Development of the reference model for the technological process management and decision-making support in refrigerated semi-product production

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Abstract - **The aim of this study was to develop the reference model for the technological process management and decision-making support in refrigerated semi-product production. The refrigerated meat raw material in half carcasses, refrigerated semi-product (large chunks of meat) as the final product and the technological system of production processes were the subjects of research. The assessment of the indices of raw material and final product safety was conducted by established methods and by simulation modeling. The analysis of risks and factors affecting the final product characteristics was carried out. The different conditions of raw material processing and final product packaging (1.5^0C, 8^0C, 15^0C) were simulated. We showed that the temperature of raw material and premises, and the process duration had the most influence on the final product safety and quality. Under the comparatively similar initial microbial contamination of meat raw material the product produced and packed at $+1.5^0$C was the most beneficial regarding the microbiological quality. The dynamics of the microbial contamination change in this type of the refrigerated semi-products over time as a function of the initial temperature of meat raw material and production conditions was established. The obtained data provide the basis for the development of the production management model in meat processing plants.**

Keywords — **safety, model, refrigerated**

I. INTRODUCTION

Preservation and safety of refrigerated meat products depend on many factors. The conditions of livestock transportation and final product manufacturing, as well as its storage, transportation, sales and consumption should strictly comply with the established rules. These rules include maintenance of low temperature in the premises of raw meat processing and storage, ensuring low initial bacterial content, pH control, high hygiene standards of production facilities and equipment, systematic approach, and risk analysis.

The purpose of this work was to develop the reference model for the technological process management and decision-making support in refrigerated semi-product production, as well as the establishment of mandatory control points of the production process based on risk analysis system.

II. MATERIALS AND METHODS

The targets of this study were: refrigerated raw meat in form of carcass sides of the same category; the final product - semi-product made from refrigerated meat and packed in vacuum; technological system of the production processes.

Safety parameters assessment of raw materials and final products was carried out using procedures established by regulatory documents, as well as using simulation model approach. Description of production systems was carried out using SADT methodology (Structured Analysis and Design Technique). Risk analysis was carried out in accordance with risk analysis chart.

III. RESULTS AND DISCUSSION

At the first stage, analysis of the risks and factors that influence the quality of final product was conducted. As a result, it was found that the temperature of raw materials and premises, as well as the operation duration has the greatest impact on the safety and quality of final product. At the next stage, various conditions of final product processing and packaging were simulated.

A series of experiments was conducted as follows: after slaughter raw meat were placed in refrigerating chambers for 24 hours, then it was subjected to pH

measurement for inclusion in RSE, PSE, NOR or DFD group, and to temperature measurement. At relatively the same initial bacterial content (1.6 x 10^2 CFU/g ± 0.2), raw meat was stored for a certain time (2 hours) under the following temperature conditions: at 1.5 °C, at 8 °C, and at 15 °C. Afterwards the samples No. 1, No. 2 and No. 3 were deboned and sliced. Product No. 1 and product No. 2 were separated out of each sample and packed in vacuum.

The results showed that the product with most satisfactory microbiological quality was produced and packed at 1.5 °C from sample No. 1 (bacterial content at 5th and 10th days was 9.4 x 10^4 CFU/g and 4.4 x 10^5 CFU/g, respectively). Bacterial content of products manufactured and packed at 15 °C from sample No. 3 at 5th and 10th days was 3.1 x 10^6 CFU/g and 7.6 x 10^7 CFU/g, respectively, which exceeds the regulated level of 5.5 x 10^5 CFU/g. Exceeding levels were observed as early as at 5th day, while the recommended shelf life is 10 days. The data are presented in Fig. 1 and Fig. 2.

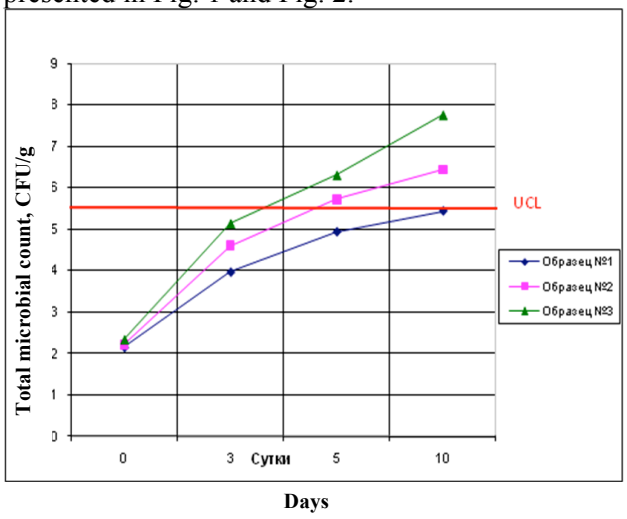

Fig. 1 Total microbia ynamics in product No. 1

The dynamics of ial count in refrigerated semi-products depen he initial temperature of raw materials and on conditions also was studied. Thus, the g te of mesophilic aerobic and facultative an microorganisms (total microbial count) in p lo. 1 manufactured at 15 °C was 35% higher than in product No.1 manufactured at 1.5 °C.

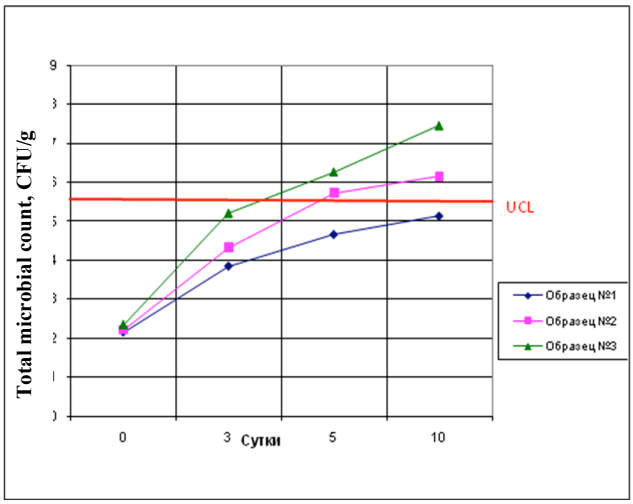

Fig. 2 Total microbial count dynamics in product No. 2

All technologic processes of refrigerated semi-product production were presented as consequent blocks with indication of controlling parameters. In each block the following parameters were defined:

- process inputs (raw materials, signal, data, etc.);
- process outputs (documents, records, reports, semi-products, products, etc.);
- necessary resources of the process (equipment, personnel, facilities, etc.);
- process managing actions (procedures, standards, verbal instructions, etc.);
- process algorithm (description of operation sequence transforming process input into process output).

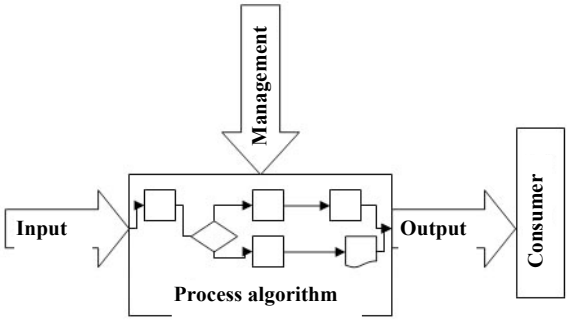

Fig. ram rep tecl c process

IV. CONCLUSION

Based on the analysis and the experimental data the main principles of reference model functioning were stated. Time of raw meat storage and its temperature before deboning process, bacterial content and pH of raw materials, as well as temperature in the cutting room may be considered as the reference points of the final product shelf life. The data obtained were used as the basis for process control and were presented as algorithm of decision-making support in refrigerated semi-product production. The algorithm was used as the basis for a model that can be used to develop software for process control at meat-processing factories. Application of this model will enable process optimization, reduction of human factor influence, and prediction of final product characteristics and shelf life.