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EXPERIMENTAL STUDIES OF THE GASTROINTESTINAL SYSTEM - QARTA OF THE HORSE

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The present study provides a comprehensive investigation into the biochemical, nutritional, and physicochemical properties of qarta, the terminal segment of the horse's gastrointestinal tract, traditionally consumed in Kazakh cuisine. Despite its cultural importance and increasing market interest, little is known about the compositional profile of this intestinal material. Boiled qarta samples were analyzed for mass fraction of moisture, fat, protein, ash, pH, water activity (a_w), and functional properties such as water-holding, water-binding, and fat-hiding capacities. Furthermore, cholesterol levels, free amino acid profiles, and fatty acid composition were determined using standardized GOST protocols and modern analytical equipment.

The results revealed that qarta is characterized by a low cholesterol content (29.9±0.72 mg/100g), a high proportion of unsaturated fatty acids (MUFA - 42.5%, PUFA – 17.7%), and a substantial amount of free and essential amino acids (total 41.3%). Functional parameters such as water and fat-binding capacities remained high after boiling, indicating technological suitability for meat processing.

These findings highlight qarta as a valuable source of high-quality protein and lipids, with potential applications in health-oriented and functional food products. The study contributes new insights into the valorization of underutilized meat by-products and supports the development of novel formulations basedon equine tissues.

Key words: horse meat, qarta, gastrointestinal system, nutritional composition.

ЭКСПЕРИМЕНТАЛЬНОЕ ИССЛЕДОВАНИЕ ЖЕЛУДОЧНО-КИШЕЧНОГО ТРАКТА ЛОШАДИ ҚАРТА

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В настоящем исследовании дана всесторонняя характеристика химического состава, пищевой и физико-химической ценности қарта – терминального отдела желудочно-кишечного тракта лошади, традиционно употребляемого в казахской кухне. Несмотря на культурное значение и растущий интерес со стороны рынка, состав этого субпродукта остается малоизученным. Образцы қарта были проанализированы по показателям массовой доли влаги, содержании жира, белка, золы, pH, водной активности (a_w), а также по функциональным свойствам - влагоудерживающей, водосвязывающей и жироудерживающей способности. Кроме того, были определены уровни холестерина, профиль свободных аминокислот и состав жирных кислот с применением стандартов ГОСТ и современных аналитических методов.

Результаты показали, что қарта характеризуется низким содержанием холестерина (29.9±0.72 мг/100г), высоким содержанием ненасыщенных жирных кислот (МНЖК - 42.5%, ПНЖК - 17.7%) и значительным уровнем свободных и незаменимых аминокислот (всего 41.3%). Функциональные свойства сохранялись после термообработки, что указывает на технологическую пригодность қарта для переработки в мясной промышленности.

Полученные данные позволяют рассматривать қарта как ценный источник полноценного белка и липидов с высоким потенциалом для производства деликатесных мясных продуктов питания.

Ключевые слова: конина, қарта, желудочно-кишечный тракт, пищевая ценность.

ЖЫЛҚЫНЫҢ АСҚАЗАН-ІШЕК ЖОЛЫ - ҚАРТАНЫ ЭКСПЕРИМЕНТТІК ЗЕРТТЕУ

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Бұл зерттеу жұмысы дәстүрлі қазақ деликатесі саналатаын қарта өнімінің - жылқының тоқ ішек бөлігінің - химиялық, тағамдық және физика-химилық қасиеттерін кешенді түрде сипаттайды. Мәдени маңыздылығына қарамастан және нарықта қызығушылықтың артуына қарамастан, бұл өнім түрінің құрамы жеткілікті дәрежеде зерттелмеген. Қарта үлгілері ылғалдың массалық үлесі, май, ақуыз, күл, pH, су белсенділігі (a_w), сонымен қатар технологиялық қасиеттері - ылғал-май ұстағыштық пен су байланыстыру қабілеті бойынша зерттелді. Сонымен қатар холестерин мөлшері, бос аминқышқылдары мен май қышқылдарының құрамы анықталды (СТ ҚР стандарттары және заманауи аналитикалық әдістерімен).

Зерттеу нәтижелері бойынша қарта төмен холестерин құрамымен (29.9±0.72 мг/100г), жоғары моно- және полиқанықпаған май қышқылдарымен (МНМҚ - 42.5%, ПНМҚ - 17.7%) және едәір мөлшердегі бос және алмастырылмайтын аминқышқылдарымен (41.3%) ерекшеленетіні анықталды. Термоөңдеуден кейін де технологиялық қасиеттері жоғары деңгейде сақталған.

Осы нәтижелер қарта өнімін ақуыздар мен майлардың толыққанды көзі ретінде және денсаулыққа пайдалы функционалды өнімдерге арналған шикізат ретінде қарастыруға мүмкіндік береді.

Түйін сөздер: жылқы еті, қарта, ішек-қарын жүйесі, тағамдық құндылық.

Introduction. Horses are unique hindgut fermenters, utilizing a well-developed caecum and colon for microbial digestion of structural carbohydrates and absorption of volatile fatty acids. Despite widespread knowledge of their digestive anatomy, the biochemical composition of equine intestinal tissues, particularly the final segment (rectum, known as qarta in Kazakh culture), remains underexplored. While muscle, adipose, and milk tissues of horses have been frequently characterized for amino and fatty acid profiles [1], little is known about the free amino acids, lipid fractions, and physicochemical properties of qarta.

In Kazakhstan and other Central Asian countries, growing attention has been paid to the valorization of traditional meat by-products as sources of high value nutrients and functional materials. The rational use of edible offal contributes to sustainable meat processing and the creation of functional semi-finished products rich in bioactive compounds. Similar studies emphasize the importance of domestic research in developing technologies for the efficient utilization of by-products within national meat industries [2].

Building upon this background of sustainable processing and traditional product valorization, several domestic studies have focused on improving the quality and sustainability of national meat products. Recent works have demonstrated the development of new-generation Kazakh horse-meat products enriched with natural antioxidants such as goji extract and buckwheat flour, which enhanced oxidative stability and product quality [3].

In Central Asian cuisine, qarta has long been consumed for its unique texture and rich nutritional content. Preliminary evidence suggests that equine intestines may contain high levels of unsaturated fatty acids and free amino acids beneficial for health and digestion (e.g., glutamic acid, taurine, oleic and linoleic acids).

The chemical composition of horse gastrointestinal

tissues - measured by their content of water, fat, protein, minerals, carbohydrates, and other substances - offers essential insight into the nutritional quality of horse meat. These intestinal by-products are increasingly valued in the market due to their distinctive levels of proteins, fats, and glycogen. The high concentration of essential amino acids, balanced fatty acid profiles, and the presence of both macro- and micronutrients make horse meat and its gastrointestinal components especially suitable for individuals with higher nutritional requirements.

Horse meat is particularly digestible due to its high protein, vitamin B12, and iron content, coupled with a low fat (approximately 3%) and cholesterol level [4]. Meat quality is a comprehensive measure that includes nutritional, sensory, hygienic, technological, and processing characteristics [5]. Compared to ruminant or pig meat, horse meat and its intestinal parts are richer in water, proteins, glycogen, iron, and water-soluble vitamins, while containing lower levels of lipids and fat-soluble vitamins, giving them distinct dietary advantages [6].

Regional studies conducted in Kazakhstan confirm that horse meat and its by-products possess a favorable amino acid balance, high digestibility, and good safety indicators under local production conditions. These findings reinforce the nutritional benefits of horse-derived products for functional and health-oriented food applications [7].

With muscle fibers comprising about 70% of horse meat and minimal fat tissue, the meat has favorable dietary properties. Fat content typically ranges between 0.5% and 3.0%, with unsaturated fatty acids accounting for a larger proportion (approximately 56-60%) than saturated ones (around 40%) [8]. Key unsaturated fatty acids include linoleic, linolenic, palmitic, and oleic acids.

Qarta, also known as digestive system in Kazakh culture, is a traditional delicacy prepared from the terminal portion of the horse's large intestine, including the rectum. It is distinct in structure, consisting of a dense outer layer of connective tissue and a fat-rich inner surface, which contributes to its unique texture and taste after cooking. Traditionally, qarta undergoes thorough cleaning and multiple soaking steps to remove odors. It is typically boiled in salted water, often with spices like black pepper and bay leaf, although variations include smoking or drying. Once prepared, it is sliced and served as an appetizer or main dish. In Kazakh culture, qarta is highly valued as a symbol of hospitality, often served to esteemed guests during festive gatherings.

From a nutritional standpoint, qarta differs notably from lean horse meat. While horse meat is recognized for its high protein, low fat, and favorable unsaturated fatty acid profile, qarta contains significantly higher fat levels on its inner surface, increasing its energy value and influencing its sensory properties. Analytical data from experimental studies that horse meat, including gastrointestinal components.

Research by Dufey and Segato et al. [9,10] found that as horses age, fat content increases while water and protein levels decline, though cholesterol levels remain stable throughout aging.

Fat accumulation also increases with age. The proportion of abdominal fat rises from 9.4% at 6 months to 14.2% by 30 months. Similarly, subcutaneous and visceral fat increase with age, whereas intramuscular fat decreases-from 51.4% at 6 months to 43.8% at 30 months.

Genetics significantly influence both the efficiency of horse meat production and the meat' s quality. Although no horse breeds are raised exclusively for meat, heavy cold-blooded breeds are well-suited for this purpose. Meat is also sourced from warm-blooded horses that are no longer viable due to age or injury. Existing studies confirm a strong relationship between genotype and both qualitative and quantitative slaughter traits. For example, analyzed slaughter performance across five French heavy horse breeds aged between 12 and 30 months, demonstrating these genetic correlations.

Materials and methods. In accordance with the set goal and objectives the scheme of research organisation was developed. Experimental work of the research was carried out in the

laboratories of the departments of «Technology of food and processing industries», accredited testing laboratory «Food safety», «Research laboratory for quality assessment and safety of food products», «National Center for Biotechnology» at the «Laboratory of genetics and biochemistry of microorganisms». Theoretical and practical skills were learnt during an internship abroad at the Swedish University of Agricultual Sciences, Department of «Molecular Sciences», Uppsala, Sweden.

The study was conducted on gastrointestinal raw materials of equine origin - specifically, the terminal segment of the large intestine (rectum), traditionally referred to as Qarta in Kazakh culture. Samples were obtained from clinically healthy horses aged 1 to 3 years post-slaughter at a certified meat-processing facility.

Determination of the total composition of meat and meat products. Determination of the chemical composition gives the opportunity to get an idea of the quality of meat and meat products, their nutritional value, depending on the quantitative ratio of moisture, protein fat and mineral substances. The content of basic nutrients in meat products is determined by their recipe and the nature of technological processing.

Determination of moisture content. GOST 9793-2016 [11]. Methods for determining moisture. A sample of ground product weighing 3-5 g, taken to an accuracy of 0.001, dried in a metal bouquet with a glass rod in a desiccator at 150°C for 1 hour or in the apparatus SAL at 150°C for 15 min.

Moisture content is calculated according to the formula:

$$x_1 = \frac{m_1 - m_2}{m_1 - m} \cdot 100$$

where, x_1 - moisture content, %;

m_1 - weight of the bunker with the sample before drying, g;

m_2 - mass of the bucket with the sample after drying, g;

m - weight of the bucket, g.

Determination of fat content. GOST 23042-2015 [12]. Methods of fat determination. The dried sample after determination of moisture is quantitatively transferred into a bouquet and poured 10-15 ml of solvent (petroleum or ethyl ether). Extraction of fat is carried out for 3-4 min with 4-5 times repeated frequency. During the process the suspension is periodically stirred with a glass rod and the solvent is poured each time with the extracted fat. After the last pour the residual solvent is evaporated in air. Buex with defatted sample is dried in a desiccator at 105°C for 10 min.

The fat content is determined according to the formula:

$$x_2 = \frac{m_1 - m_2}{m_0} \cdot 100$$

where, x_2 - fat content, %;

m_1 - weight of bouquet with sample after drying before degreasing, g;

m_2 - mass of the bunker with the sample after degreasing, g;

m_0 - weight of the sample, g.

Determination of ash content. GOST 31727-2012 [13]. Method for determining the mass fraction of total ash. After degreasing the contained bunks are transferred into a pre-calcined and weighed crucible. The residue of the suspension from the walls of the bouquet is washed off with a small amount of solvent, which is then removed by heating on a water bath until it disappears. In the crucible to the dry defatted suspension add 1 ml of magnesium acetate.

The crucible with the suspension is charred on an electric cooker, then placed for 30 min in a muffle furnace, inside which the temperature is 500-600°C.

In the same way 1 ml of magnesium acetate is mineralised.

Ash content is calculated according to the formula:

$$x_3 = \frac{m_1 - m_2}{m_0} \cdot 100$$

where, x_3 - ash content, %;

m_1 - mass of ash, g;

m_2 - mass of magnesium oxide obtained after mineralisation of magnesium acetate solution, g;

m_0 - mass of suspension, g.

Determination of protein content. GOST 25011-2017 [14]. Methods for determining the mass fraction of protein. Protein content is determined by calculation according to the formula:

$$x = 100 - (x_1 + x_2 + x_3)$$

where, x - protein content, %;

x_1 - moisture content, %;

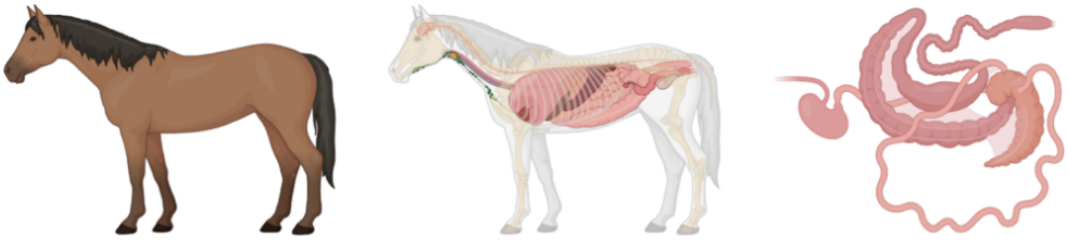
x_2 - fat content, %.

Ash content, petroleum or ethyl ether, magnesium acetate solution.

GOST 32886-2014 [15]. Determination of cholesterol content by gas chromatographic method. This method is used to quantify the amount of cholesterol present in various meat and poultry samples. The standard outlines the procedures for sample preparation, analysis, and calculation of results, ensuring consistent and reliable measurements of cholesterol levels.

Determination of amino acids composition. GOST 34132-2017 [16]. Chromatographic method for determining the amino acid composition of meat proteins, including poultry meat, offal, meat and meat-containing products, as well as products made from poultry meat.

Determination of fatty acid composition. GOST 34987-2023 [17]. This standard applies to slaughter products (meat, offal) of all types of slaughtered animals and poultry, as well as meat products (including canned meat and meat–containing products), including poultry meat (hereinafter referred to as meat products), and establishes the following methods for determining fatty acid composition: - a method for determining the mass fraction of fatty acids in the form of methyl esters using gas chromatography with a flame ionization detector (GC-PID) with a measurement range from 0.1% to 100% - a method for determining the mass fraction of saturated fatty acids using near-infrared spectroscopy (BIC spectroscopy) with a measurement range from 0.4% to 80.0 %.



Horse (1-3 years) **Carcass of horse** **Digestive system of horse**

Fig.1 - Anatomical diagram of the horse and its gastrointestinal system

Determination of fat-holding capacity (FHC). GOST 23042-2015 [18]. This standard applies to meat and meat products and establishes methods for determining fat content and fat-holding capacity (FHC), as well as moisture-holding capacity (MHC). The fat-holding capacity is determined by thermal treatment of the sample followed by gravimetric analysis of fat released. The moisture-holding capacity is calculated based on mass loss after heating in a water bath at 70±2°C for 15 minutes and subsequent pressing and weighing.

GOST 25179-90 [19]. This standard describes a refractometric method for determining the protein mass fraction, which. Is widely adapted in research and analytical practice for meatraw material. In meat analysis, this method is used to estimate the refractive index of aqueous meat extracts, indirectly reflecting the protein content, and is applied to assess moisture-retaining properties.

Determination of water-binding capacity (WBC).

Method of Vartanyan (Pressing Method) [20]. This mthod is used for determining the water-binding capacity (WBC) of meat and is based on compressing a ground meat sample between filter paper layers under a standardized pressure (1 kg load for 10 minutes at room temperature). The moisture area (exudate) formed is measured using planimetry.

Figure 1 provides a schematic overview of the horse's digestive anatomy. The entire gastrointestinal tract is depicted, highlighting the large intestine and its terminal section – the rectum – traditionally known as qarta in Kazakh culture. The caecum, colon, and rectum are clearly visualized, establishing anatomical context for the studied tissue.

A detailed figure 2 of the horse's large intestine, emphasizing the colon's length, thickness, and internal structural features. The image offers visual clarity for understanding where qarta originates and its relation to other digestive organs.

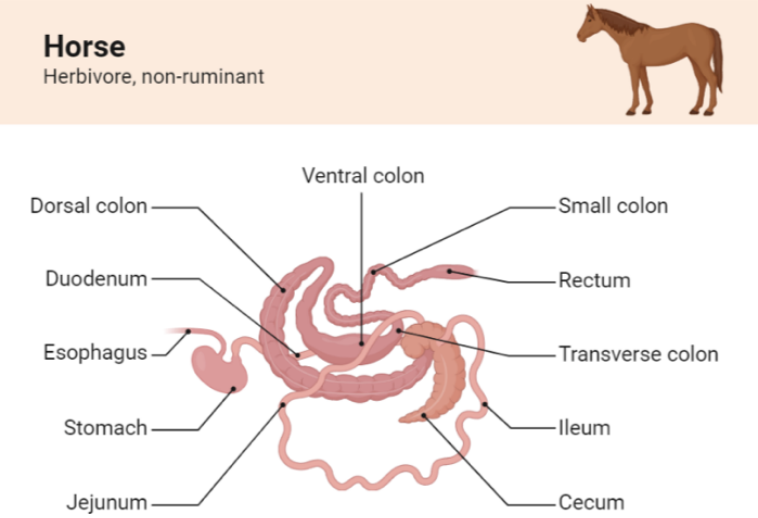


Fig.2 - The anatomy of the gastrointestinal tract in horse



a) **b)**

Fig.3 - Intestinal raw materials of horse meat - qarta (a) external; b) internal)

Figure 3 shows the external and internal surface of qarta. The outer layer appears dense and fibrous, composed largely of connective tissue, while the inner layer displays visible fat deposits – a key contributor to qarta's flavor and texture upon cooking.



Fig.4 - Cross-sectional view of Qarta, showing fat-muscle structure

The cross-section reveals the layered architecture of qarta: a fatty inner surface juxtaposed with muscular and connective tissue structures. This figure 4 reinforces qarta's technological characteristics relevant for culinary and meat-processing applications.

Results and discussion. Chemical composition of fresh gastrointestinal tract from cattle, pig, and horse, as well as the boiled products derived from these animals. Their analysis revealed that the water activity (a_w) values in boiled meats from bovine, horse, and pig are consistent with expected standards for such products. Notably, the pH levels were generally high, except in the case of horse meat, which may indicate ongoing proteolytic activity driven by endo- and exoenzymes produced by microorganisms involved in the curing and ripening process (Table 1, 2).

Fresh qarta demonstrated high moisture (60.46%) and fat (21.61%) content, with moderate protein levels (9.56%). The pH value (6.12%) and high water acivity (0.94%) suggest susceptibility to microbial growth, requiring proper processing. Functional indicators (WHC, WBC, FHC) were relatively high, indicating good technological potential.

Table 1 - pH, a_w content of fresh gastrointestinal tract of horse after thawing

Name of indicators, unit of measurement	Actual results
pH under the hood, %	6.12±0.06
aw, %	0.94±0.01
Mass fraction of moisture, %	60.46±0,91
Mass fraction of proteins, %	9.56±0.14
Mass fraction of fats, %	21.61±0.32

Water-holding capacity (WHC) , %	45.87±0.20
Water-binding capacity (WBC) , %	24.96±0.96
Fat-holding capacity (FHC) , %	44.91±0.14
Ash, %	1.3±0.09

Boiling led (Table 2) to a reduction in moisture (52.10%) and fat (15.84%), while protein content increased significantly to 19.11% due to water loss. Functional parameters (WHC, WBC, FHC) slightly decreased but remained within acceptable technological limits. Ash content increased to 7.7% reflecting mineral concentration after cooking.

Table 2 - pH, a_w and approximate content in final boiled gastrointestinal tract

Name of indicators, unit of measurement	Actual results
pH under the hood, %	5.81±0.15
aw, %	0.90±0.02
Mass fraction of moisture, %	52.10±0.93
Mass fraction of proetins, %	19.11±0.28
Mass fraction of fats, %	15.84±0.24
Water-holding capacity (WHC) , %	38.41±0.57
Water-binding capacity (WBC) , %	18.84±0.28
Fat-holding capacity (FHC) , %	38.41±0.57
Ash, %	7.7±0.22

Among all the meats studied, boiled horse meat exhibited the lowest cholesterol content, a finding of particular nutritional interest. Horse meat stood out for its notably significant level of polyunsaturated fatty acids. Meat products had a moderate level of these fatty acids, whereas bovine products had the lowest (Table 3). Cholesterol level was measured at 29.9mg/100g, which is notably low compared to traditional red meats.This reinforces the dietary suitability of horse-derived gastrointestinal products for individuals with cardiovascular concerns.

Table 3 - Levels of cholesterol (mg/100 g) in final boiled meat products

Name of indicators, unit of measurement	Actual results
Cholesterol, %	29.9±0.72

The fatty acid profile of boiled qarta showed dominance of monounsaturated (MUFA – 42.5%) and polyunsaturated fatty acids (PUFA – 17.7%), especially oleic and linoleic acids. Saturated fatty acids (SFA) accounted for 39.84%. This composition highlights qarta's favorable lipid profile with potential health benefits (Table 4).

Table 4 - Content of fatty acids (%) of gastrointestinal raw material of final boiled qarta

Name of indicators, unit of measurement	Actual results
Saturated fatty acids (SFA), %	
C10:0 capric fatty acid	0.095±0.005
C12:0 lauric fatty acid	0.159±0.009
C14:0 miristinic fatty acid	3.265±0.163
C15:0 pentadecanoic fatty acid	0.492±0.025
C16:0 palmitic fatty acid	28.996±1.450
C17:0 margaric fatty acid	0.606±0.030
C18:0 stearic fatty acid	5.892±0.295
C21:0 geneticosanic fatty acid	0.170±0.009
C22:0 behenoic fatty acid	0.055±0.003
C23:0 tricosanoic fatty acid	0.113±0.006
Monounsaturated fatty acid (MUFA), %	
C14:1 (cis-9) myristoleic fatty acid	0.229±0.011
C15:1 (cis-10) pentadecenoic fatty acid	0.046±0.002
C16:1 (cis-9) palmitoleic fatty acid	5.999±0.300
C17:1 (cis-10) margarinoleic fatty acid	0.632±0.032
C18:1 (trans-9) oleinic fatty acid	0.023±0.001
C18:1 (cis-9) oleinic fatty acid	35.025±1.751
C20:1 (cis-11) eicosenoic fatty acid	0.393±0.020
C22:1 (cis-13) erucic fatty acid	0.048±0.002
C24:1 (cis-15) selacholic fatty acid	0.059±0.003
Polyunsaturated fatty acid (PUFA), %	
C18:2n6c linoleic fatty acid	14.420±0.721
C18:3n6 Y- linoleic fatty acid	3.012±0.151
C18:3n3 linoleic fatty acid	0.035±0.002
C20:3n6c (cis-8,11,14) eicosatrienoic fatty acid	0.235±0.012
Total SFA	39.843±1.995
Total MUFA	42.454±2.122
Total PUFA	17.702±0.886

Boiled qarta contained a high total level of free amino acids (13 177.93 mg/100g), including essential amino acids (5 455.56mg/100g or 41.3%). Dominant amino acids included glutamic fatty acid, aspartic fatty acid and leucine. This confirms qarta as a valuable source of high-quality, bioavailable protein.

Table 5 - Free amino acids (mg/100g) in final boiled qarta

Name of indicators	Actual results
ASP	1334.96±133.50
THR	645.45±64.55
SER	607.69±60.77
GLU	2056.64±205.66
PRO	647.45±24.55
GLY	602.09±60.21
ALA	722.37±72.24
VAL	487.06±48.71
CYS	210.48±21.05
MET	330.76±33.08
ILE	558.74±55.87
LEU	1044.75±104.48
TYR	480.41±48.04
PHE	599.30±59.93
LYS	1216.08±121.61
HIS	573.42±57.34
ARG	975.52±97.55
TOTAL	13 177.93
Essential amino acids (%)	5 455.56 (41.3%)

Conclusion. The present study comprehensively characterizes the biochemical, nutritional, and functional properties of qarta, as traditional Kazakh meat delicacy derived from the terminal segment of the horse's gastrointestinal tract. The analysis revealed that qarta is a valuable source of high-quality protein (notably rich in essential amine acids), unsaturated fatty acids (particularly oleic and linoleic acids), and minerals. Despite its anatomical origin, qarta displayed favorable technological characteristics, including strong water- and fat-binding capacities, even after thermal processing.

Notably, qarta contains significantly lower cholesterol levels than conventional red meats, while offering a superior lipid profile – making it a promising ingredient for health-oriented and delicatessen food products. The considerable content of free and essential amina acids further enhances its biological value and digestibility, supporting its potential role in dietary formulations for vulnerable or nutritionally demanding populations.

These findings contribute novel scientific data to the underexplored area of equine by-product utilization and offer a foundation for the valorization of qarta in meat science, gastronomy, and food technology. Given the increasing market demand for culturally rooted, protein-rich, and nutritionally balanced foods, qarta holds considerable potential both as a traditional product and as a functional ingredient in modern meat processing and product development.

Литература

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