Effect of Alkali-Salt Treatment of Meat By-Products on Physical, Chemical and Rheological Properties

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***Abstract*: Meat by-products, in particular collagen-containing, are one of the promising types of animal raw materials. Treatment of these by-products with acids will improve the physicochemical and technological properties. The beef rumen treated with an alkaline-saline solution to determine the loss of collagen and non-collagen proteins, change the water-binding capacity and structural-mechanical characteristics. The protein loss increases up to 1.1 times with increasing of treatment time from 0.5 to 2 days at an alkali concentration of 1.0% and 1.67 times at 0.5 % concentration of sodium hydroxide. Accordingly, a sharp decrease in the shear stress was determined. The water-binding capacity of the product increased from 54% in control sample to 86.33%.**

***Index Terms*: rumen, treatment, alkaline, sodium hydroxide, protein loss, water-binding capacity**

I. INTRODUCTION

Foods of animal origin are the main and traditional source of protein in human nutrition. Deficiency of these kind of foods in the food market is associated with a reduction of livestock number, livestock productivity [1]. One of the real ways to solve this problem is the complex processing of secondary protein rich by-products using biotechnology methods, including the creation of multifunctional biologically active additives and development of combined meat products of high biological value, including those with therapeutic and prophylactic properties [2, 3].

One of the ways to increase production efficiency is to introduce low-waste technological processes at meat processing plants and fully use of meat by products, such as, rumen. Recent advances in science have allowed the use of methods that are not destructing the molecular structure of the protein and at the same time selectively affect its properties. After such modification, by-products can be used for the production of meat products (without a significant change in the quality characteristics of meat products) [4, 5].

Introduction of by-products into food products improves metabolism and the functioning of the human digestive system. Proteins such as collagen and elastin, which are part of the connective tissue, contain minerals that help strengthen the musculoskeletal system, both in the elderly and in young people [6].

Biochemical changes happening in meat by-products under the influence of enzymes and microorganisms contribute to the modification of its functional and technological properties, shortening the technological cycle, increasing the nutritional value of the finished product, improving its digestibility and storage stability [7, 8].

The mechanism of action of biopreparations is based on their ability to change the quaternary, tertiary, secondary and even primary structures of proteins and thereby affect the texture, taste and aroma of finished products [9]. Surface proteolysis, in which partial destruction of protein molecules occurs, leads to an increase in the content of free amino acids and an improvement in the consistency and structure of meat. However, proteolytic biopreparations have several disadvantages. So, most proteases are inactive at pH, temperature and substrate concentrations, which are determined by the production technology. Proteases are almost impossible to reuse, since they are difficult to separate from the products and the substrate [10].

The deep proteolysis of meat is accompanied by the destruction of all four structural levels of protein macromolecules. At the same time, the number of free amino acids sharply increases (up to 20-30% of their total protein content). Meat consistency rankly softens and almost completely loses its original structure. Therefore, during the treatment meat with biopreparation, it is very important correctly determine their concentration, duration of exposure and degree of hydrolysis of protein components [11, 12].

The development of methods for modifying collagen-containing meat by-products, in particular rumen and testicles, to produce a new protein rich products, the main part of which will be represented by collagen with improved technological and consumer properties compared to the feedstock, can help to solve the problems of rational use of raw materials and the

Revised Manuscript Received on December 05, 2019.

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introduction of effective non-waste technology [13].

These substances do not have a negative effect on the human body. Compounds formed during processing easily dissociate, removed from the meat by-products during washing, and sodium chloride prolongs the shelf life of the resulting product without additional preservation [14].

The purpose of this paper is to study the effect of alkali-salt treatment of rumen on the loss of collagen and non-collagen proteins, chemical profile and rheological properties.

II. MATERIALS AND METHODS

The authors of this publication suggested that to modify the rumen it is possible to reduce the content of the used ingredients in the solution, which will positively affect the protein loss during scar treatment - they will be minimal. Therefore, at the first stage of the research, the following parameters of alkaline salt treatment were chosen: the concentration of sodium hydroxide was 1.0% and 5.0%, sodium chloride was 15.0%, and the processing time was 0.5–2.0 days.

Chemical composition

The chemical composition of meat was based on determination of moisture, fat, ash, and protein content according to [15]. To determine water content, a 2-3 g aliquot of each sample of meat was weighed to the nearest 0.001 g using a Mettler Toledo electronic balance (Greifensee, Switzerland) and placed into a metallic cup (IngoLab, Moscow. Russia). It was then dried for 1 h, in a drying oven (SNOL 67/350; Umega, Utena, Latvia) at 150 °C. The moisture content was calculated using Equation 1, according to the standard GOST 9793-74 (2010) and GOST R 51479-99 (2010).

$$x_1 = (m_1 - m_2) \cdot 100 / (m_1 - m), \quad (1)$$

where x_1 is the moisture content (in %), m_1 is the weight of the sample with cup before drying (in g), m_2 is the weight of the sample with cup after drying (in g), and m is the weight of the cup alone (in g).

After determining the moisture, each dried sample was moved to a glass cup. Then, 15 mL of ethyl ether (100% chemically pure; Skat, Almaty, Kazakhstan) was poured into the glass cup, and the contents were mixed for 3-4 min. During the extraction process, the organic fraction containing the fat residues was poured out and replaced with fresh ethyl ether. After 4-5 repetitions, the residual ethyl ether was evaporated at room temperature. The metallic cup containing the fat-depleted sample was dried at 105 °C for 10 min. The fat content was calculated according to the standard GOST 23042-86 (2010) using Equation 2.

$$x_2 = (m_1 - m_2) \cdot 100 / m_o \quad (2)$$

where x_2 is the fat content (in %), m_1 is the weight of the cup and dry sample before extraction (in g), m_2 is the weight of the cup and sample after extraction (in g), and m_0 is the weight of the cup alone (in g).

In order to obtain the ash content, the sample from which the fat was extracted was placed into a weighed and preheated (to 150 °C) crucible (50 cm^3; Mankor, Kiev, Ukraine). Then, 1 mL of magnesium acetate (98% purity; Labofarma, Almaty, Kazakhstan) was added to the crucible and burned on an electric hot plate. After that, it was placed into a muffle furnace set at 500–600 °C (SNOL 7.2/1100; Umega) for 30 min. The ash content was calculated using Equation 3:

$$x_3 = (m_1 - m_2) \cdot 100 / m_0, \quad (3)$$

where x_3 is the ash content (in %), m_1 is the weight of the ash (in g), m_2 is the weight of the magnesium oxide obtained after mineralization of the magnesium acetate (in g), and m_0 is the weight of the sample alone (in g). Protein content was assayed according to the GOST 25011-81 (2010) standard and calculated using Equation 4:

$$x = 100 - (x_1 + x_2 + x_3), \quad (4)$$

where x is the protein content (in %), x_1 is the moisture content (in %), x_2 is the fat content (in %), and x_3 is the ash content (in %).

III. RESULTS AND DISCUSSION

The loss of collagen and non-collagen proteins during alkaline-salt treatment of the rumen was determined both with a change in the duration of alkaline-salt treatment and the concentration of sodium hydroxide in the solution (Table 1).

Table 1 – Loss of protein, collagen and non-collagen proteins of rumen under the alkali-salt treatment

Concentration in solution of		Treatment time, days	Loss, %		
Sodium hydroxide	Sodium chloride		Protein	Collagen	Non-collagen proteins
1.0	15.0	0.5	2.11	0.53	1.58
1.0	15.0	1.0	2.26	0.71	1.55
1.0	15.0	2.0	2.37	0.81	1.56
5.0	15.0	0.5	3.05	0.76	2.29
5.0	15.0	1.0	3.55	1.08	2.47
5.0	15.0	2.0	5.13	1.39	3.74

The data shown in Table 1, revealed that protein loss increases up to 1.1 times with increasing of treatment time from 0.5 to 2 days at an alkali concentration of 1.0% and 1.67 times at 0,5 % concentration of sodium hydroxide. The results obtained illustrate the effect of alkaline-saline solution on the rumen: protein loss was increased.

The swelling of by-product occurred as a result of the loosening effect of the solution to the protein, and retained even when neutralized with a hydrochloric acid solution. However, with neutralization, this indicator increases slightly, the protein loss in this case was low and at maximum values of the processing parameters reach 2.45%.

Changes in the quality parameters of the modified rumen depending on the treatment option are presented in Table 2. Analysis of the main chemical, structural, mechanical, and biological properties of the samples shows that, under alkaline hydrolysis, the structure of the collagen undergoes certain changes. Indicators such as protein and oxyproline content, although almost the same for the studied variants, but the broken bonds stabilizing the collagen conformation vary to different degrees, which affects the reduction of the shrinkage temperature to 43 °C in the case of rumen treatment according to

variant IV.

Such shrinkage temperature is inherent in tropocollagen and is associated with the destruction of only intermolecular bonds. The violation of the stability of the three-helix protein molecule was not happened; only partial (8.2%) dissolution of the protein in 0.5 M acetic acid is observed. The molecular weight of collagen fragments reached 39-45 thousand dl, which contributes to the formation of gelatinous structures. Other samples after treatments not dissolved in 0.5 M acetic acid.

Table 2 – Effect of treatment on the physical and chemical properties of rumen

Treatment method	Content, %					Shrinkage	Shear stress, $Q*10^{-4}$ Pa	Cutting strength, $A*10^{-2}$ J/m^2	Pepsin digestibility, mg of tyrosine to 1g of protein
	protein	water	fat	ash	oxyproline				
I	15.15	83.33	1.30	0.33	8.03	60	40.17	18.50	3.83
II	15.09	83.61	0.77	0.20	7.29	53	11.54	5.48	5.74
III	15.07	83.43	1.24	0.26	7.84	53	10.50	4.37	4.45
IV	14.82	83.86	1.24	0.38	7.10	43	0.61	0.18	6.46
Control	16.54	79.61	2.82	0.54	8.23	66	80.70	42.50	2.68

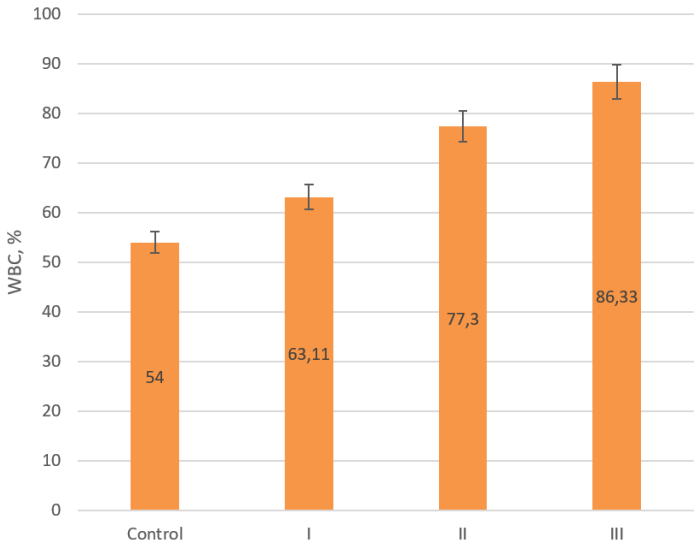

Figure 1: Changing of water-binding capacity depending on the type of treatment

Increasing the duration of treatment up to 1 day and the content of sodium hydroxide up to 5.0% leads to a significant loosening of the protein structure, associated with an increase in watering because of “moisture swelling”. Accordingly, a sharp decrease in the shear stress was determined. The water-binding capacity of the product increased from 54% in control sample to 86.33% in Sample III.

IV. CONCLUSION

Thus, it was found that the change in the concentration of sodium hydroxide in the alkaline-salt solution and the duration of exposure to this solution lead to a change in the nativeness of proteins, which is expressed in an increase in their losses, a decrease in the shrinkage temperature, and the increasing of dissolution ability. This indicates the possibility of improving the functional properties of collagen-containing by-products, in particular rumen, and its introduction in the production of high-quality meat products.

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