meat, one of the limitations is the magnitude of demand for products. In this respect, a demand study of the territory of Dnipropetrovsk's meat market. The dynamics of meat consumption, including poultry meat, in the research region in comparison to the consumption of this commodity throughout Ukraine was also examined for a more thorough understanding of demand (Fig. 1).

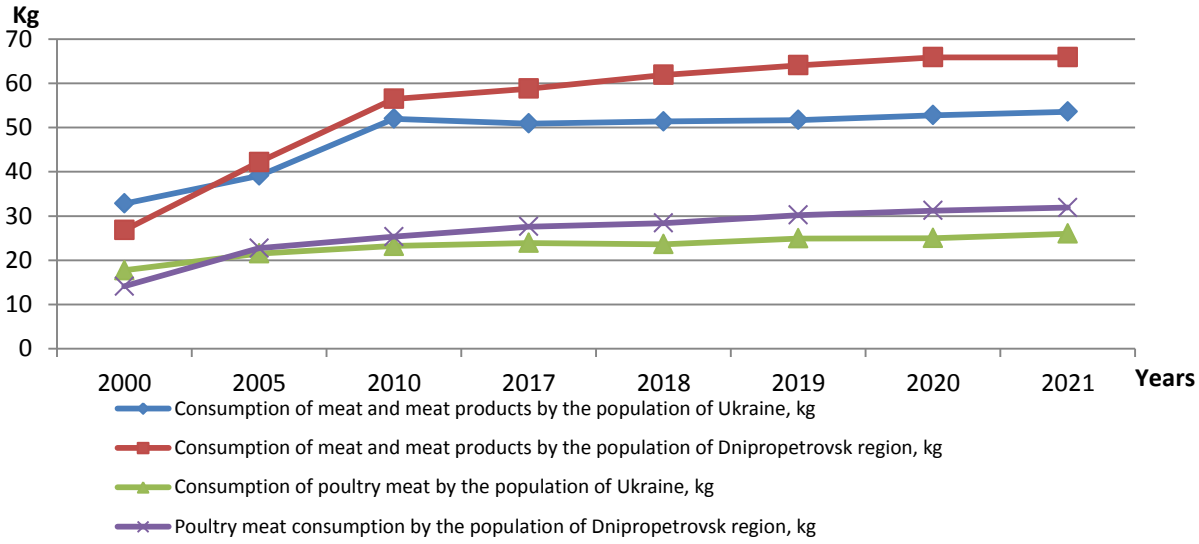

Figure 1. Consumption of meat and meat products by the population

The data show that the consumption of both meat and meat products, as well as poultry meat, in particular, in the Dnipropetrovsk region, exceeds the consumption in general in Ukraine. Analysis of the demand on the meat market in the study area shows an increase in consumption of poultry meat and processed products by almost 2 times. It should be emphasized that the amount of meat consumed per person varies significantly across the nation and is influenced by regional availability, national traits, cultural practices, and household income levels.

Today there are 31 poultry enterprises in Dnipropetrovsk region, including 6 large egg enterprises and 4 meat enterprises. In terms of the level of consumption, as well as production volumes, in general, we can conclude that the advantage of several times the consumption of poultry products over other types of meat. This factor is an unconditional advantage for poultry enterprises in Dnipropetrovsk region. In addition, it should be noted that feeds, which are the main part of the diet, are local, which allows you to optimize their cost.

The people who live in the Dnipropetrovsk region are a group of purchasers who may be identified by their level of effective demand and buying habits. The total amount of poultry meat that people and businesses are really willing to purchase at the going rate is known as aggregate demand. The customer demand for chicken meat from domestic production in the Dnipropetrovsk region is not entirely satisfied despite the excellent efficiency indicators. This demonstrates that neighborhood poultry producers have the capacity to increase chicken output and satisfy overall demand.

Analysis of the demand for poultry meat in the Dnipropetrovsk region according to a sociological survey of the population of the region showed that consumers have a positive attitude to this type of product (Fig. 2). According to research, the total number of meat consumers in the study region is about 95% of the surveyed population.

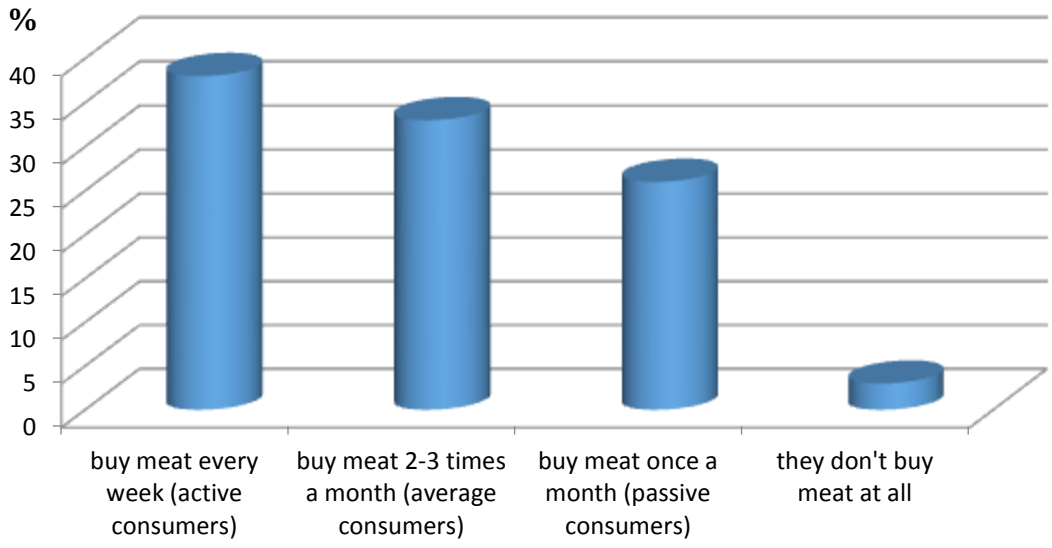

Figure 2. The results of a sociological survey of the population on meat consumption

When buying meat, consumers prefer poultry (Fig. 3). This situation is due to the fact that this type of meat is affordable, easy to cook, low in fat and contains a lot of protein and nutrients that our body needs.

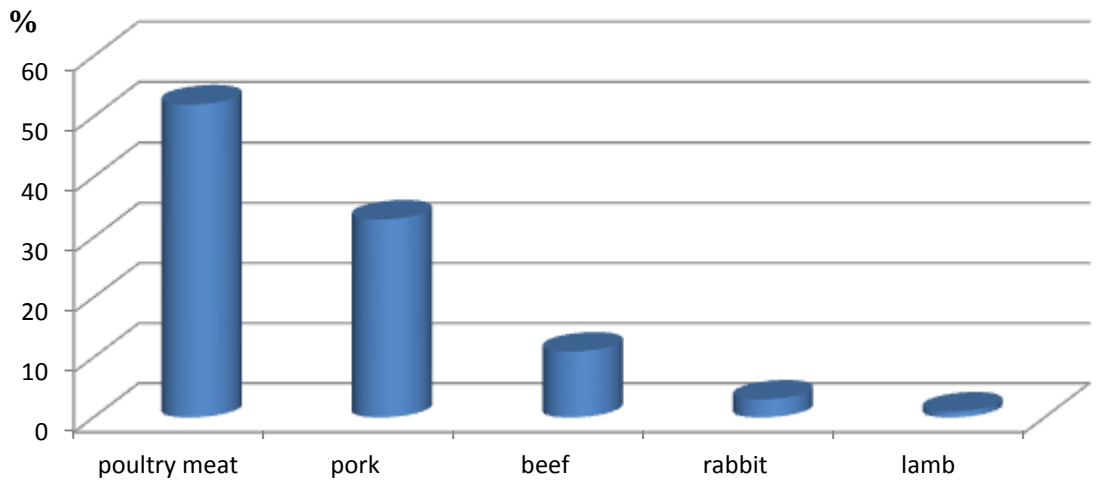

Figure 3. The results of a sociological survey of the population on the consumption of meat

The increase in the consumption of chicken meat, or rather the replacement of beef and pork, is associated with the economic crisis, as well as low incomes of the majority of the population of the region. However, in this area there is instability both within production and at the stage of distribution of the product to the final consumer.

It should be noted that poultry companies produce a wide range of poultry products in both frozen and chilled form. Most respondents prefer chilled meat (72%), because in this form the meat better retains trace elements and nutrients, and it does not lose flavor. According to the sociological survey, the structure of consumer preferences by type of product made from poultry as a result of its slaughter and processing has the following structure (Fig. 4).

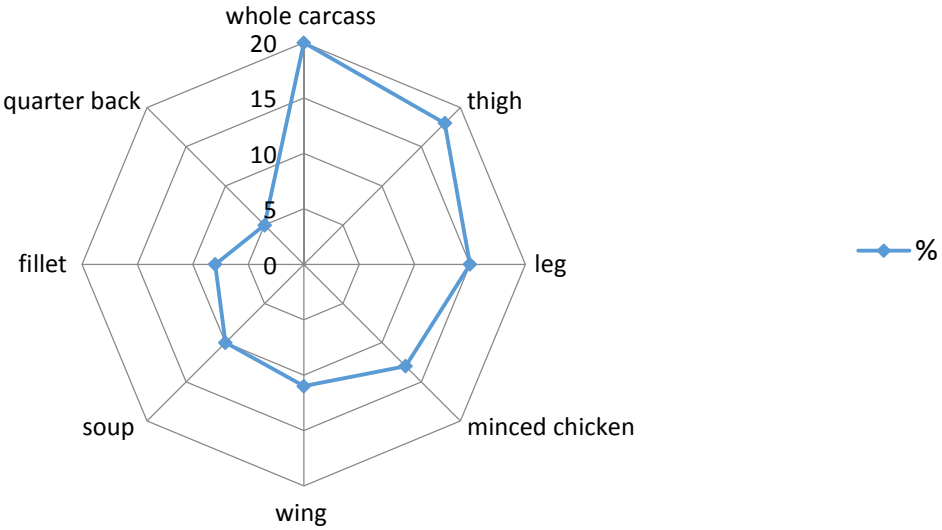

Figure 4. Structure of consumer preferences by types of products made from poultry meat

A study of the enterprises of the Dnipropetrovsk region that produce poultry meat shows that an increase in production is not always economically justified, as it may remain unclaimed from potential buyers. Therefore, for the effective marketing of poultry meat and products of its processing, it is necessary to adhere to the modern concept of marketing, the essence of which is to assess consumer demand and its changes in the future. Thus, poultry production volumes should be functionally dependent on consumer preferences.

One of the main issues of poultry production is to improve the production and marketing activities of producers by identifying the main factors influencing consumer motivation in the choice, purchase and consumption of poultry meat products. These elements, in our opinion, include the cost of poultry meat, the quantity produced (supply), the average per capita income, and the cost of substitute goods.

Table 1. Factors influencing the demand for poultry meat in Dnipropetrovsk region

Factors	**Years**					**Growth rate**
	2017	2018	2019	2020	2021	
Price of poultry meat, UAH / t	22809,1	25060,2	26390,4	29195,3	31400,7	1,3
Production of poultry meat in slaughter weight, thousand tons	167,4	186,0	206,1	203,6	205,1	1,2
Price of cattle meat, UAH / t	25072,6	27226,5	29544,0	35037,3	38038,7	1,5
Pork price, UAH / t	22419,0	28343,1	30441,8	32139,0	32794,7	1,4
Average cash income per capita, UAH / month.	3261,8	3697,2	4777,8	6229,6	7420,2	2,3

During the analysed period, the growth rate of pork prices (1.4 times) and the growth rate of poultry meat prices (1.3 times), which, in turn, should lead to an increase in demand for poultry meat. At the same time, a 1.5-fold increase in the price of cattle meat may stimulate its replacement by poultry meat. It cannot be said unequivocally that the population will reduce its consumption of poultry meat as its income increases. Poultry production in the Dnipropetrovsk region increased 1.2 times during the study period, while the price of poultry meat increased 1.3 times, which is quite logical.

To increase the efficiency of production and sale of poultry meat and to improve the supply of this type of product to the population of the region, we have developed an economic and mathematical model for optimizing the plan of production, processing and sale of poultry based on consumer demand. Data from the analysis of poultry meat production in the Dnipropetrovsk region in terms of enterprises show that 55.3% of production and 56.7% of sales of poultry meat in the region account for PJSC "Eagle Leader", which allows us to choose this company as object of modelling of the optimization plan of production, processing and realization of researched production.

According to annual reports in 2021, PJSC "Oril-Leader" produced 64,149 tons of finished products. Thus, for one shift the company can produce an average of 175 tons of finished products. The specific weight of the yield of 100 kg of raw material for each of the four options for processing the broiler carcass is given in table. 2.

Table 2. Types of products by options for processing broiler carcasses

Product name	**Options for processing chicken carcass**				**Production per year, tons**
	1	2	3	4	
	Yield of 100 kg of raw materials, kg				
Whole carcass	86,30	-	-	-	16935
Thigh	-	21,50	-	-	4233
Shank	-	11,62	-	-	2309
Goulash	-	-	57,30	-	11226
Quarter back	-	19,50	-	-	3849
Wing	-	11,50	-	-	2245
Fillet	-	21,60	-	-	4234

Bone remnant	-	-	14,30	-	2823
Stomach	-	-	1,70	-	320
Liver	-	-	1,30	-	257
Heart	-	-	1,30	-	257
Neck	-	-	2,30	-	450
Stuffing	-	-	-	69,40	13664
Heads	-	-	2,5	-	513
Paws	-	-	4,4	-	834
Total	86,30	85,72	85,10	69,40	64149

The calculation of resource consumption rates per unit of production for the i-th variant of poultry processing is given in table. 3.

Table 3. Initial data for optimization of the plan of production of poultry products

Volume of raw materials processed in the i-th variant, kg (X_i)	**Resources per unit of output**	
	Labor resources, persons (a_{i1})	Equipment, units (a_{i2})
X_1	0,00157	0,000392
X_2	0,00156	0,000390
X_3	0,00155	0,000387
X_4	0,00126	0,000316
Number of resources (b_j)	320	80
The unit cost of the resource, UAH (d_j)	375,00	850,00

It should be emphasized that the company has limited resources. Based on this, the workforce is limited to 320 people, the equipment is 80 units. The basic selling prices for the products produced by the company are listed in table 4.

Table 4. Basic selling prices for manufactured products

Product name	**Base price, UAH / kg**
Carcass	29,25
Thigh	36,30
Shin	29,10
Goulash	42,56
Quarter back	28,11
Wing	31,57
Fillet	50,74
Bone remnant	13,82
Stomach	22,14
Liver	31,02
Heart	34,90
Neck	13,50
Stuffing	49,00
Heads	9,90
Paws	8,27

The proposed model of optimization of poultry meat production within the limits of profit maximization allowed us to obtain the structure of production volume and sales volume within the minimum and maximum demand (Tab. 5).

The company will be able to get the maximum profit if it sells poultry meat (Tab. 5) provided that the selling price (Tab. 4), consumption and cost of resources used with the values (Tab. 3) used in our model.

Table 5. Recommended poultry production by product type

Product name	Actual production volume, kg	The planned volume of production, kg, when:	
		minimum demand	maximum demand
Carcass	46397	11543	40846
Thigh	11597	6888	14071
Shin	6326	5464	12215
Goulash	30756	13685	9180
Quarter back	10545	4515	10359
Wing	6150	3961	9741
Fillet	11600	11158	27991
Bone remnant	7734	3482	3712
Stomach	877	2059	2474
Liver	703	1980	2320
Heart	705	1900	2165
Neck	1234	2612	2010
Stuffing	37436	6515	14173
Heads	1405	1742	1856
Paws	2285	1584	1547
Total	175750	79088	154660

Therefore, as a result, the application of this model, taking into account the maximum and minimum demand for finished products on different days, determined the optimal plan for the production, processing and sale of poultry meat (Tab. 6).

Table 6. Optimal poultry production plan

Demand for finished products	Weight categories of birds	Poultry production by processing options, kg				Profit, UAH million
		Whole carcass	Processed carcass	Soup products	Stuffing	
Minimum	First	-	14947	-	-	1,5
	Second	11543	17039	26384	-	
	Non-standard	-	-	2660	6515	
	Total	11543	31986	29044	6515	
Maximum	First	-	29231	-	-	2,9
	Second	40846	45146	21497	-	
	Non-standard	-	-	3767	14173	
	Total	40846	74377	25264	14173	

Thus, with a minimum demand, 21% of broiler carcasses of the second weight category should be sent for the production of whole carcasses, 31% of carcasses are recommended to be sent for processing and 48% for the production of soup products. Broilers of the first weight category must be used in full to process the carcass. We propose to distribute the bird of the third weight category, which belongs to the non-standard category, as follows: 29% to be used for the production of soup products, 71% - to be used for the production of minced meat.

With increasing demand for finished products, for example, on weekends and holidays, compared with weekdays, the production structure will change, i.e. there will be a different redistribution of poultry of all categories for different types of processing. In the case of maximum demand for products (provided that all products will be sold) it is recommended to send for the production of whole carcasses only 38% of broilers of the second weight category, the remaining broilers of this weight category to distribute as follows: 42% send for

carcass processing, 20% - for the production of soup products. Broilers of the first weight category should be sent entirely for carcass processing. The non-standard should be distributed as follows: 21% should be used for the production of soup products, the rest should be used for the production of minced meat.

4. Conclusions and recommendations

Thus, the proposed model of optimization of poultry production plan within the framework of profit maximization will allow to determine the range of products, taking into account not only the cost and speed of resource consumption, but also to limit their use depending on the number of available equipment, workers and more. The use of the optimization model of production will help to avoid overproduction, as this model is focused on changing market demand, which is important for enterprises that produce products whose demand changes dynamically depending on the influence of objective factors. The developed model will allow the management of enterprises to respond quickly to changes in demand for marketable products and make scientifically sound management decisions regarding the planning of production of its various types in order to obtain maximum profit. The introduction of the economic-mathematical model will provide an opportunity to optimize production processes, rationally use resources, get the maximum profit, which is a priority for enterprises in the poultry industry.

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