

ATAMBAEVA ZHIBEK MANAPOVNA

«Comprehensive system for ensuring the quality and safety of composite meat products using plant-based components»

ABSTRACT

for the dissertation submitted by Atambayeva Zhibek Manapovna for the degree of Doctor of Philosophy (PhD) in the specialty 6D073500 – «Food Safety»

Relevance of the study. One of the priority areas for the development of Kazakhstan's agro-industrial complex is the production of meat and meat products. In his Address to the Nation on September 8, 2025, the President of the Republic of Kazakhstan, Kassym-Jomart Tokayev, identified the key directions of the country's socio-economic development, emphasizing the importance of ensuring food security and modernizing the processing industry. As the President noted, the stability and efficiency of domestic production are directly linked to the adoption of innovative technologies and the improvement of product quality. In this context, the production of high-quality, environmentally friendly food products is a key prerequisite for ensuring national food independence and protecting public health.

To achieve these objectives, it is essential to expand domestic production and ensure the supply of socially significant food products. The Concept for the Sustainable Development of the Agro-Industrial Complex highlights the increase in food production and the assurance of its safety as strategic priorities. In the face of growing market competition and rising consumer expectations, the quality and safety of products play a decisive role.

A crucial task of modern meat processing is to expand the range of high-quality products with improved consumer properties through the rational use of local resources. In recent years, adverse trends have been observed in public health across Kazakhstan, particularly in the Abai region, due to increased technogenic load and deteriorating environmental conditions. Consequently, the incidence of cardiovascular and oncological diseases has risen, which is partly associated with nutritional imbalance. Statistical data and nutritional studies indicate insufficient intake of essential micro- and macroelements such as calcium, iodine, iron, and selenium, as well as a general imbalance in protein metabolism.

The environmental situation in Kazakhstan further aggravates the problem: air, water, and soil are contaminated with radionuclides, pesticides, and toxic heavy metals such as mercury, lead, and cadmium, all of which negatively affect human health. Although some of these elements are necessary in trace amounts, their excess concentrations exhibit pronounced toxic effects.

Improving this situation is possible through two main directions: mitigating adverse environmental impacts and developing new functional food products capable of neutralizing harmful external factors and correcting nutritional status. According to national health data, the proportion of cardiovascular and oncological diseases has increased from 67.56% to 70.43%. Additionally, disorders associated with iodine deficiency and digestive system dysfunction affect up to 50% of the population.

The modern food industry faces new challenges related to meeting the growing demand for balanced nutrition, improving product quality, and ensuring safety. Consumers increasingly prefer nutritionally rich products produced in accordance with environmentally sustainable principles and aligned with healthy lifestyle practices. Accordingly, there is a growing interest in developing composite food products that combine traditional meat raw materials with plant-based ingredients. This approach not only enhances the nutritional value of the food but also reduces production costs and expands the product range.

Combining plant and animal ingredients to increase the nutritional and functional value of meat products represents one of the most relevant technological directions. In this regard, the development of semi-finished meat products based on horse and poultry meat enriched with sprouted buckwheat in specific proportions is considered a promising technological solution. Such technologies not only improve the nutritional profile but also increase the levels of protein, dietary fiber, and bioactive components in the final product, thus contributing to both food safety and human health.

The purpose of the dissertation work is to develop and implement a comprehensive system for ensuring the quality and safety of composite meat semi-finished products using sublimation-dried sprouted green buckwheat.

To achieve this goal, the following objectives were defined:

1. To investigate the nutritional value and safety of sprouted green buckwheat, including the determination of its vitamin–mineral and amino acid composition, as well as the content of toxic elements and radionuclides.
2. To develop the formulation and technology of composite meat-plant semi-finished products with varying proportions of sprouted green buckwheat and to identify the optimal recipe.
3. To study the effect of sprouted green buckwheat addition on the quality of experimental samples of composite meat-plant products through physicochemical, functional-technological, rheological, organoleptic, and microbiological analyses.
4. To perform hazard analysis and identify critical control points (HACCP) in the production process of cutlets containing sprouted green buckwheat.
5. To prepare the relevant normative-technical documentation and conduct pilot testing in industrial meat-processing conditions.

Research objects:

First-category horse meat, chicken thigh meat, sprouted green buckwheat, experimental samples of semi-finished products containing sprouted green buckwheat, and the developed “Shygys” cutlet.

Research methods:

In accordance with the defined scientific objectives, both theoretical and experimental studies were carried out at the Department of Food Technology, Shakarim University (Semey), the Semey branch of the National Center for Expertise and Certification JSC, the Kazakh Research Institute of Processing and Food Industry LLP, and the laboratories of Almaty Technological University. Experimental investigations included physicochemical, organoleptic, histological, microbiological, and biotechnological analyses, as well as technological process experiments. The

obtained results were processed using statistical analysis and mathematical optimization methods.

Scientific novelty of the research.

A scientific rationale was developed for the use of sublimation-dried sprouted green buckwheat as a functional component in the production technology of composite meat cutlets, and its effectiveness was experimentally verified. The results demonstrated that the inclusion of sprouted green buckwheat enriches the product with vitamins, minerals, flavonoids, and biologically active compounds, thereby enhancing its overall biological and nutritional value.

The food safety of sprouted green buckwheat, along with its physicochemical and microbiological parameters, was comprehensively evaluated. The findings confirmed that this raw material fully complies with current food safety standards.

The ingredient composition and optimal ratio of components in the composite meat–plant semi-finished products containing sprouted green buckwheat were scientifically substantiated. The developed formulations maintain a balanced profile of proteins, vitamins, and minerals, while improving the product's water-holding capacity and reducing thermal processing losses.

A HACCP-based safety assurance system was designed and experimentally validated for the production of meat–plant semi-finished products enriched with sprouted green buckwheat. This approach broadens the scientific and practical foundations for establishing an integrated system that ensures the quality and safety of such composite products.

The scientific novelty of the research is confirmed by the Patent of the Republic of Kazakhstan №5173 (26.03.2020) titled «Composition for the Preparation of Composite Meat-Plant Semi-Finished Product».

Author's personal contribution.

The personal contribution of the author consists of formulating the aim and objectives of the research, organizing and conducting scientific and practical experiments, developing the technology and formulation of a new product, processing the obtained results with their subsequent scientific publication, as well as carrying out further industrial testing.

Key scientific propositions submitted for defense:

- The feasibility of using sprouted green buckwheat as a functional component in composite meat products was established, and comprehensive experimental results supporting its effectiveness were obtained.
- During the development of the formulation and production technology for the «Shygys» semi-finished meat product, critical control points (CCPs) aimed at ensuring food safety were identified.
- Comprehensive experimental results were obtained confirming the technological and nutritional characteristics of the «Shygys» semi-finished meat product.

Practical significance of the research.

A formulation for a composite meat-plant semi-finished product based on horse meat, chicken meat, and sprouted green buckwheat was developed and tested under industrial conditions. The incorporation of sprouted green buckwheat enhanced the

product's water-binding capacity and antioxidant activity, thereby improving its quality and extending its shelf life. Normative and technical documentation confirming the product's safety and compliance with relevant standards was prepared and approved. Industrial trials were successfully conducted at the «Bizhan» Meat Processing Plant in Almaty, Kazakhstan. The work resulted in the Patent of the Republic of Kazakhstan №5173 (26.03.2020) for the utility model «Composition for the Preparation of Composite Meat-Plant Semi-Finished Product».

Research dissemination.

The main findings of the dissertation were presented and discussed at several international scientific and practical conferences, including: «Ensuring Food Security of Kazakhstan under Globalization Conditions» dedicated to the 60th anniversary of Doctor of Technical Sciences, Professor K.Zh. Amirkhanov (Semey, 2017); «Current Issues in Food Production: Present State and Development Prospects» dedicated to the 75th anniversary of Corresponding Member of KazAAS, Doctor of Technical Sciences, Professor E.T. Tuleuov (Semey, November 24, 2017); «Product, Technology, and Quality of Education: Topical Issues of Applied Biotechnology» International Scientific Conference (Moscow, Russian Federation, 2018); «Poultry Meat Processing: Integrated Approaches to Ensuring Food Safety» International Scientific and Practical Conference (Moscow, Russian Federation, 2019); and the results were also published in the international scientific journal Science, Research, Development, №17 (Belgrade, Serbia, 2019).

Publications.

Based on the results of the dissertation research, a total of 13 scientific papers were published. Among them, three articles appeared in journals indexed in the Scopus and Web of Science databases with non-zero impact factors. Additionally, four papers were published in journals recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan. The research findings were also presented at two international scientific and practical conferences held in Kazakhstan, CIS countries, and abroad, including one publication in a foreign journal. Furthermore, two papers were published in Kazakhstani scientific journals and one article appeared in a scientific publication of the CIS countries. The study also resulted in the Patent of the Republic of Kazakhstan №5173 (26.03.2020) for the utility model «Composition for the Preparation of Composite Meat–Plant Semi-Finished Product».

Structure and scope of the dissertation.

The dissertation consists of an introduction, six chapters, a conclusion, and a list of 115 references. The total volume of the work is 100 pages, including 23 tables, 20 figures, and 5 appendices.

Evaluation of the completeness of the research objectives. The data obtained fully correspond to the aim of the dissertation and confirm that all assigned tasks were successfully accomplished as follows:

1. The study established the high nutritional value and safety of sublimation-dried sprouted green buckwheat. Analysis of its vitamin composition revealed a predominance of B-group vitamins, particularly niacin (B₃) at 3.12 mg/100 g,

pantothenic acid (B₅) at 1.19 mg/100 g, vitamin C at 10.6 mg/100 g, and vitamin A at 0.053 mg/100 g. Among the mineral elements, magnesium content was the highest (>230 mg/100 g), followed by calcium (22.9 mg/100 g) and iodine (2.5 µg/100 g). Amino acid profiling showed that sprouted green buckwheat is rich in both essential and non-essential amino acids, including proline (1.74 mg/100 g), glycine (1.48 mg/100 g), valine (1.35 mg/100 g), threonine (1.22 mg/100 g), and arginine (1.09 mg/100 g), confirming its strong protein and energy potential. From a safety perspective, the lead content was 0.19 mg/kg, well below the permissible limit of 0.5 mg/kg. Arsenic, cadmium, and mercury were not detected, and no traces of mycotoxins or pesticides were found. Radionuclide activity levels were also within safe limits: cesium-137 at 4.9 Bq/kg and strontium-90 at 4.1 Bq/kg, significantly lower than the established thresholds (60 and 11 Bq/kg, respectively). Overall, the findings demonstrate that sprouted green buckwheat is a nutritionally rich, biologically valuable, and environmentally safe raw material, scientifically validated as an effective functional ingredient for use in meat product technology.

2. A formulation and production technology for cutlets containing varying proportions of sprouted green buckwheat were developed, and the sample containing 10% sprouted buckwheat was identified as the most optimal variant. This formulation exhibited the highest increase in protein content, reaching 17.5%. The water-holding capacity (WHC) reached its maximum value of 67.18% in the 10% buckwheat sample, which was higher than that of the control sample (65.87%). The fat-holding capacity (FHC) values for the tested samples ranged between 80.1% and 81.4%, slightly lower than the control (83.3%). Meanwhile, emulsion stability (ES) and emulsion capacity (EC) showed minor variations, with values of 53% and 61%, respectively, observed in the same (10%) sample. These results indicate that incorporating 10% sprouted green buckwheat into the formulation enhances the physicochemical and functional–technological properties of the final product. Specifically, it improves moisture and fat retention, reduces mass loss during thermal processing, and increases structural density, thereby contributing to overall product quality.

3. The quality indicators of composite meat semi-finished products containing sprouted green buckwheat (SGB) were comprehensively evaluated. All samples showed a decrease in shear stress ($\tau_{\max}$) compared to the control sample (3.42 kPa): for products containing 5% and 10% SGB, the values were 2.28 kPa and 2.24 kPa, respectively, while the 15% sample showed 2.45 kPa. These results indicate a softer and more elastic texture in the finished products. During thermal processing, the mass loss of the control sample was 25.6%, while the loss decreased to 24.8% in the 5% SGB sample and reached the lowest value of 12.7% in the 10% SGB sample. At 15% SGB, the value slightly increased to 15.1%. These data confirm that the inclusion of sprouted green buckwheat enhances the product's water-holding capacity and significantly reduces mass loss during cooking. Organoleptic evaluation revealed that the 10% SGB sample achieved the highest overall sensory score of 4.55 points, characterized by a pleasant aroma (4.7 points) and favorable consistency (4.4 points). Overall, the findings demonstrate that incorporating 10% sprouted green buckwheat improves the physicochemical, functional–technological, and sensory properties of

the product, making this formulation the most effective option for producing functional meat products.

4. To ensure food safety in the production of the «Shygys» meat semi-finished product containing sprouted green buckwheat, four critical control points (CCPs) were identified: CCP 1 and CCP 2: Raw material acceptance (meat and sprouted green buckwheat), focusing on preventing microbiological and chemical contamination (pathogens, antibiotic residues, heavy metals, and pesticides). CCP 3: Grinding, mixing, and forming stages, ensuring uniform raw material distribution and protection against physical contamination. CCP 4: Metal detection, aimed at identifying metallic particles in the finished product. The hazard analysis confirmed that these control points enhance process safety and ensure that the final product meets microbiological and physical safety standards.

5. As a result of this work, normative and technical documentation for the «Shygys» cutlet was developed and approved under Organization Standard ST 4429 095 130840007973-2024 (30.11.2024). Industrial trials conducted at the «Bizhan» Meat Processing Plant in Almaty (07.11.2024) confirmed the practical applicability and effectiveness of the developed technology. The innovation is protected by the Patent of the Republic of Kazakhstan No. 5173 (26.03.2020) for the utility model «Composition for the Preparation of Composite Meat–Plant Semi-Finished Product».

The research established a scientifically grounded and effective system for ensuring the quality and safety of composite meat products incorporating sprouted green buckwheat. The proposed technology contributes to strengthening the competitiveness of domestic food production, expanding the range of functional food products, and enhancing Kazakhstan's overall food security.