Irreversible protein transformation of multi-component animal raw materials systems under the influence of microbiological and technical factors

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Abstract. In order to change the composition of natural food systems based on animal raw materials, we studied some features of thermodynamic changes of proteins under the influence of technological factors in the presence of biocultures. We revealed the important features of the influence of denaturation temperature and enthalpy of thermal transitions of myofibrillary proteins used in the technology of obtaining sodium chloride products, which is important for the effective optimization of parameters for obtaining high-quality products.

1. Introduction

Proteins are natural objects that form the basis of high-quality food systems [1–3]. In the process of technological transformations under the influence of temperature and enzymes, proteins undergo an irreversible transformation. The transformed state of protein systems has a significant impact on consumer properties of the resultant products.

In order to change the composition of natural food systems based on animal raw materials, we studied some features of thermodynamic changes of proteins under the influence of technological factors in the presence of biocultures.

The formation of food systems under the influence of physicochemical and biotechnical factors is the basis of modern food production. At the same time, ingredients of food systems undergo irreversible changes in macrostructures. Combining technological factors makes it possible to obtain modern products, ensuring their diversity. The most important part of the products is proteins, which undergo certain transformations during technological operations [1].

The purpose of the work was to establish the features of thermodynamic changes in the food protein of animal origin in the process of forming a multicomponent food matrix under exposure to thermal factors and the hydrolytic activity of micro cultures, used as additives in modern technologies of accelerated production of raw meat products.
2. Results

The objects of the study were proteins isolated by extraction with 5% sodium chloride solution from standard meat mixture formulations of products manufactured according to GOST RU 55456-2013 followed by fractionation and desalting on Sephadex G-25, G-50 and lyophilization. For comparison, the protein system of the standard product was taken into which, for accelerated formation, the culture of *Lactobacillus plantarum* ATCC 8014 in the amount of 1.107 CFU/g was introduced and kept for 20 days at pH compared to the traditional processing of raw materials without using starter cultures. Thermodynamic tests were performed on a DASM-4 differential scanning calorimeter manufactured by IBP RAS (Pushchino, Russia). Fractionation and electrophoresis were performed by a standard method in an 18% polyacrylamide gel [2].

Protein in food systems is contained in an amount ranging from 10 to 20% and includes the sum of multiple fractions of protein molecules with different molecular weight from several to hundreds of thousands [3]. In the process of technological processing of raw materials under the influence of temperature and other factors, there occur irreversible changes in the fractional composition [4, 5].

The study of the stability of proteins to denaturational changes provides the possibility of directional control of the technological characteristics and quality of the finished product. It is of interest to use the method of differential scanning calorimetry (DSC) to study the thermodynamic properties of protein systems. The method is based on a comparison of temperatures between the sample being measured and the thermally stable material. DSC provides measurement of the difference in heat flow between the sample and the standard. In this regard, the use of the DSC method makes it possible to evaluate the effect of the main preservative component of food systems, sodium chloride, on the stability of proteins to thermal denaturation.

![Figure 1](image1)

**Figure 1.** a) Dependence of the denaturation temperature \( T \) of the main protein fractions of the food system on the value of the heat flux \( W \) in the absence of NaCl additives (1) and in the presence of 2% salt (2) b) Dependence of the denaturation temperature \( T_{c} \) of the main proteins of actin (1) and myosin (2) on the ionic strength \( I_{c} \) of the NaCl solution in the system

As a result of research, 3 peaks were recorded - 30.9 ± 0.2 ° C (I), 52.6 ± 0.2 ° C (II) and 74.6 ± 0.3 ° C (III) on the thermogram for the sample without salt (Figure 1a), the peaks corresponding to the melting point of fat (I), the denaturation of myosin (II) and actin (III). The addition of salt shifted the temperature of denaturation of myosin and actin proteins towards lower temperatures (\( P <0.95 \)). An increase in the ionic strength of the system decreased (\( P <0.9 \)) the temperature of denaturation \( T_{c} \) of proteins (Figure 1b).
Figure 2. a) Thermograms of protein denaturation of the raw mix and (1) fermented product (2) 
b) Electrophoretic separation of protein fractions: 1 - protein standards 10 ... 250 kDa, 2 - initial 
mixture, 3 - fermented product

Table 1. The main fractions of the protein of the source system and the system processed according 
to the standard technology in the presence of the starting culture

| Molecular weight, kDa | Animal raw materials system | Fermented product |
|-----------------------|-----------------------------|-------------------|
| 230 – 400             | 0,5                         | –                 |
| 170 – 230             | 4,5                         | –                 |
| 100 – 170             | 7,0                         | 9,0               |
| 40 – 100              | 26,7                        | 21,2              |
| 20 - 40               | 30,0                        | 35,4              |
| 10 – 20               | 30,8                        | 34,4              |

The use of biological products in the technologies of natural multicomponent systems allows for 
the targeted degradation of the component components. Figure 2a shows the observed decrease in $T_c$
protein denaturation. In this case, the enthalpy of denaturation, defined as the peak area in the diagram, 
$\Delta H$ decreased from 13.3 ± 0.6 to 4.8 ± 0.3 J / g of the product. The reason for this phenomenon is 
associated with a change in the fractional composition of the proteins of the system (Figure 2b). The 
actual use supplements of biocultures leads to a decrease in the proportion of high molecular weight 
protein fractions and increases the proportion of most valuable in nutrition proteins with a molecular 
mass of 10–35 kDa MM (Table 1). The optimization of the technical parameters of the processing of 
the food system will make it possible to increase this indicator.

3. Conclusion
1. The variation of the technical parameters of the physicochemical and biotechnical processing of 
natural food systems makes it possible to obtain degraded protein structures favorable to humans.
2. The important features of the effect of sodium salt on the denaturation temperature and enthalpy 
of thermal transitions of myofibrillary proteins are revealed, which is important for the effective 
optimization of parameters for obtaining high-quality products.

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