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THE DETERMINATION OF THE COLLAGEN HYDROTHERMAL RESISTANCE OF BEEF GULLET MEAT TISSUE

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The subject of the study was the histological analysis of the collagen in raw meat tissue of beef gullets and the determination of the range of structural changes and the degree of hydrothermal degradation of collagen in the raw material used for the production of model edible by-products both scalded and sterilized. On the basis of electron micrographs in scanning electron microscopy, the characteristics and specific structure of the endomysium, found in the raw material as being a membrane of remarkable thickness in collagen fibres, compactly and multidisectionally joined with single muscle fibres, have been established. During thermal processing (scalding) the endomysium shows a significant structural resistance. The results of ultrastructural pictures are confirmed by a comparatively low degree of hydrothermal collagen degradation (23,84%) under thermal processing conditions typical for manufacture of scalded meat products. Collagen of the endomysium of the examined raw material reveals also great resistance to the temperature of sterilization. This is also proved by the pictures of structure showing the traces of natural fibrous structure of the protein. The results obtained for the thermal collagen degradation (88,11%) in the case of model sterilized pâtè show that a certain part of the raw material examined is resistant to the temp. of 121°C. On the basis of the evaluation of thermal collagen degradation in beef gullet meat tissue can be concluded, that the experimental raw material can be recommended for the manufacture of sterilized pâtè as a recipe ingredient and/or as a substitute of beef.

Introduction

Possibilities of using less valuable meat by-products as the additional source of protein encouraged the authors to conduct the studies on the evaluation of beef gullets' technological usability in the manufacture of meat products. Our studies conducted hitherto, concerned the characteristics of chemical composition of the beef gullets, the content of mineral substances and the amino acid composition as well as functional properties of protein in this sort of offals. Moreover, an attempt has been made to use the beef gullets in the manufacture of fine comminuted sausages and liver products (scalded, roast and sterilized) whereby beef gullets substituted beef [7].

In the last years, a remarkable progress has been observed concerning the studies on functional properties of the connective tissue as well as its structure and chemical composition; primarily collagen [1,5,12,13,14,15,16]. Contemporary opinions on polymorphism of the collagen molecule have been the basis for histological classification of various types of collagen fibres found in epi-, peri- and endomysium [16]. A lot of valuable data has been introduced regarding the network of collagen molecule [3,5,12], the quantitative and qualitative differentiation of the protein with respect to the species, breed, sex and age of the animals as well as the kind of a muscle [13,16]. Different susceptibility to the thermal degradation of collagen has also been investigated [11,12]. The purpose of the present study was ultrastructural analysis of endomysium collagen in raw beef gullets. Moreover, in several sorts of model sausages, the range of thermal destruction and the degree of hydrothermal degradation of this protein have been determined.

Material and methods

Beef gullets were obtained from the carcasses of young cattle of lowland black-white breed. The fattening system applied to all the animals was the same and the pre-slaughter weight was appox. 450 kg. The studies were conducted in 5 experimental series. Each series contained beef gullets from 50 animals, slaughtered on the same day. The experimental raw material, after initial post-slaughter treatment and after cooling, was used in the manufacture of model sausages; liver sausages and canned sterilized pâtè (Table 1). The samples were taken for the ultrastructural analysis. The experimental material for the studies in an electron microscope was fixed with a 2.5% solution of glutaraldehyde and with a 1% osmium tetroxide solution and it was analyzed in a Tesla BS-300 scanning electron microscope at 11 kV. The content of

collagen was determined by the methods of Stegemann and Stalder [17] and Arneth and Hamm [2] in the modification of Janitz [9].

Table 1. Temperature conditions for model products processing

Model products	Beef gullet meat tissue %	Water %	Thermal treatment	
			initial	final
Liver sausages	95	5	temp. = 90°C t = 30 min.	temp. = 85°C t = 90 min.
Canned sterilized pâtè	75	25	-	temp. = 121°C t = 50 min.

Results and discussion

The ultrastructural electron micrographs of the beef gullet endomysium chilled at 4°C for 24 hr are shown in Figs.1 and 2.

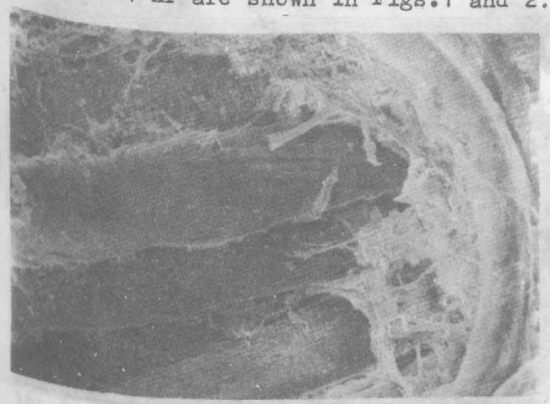

Fig.1. Electron micrograph of raw meat tissue of beef gullets, x 440

Fig.2. Electron micrograph of endomysium in raw meat tissue of beef gullets, x 1300

The structures of the connective tissue investigated form a compact network of collagen bundles of 5 μm thickness, being tightly and multidirectionally joined with the muscle fibres. The thickness of endomysium fibres in the beef gullets is significantly larger than the diameter of these structures described in m.semitendinosus of cattle [10] which should affect the collagen resistance to the comminution and thermal treatment [12]. On the basis of electrophoretic analysis and immunofluorescence studies, Sims and Bailey [16] proved the presence of collagen type III, IV, V in the endomysium, whereas type III, corresponded to reticular fibres. In the muscles of considerable toughness, a higher content of collagen type III was observed [16]. Further studies of Sims and Bailey [16] confirm that the endomysium is made up of 3 layers, out of which the external layer consists of reticular fibres, the middle layer is made up of amorphous collagen fibres set in a mucopolysaccharide ground substance whilst the outermost layer is comprised of the fine fibrils and is often referred to as reticulin. An attention has been drawn to the relationship between the collagen content, its types and bonds within them and the texture of various muscles in cattle carcasses [12]. On the basis of the ultrastructural pictures we can assume that the endomysium of gullet meat tissue is represented by numerous reticular fibres, which as mentioned above, are characterised by physicochemical properties different from typical collagen fibres [16]. A close junction of the structural elements within the endomysium with meat tissue fibres also accounts for high mechanical resistance of the experimental raw material. It can be assumed that the inter-fibre junctions of the connective tissue in the muscles described are more resistant than inter-bundle junctions [1,12]. Thermal stability of molecular collagen is linked with hydroxyproline which stabilises the helix by the formation of additional hydrogen bridges [1]. The data in literature prove that structural changes in collagen fibres under thermal treatment depend on the species, age and weight of the animal as well as on the type of muscle and collagen types [4,10,13,14]. At the same time, the relationship between the thickness of fibres in the endomysium and the occurence of heat resistant bonds is emphasized [12]. Schaller and Powrie [14] using as the example thermal destruction of reticular fibres in pork m.longissimus dorsi indicated that within the temp. range of 66-85°C, gelatinisation of these structures occured. Furthermore, Jones et al. [10] emphasize that collagen of epi-, peri- and endomysium in m.semitendinosus shows various susceptibility to thermal destruction. Electron micrograph 3 show the connective tissue in the endomysium after initial thermal treatment at 90°C for 30 min. and after final thermal treatment at 85°C for 90 min. (model of liver sausage). The obtained pictures prove that apart from amorphic changes in the endomysium, a typical fibrous structure is retain-

ed. Jones et al.[10] proved that collagen in the endomysium of cattle m.semitendinosus did not undergo any changes until the temp. of 50°C was reached, whilst at 60°C it lost the fibrous structure and became compact mass, whereas at 90°C, the protein being discussed revealed amorphous structure. Our observations indicate higher thermal resistance of the endomysium in the raw material examined in comparison with the changes in the structure of typical skeleton muscles. Additional confirmation of structural stability of the beef gullet meat tissue has been proved in our earlier studies using an electron transmission microscope with regard to the muscles thermally treated at 90°C for 6 hr. The results showed that a long lasting thermal treatment (6 hr) did not cause total destruction of collagen fibres [7]. The electron micrograph 4 shows the picture of the beef gullet meat tissue which undergoes thermal treatment at 121°C for 50 min. (model of canned sterilized pâtè) which proves that collagen still retains traces of natural fibrous structure. It can be assumed that thermal destruction of collagen is specific for the experimental raw material and most probably results from the molecular network characteristic for this protein.

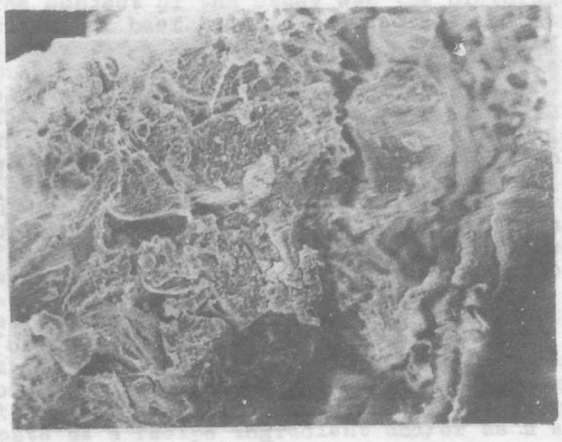

Fig.3. Electron micrograph of endomysium of a model liver sausage, x 440

Fig.4. Electron micrograph of endomysium of a model canned sterilized pâtè, x 440

The content of total collagen in the endomysium of beef gullet meat tissue amounts to 2.31% on average, i.e. 12.88% of total protein (Table 2).

Table 2. The content of total and soluble collagen in raw meat tissue of beef gullets and of model meat products

Characteristics \ Experimental materials	Raw meat tissue of beef gullet		Model liver sausages		Model canned sterilized pâtè	
	$\bar{x}$	S	$\bar{x}$	S	$\bar{x}$	S
Total protein (%)	17.97	0.21	25.13	0.45	15.14	0.35
Total collagen (%)	2.31	0.21	3.22	0.12	1.96	0.08
Total collagen (% of total protein)	12.88a	0.29	12.81a	0.52	12.96a	0.71
The solubility of collagen (%)	0.25a	0.04	0.76b	0.09	1.73c	0.09
The solubility of collagen (% of total collagen)	11.09a	0.53	23.84b	0.50	88.11c	0.71
The solubility of collagen (% of total protein)	1.41a	0.27	3.05b	0.42	11.42c	0.82

a,b,c - Mean within a column having different superscripts are significantly different ($P < 0.01$).

The data mentioned above prove that the beef gullet meat tissue contains considerably high amount of collagen in comparison with other muscles and edible by-products. The content of total collagen in the model meat products amounts to 1.96% in canned sterilized pâté and 3.22% in liver sausage. The content of soluble collagen in the experimental meat products increased with rising temp. of thermal treatment. Susceptibility of collagen to thermal degradation is also determined by such factors as: species, breed, sex and age of the animal and even the type of a muscle [8]. The amount of soluble collagen expressed in relation to its total amount illustrates the degree of termal hydrolysis more clearly. The results of the studies show that after 50 min. of heating the model products at 121°C, thermal hydrolysis comprised 88.11% of total collagen, on average, whereas double thermal treatment, i.e. initial at

90°C for 30 min. and final at 85°C for 90 min. resulted in 23,84% of the collagen degradation. According to Goll [6], after 240 min. of cooking the beef at the temp. of 100°C, approx.95% of collagen undergous solubilization. The temp. used for thermal treatment of liver sausages with the addition of beef gullet meat tissue does not result in the desired thermal destruction of collagen. Even at such a severe thermal treatment as sterilization, a certain part of collagen in the raw material is not destructively affected. The determined degree of thermal hydrolysis of collagen of the experimental raw material is considered max.possible. The degree of collagen hydrothermal resistance of the raw material examined as well as thermal destruction are considered specific for these muscles being responsible for particular physiological functions and most probably they are due to molecular network of this protein.

The results of the present study prove that the beef gullet requires effective comminution and adequate thermal treatment. The beef gullet meat tissue can be recommended as the substitute of beef in the recipe of sterilized pâtè.

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