

## ARTICLE

MEDICAL AND BIOLOGICAL FEATURES OF RAW MATERIAL  
RESOURCES OF THE YAKUTIAN HORSE

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## ABSTRACT

Since ancient times, the inhabitants of the Far North have developed a "northern" type of metabolism, where the predominance of protein/fat components in food is necessary, rather than carbohydrates. The Republic of Sakha (Yakutia) has significant potential for rationalizing nutrition, taking into account protein/lipid metabolism and the physiological needs of a person living in extreme conditions of the North, through the production of meat products from local raw materials. Isolation of lipids from fat samples was carried out according to Folch's method. Determination of the composition of fatty acids was carried out using gas-liquid chromatography. Determination of the biochemical composition of blood was carried out using infrared spectroscopy and infrared drying. The Yakutian horse meat is unique due to its high energy content, the balanced amino acid composition of proteins, the content of vitamins, and the presence of bioactive substances, including polyunsaturated fatty acids. The highest percentage of polyunsaturated fatty acids is found in the internal fat and equals 27.3%, the optimal composition of polyunsaturated fatty acids is found in the kidney suet equaling 24.95%, and abdominal fat has a low content of polyunsaturated fatty acids (21.03%). It is worth noting that of all the studied samples of fat from different parts of the carcass, only the inner fat showed the highest content of  $\gamma$ - and  $\alpha$ -linolenic fatty acids. The authors carried out work to obtain a concentrate from the fat of a Yakutian horse as a raw material for a food additive. The dry blood of Yakutian horses contains a whole range of biologically active substances. The research results indicate that the raw materials of the Yakutian horse have a high biological value and can be used to obtain specialized food products. The results obtained allow the authors to conclude that the products of the Yakutian horse breeding fully meet the nutritional requirements and, with proper planning, can provide the population with protein/fat food. The meat, internal fat, and blood of the Yakutian horse can be used as a preventive product to compensate for the deficiency of animal protein, polyunsaturated fatty acids, and iron and as a raw material for obtaining specialized food products.

## KEY WORDS

Yakutian horse, horse meat, foal meat, subcutaneous fat, internal fat, polyunsaturated fatty acids, dry blood, proteins, organic iron.

## INTRODUCTION

One of the fundamental bases for the formation of human health is the nutritional factor. It has been established that the "northern" type of metabolism requires the predominance of protein/fat components in food [1-3]. In the North, in humans, the energy role of carbohydrates decreases, and the role of fats and, to a lesser extent, proteins increases; the so-called polar metabolic type is formed [1]. According to Steegmann [2], in aboriginal people living in cold climates, the increased basal metabolic rates appear to be genetically induced. During exposure to cold, the body controls heat storage through well-known channels but also specialized thermogenic functions, such as metabolism in brown adipose tissue [3]. Snodgrass et. al. [3] studied the basal metabolic rates (BMR) in the Yakuts, an indigenous high-latitude population from the Sakha Republic of Russia. It was found that the Yakuts had an increased BMR. The results obtained suggest the possibility of a genetic or evolutionary mechanism [3]. The inhabitants of the Far North need an increased amount of fat – up to 140 g per day (36% of the calorie content of 3,500 kcal), and 60-90% of them should be represented by animal fats, given the specificity of northern sources of animal proteins and fats [4, 5]. It has now been established that in the diet of northerners, there are some violations in the principles of rational nutrition: in energy balance and balance in basic nutrients, proteins, fats, carbohydrates, vitamins, and minerals [1]. Katyukhin et al. (2004) have shown that in the Russian Arctic, cerebrovascular accidents are the most common diseases of the cardiovascular system [6]. According to the "Strategy of socio-economic development of the North-West Federal District for the period up to 2020", the development of the agro-industrial complex should be aimed at the formation of food resources, meeting the needs of the population of the district in affordable and high-quality Russian-produced food products following the recommended rational norms of food consumption. Under this strategic direction in the development of the agro-industrial complex of the regions of the Far North, the main goal should be an increase in production volumes to ensure regional food security, and the development of production of local products. Dairy and beef cattle breeding, pig breeding, poultry farming, etc. will be of the biggest importance in the development of the agro-industrial complex [7].

The Republic of Sakha (Yakutia) has significant potential for rationalizing nutrition, taking into account protein/lipid metabolism and the physiological needs of a person living in extreme conditions of the North, through the production of meat products from local raw materials. In the traditional Yakut cuisine, horse meat, beef, venison, game birds, as well as offal and blood, are traditionally used for food. A distinctive feature of Yakut cuisine is the fullest possible use of all components of the original product. Almost all by-products are actively used. In particular, offal soups, blood delicacies, etc. are very popular. Frozen meat and fish are used to make stroganina (frozen meat or fish cut into thin slices); beef or horse blood is used to make khaan (Yakut blood sausage) [8].

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The Yakutian horse meat is unique due to its high energy content, the balance of the amino acid composition of proteins, the content of vitamins, the presence of bioactive substances, and high digestibility. In addition to meat carcasses, several other slaughter products are obtained during the primary processing of horses, such as by-products (internal fat, blood, intestinal raw materials, etc). Many of them are not fully utilized, although they could represent a valuable raw material for the food and processing industry. The products of northern animals, including meat of horse breeds bred in Yakutia, have a high nutritional value and contain more proteins, fats, minerals, vitamins, and biologically active substances than meat from animals bred in southern latitudes [9]. The high quality of the meat of Yakutian horses is conditioned by the peculiarity of the accumulation of nutrients in the fodder plants of the North. For the Yakuts, the meat of the Yakutian horse has long been a favorite food, from which more than 80 different meat dishes with high nutritional value are prepared. In Yakut traditional cuisine, horse meat is often eaten as stroganina (frozen and cut into slices), or boiled and fried [8].

In this article we analyzed the medical and biological aspects of food products made from various raw materials of the Yakutian horse.

## MATERIALS AND METHODS

When conducting the research, ethical standards in relation to animals were observed and approved by the commission of the Yakutsk Scientific Research Institute of Agriculture named after M.G. Safronov. The work was carried out in the laboratory of selection and breeding of horses of the Yakutsk Scientific Research Institute of Agriculture named after M.G. Safronov. The studies were carried out on the slaughter products of the Yakutian breed of horses. The most important points were the calorie content of meat and the biochemical composition of by-products (subcutaneous and internal fat) and slaughter blood (mass fraction of proteins and minerals). The collection of raw materials was carried out directly during slaughter. Raw materials were subjected to immediate freezing by natural cold and freshly delivered to the place of processing within 24 hours in dark packaging.

For the study, we took fat samples of the Yansky and indigenous types of the Yakut breed from the following parts of the carcass: subcutaneous, internal, cervical, and abdominal. Fat samples were taken during the mass slaughter of horses when a stable low temperature of -20 to -30°C was reached at the end of October – the beginning of November. Immediately after slaughter, fatty raw materials were cleaned of contaminants, blood clots, and muscle tissue and frozen at a temperature of -25 to -30°C. To isolate fat from raw fat, we chose the low-temperature method. The low-temperature method of obtaining fat has the following technological parameters: grinding fat at a temperature of -10 to -5 °C to particles with a size of 3-4 mm, centrifugation at 3,000 rpm for 45 minutes, followed by separation [7]. The determination of the composition of fatty acids was carried out in the laboratory of the All-Union Scientific Research Institute of the Meat Industry named after V.M. Gorbatov. Isolation of lipids from the samples was carried out using extraction with chloroform/methanol according to Folch's method. The purity of the isolated lipids was checked using thin-layer chromatography. The determination of the composition of fatty acids was carried out using an HP 6890 gas chromatograph (Hewlett Packard) [11, 14]. Blood samples for food purposes were taken only from healthy animals. Slaughter blood was prepared in stationary conditions at blood collection points in special standard polymer containers with a volume of 250 and 500 ml. Each blood batch was defibrinated before analysis.

Studies of the biochemical composition of blood were carried out at the accredited testing center of the All-Union Scientific Research Institute of the Meat Industry named after V.M. Gorbatov in accordance with GOST 30178-96 [11]. Drying was carried out using infrared drying to ensure maximum preservation of the properties and biological value of blood proteins. Complete drying of blood using infrared radiation was achieved after 2 hours and 20 minutes. To determine macro and microelements, whole blood was dried at a temperature of 70 to 80 °C and the dried blood was ground in a mill.

Statistical data processing was carried out using the Excel for Windows XP 2002 software package and was expressed as  $M \pm m$ . The degree of reliability of the revealed differences was determined using Student's t-test.

## RESULTS AND DISCUSSION

The Yakutian horse is distinguished by a high slaughter yield and meat yield from the carcass. Yakutian horses, depending on age, after autumn grazing and fattening, have the following average carcass weight: 102.3 kg at 6 months of age, 165 kg at 2.5 years, and 228 kg when they are fully grown. Their slaughter yield equals 55.8, 49.1, and 55.5% respectively [9]. The live weight of 6-month-old foals varies considerably depending on the type and breed. If the Yansky type of the Yakutian breed weighs on average 170.23 kg, then the foals of the Prilensky breed weigh 215.6 kg. Foals of the Kolyma type of the Yakutian breed are distinguished by a high content of internal fat (11.3 kg), while in foals of other types and breeds it ranges from 4.7 to 6.0 kg.

The minimum slaughter yield is observed in young animals of 2.5 years, especially in the indigenous (46.3%) and Yansky (46.48%) types of the Yakutian breed.

Depending on the fatness category, the calorie content of 1 kg of meat from Yakutian horses ranges from 1,922 to 2,724 kcal. The chemical composition of meat and its caloric content largely depends on the category of horse nutrition rather than age and gender.

Currently, about 80% of the meat of the Yakutian horse is produced from the meat of foals at the age of six months. From the data presented in Table 1, it can be seen that the meat of foals of the Prilensk breed and the Kolyma type had the highest calorie content (2,415 and 2,536 kcal). The highest fat content is observed in the meat of the Prilensk and Kolyma type foals – 18.4 and 17.1%. The meat of foals, in addition to the Yansky type, contained almost the same amount of protein (from 17.2 to 18.6%). The meat of the Prilensk foals contained a greater amount of phosphorus.

**Table 1:** Chemical composition and energy value of meat of 6-month-old foals of the Yakutian horse [9]

Indicators	Prilensk breed	Megezhek breed	Yakutian breed			Average for the Yakutian horse
			Root type	Yansky type	Kolyma type	
Moisture, %	62.8	67.9	65.0	67.6	62.9	65.2
Fat, %	18.4	12.7	16.4	14.7	17.1	16.0
Protein, %	17.2	18.0	17.3	16.3	18.6	17.2
Ash, %	1.6	1.4	1.4	1.4	1.4	1.4
Calcium, %	0.13	0.09	0.11	0.10	0.13	0.11
Phosphorus, %	0.37	0.29	0.28	0.26	0.29	0.28
Caloric content of 1 kg of meat, kcal	2,415	1,922	2,235	2,027	2,536	2,197

Based on the Table 1, it can also be noted that the chemical composition and energy value of foals depend on the breed and types of horses.

Yakutian horse offal is one of the favorite delicacies of the Yakuts. Dozens of dishes are prepared from offal, including high-quality products. Subcutaneous and internal fats obtained from horse meat and foal meat of the Yakutian horse are of no small interest in terms of by-products. The fat yield, depending on the age, breeds, and types of the Yakutian horse, varies within the following range: older mares weigh up to 23.06 kg, young horses of 2.5 years weigh 6.37-9.70 kg, and 6-month-old foals weigh 4.68-5.75 kg. The fat of the Yakutian horse is represented by a unique composition. Fat has high digestibility, low melting point and surpasses other farm animals in the content of fatty acids of the omega-3 and omega-6 classes, which are essential fatty acids since they are not synthesized in the human body. Cholesterol and unsaturated fatty acid fraction are in the most beneficial balanced state.

Polyunsaturated fatty acids (PUFAs), which are of particular importance for maintaining normal human health, are of great practical interest. The high biological value of PUFAs is as follows: they are the structural components of the lipids of the body cells. The presence of PUFAs determines the biological activity of phospholipids and the properties of biological membranes. They have an anti-atherosclerotic effect: an increase in the excretion of cholesterol from the body, a decrease in the formation of low-density lipoproteins, an increase in elasticity, and a decrease in the permeability of the vascular wall. They are substrates for the synthesis of prostaglandins, thromboxanes, leukotrienes, and eicosanoids – powerful intracellular regulators of the functioning of almost all body systems: in the regulation of immune genesis and hemostasis and the development of inflammatory, allergic, and proliferative reactions [10].

As a result of our studies of the fat of the Yakutian horse, we found that fats from different parts of the carcass differ in the composition of fatty acids. The highest percentage of PUFAs is found in the internal fat and equals 27.3%, the optimal composition of PUFAs is found in the kidney suet equaling 24.95%, and abdominal fat has a low content of PUFAs (21.03%). It is interesting to note that of all the studied samples of fat from different parts of the carcass, only the internal fat was found to have the highest content of  $\gamma$ - and  $\alpha$ -linolenic fatty acids. In our previous studies, it was noted that deer and pork fats were inferior in terms of  $\gamma$ - and  $\alpha$ -linolenic fatty acids to the fat of the Yakutian breed. Besides, when comparing the fat of a Yakutian horse with deer and pork fat, it was noted that horse fats were distinguished by a relatively low content of saturated acids and a higher level of PUFAs [11].

In general, it can be noted that the fat of the Yakutian breed horse, especially the internal fat, in its fatty acid composition differs from similar fats of slaughter animals and is the closest in the presence of omega-3 fatty acids to the fats of inhabitants of cold sea waters. After studying the biochemical composition of the fat of the Yakutian horse, we carried out work on obtaining a concentrate from the fat of the Yakutian horse as a raw material for a food additive to obtain fat-containing raw materials with PUFAs.

The results of work on the extraction of concentrate from the fat of a horse of the Yakut breed are secured by the patent for invention No. 2538367 RF. We developed technical specifications (TU) and technological instructions for the document TU 9215-036-00670203-2013 "Internal fat of the Yakutian breed horse". The internal fat of a horse of the Yakut breed can serve as a valuable raw material for the production of

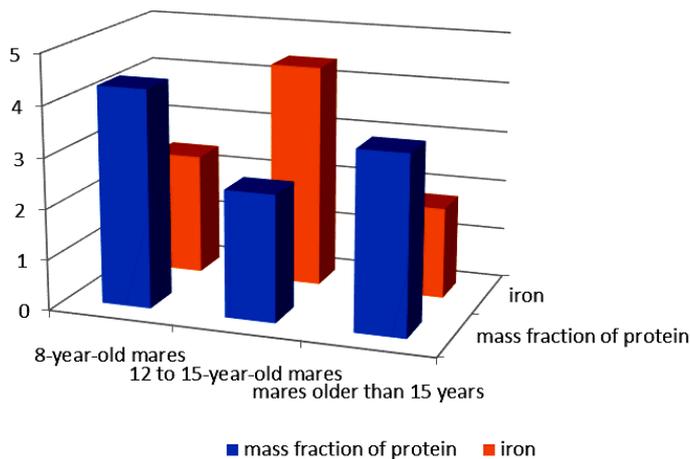
food products and prophylactic preparations for humans as a source of PUFAs, as well as biologically active food additives with an effective method of extracting them from raw fat.

Based on the results of the research, a technological process for obtaining new types of products from the fat of the Yakutian horse may be developed.

Slaughter blood is also a valuable raw material for obtaining specialized food products. It can serve as a source of nutrients and biologically active substances, including high-value protein and organic iron [12]. The biological value of blood is that in terms of the content of protein substances it is equal to meat, so the meat of a Yakutian horse contains 17.0-19.7% of proteins, and the level of proteins in horse blood reaches 18% [13]. The content of a complex of all substances necessary for the normal functioning of the body in the blood indicates the possibility of its use not only as food raw material but also as a valuable therapeutic agent. The composition and properties of horse blood in terms of biochemical composition, including amino acid and mineral composition, are not inferior to the blood of other slaughter animals; in some respects, they even exceed it [14].

The presence of a significant amount of iron in the horse's blood predetermines its use for the production of food products that contribute to the prevention and treatment of iron deficiency conditions, to which a significant part of the population is exposed. Therefore, as a dietary product, horse blood can be used in case of anemia, general weakness, growth retardation, and a lack of nutrition to restore protein reserves [15].

The dynamics of the protein content in the dry blood of mares depend mainly on the age and physiological state. According to Fig. 1, the largest mass fraction of protein is observed in the blood of 8-year-old mares, and the smallest mass fraction is found in the blood of mares of 12-15 years. It should be noted that there are no significant fluctuations in the mass fraction of blood protein since all studied animals of the same contingent are sexually mature mares 8-19 years old.



**Fig. 1:** Mass fraction of protein and minerals in the blood of the Yakutian horse depending on age

The iron content in the dry blood of Yakutian horses varies insignificantly from 220.95 to 234.61 mg/kg, which indicates a stable level of supply of the horses with this element. The dry blood of Yakutian horses effectively affects the human body due to a whole complex of biologically active substances. It contains peptides, amino acids, hormones, nucleotides, minerals, and vitamins. The high iron content in the blood makes it a promising raw material for the production of dietary supplements as an additional source of iron, iron-containing preparations, and specialized food products. We have developed TU 9215-038-00670203-2013 "Dry blood of Yakutian breed horses". In the laboratory center of the All-Union Scientific Research Institute of the Meat Industry named after V.M. Gorbатов, tests were carried out to verify compliance with the requirements of technical specifications for physical, chemical, microbiological, and safety indicators.

## CONCLUSION

The research results indicate that the raw material resources of the Yakutian horse have a high biological value and can be used to obtain specialized food products. The results obtained allow us to conclude that the products of the Yakutian horse breeding fully meet the above requirements, and with proper planning, they can provide the population with protein and fat food. The meat, internal fat, and blood of the Yakutian horse can be used as a preventive product to compensate for the deficiency of animal protein, PUFAs, and iron and as a raw material for obtaining specialized food products.

### CONFLICT OF INTEREST

There is no conflict of interest.

### ACKNOWLEDGEMENTS

None.

### FINANCIAL DISCLOSURE

None.

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