Вісник Тернопільського національного технічного університету
https://doi.org/10.33108/visnyk_tntu
Scientific Journal of the Ternopil National Technical University
2023, № 3 (111) https://doi.org/10.33108/visnyk_tntu2023.03
ISSN 2522-4433. Web: visnyk.tntu.edu.ua

UDC 637.02

STUDY OF THE WORK OF THE GRINDER IN DIFFERENT TYPES OF MEAT CROPPING

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Summary. *In the work, analytical studies were performed to determine the working time of the grinder on different types of meat grinding, depending on the design parameters of the grinding mechanism. The production of sausage products, despite the high level of competition, is attractive for producers. The opening of such a production is a profitable investment for starting a business, which gives a relatively quick financial return due to a quick change in the range of products made according to original recipes. One of the main technological operations for the preparation of sausage products is the grinding of meat, which accounts for 70% of the time for their production. The main mechanism for grinding meat raw materials is grinder. Selection of grinding equipment with appropriate parameters will prevent its underloading and downtime, as well as forced interruptions in the operation of devices for mixing minced meat and forming sausage products. Regulating the operation modes of the equipment for grinding meat will ensure the uniformity and rhythm of the operation of the rest of the equipment and will affect the output time of finished products, namely, sausage products. The methodology for determining the necessary duration of meat grinding, taking into account the need for raw materials for the stable operation of the sausage production shop, has been developed. The method is based on the influence of the parameters of the grinding mechanism of the lobules on the grinding time and makes it possible to take into account their change. Research results make it possible to improve the process of production of sausage products, simplify the selection of equipment and increase the productivity of the technological line for the production of products in small and medium production. Based on the obtained results, recommendations are given for determining the parameters of the grating-knife grinding mechanism, which would ensure the work of the grinder in the same time frame, regardless of the type of grinding and slight fluctuations in the technological mass of raw materials for the production of sausage products in the amount of 100 to 1000 kg per day of finished products.*

Key words: *grinder, lattice-knife mechanism, meat trimming, sourdough bread, time of work grinder.*

https://doi.org/10.33108/visnyk_tntu2023.03.076 *Received 27.06.2023*

Statement of the problem. Meat processing production combines various technological processes and uses specialized equipment to implement them. Equipment is selected based on various criteria, such as quality, price, cooking time, etc. Enterprises that process raw meat and manufacture finished products differ significantly in production volumes, product range, and equipment for making sausages and other meat products. Small processing enterprises also have their own niche, providing employment in the labor market and ensuring the appropriate quality of products. To improve the performance of small meat processing plants in terms of rational use of equipment operating time and, accordingly, employee involvement, it is necessary to ensure well-coordinated operation of the equipment. This is especially relevant for equipment used to grind raw meat when processing it into sausages. Selecting the right grinding equipment with the appropriate parameters will prevent underloading and downtime, as well as forced interruptions in the operation of devices for mixing minced meat and forming sausages. Adjusting the operating modes of the meat grinding equipment will ensure the uniformity and rhythmicity of the rest of equipment and influence the time of output of finished products, namely sausages.

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Analysis of available research results. Sausage products are products in which fresh ground meat is modified by various processing methods to provide the desired organoleptic and nutritional properties.

The main stages of sausage production include grinding raw ingredients, mixing minced meat into a homogeneous mass, filling sausage casings, and heat treatment. All of them influence the quality of the finished product.

Thin, fine, and medium grindings are used to make sausages. The average size of the pieces after grinding, depending on the type of mincing, ranges from 0.4 to 2 mm for thin grinding, from 2 to 10 mm for fine grinding, and from 10 to 60 mm for medium grinding. The degree of grinding determines the structural and mechanical characteristics of the raw meat, which have the greatest impact on the yield and quality of the finished product. The other key parameters of sausage quality are the rheological properties of minced meat and the recipe [2].

High-quality minced meat for sausage products is manufactured by optimizing the degree of grinding of different kinds of raw meat and selecting the operating modes of cutting equipment, as well as creating and applying controls to monitor the quality of minced meat and the completion of the grinding process.

Grinding of raw ingredients, in particular meat, occurs under the mechanical action of grinding mechanisms and results in the formation of new surfaces. When cutting meat, there occurs plastic deformation, friction between the contacting surfaces of the grinding mechanisms and the meat [2, 5, 6].

Meat raw materials are ground in grinders, cutters, colloidal mills, emulsifiers and other equipment. The grinding process in all of these machines is similar, but the minced meat has different characteristics. The optimal grinding time that ensures the required values of the physicochemical and technological properties of minced meat is not the same. It depends on the design parameters of the grinding mechanisms and the kinematic characteristics of the equipment.

The main tools for grinding meat are grinders and cutters. Grinders are the most convenient and cheapest compared to cutters, so they are widely used in small sausage-making businesses.

The advantages of the grinders are simple design of the feeding device, high productivity, reliability, ease of maintenance and operation. The grinders must meet certain technological requirements: ensuring different degrees of grinding; ensuring uniform feeding of raw materials to the grinding mechanism; preventing the raw materials from heating above the temperature required by the technology of sausage production; the working bodies of the machine must be easily disassembled and assembled during the sanitization of the machine and replacement of the cutting mechanism set [2, 5].

The design of the grinders differs in the following variations: the cylinder is horizontal relative to the raw ingredient, which freely falls on it; the feeder and the working auger are inclined; raw ingredients mechanically fall into the cylinder, which is horizontal relative to it; raw ingredients mechanically (forcefully) fall into the cylinder, which is inclined relative to it; the feeder and the working auger are parallel; the feeder and the working auger are perpendicular [2, 4].

The chopping mechanism of the grinders is a grating and knife mechanism, consisting of different types of grates (intake, intermediate, output) and knives with many teeth. A special feature of the grating as a tool is the shape and size of the holes. The holes in the gratings can be round, square, oval, or bean-shaped. The holes can have bevels or not. The diameter of the holes affects the degree of grinding. The raw ingredients flow out at a speed and degree of grinding that depends on the diameter of the holes and their number.

The knives used on grinders usually have three to four teeth with different types of cutting edges (curved and straight) [2].

Grinders are quite versatile equipment, as in addition to grinding meat, they can also perform various operations in the production of sausages, such as casing, salting, and filling food casings with minced meat.

Both domestic and foreign companies produce grinders, such as «Kramer + Grebe», «Wolfking», «Palmia», and others.

Objective of the research is to develop methods for determining the required duration of meat grinding, taking into account the need for raw ingredients for stable production, depending on the parameters of the grinding mechanism of the grinders.

Formulation of the problem. The operation of a small sausage processing plant depends on the market offers, which tend to change frequently, and this requires a change in the product range. Therefore, it is necessary to change the weight of raw ingredients and the configuration of the grinding mechanism to obtain minced meat with different degrees of grinding. This causes a rhythm change in the operation of the grinders and leads to a rearrangement of the work organization of the plant. To improve the organization of the work of the staff, it is necessary to ensure that the grinder operates within the same time frame, taking into account the need for raw ingredients, regardless of the degree of grinding of minced meat. Analyze the parameters that determine the performance of the grinder. Determine the parameters that affect the operating time of the grinder depending on the degree of meat grinding. Study the change in the parameters of the grinder depending on the operating conditions, i.e., at a constant shaft rotation speed that ensures high-quality grinding.

Fine grinding of raw meat occurs at a high rotational speed of the shaft on which the cutting tools are installed. Long-term operation of the equipment in this mode is followed by heat generation. This can lead to a change in the characteristics of the ground product, in particular the water-binding capacity of minced meat and denaturation of proteins, which is a negative phenomenon in the production of minced meat. This can be prevented by developing techniques for determining the required grinding time, taking into account the need for raw ingredients for stable operation of production plants. The parameters of grinding mechanism, namely the number of holes in the grates and the size of the grate holes of the grinding equipment, will also be important. The obtained values of the criteria for the completion of grinding can be also used to design tools and devices for monitoring the readiness of minced meat.

Results of the research. The most common specialized equipment for meat processing is grinders, which provide grinding of technological raw materials for thin, fine and medium grinding. Grinders are used to grind both frozen and unfrozen meat, fat-containing products, and other raw materials.

Grinders are used in technological lines for the production of sausages and other products from chopped raw ingredients.

The most common grinding mechanism for grinders is flat (grating-knife). It is simple to manufacture, easy to maintain, reliable in operation, and has a high performance speed.

For the purpose of this study, we will consider a grinder (Figure 1), which has an electromechanical drive and mechanical feeding of raw ingredients with a parallel arrangement of feed and working augers. Structurally, the grinding mechanism of such a grinder includes intermediate, intake, and outlet grates and one-sided multi-tooth knives.

The peculiarity of gratings is that the raw material flows out of them at a speed and degree of grinding that depends on the number of holes and their diameters. The holes can be of different shapes (square, oval, bean-shaped, etc.). The knives of the four-tooth grinder are solid, single-sided sharpening with straight cutting edges.

The main technical characteristic of grinders is the diameter of the holes of the replaceable gratings.

The preparation time of technological produce, namely, chopped meat of different degrees of grinding for the manufacture of sausages in a relatively small production plant (up to 600 kg of finished products per day), can be adjusted by ensuring the rhythmic operation of the grinder with other mechanisms integrated into the production line. The rhythmic operation of the grinder depends on the diameter of the holes and their number in the grating of the grinding mechanism.

The time it takes to prepare the required amount of minced meat with the appropriate degree of grinding depends on the performance of the grinder

$$t = m/Q, \tag{1}$$

where m is the weight of minced meat necessary for making sausages, kg;

Q is is the performance of the grinder, which ensures the preparation of minced meat with a certain degree of grinding, kg/s, is determined by the formula [2].

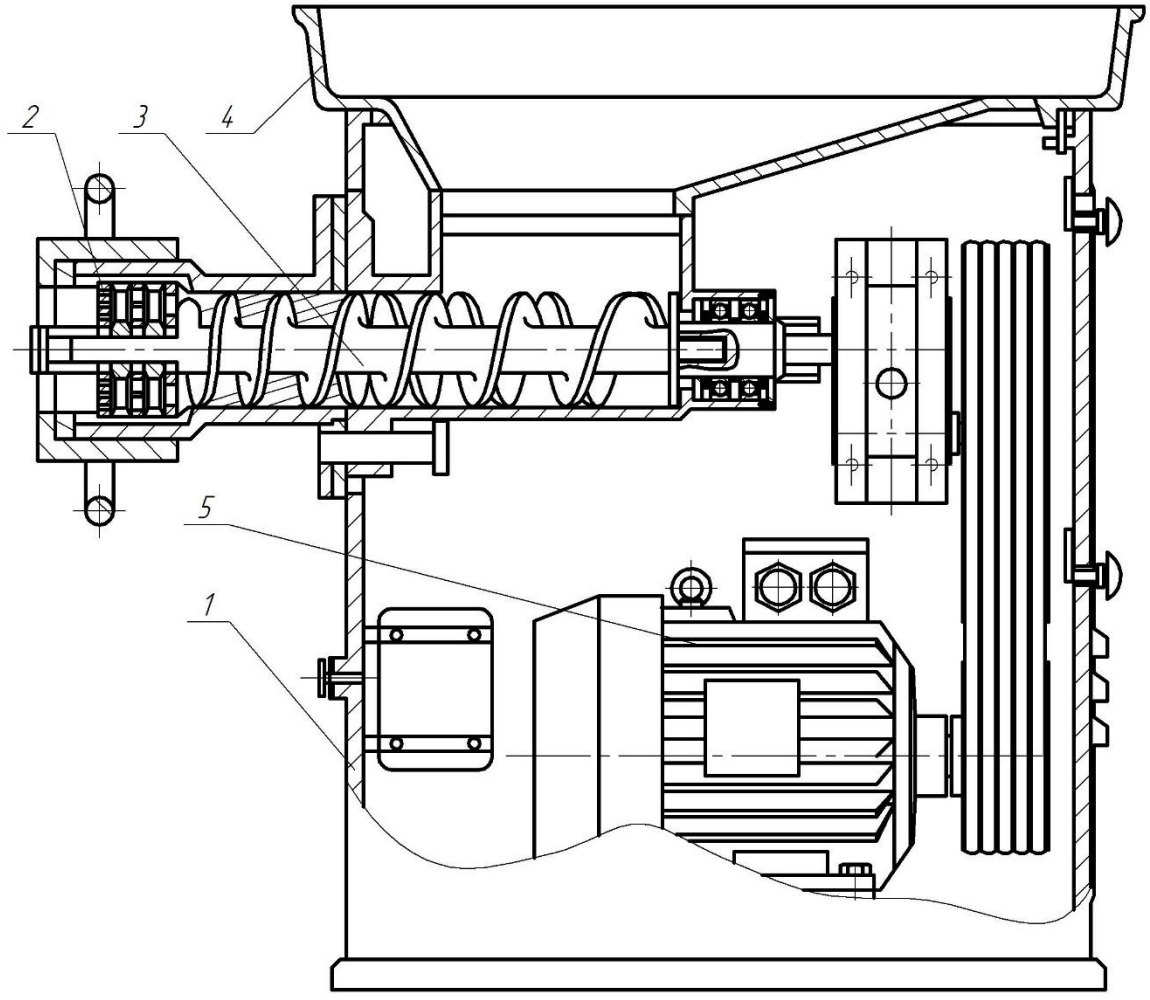


Figure 1. Scheme of a grinder
1 – body; 2 – grinding mechanism; 3 – mechanism for supplying technological raw ingredients; 4 – container for loading raw ingredients; 5 – drive

The determining parameter that affects the productivity of the grinder and, accordingly, the time for preparing the required mass of technological raw ingredients is the diameters of the grating holes and their number (Figure 2).

$$Q = \frac{\pi \cdot n \cdot d_0^2 \cdot z_0}{4} \cdot (r_3 + r_B) \cdot \rho \cdot k_n \cdot \varphi \cdot tg\beta \cdot \cos\alpha \quad , \qquad (2)$$

where n – is the rotational rate of the working body of feeding technological raw products, we accept n=16,7 c^{-1};

d_0 is the size of knife grating holes, m;

z_0 is the number of holes in the grating, pcs.;

ρ is the density of the process raw ingredients, we accept ρ =1100 kg/m3;

r_3 is the outer radius of the raw ingredients feeding mechanism, we accept $r_3 = 50 \cdot 10^{-3}$ m;

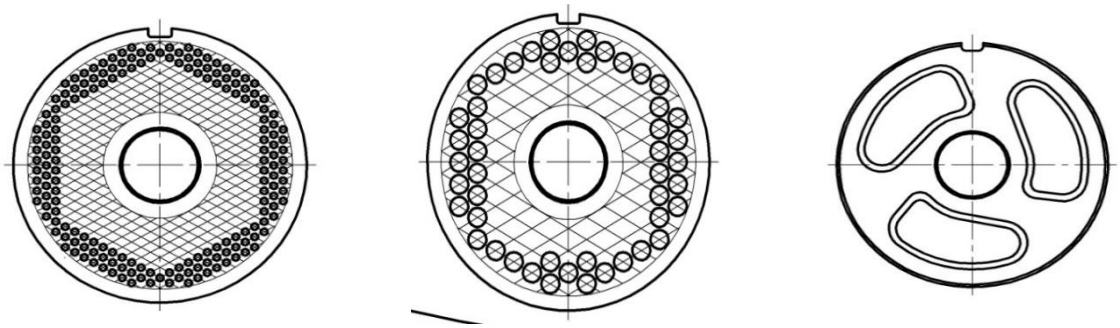
φ is the coefficient of usage of the knife grate holes by minced meat, we accept φ =0,6;

r_B is the inner radius of the auger for feeding raw ingredients, $r_B = 20 \cdot 10^3$ m;

β is the angle of inclination of the coil of working body of the raw material feeder to the axis, we accept $\beta = 10°$;

k_n is a coefficient that takes into account the movement of minced meat together with the working body of the raw ingredient feeder, we accept k_n =0,5;

a is the angle of inclination of the last turn of the working body of the raw material feeder (for normal operation of the grinder a=0°).



a) *b)* *c)*

Figure 2. Grinder grates for different types of meat grinding: a – thin grinding; b – fine grinding; c – medium grinding

Consider the effect of the studied parameters of the grinding mechanism of the grinder on the time of preparation of a certain amount of technological raw ingredients.

For the purpose of the study, we assume that the minced meat for making sausages will consist of three fractions with different degrees of grinding. For each type of meat grinding, we will use gratings with holes of the following sizes: thin 2 mm, fine 6 mm, medium 35 mm.

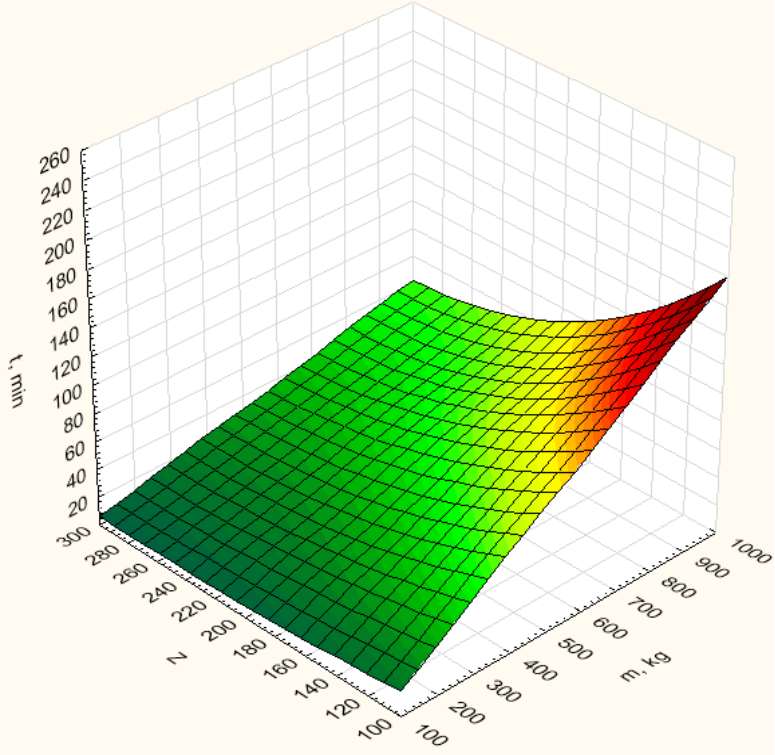
Using Matlab software, we plotted graphs of changes in the operating time of the grinder (Figures 3, 4) depending on the number of holes in the grates and the weight of the processed raw ingredients required to prepare the corresponding mass of sausages.

Using these dependencies, it is possible to optimize the operation of the equipment in terms of time for the preparation of a certain amount of products.

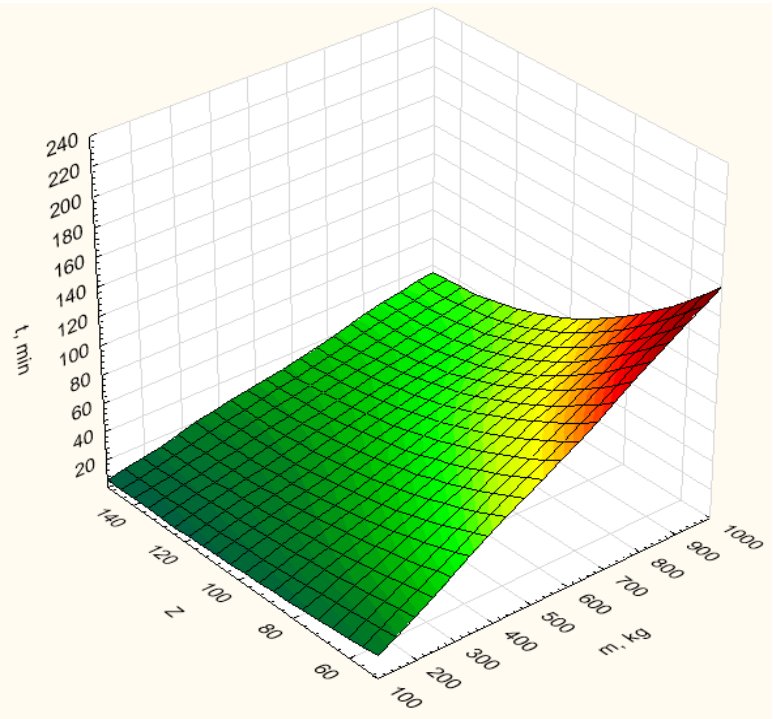
Conclusions. Methods for determining the required duration of meat grinding, taking into account the need for raw ingredients for the stable operation of a sausage production plant, have been developed. The technique is based on the influence of the parameters of the grinding mechanism of the grinders on the grinding time and makes it possible to take into account their change.

The obtained values of the criteria for the completion of the grinding process can also be used to design means and devices for monitoring the readiness of minced meat.

The results of the research will improve the sausage production process, simplify the selection of equipment and increase the performance of the production line for small and medium-sized sausage manufacturing facilities.



a)



b)

Figure 3. Graphs of changes in the working time of the grinder: a – for fine grinding, d_0 =2 mm; b – for thin grinding, d_0 =6 mm

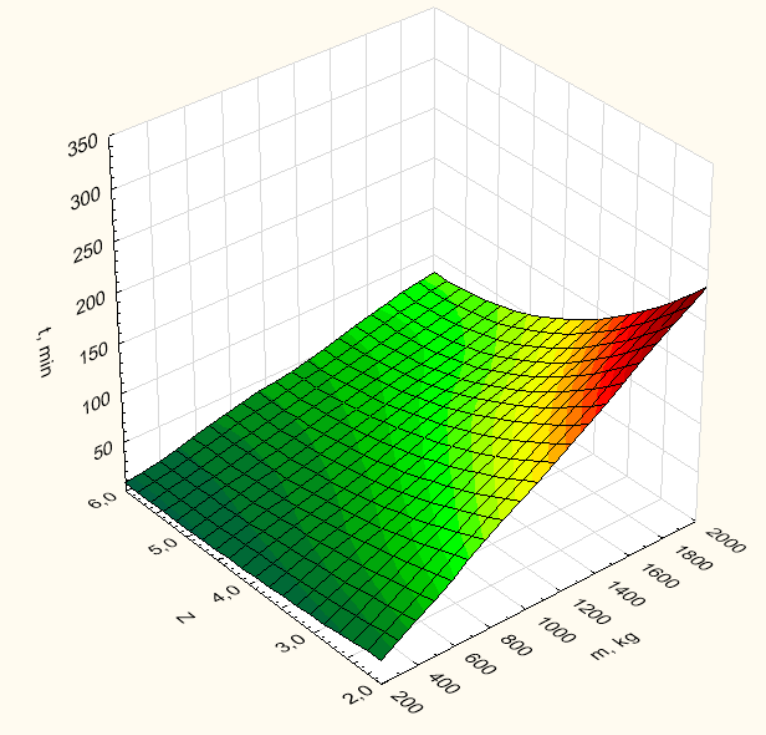


Figure 4. The graph of changes in the working time of the grinder for medium grinding d_0 = 35 mm

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УДК 637.02

ДОСЛІДЖЕННЯ РОБОТИ ВОВЧКА ПРИ РІЗНИХ ВИДАХ ПОДРІБНЕННЯ М'ЯСА

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Резюме. *Виконано аналітичні дослідження визначення часу роботи вовчка на різних видах подрібнення м'яса залежно від конструктивних параметрів подрібнювального механізму. Виробництво ковбасних виробів, незважаючи на високий рівень конкуренції, є привабливим для виробників. Відкриття такого виробництва вигідне вкладанням коштів для початку бізнесу, який порівняно швидко дає фінансову віддачу завдяки швидкій зміні асортименту продукції, виготовленої за оригінальними рецептами. Однією з основних технологічних операцій приготування ковбасних виробів є подрібнення м'яса, яке складає 70% часу на їх виготовлення. Основним механізмом для подрібнення м'ясної сировини є вовчки. Підбір подрібнювального обладнання з відповідними параметрами запобігатиме його недовантаженню та простоям, а також вимушеним перервам у роботі пристроїв для перемішування фаршу та формування ковбасних виробів. Регулювання режимів роботи обладнання для подрібнення м'яса забезпечуватиме рівномірність та ритмічність роботи решти обладнання та вплине на час виходу готової продукції, а саме, ковбасних виробів. Розроблено методику визначення необхідної тривалості подрібнення м'яса з врахуванням потреби у сировині для стабільної роботи цеху з виробництва ковбасних виробів. Методика ґрунтується на впливі параметрів подрібнювального механізму вовчків на час подрібнення і дає можливість враховувати їх зміну. Результати досліджень дозволяють покращити процес виробництва ковбасної продукції, спростити підбір обладнання та підвищити продуктивність технологічної лінії для виробництва продукції в малому та середньому виробництві. Виходячи з отриманих результатів, дано рекомендації для визначення параметрів решітчасто-ножового подрібнювального механізму, які б забезпечували роботу вовчка в однакових часових рамках незалежно від виду подрібнення та незначного коливання технологічної маси сировини для виготовлення ковбасних виробів обсягом від 100 до 1000 кг на добу готової продукції.*

Ключові слова: *вовчок, решітчасто-ножовий механізм, подрібнення м'яса, ковбасні вироби, час роботи вовчка.*

https://doi.org/10.33108/visnyk_tntu2023.03.076 *Отримано 27.06.2023*