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Preliminary Physico-chemical and Histological Characteristics of Beef Gullet Meat Tissue

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ABSTRACT

The muscle layer of beef gullet meat tissue is made up of striated muscles and the tissue layer is composed of compact muscle bundles. The muscle fibres (43·3 μm in thickness) are tightly joined by endomysium. The protein content of the gullet meat tissue is similar to that found in less valuable sorts of meat. The muscles are high in collagen. The amino acid composition of the gullet protein shows a favourable balance of essential amino acids, including a high lysine level. Moreover, the raw material is a valuable source of mineral substances. The results obtained in the present study prove that this unconventional offal can be utilized as a substitute for processed beef.

INTRODUCTION

One of the major problems which the food industry faces nowadays is the most effective utilization of the existing traditional protein resources and the search for new sources of this valuable nutrient.

Contemporary studies on meat and the technologies applied in meat processing are aimed at rational utilization of the offals containing less valuable meat tissues, constituting an extra source of cheap protein of animal origin (Olson, 1970; Lawrie, 1980; Kosiba, 1983; Pezacki, 1984).

Rational utilization of the offals high in this nutrient, which can successfully substitute meat protein, is a problem requiring thorough investigation. However, there is a considerable group of offals, including

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beef gullet* meat tissue, neglected by meat technologists due to their specific and/or undesirable sensoric features, lower protein value and usually high microbial contamination (Kosiba, 1983).

Varied assortments of several less valuable meat tissues show that the histological structure and chemical composition differ from those found in better quality meat; hence, multidirectional utilization of such raw material in processing is often based on the practical experience of food technologists. In many countries, utilization of offals is uncommon and their processing has not become a common practice. This is partly due to the culinary traditions and habits of the consumers and partly to the fact that processing of offals is considered by manufacturers as too energy—and time-consuming. Moreover, the anatomo-histological predisposition of offals for food processing has been disregarded (Pezacki, 1984).

In ruminants the entire muscle layer of gullets is made up of striated muscles. From one beef gullet 200 g of meat tissue can be obtained and this amount constitutes a cheap source of animal protein. The authors of the present paper have therefore been encouraged to undertake the studies on technological, nutritional and histological characteristics of beef gullet meat tissue.

Data in the literature show that beef gullet meat tissue has been traditionally neglected as an offal of undesired organoleptic features and for this reason, up to the present day, its structure and physico-chemical features have not been analysed or described.

MATERIALS AND METHODS

The beef gullet meat tissue was obtained from the carcasses of young Polish Black-Pied slaughter cattle (lowland black and white breed), pre-slaughter weight about 450 kg.

Immediately after slaughter the mucous membrane of the gullet and fat were removed. The experiment was conducted in five series. The samples in each series included ten gullets. The samples were cooled for 24 h and then comminuted in a laboratory grinder with a plate of 2 mm holes in diameter.

For histological analysis in an optical microscope the samples were fixed in 10% buffered formalin and embedded in paraffin. The sections were stained with hematoxyline and eosine and by the method of Debreull and Curtis (Burck, 1975). Thickness of the fibres was measured by an eyepiece micrometer and the results from 100 measurements were considered as mean values.

* Defined as the muscle layer of oesophagus.

For ultrastructural examinations, the material was fixed in 2% osmium tetroxide solution. The sections were stained with uranyl acetate and lead citrate (Mercer & Birbeck, 1970) and were analyzed in a Tesla BS 613 microscope at 100 kV.

The basic chemical composition, i.e. protein, fat, water and ash content, was determined according to standard methods (Budsławski & Drabent, 1972).

For ash determination, the samples were mineralized at 550°C for 16 h. The amounts of Fe, Mg, Zn, Cu and Mn were determined by means of atomic absorption spectrophotometry. The contents of K, Na, Ca and P were determined by flame photometry (Rutkowska, 1981).

Total collagen content was determined by the methods of Stegemann & Stalder (1967) and Arneth & Hamm (1971) modified by Janitz (1985).

The amino acid composition, excluding tryptophan, was determined in standard acid hydrolyzate using an automatic amino acid analyzer (Janitz, 1985). Tryptophan was determined after hydrolysis of a sample in 3N NaOH according to Graham *et al.* (1947) with modification of sample preparation (Janitz & Korzeniowska, 1976). Chemical score (CS) was determined according to Mitchel and Block and index of essential amino acids (EAA ind.) according to Rutkowska (1981).

Water-holding capacity was determined by the Grau-Hamm method (Tyszkiewicz, 1969) and was expressed in % of water held by the tissue.

The physical colour parameters were determined by spectrophotometric reflectance measurements at 560 and 640 nm (Tyszkiewicz, 1964; 1969).

RESULTS AND DISCUSSION

Histological analysis

Figure 1 illustrates the histological structure of beef gullet meat tissue after cooling for 24 h. The gullet meat tissue is composed of two layers of longitudinal and transverse muscles containing compact muscle bundles. The endomysium adheres tightly to meat fibres, binding them together and thus forming a compact structure. The general histological picture indicates that the compact structure of the meat layer is highly resistant to mechanical factors.

The average thickness of meat fibres reached 41·3 μm and several measurements of fibre thickness determined for specific topographic allocation of the fibres did not show any significant difference at $p = 0{\cdot}05$.

The electron micrograph (Fig. 2) shows the ultrastructure of the meat fibre

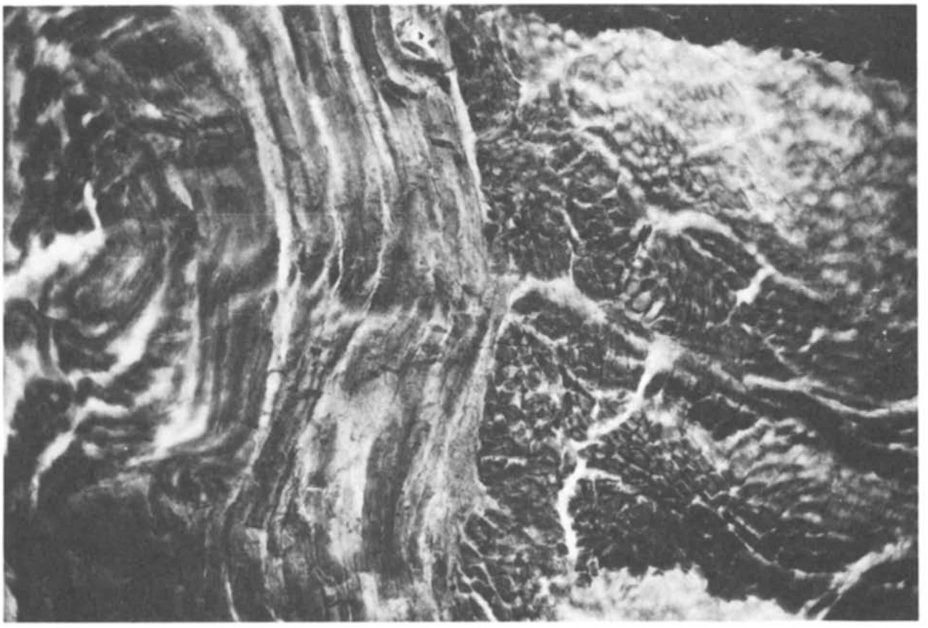

Fig. 1. Histological picture of beef gullet meat tissue.

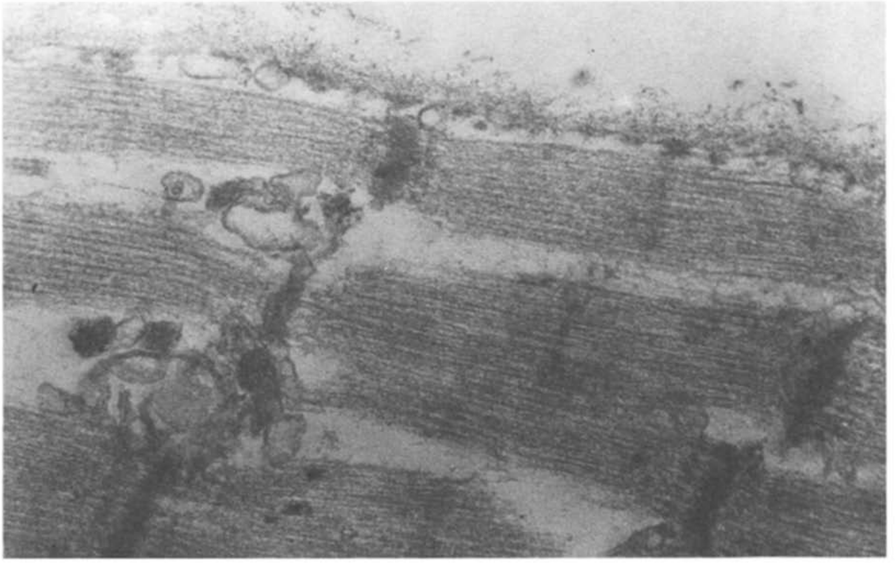

Fig. 2. Electron micrograph of myofibrils of beef gullet meat tissue.

of the muscles examined as typical skeletal meat tissue with clearly marked myofilaments, Z line and well developed sarcoplasmic reticulum.

Chemical composition

Table 1 gives the basic chemical composition of the beef gullet meat tissue. The results obtained prove that the experimental material is characterized by a relatively constant chemical composition. The total protein in the beef gullet meat tissue averaged 18% and was similar to that found in lower quality beef. The mean fat content in the experimental material was relatively low (2·9%) and it was nearly the same as in lean beef. The moisture content in the beef gullet meat tissue was relatively high (77·4% on average) and approximated to that in lean beef (Baryłko-Pikielna & Jacórzyńska, 1979).

TABLE 1
Chemical Composition of Beef Gullet Meat Tissue

Parameters (%)		$\bar{X}$	*S*
Protein		18·0	0·54
Water		77·4	0·45
Fat		2·9	0·13
Ash		0·8	0·03
Collagen	Total protein (%)	12·9	0·29
	Tissue (%)	2·31	0·21

Collagen content

The beef gullet meat tissue is high in collagen content. It reaches the level of 12·9% in total protein which, in conversion to the tissue, amounts to 2·31% (Table 1).

Mineral substances

Table 2 shows the average level of mineral substances found in the beef gullet meat tissue as well as in roast beef samples taken from the same animals and determined in the present investigation.

The analyses of macroelements indicate that the amounts of potassium, phosphorus and magnesium in the experimental material were higher than in skeletal muscles. Potassium and phosphorus contents were 16% higher

TABLE 2
Content of Mineral Substances in Beef Gullet Meat Tissue in mg/100 g of Raw Meat

Elements	*Beef gullet meat tissue*	*Roast beef* (m. longissimus lumborum)
Ca	6·42	5·35
Na	39·0	60·7
K	257	221
P	184	158
Mg	24·9	21·2
Fe	4·43	4·95
Mn	0·03	0·02
Zn	2·89	3·55
Cu	0·12	0·11

and magnesium content was 11% higher. Worth noting is the low sodium content in the beef gullet meat tissue as compared with typical meat tissue. The difference is 36%. However, its amount in the experimental material is not lower than the lowest values found for beef (Rutkowska, 1981). Among microelements, the amount of Zn in the beef gullet meat tissue is 19% lower than in roast beef whereas the level of Mn and Cu in both tissues is similar.

According to Kühne (1983) the amount of mineral substances depends on anatomical position of the muscle in a carcass. On the other hand, Rafalski & Świtoniak (1984) reported that the species, breed, feeding and processing procedures, in particular, can affect the content of mineral substances in the meat tissue. Nour *et al.* (1983) report that there is a relationship between mineral content and sensoric value of beef.

In conclusion, it is worth noting that the beef gullet meat tissue is a valuable source of minerals which is undoubtedly important from the nutritional point of view.

Amino acid composition

The level of essential amino acids in the beef gullet meat protein averaged 40% of total amino acids (Table 3). Index of EAA amounts to 65 and indicates that the amount of essential amino acids in the beef gullet meat tissue is slightly different from that found in the protein of beef muscle (Table 4). However, it should be noted that the group of essential amino acids mentioned above exhibits very low chemical score (CS) due to too low methionine and cystine levels (CS = 20·31). The beef gullet meat tissue is high

TABLE 3
Content of Amino Acids in Beef Gullet Meat Tissue in g/16 gN

Amino acid	*Beef gullet meat tissue*	*FAO standard (Rutkowska 1981)*	*Beef*
Isoleucine	3·97	5·4	5·06
Leucine	7·03	8·6	8·23
Lysine	7·65	7·0	9·30
Methionine	1·16 }	5·7	2·41
Cysteine	trace }		1·38
Phenylalanine	3·58 }	9·3	3·94
Tyrosine	3·21 }		3·50
Tryptophan	0·92	1·7	1·17
Threonine	4·04	4·7	4·12
Valine	4·41	6·6	5·68
Arginine	6·12		7·69
Histidine	2·94		4·18
Alanine	5·72		6·66
Aspartic acid	7·90		8·39
Glutamic acid	14·9		16·9
Glycine	6·52		4·86
Proline	5·93		4·31
Serine	3·62		4·33
Amino acid (essential)	36·0	49	44·8
Amino acid (non-essential)	53·6		
CS	20·4 (Met. + Cys.)		68·9 (Met. + Cys.)
EAA	65		87

TABLE 4
Chemical Scores (CS) and Index of Essential Amino Acids (EAA ind.) in Protein of Beef Gullet Meat Tissue

Amino acid	*Chemical scores (CS)*
Isoleucine	73·5
Leucine	81·7
Lysine	109
Methionine } Cystine }	20·4
Phenylalanine } Tyrosine }	73·0
Threonine	86·0
Tryptophan	54·1
Valine	66·8
EAA index	65

in lysine (7·65 g/16 g N), whereas the level of tryptophan is lower (CS = 54·11). The beef gullet meat tissue is deficient in isoleucine and aromatic amino acids in comparison with beef.

Physico-chemical properties

The pH value of the beef gullet meat tissue was determined 45 min after slaughter and was 6·7. After cooling for 24 h the pH value dropped to 5·8 (Table 5). Thus the examined raw material differs from the values generally accepted for beef muscle.

TABLE 5
Selected Physico-chemical Characteristics of Beef Gullet Meat Tissue

Parameters	$\bar{X}$	*S*
pH_1	6·70	0·05
pH_{24}	5·80	0·06
Water-holding capacity (%)	73·50	0·21
Physical colour parameters		
Dominant wavelength (λ_d) (nm)	622·1	0·31
Photometric luminance (*Y*) (%)	22·60	0·27
Excitation purity (*Pe*)	0·551	0·003

Water-holding capacity is one of the very important properties of meat proteins determining the technical utilization of the meat. Water-holding capacity of the beef gullet meat tissue is high—73·5% (Table 5) and this accounts for unquestionable usability of this raw material in the manufacturing of comminuted meat products. Table 5 shows physical parameters of the beef gullet meat tissue colour.

Comparing the data obtained for beef *longissimus dorsi* (Kozioł, 1980) with the results obtained in the present study, we find that the colour of the beef gullet meat tissue is characterized by lower values of the dominant wavelength and excitation purity, whereas photometric luminance values are higher in the experimental material. The examined values show lower intensity of the colour of beef gullet meat tissue than that observed in *longissimus dorsi* muscle. Reduced colour intensity observed in the beef gullet meat tissue may result from higher fat and connective tissue content as well as varied pH values. Moreover, specific features of pigment conversion (different in each meat tissue) affect the colour accordingly (Pezacki, 1968).

Organoleptical evaluation of the beef gullet meat tissue proves that this raw material, being dark-red in colour, resembles that of beef muscle tissue of mature animals.

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