

## **ABSTRACT**

thesis for the degree of Doctor of Philosophy (PhD) in specialty  
6D073500 – "Food Safety"

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### **ENSURING FOOD SAFETY of MEAT PRODUCTS with SPREADABLE CONSISTENCY USING MEAT and BONE PASTE**

The dissertation work is devoted to ensuring the food safety of the production of meat and bone paste from the rib bones of cattle and its application in the technology of meat paste. The paper presents the results of studies of the effect of fermentation on the splitting of bone particles in meat and bone paste from rib bones of cattle. A system has been developed to ensure food safety in the production of meat paste with meat and bone paste, by identifying risks using Hazard Analysis and Critical Control Points (HACCP) and analyzing the types and consequences of potential inconsistencies by Failure Mode and Effects Analysis (FMEA).

**Relevance of the research topic.** President of the Republic of Kazakhstan Kassym-Jomart Tokayev in his Address to the People of Kazakhstan "Kazakhstan in a new reality: time for action" in 2020 noted: "The most important task facing Kazakhstan is the full disclosure of its industrial potential. About two-thirds of processed goods are imported from abroad. In order to ensure the strategic self-sufficiency of the national economy, it is necessary to urgently begin the development of new food products".

Almost a third of all food products produced in the world suitable for human consumption currently goes to waste. One of the goals in the framework of Sustainable Development Goal No. 12 "Responsible consumption and production" provides for halving the amount of food waste per capita at the consumer level, as well as throughout the supply chain by 2030.

The improvement of the technology of processing secondary bone raw materials of the meat processing industry contributes to the development of new types of meat products with increased nutritional and biological values. Food bone, an essential source of food raw materials, characterized by a high content of fat, protein and phosphorus-calcium salts.

The spread of coronavirus disease (COVID-19) in 2020 has drawn additional attention to the risks of significant food losses, especially meat, dairy products, fruits and vegetables, as social distancing measures have led to supply chain disruptions and a drop in demand in many countries, which could potentially lead to increased losses, especially in high-value and nutrient-rich food products.

**The purpose of this work** is to develop a system for monitoring and ensuring food safety of a meat product of a smeared consistency – pate with the addition of meat and bone paste from the rib bones of cattle.

To achieve this goal, the following **tasks** were formulated and consistently solved:

1. Based on the analysis of scientific literature to determine the methods of enzymatic processing of bone particles in meat and bone paste.

2. To determine the parameters of the enzyme activity for splitting bone particles in meat and bone paste ensuring its safe use in meat paste technology. On the basis of mathematical analysis to determine the effective parameters of fermentation of bone particles in meat and bone paste;

3. To investigate the quality indicators and food safety of meat and bone paste from the rib bones of cattle;

4. To develop the technology of meat paste with meat and bone paste. To investigate organoleptic, physico-chemical, microbiological indicators and indicators of food safety of meat paste with meat and bone paste;

5. To ensure quality and food safety in the production of meat paste with meat and bone paste, by identifying risks using HACCP and FMEA systems;

6. To develop a map of metrological quality assurance and safety of raw materials and finished product in the production of meat paste with meat and bone paste.

7. To develop regulatory and technical documentation and to test the technology of production of meat paste with meat and bone paste. To determine the economic indicators of cost in the production of meat paste with meat and bone paste.

**The object of research** is rib bones of cattle, meat and bone paste from rib bones of cattle, meat paste with the addition of meat and bone paste from rib bones of cattle.

**Research methods.** The laboratories of the departments "Food Technology and Biotechnology" and "Technological Equipment and Mechanical Engineering", the Scientific Center for Radioecological Research of the NJSC "Shakarim University of Semey", the Federal Altai Scientific Center for Agrobiotechnologies (Barnaul, Russia), the Semey Branch of the Kazakh Research Institute of Processing and Food Industry LLP, the testing laboratory of Nutritest LLP and the Semey branch of the National Center for Expertise and Certification JSC were involved in the experimental research of the work. During the experiments, proven research methods, modern instruments and equipment, methods of mathematical statistical processing of results using MathCAD and OriginPro software were used.

**Scientific novelty of the work.** The application of the method of enzymatic cleavage of bone particles in meat and bone paste for its safe use in products of smearing consistency has been scientifically substantiated and experimentally confirmed. Technological factors affecting the safety of meat paste are determined. The critical control points of the technology of production of meat paste with meat and bone paste have been determined. An application for the grant of a patent of the Republic of Kazakhstan for a utility model 2021/0701.2 has been filed from 13.07.2021 on the technology of production of meat paste "Phirmennyi" with the addition of meat and bone paste.

### **The main provisions submitted for protection:**

1. Parameters affecting the rate of enzymatic reaction of bone particles splitting in meat and bone paste from rib bones of cattle for its safe use in meat paste technology;
2. Technology of production of meat paste with the addition of meat and bone paste from rib bones of cattle in accordance with the requirements of food safety;
3. Quality control and food safety system in the production of meat paste with meat and bone paste, through risk identification using HACCP, FMEA systems.

**Scientific and practical significance of the work.** The results of studies of physico-chemical, microbiological indicators and indicators of food safety of meat paste using meat and bone paste are presented; a quality control system has been developed for the production of meat paste with meat and bone paste, through risk identification using HACCP, FMEA systems. Regulatory and technical documentation for the production of meat pate "Phirmennyi" (ST 9210-01-50768864-2021) has been developed. An experimental batch of meat paste with the addition of meat and bone paste was developed and tested in the Semey branch of Kazakh Research Institute of Processing and Food Industry LLP and in the production of IE Alteev.

**Connection of work with research projects.** The dissertation work was carried out within the framework of program-targeted financing of the Ministry of Agriculture of the Republic of Kazakhstan in the priority direction "Sustainable development of the agro-industrial complex and safety of agricultural products" on the topic "Development of resource-saving technology for processing secondary raw materials of cattle and poultry in the production of functional meat products", the amount of funding for 2021-2023 is 75 million tenge (IRN BR10764970).

**Personal contribution of the author.** Development of technology for processing bone raw materials from rib bones of cattle into meat and bone paste and ensuring its safe use in meat paste technology.

**Approbation of the results of the dissertation.** The main results of the dissertation work were reported at International scientific and practical conferences: IX International Scientific and Technical Conference "Kazakhstan-Cold 2019" (Almaty, 2019); "Modern problems of technology and technology of food production" (Barnaul, 2019); "State and prospects of development of the best available technologies of specialized food products" (Omsk, 2019); X Anniversary international scientific and technical conference "Kazakhstan-Cold 2020" (Nur-Sultan, 2020).

**Publications.** 16 scientific papers have been published on the topic of the dissertation, including: 5 articles in journals recommended by the Committee for Quality Assurance in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan; 2 articles included in the Scopus database and having a non-zero impact factor; 1 monograph; 1 analytical review; 6 materials of International scientific and practical conferences; 1 application for a patent of the Republic of Kazakhstan for a utility model 2021/0701.2 from 13.07.2021.

**The structure and scope of the dissertation.** The dissertation work consists of an introduction, five chapters, a conclusion, a list of references and appendices. The main text is presented on 95 pages of typewritten text, contains 30 tables, 23 figures, the list of references includes 143 sources and 16 appendices.

**Assessment of the completeness of solutions to the tasks.** The data obtained allow us to assume that the purpose of the dissertation work has been achieved and all the tasks set have been completed:

1. The scheme of processing meat and bone raw materials into a fine paste consists in multi-stage grinding and freezing from -18 to -20 °C using a top-crusher with output grid diameters of 5 mm and a micro-grinder "Supermaskoloider" with a gap between the working bodies of 0.02 mm. Based on the scientific and technical literature, a method of enzymatic processing of bone particles in meat and bone paste by using pepsin and ascorbic acid has been determined.

2. The technology of obtaining meat and bone paste from the rib bones of cattle has been investigated. Microstructural analysis of meat and bone paste revealed the presence of bone particles ranging in size from 0.05 to 1 mm. The method of enzyme treatment with pepsin and ascorbic acid was used to break down bone particles. The dependences of enzyme activity on temperature, reaction duration, amount of enzyme and substrate were determined. The highest activity of pepsin with ascorbic acid was found at pH = 2, temperature = 30 °C, time = 4 h, the amount of the enzyme is 10 g per 100 g of meat and bone paste. Mathematical processing of experimental results and parametric identification of experimental dependences is carried out.

3. The physicochemical, microbiological composition and indicators of food safety of meat and bone paste from rib bones of cattle were studied. The use of meat and bone paste as a raw material in the technology of a meat product is justified. Meat and bone paste from the rib bones of cattle has a high protein content – 10.1 g/100 g and minerals (calcium – 5318.13 mg/100 g, magnesium – 207.62 mg/100 g). The content of radionuclides and toxic elements, microbiological indicators correspond to the norms of maximum permissible concentrations.

4. Organoleptic, physico-chemical, microbiological indicators and indicators of food safety of meat paste with meat and bone paste from rib cattle were investigated. The analysis of the data indicates the high nutritional and biological value of the meat paste "Branded" (energy value – 350 kcal/100 g). According to organoleptic indicators, the best option for applying meat and bone paste is 20% instead of meat raw materials. The technology of meat paste "Phirmennyi" with the addition of meat and bone paste from rib bones of cattle, fermented with pepsin and ascorbic acid, has been developed.

5. Critical control points have been determined in the production of meat pate "Phirmennyi" with meat and bone paste by building a "Decision tree". In the technological process of meat pate production, 5 critical control points were identified: acceptance of raw materials, blanching, cooking and cooling, packaging and storage. Possible risks and measures to reduce them during production are also

identified through the application of the principles of analysis of the types and consequences of potential nonconformities (FMEA).

6. A map of metrological support of the technological process of production, quality control and safety of raw materials and finished product in the production of meat pate "Phirmennyi" with meat and bone paste from cattle bones has been developed. The maximum number of risks (LNR = 70) in the production of meat paste is determined. Measures are proposed to reduce the risk of producing pate of inadequate quality.

7. Regulatory and technical documentation has been developed (ST 9210-01-50768864-2021). An experimental batch of meat paste with the addition of meat and bone paste was developed and tested in the Semey branch of Kazakh Research Institute of Processing and Food Industry LLP and in the production of IP Alteev. The calculation of the economic efficiency of the production of meat pate "Phirmennyi" was carried out, the cost of meat pate was 1,697 tg /kg, which is 34.5% lower than the cost of meat pate produced using traditional technology.