PRODUCTION OF HOMOGENIZED CANNED BABY FOOD USING INNOVATIVE TECHNOLOGY OF MEAT RAW MATERIAL GRINDING

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Abstract – An innovative method of meat raw material grinding is proposed for the production of homogenized canned baby food. Grinding of frozen raw materials by milling allows obtaining meat particles with a size in the following range: 90-300 µm (width) and 30-100 µm (thickness). About 10% of the product particles have a width of 300 to 400 µm, which is allowed by regulations on homogenized meat products for baby food. Application of the new method allows obtaining the product with required grinding size at the stage of raw material preparation, which leads to intensification of production by eliminating canning mass disintegrators performing fine grinding. To ensure stable quality of the product obtained, it is necessary to use the automatic process control system for production of minced meat on an automatic line for homogenized canned baby food. Such system may be developed using artificial intelligence methods and technologies. The control system is trained during the work, adapts to changes in the parameters of processed raw materials and external influences affecting the system operation, ensures the production of meat chips with minimal variation in a particle size. This allows real-time monitoring of technological process with guaranteed high quality of the finished product.

Key Words – particle size, meat grinding, milling, intelligent control system, morphometry.

I. INTRODUCTION

When using innovative energy- and resource-saving technology for grinding of meat raw material using milling method [1], it is necessary to ensure stable quality of a product obtained at minimal cost. It is possible only if there is an automatic control system for the processes that take place in manufacturing of finished products. In case of frozen meat processing into chips with mills of different design, the grinding process may be controlled using the principle of "non-destructive evaluation". This means the absence of measuring elements directly in minced meat. To develop such control system, it is necessary to take into account the dependence of physical and mechanical properties of frozen meat raw material on its current temperature and property anisotropy typical for frozen meat, which affects its grinding. In the literature, there is a significant effect of frozen meat temperature on its mechanical properties (hardness, toughness) and strength parameters (compression strength, tensile strength, shear force and bending strength) [2]. Thus, it is necessary to control raw material temperature at the input to milling machine and to change grinding parameters (cutting speed and feed rate) depending on the signal from temperature sensor. The ultimate goal for the grinding process control system using a milling machine is to reduce the range of particle linear dimensions in minced meat, i.e. to obtain particle sizes in accurately specified range. The importance of solving this problem for baby food should be noted. A child aged 4-5 months can only absorb emulsified fat, mainly milk fat, and products with minimum content of fibers and cell membranes. Fiber accounts for 40-60% of cell membrane dry matter and does not hydrolyze when cooking (only a small part of it) [3]. Digestive juices penetrate only into surface layers of food pieces and do not penetrate into inner layers. Therefore, we need to grind food by chewing it to increase its surface. For infants (up to 1 year) it is not possible due to the physiology of development. Hence, there is a need to produce meat products for baby food with particle size in in a certain range.

To obtain the required particle size in the production of homogenized canned food on batch equipment, the canning mass is processed in a colloid mill or microcutter or system of disintegrators after grinding of meat raw material in mincing machine, and then it may be additionally homogenized. However, another technological solution is possible using one-stage grinding of raw material by milling. In this case, a rotary type meat cutting machine is used, the working shaft of which is a screw-formed cylindrical body with cutting edges on the flanges. This shaft may be designed as a set of milling cutters with a screw tooth made from material permitted for contact with food.

II. MATERIALS AND METHODS

Experimental frozen meat blocks obtained from blocks of industrial size (beef) were used as a raw material for grinding. The dimensions of the experimental blocks were: height 0.070 m; width 0.075 m; length 0.3-0.4 m. In this work, one-stage grinding of raw meat frozen blocks was used by milling in IBF-1 experimental machine designed by the V. M. Gorbatov All-Russian Meat Research Institute.
Determination of raw material grinding size was carried out by the microstructural method in accordance with GOST R 54047-2010 "Meat and meat products. Method for particle size determination" [4]. Microscopic sections with a thickness of 14 μm were made on MIKROM-HM525 cryostat (Thermo Scientific), mounted on Menzel-Glaser slides (Thermo Scientific) and stained with Ehrlich's hematoxylin and fresh 1% ethanol-aqueous solution of eosin (BioVitrum). Histologic specimens were studied and photographed using an AxioImaiger A1 light microscope (Carl Zeiss) with a connected AxioCam MRc 5 camera (Carl Zeiss). Image processing and morphometric studies were performed using AxioVision 4.7.1.0 computer image analysis system (Carl Zeiss). Morphometric studies in the interactive mode of specified parameters measuring were carried out in accordance with the principles of systemic quantitative analysis in triplicate. The results were presented in tabular form and transferred to Exel for further statistical processing.

III. RESULTS AND DISCUSSION

Microstructural studies of ground meat sample produced with IBF-1 machine (Figure 1) showed that the use of new grinding method allowed obtaining a dense, stable structure of minced meat, which is necessary to ensure uniform texture of the final product.

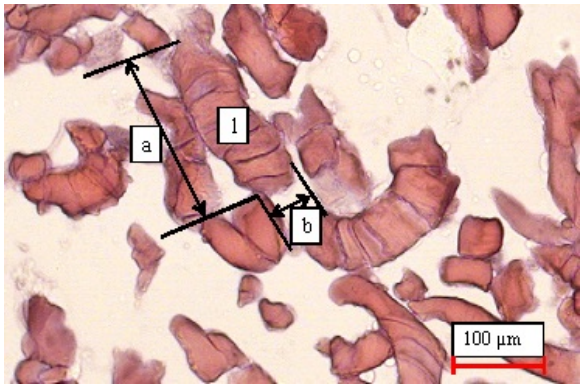
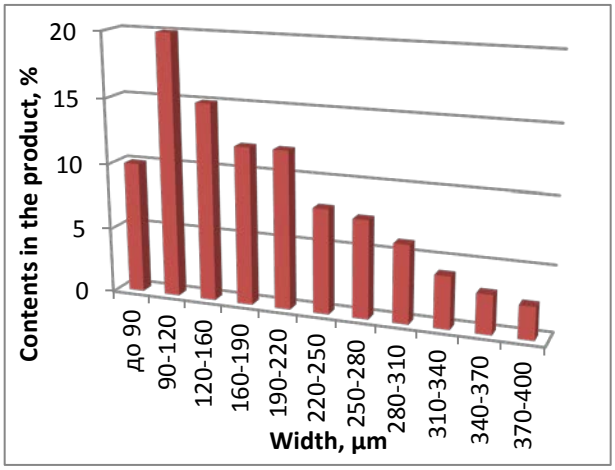


Figure 1. Microstructure of ground meat sample (x10 magnification), where 1 - meat chip particle, a – particle width, and b – particle thickness

The results of particle size evaluation in meat chips obtained by milling method are shown in Figure 2 and Figure 3. Data analysis shows that the sizes of meat particles are distributed over the following ranges: 30-100 μm (thickness - Figure 2) and 90-300 μm (width - Figure 3). About 10% of the product particles have width of 300 to 400 μm, which is allowed by regulations on homogenized meat products for baby food. Thus, application of the new method allows obtaining a product with required grinding size at the

stage of raw material preparation, which leads to intensification of production by eliminating canning mass disintegrators performing fine grinding.



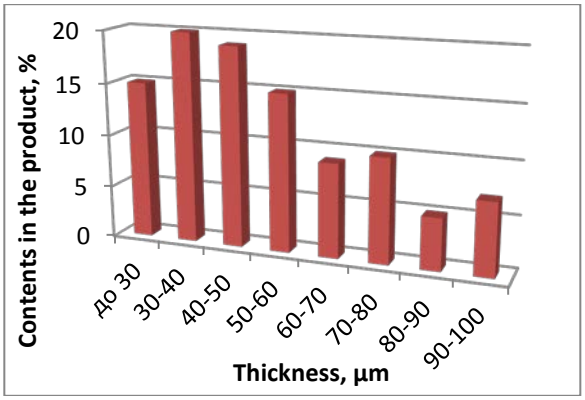


Figure 2. Distribution of thickness values for ground meat particles

Figure 3. Distribution of width values for ground meat particles

Grinding of raw materials by milling can provide for complete automation of the technological process for canned baby food by the principle of "unattended processing". Thus, specialized factories will ensure high production culture while saving wage fund. The proposed technology allows implementation of continuous automatic monitoring of minced meat technological parameters. For this purpose, it is proposed to create a management system designed to work in the conditions of initial information incompleteness and uncertainty of the environment and external disturbances. Such system may be created using methods and technologies of artificial intelligence [5]. A distinctive feature of the intelligent control system (ICS) is the ability to systematically process the information. In the proposed technology, there is an automatic process of statistical information accumulation obtained when grinding a batch of frozen meat blocks with certain temperature conditions of raw material storage. The information systematized by the ICS itself is automatically entered into the program unit that controls the technological process of minced meat preparing. Thus, we get trainable management system adapted to changes in parameters of the processed raw materials and external influences that affect the operation of the ICS. For a one-stage process of meat raw material grinding, the system ensures the production of meat chips with minimal variation in a particle size. Therefore, there is principle possibility to automatically control the technological process of minced meat production in real time. Thus, the instrumental control of minced meat technological indicators is introduced, which allows obtaining products with stable quality. When constructing the ICS for the entire technological process of minced meat production on the automatic line for homogenized canned baby food, the system for automatic maintenance of a specified grinding size should be supplemented with a device for rapid analysis of a minced meat chemical composition. Also, all machines and devices of the technological chain should be combined into the single information space. The configuration of such ICS in the technological process of minced meat production is shown in Figure 4.

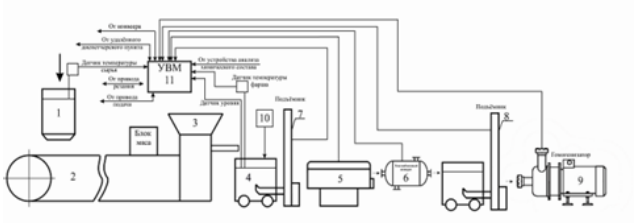


Figure 4. ICS configuration for minced meat production

Frozen meat blocks are transported from feed hopper (1) to milling machine (3) by conveyor (2). Ground raw material from cart (4) is loaded into formulation mixer (5) by elevator (7). After mixing, the formulation mass is heated in heat exchanger (6) and loaded into the homogenizer (9) by elevator (8). The ICS unit (10) monitors a raw material temperature, chemical composition of minced meat (moisture, protein, fat, pH), its temperature, and issues a command for mixing (producing) of minced meat with optimal parameters. In addition, the ICS controls the process of raw material grinding in milling machine and maintains specified grinding size. The control system predicts the average size of meat chips at the output of milling machine and determines the limits for deviations from this size. Analyzing this information, as well as data from the rapid analysis of the ground meat chemical composition and its temperature, the ICS selects optimum mode of minced meat mixing in a formulation mixer to ensure the desired quality of the final meat product. The technological process of canning mass production is controlled by UVM 11 (an industrial computer or programmable logic controller).

IV. CONCLUSION

Application of meat raw material grinding by milling allows intensifying production of homogenized canned baby food using fully automated technological operations with ensuring the high quality of the finished products.

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