Sensory, physical and chemical characteristics of fermented minced meat

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Abstract: In the meat processing industry, biotechnological technologies are becoming more widespread every year. The use of plant and animal enzyme sources enables to obtain products with the desired properties. The paper presents the results of a study of the physicochemical characteristics of minced meat subjected to enzymatic treatment with transglutaminase and sequential treatment with pepsin and transglutaminase. The object of the study is beef with a connective tissue content of 20%. It was found that the sample was sequentially treated with pepsin, the proportion of 0.1%, followed by 0.3% transglutaminase, has the highest organoleptic characteristics, and there is also an increase in the yield of the finished product by 9.5% compared to the control sample. Thus, it can be concluded that the sequential processing of lower-grade meat raw materials with pepsin and transglutaminase can improve the physicochemical parameters of minced meat.

1. Introduction
The growth in the consumption of meat products in Russia determines the need to find new opportunities to increase the technical and economic efficiency of production and improve the quality of products [1–8]. In the successful solution of these problems, a major role belongs to the use of technological approaches to improving the quality of raw materials and, in particular, to the use of proteolytic enzyme preparations for meat processing.

This processing method has been studied, both in our country and in foreign countries [9–13, 26]. Experience in the practical use of enzymes proves that this relatively new processing method is very effective. It is suitable for softening hard meat and increasing on this basis the volume of production of meat products, improving their quality, the production of meat pastes, emulsions, hydrolysates, used as protein fortifiers of various food products, as well as in clinical nutrition [14–18].
Enzymes are functional units of cellular metabolism that are present in all living cells and contribute to the conversion of some substances (substrates) into others (products). They act as catalysts in almost all biochemical reactions taking place inside living organisms. The use of enzyme preparations positively affects the tenderness, juiciness, nutritional value of raw materials, the formation of the required level of moisture-binding and adhesive ability, improves organoleptic characteristics due to the targeted effect of enzymatic complexes on muscle tissue components [19–27].

The purpose of the current study is to establish the effect of enzyme processing on the change in the physicochemical parameters of minced meat.

2. Materials and method
The main raw material used in the study was second-class veined beef with a connective tissue content of 20%. Raw meat was ground in a meat grinder with a meat grinder plate with the 2-3 mm holes, and then the minced meat was distributed into three parts - to prepare a control sample without adding enzymes; for the preparation of samples with transglutaminase; for the preparation of samples followed by sequential treatment with pepsin and transglutaminase.

Pork pepsin produced by Belmedpreparaty and transglutaminase (BioBond TG-EV3 (classic) produced by Flora Ingredients) were chosen as enzymes. To prepare samples with transglutaminase, the enzyme in an amount of 0.1%, 0.2%, and 0.3% by weight of the meat sample was dissolved in water (10% of the weight of the meat samples) and then added to the meat in this form and mixed thoroughly, kept in at a temperature of 4 °C for 1 hour; for the preparation of samples followed by sequential treatment with pepsin and transglutaminase, first pepsin (0.1%, 0.2% and 0.3% by weight of the feedstock); dissolved in water in an amount of 5% by weight of raw materials and added into minced meat, then kept in an thermostat at 37 °C for 3 hours, after which transglutaminase was previously dissolved in water (5% by weight of raw materials) and added into minced meat and processed as described above.

The preparation of samples is shown in figure 1.

![Figure 1. The scheme for the manufacture of mince test samples.](image-url)
3. Research results and discussion

Organoleptic characteristics were determined in raw minced meat and after heat treatment. The results of the indicators are shown in tables 1 and 2. Studies have shown that the consistent use of pepsin and TG favorably affects the consistency of meat and appearance attributes both raw and after heat treatment, such indicators as smell, color do not change.

Table 1. Organoleptic characteristics of model minced meat in raw form.

| Sample          | Indicator                                                                 | Appearance, color, consistency                                      | Flavor                                      |
|-----------------|---------------------------------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------|
| O-K             | Minced meat colored red with visible inclusions of connective tissue, not uniform meat mass without bones, cartilage | Intrinsic to raw minced meat, without extraneous odors             |
| O-TG-0.1        | Minced meat colored red with visible inclusions of connective tissue, homogeneous mass | Peculiar to this product, without extraneous odors                  |
| O-TG-0.2        | Forcemeat colored red with visible inclusions of connective tissue, viscous, uniform mass | Intrinsic to raw mincemeat, without extraneous odors                |
| O-TG-0.3        | Forcemeat colored red, uniform soft mass                                   | Intrinsic to raw mincemeat, without extraneous odors                |
| O-P-0.1         | Forcemeat colored red, uniform soft mass                                   | Intrinsic to raw mincemeat, without extraneous odors                |
| O-(P+TG)-0.1    | Forcemeat colored red, uniform soft mass                                   | Intrinsic to raw mincemeat, without extraneous odors                |
| O-(P+TG)-0.2    | Forcemeat colored red, uniform soft, viscous mass                         | Intrinsic to raw mincemeat, without extraneous odors                |
| O-(P+TG)-0.3    | Forcemeat colored red, uniform soft, viscous mass                         | Intrinsic to raw mincemeat, without extraneous odors                |

As can be seen from Table 1, sample No. 7, subjected to sequential exposure to pepsin in an amount of 0.1% by weight of raw meat and transglutaminase introduced in an amount of 0.3%, differed in consistency from other samples, a high viscosity of minced meat was certainly noticeable. The obtained characteristic indicates the splitting of connective tissue, with the proteolytic enzyme pepsin, and the use of the enzyme of the transferase group has improved the physicochemical parameters of minced meat.

At the next stage, it was of interest to study the effect of enzyme processing on the organoleptic characteristics of prepared minced meat. Samples were cooked until done.

Table 2. Organoleptic characteristics of model minced meat after heat treatment.

| Sample          | Indicator                                                                 | Appearance, color, consistency                                      | Flavor                                      |
|-----------------|---------------------------------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------|
| O-K             | Color gray with visible inclusions of connective tissue                   | Peculiar to this product, without extraneous odors                  |
| O-TG-0.1        | Color is gray with a more uniform mass                                    | Peculiar to this product, without extraneous odors                  |
| O-TG-0.2        | Color gray, bound homogeneous mass                                        | Peculiar to this product, without extraneous odors                  |
| O-TG-0.3        | Color is gray, uniform consistency throughout the mass                    | Peculiar to this product, without extraneous odors                  |
| O-P-0.1         | Color gray, homogeneous, well-bound mass                                  | Peculiar to this product, without extraneous odors                  |
| O-(P+TG)-0.1    | Color gray, uniform, dense, well-bound mass                              | Peculiar to this product, without extraneous odors                  |
| O-(P+TG)-0.2    | Color gray, homogeneous, well-bound mass                                  | Peculiar to this product, without extraneous odors                  |
| O-(P+TG)-0.3    | Color gray, uniform, dense, well-bound mass                              | Peculiar to this product, without extraneous odors                  |
The organoleptic testing also showed that sample No. 7 has a related consistency; other characteristics did not differ significantly from other studied samples.

At the next stage, the physicochemical parameters of the model minced meat were studied. The results are presented in table 3.

**Table 3. Physical and chemical characteristics of fermented minced meat.**

| Sample                  | The results of the mass fraction of moisture, (%) | The results of the mass fraction of fat, (%) | The results of the mass fraction of protein, (%) |
|-------------------------|---------------------------------------------------|---------------------------------------------|-------------------------------------------------|
| O-K                     | 73,5±1,2                                          | 8,0±0,6                                     | 16,6                                            |
| O-TG-0,1                | 74,1±1,2                                          | 7,8±0,6                                     | 16,8                                            |
| O-TG-0,2                | 74,9±1,2                                          | 7,9±0,6                                     | 18,0                                            |
| O-TG-0,3                | 75,3±1,2                                          | 8,4±0,6                                     | 18,1                                            |
| O-P-0,1                 | 75±1,2                                            | 8,2±0,6                                     | 16,6                                            |
| O-(P+TG)-0,1            | 75,4±1,2                                          | 8,3±0,6                                     | 17,3                                            |
| O-(P+TG)-0,2            | 75,3±1,2                                          | 8,5±0,6                                     | 18,2                                            |
| O-(P+TG)-0,3            | 75,8±1,2                                          | 8,6±0,6                                     | 18,3                                            |

According to the results of physicochemical testing, it can be seen that the combined use of TG and pepsin does not change the mass fraction of protein, fat and moisture, compared with a separate use of TG.

The product yield after heat treatment (figure 2) is consistent with the results of organoleptic testing, since improving the consistency is a precondition for increasing the product yield.

**Figure 2. Model minced meat release results.**

An increase in the content of enzymes contributes to an increase in the product yield, while sequential treatment with pepsin and TG is more effective.
In the future, it is of interest to study such characteristics of minced meat as water binding and water holding capacities, the research results will establish a direct relationship between the use of enzyme preparations and the improvement of the physicochemical parameters of minced meat subjected to enzymatic processing.

4. Conclusions
The presented results indicate an improvement in the performance of minced meat during its sequential processing by enzymes. The best result was shown by a sample with the addition of 0.1% pepsin followed by 0.3% transglutaminase. The sample was characterized by high organoleptic characteristics, and its product yield increased by 9.5%. The data obtained suggest further studies to more justify the relationship between the consistent use of enzymes and changes in the physicochemical properties of minced meat.

References
[1] Kassymov S, Amirzhan T, Moldabayeva Zh, Rebezov M, Sharova T, Nikolaeva N, Gribkova V, Gaidarenko L and Karapetyan I 2020 Nutritional and biological value of bakery products with the addition of vegetable powders and milk whey Intern. J. of Psychosocial Rehabilitation 24(7)
[2] Kabulov B, Kassymov S, Moldabayeva Zh, Rebezov M, Zinina O, Chernyshenko Yu, Ardunanova F, Peshcherov G, Makarov S and Vasyukova A 2020 Developing the formulation and method of production of meat frankfurters with protein supplement from meat by-products EurAsian J. of BioSciences 14(1) 213–18
[3] Kassymov S, Rebezov M, Ikonnikova A, Fedin I, Rodionov I, Rukhadze S and Bokuchava O 2020 Using of pumpkin and carrot powder in production of meat cutlets: effect on chemical and sensory properties Intern. J. of Psychosocial Rehabilitation 24(4) 1663–70
[4] Nesterenko A, Goushchin V, Koshchaev A, Rebezov M and Khayrullin M 2019 Use of The Electromagnetic Field of Low Frequencies in the Production of Sausages Intern. J. Engineering and Advanced Technology (IJET) 9(2) 860–69
[5] Nesterenko A, Koshchaev A, Kenijz N, Akopyan K, Rebezov M and Okuskhanova E 2018 Biomodification Of Meat For Improving Functional-Technological Properties Of Minced Meat Research J. of Pharmaceutical, Biological and Chemical Sciences 9(6) 95–105
[6] Zhumanova G, Rebezov M, Assenova B and Okuskanova E 2018 Prospects of Using Poultry by-Products in the Technology of Chopped Semi-Finished Products Intern. J. of Engineering & Technology 7(3,34) 495–98
[7] Okuskanova E, Rebezov M, Yessimbekov Zh, Tazeddinova D, Shcherbakov P, Bezhinar T, Vagapova O, Shcherbakova T and Stuart M 2018 Rheological Properties of Low-calorie Red Deer Meat Pâté J.of Pharmaceutical Research International 23(1) 1–9
[8] Zinina O, Merenkova S, Tazeddinova D, Rebezov M, Stuart M, Okuskanova E, Yessimbekov Zh and Baryshnikova N 2019 Enrichment of meat products with dietary fibers: a review. Agronomy Research 17(4) 1808–22
[9] Nesterenko A, Koshchaev A, Kenijz N, Luneva A and Varivoda A 2019 Biomodification of raw meat in order to obtain functional products enriched with beneficial microflora Indo American J. of pharmaceutical sciences 06(03) 6347–53
[10] M van Boekel, Fogliano M V, Pellegrini N, Stanton C, Scholz G, Lalljie S, Somoza V, Knorr D, Jasti P R, Eisenbrand G 2010 A review on the beneficial aspects Food processing 54 1215–47
[11] Merenkova S, Zinina O, Loretz O, Neverova O and Sharaviev P 2019 Effect of Transglutaminase and Bacterial Concentrates on the Development of Functional and Technological Properties of Minced Meat Polish J. of Food and Nutrition Science 4 387–96
[12] Steinkraus K 2004 Origin and History of Food Fermentations Hand-book of Food and Beverage Fermentation Technology 6 1–9
[13] Villanueva N, de Almeida M, Gonçalves J and Contreras-Castillo C 2015 Quality attributes and consumer acceptance of new ready-to-eat frozen restructured chicken Food Sci Technol 52(5) 2869–77
[14] Baugreet S, Kerry JP, Brodkorb A, Gomez C, Auty M, Allen P and Hamill RM 2018 Optimisation of plant protein and transglutaminase content in novel beef restructured steaks for older adults by central composite design Meat Science 142 65–77
[15] Atilgan E and Kilic B 2017 Effects of microbial transglutaminase, fibrinex and alginate on physicochemical properties of cooked ground meat with reduced salt level Food Sci Technol 54(2) 303–12
[16] Kieliszek M and Misiewicz A 2014 Microbial transglutaminase and its application in the foodindustry A review Folia Microbiol 59 241–50
[17] Foegeding E and Larick D 1986 Tenderisation of beef with bacterial collagenase Meat Sci. 18 201–14
[18] Atilgan E and Kilic B 2017 Effects of microbial transglutaminase, fibrinex and alginate on physicochemical properties of cooked ground meat with reduced salt level J. of Food Science and Technology 2 303–12
[19] Koshchaev A, Nesterenko A, Shhalahov D, Lysenko A, Shabunin S, Lorets O and Goushchin V 2019 Model minced poultry meat biomodification with starter cultures Intern. J. of Engineering and Advanced Technology 9(1) 4987–92
[20] Dransfield E and Etherington D 1981 Enzymes in the Tenderisation of Meat: In Enzymes in Food Processing Applied Science, Barking, Essex 177–94
[21] Melesheny A, Kaltovich I, Savelyeva T and Melesheya A 2019 Effect of enzymatic hydrolysis of collagen-containing raw materials on indicators of its quality and safety Vestnik MGUP 1(26) 84–91
[22] Alekseeva M, Klimovsky I and Anischenko I 1993 Species composition of propionic acid bacteria in the "Soviet cheese" Dairy industry 12 12–3
[23] Moroz V and Stunda O 2012 The use of enzymes in the production of meat products Scientific Bull. of the Lviv National University of Veterinary Medicine and Biotechnology named after S.Z. Hedgehog 2–3(52) 249–53
[24] Cherevko A, Kovalenko V, Moskalenko O and Khvyla S 2008 Effect of enzymatic treatment on the microstructure of collagen-containing meat raw materials Meat industry 2 71–73
[25] Caplice E and Fitzgerald G 1999 Food fermentation: role of microorganisms in food production and preservation Int. J. Food Microbio 16 131–49
[26] Fink et al. 1997 Method for the production of soluble collagenn, United States Patent 5,670,369,
[27] Ivanova P, Chalova V I, Kalaydzhiiev H, Perifanova-Nemska M, Rustad T and Koleva L 2017 Transglutaminase Modification of Protein Isolate Food Technology and Biotechnology 3 420