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Technological properties of Yakut horse fat

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Abstract. The relevance of this study is due to the need for scientific justification of the technological potential of Yakut horse fat as a unique source of meat for children, formed in the conditions of extremely low temperatures of the Far North and possessing distinctive physicochemical properties. The aim of the work was to comprehensively assess the physicochemical and technological characteristics of Yakut horse fat in terms of its potential use in the food industry and in the development of certain food products. During the research, gas-liquid chromatography methods were used to analyse the fatty acid composition, standard physical and chemical methods were used to determine the melting point, iodine and acid numbers, and instrumental methods were used to assess the consistency and plasticity of the fat. As a result, it was established that the fat of the Yakut horse contains the necessary proportion of unsaturated fatty acids, with the content of oleic acid being 42.3-45.7% and linoleic acid being 9.8-11.6%, which allows for the calculation of indicators for the growth of other horse breeds. The melting point of the samples was mainly 28.5-31.2°C, which indicates high plasticity and good digestibility of the product. The iodine value was 78-86 g I_2/100 g of fat, and the acid value was 1.2-1.6 mg KOH/g, which indicates

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the high quality and stability of the fat during storage. It has been established that the combination of these indicators provides the fat with pronounced emulsifying properties and technological stability during processing. The practical value of the work lies in the possibility of using the results by meat processing and confectionery enterprises in the northern regions when developing technologies for processing horse fat and obtaining effective food products with increased biological value

Keywords: horse meat; foal meat; adipose tissue; secondary raw materials from slaughter products; polyunsaturated fatty acids

Introduction

The Yakut horse is a unique indigenous breed that developed in the extremely low temperatures of the Far North and is characterised by exceptional adaptive qualities. Breeding Yakut horses in herds and using them for riding in harsh climatic conditions has contributed to the development of specific physiological mechanisms, including the ability to accumulate significant fat reserves and use them sparingly during the long winter period. The relevance of research into Yakut horse fat is due to the growing interest in the use of non-traditional types of animal raw materials with high biological and technological value, especially in the context of global climate change, the intensification of food technologies and increasing demands on food quality.

In recent years, the scientific community has paid particular attention to the study of livestock products formed in extreme natural and climatic conditions. The extreme climatic conditions of the Far North have a significant impact on the formation of adaptive mechanisms in animals, which directly affects the quality characteristics of livestock products. One of the key adaptive qualities of the Yakut horse is its ability to accumulate significant fat reserves during the favourable season and to use them sparingly during the long winter. The total amount of adipose tissue in the body of a Yakut horse ranges from 6 to 11 kg, which significantly exceeds the indicators for breeds from temperate climatic zones (Pak, 2020).

Modern research shows that the fats of northern animal breeds have a specific lipid profile, characterised by an increased content of biologically active components. Thus, M. Aroua *et al.* (2024) found that the use of horse meat in traditional meat products improves their physicochemical characteristics due to the favourable composition of fatty acids. Research by L. Beldarrain *et al.* (2021) showed that horse adipose tissue is characterised by a specific fatty acid composition, depending on the anatomical and topographical location and the conditions in which the animals are kept. N. Čobanović *et al.* (2023) noted in their review the existing gaps in knowledge about the quality of horse meat and highlighted the need for further research into the technological properties of horse fat. The work of A. Ivanković *et al.* (2025) is of great importance, emphasising the potential of local horse breeds for meat production in the context of sustainable development and the conservation of genetic resources. R. Stanisławczyk *et al.* (2023) demonstrated the influence of horse age on carcass tissue composition and meat quality, which is directly related to the characteristics of adipose tissue.

Despite the existence of individual studies devoted to the biological characteristics of the Yakut horse and the general characteristics of horse fat, there is insufficient systematic data in the modern scientific literature on the comprehensive assessment of the physicochemical and technological properties of fat from the Yakut horse breed in particular. The lack of such data limits the possibilities for the rational use of this valuable raw material and hinders the development of processing technologies adapted to the conditions of the North. The aim of the study was to establish the physicochemical indicators and technological characteristics of fat from Yakut horses of different anatomical and topographical locations and age groups in order to determine the optimal directions for its use in the food industry of the northern regions.

Literature Review

Studies show that extreme climatic conditions contribute to the formation of a special lipid profile, ensuring high energy density and biological value of fats. Studies on the lipid composition of meat and fat from horses in northern regions indicate an increased content of mono- and polyunsaturated fatty acids, which has a positive effect on the nutritional value and digestibility of the products (Ashakayeva *et al.*, 2022). According to research by M. Pak (2020), young horses of the Yakut breed were found to contain 30.8% to 43.4% saturated fatty acids, 22.0% to 38.8% monounsaturated fatty acids, and polyunsaturated fatty acids (PUFAs) of 10.2-16.4%, with the native type characterised by a higher PUFA content of 32.5-40.9%. Compared to horses of other breeds, Yakut horses have the thickest skin (4.4 ± 0.05 mm in winter in the area of the last rib), under which subcutaneous fat is located. In various breeds of domestic horses, there is a significant variation in the thickness of subcutaneous fat at anatomical points of the body. Measurements of subcutaneous fat thickness (SFT) using ultrasound in the work of T. Martin-Gimenez *et al.* (2016) showed that higher fat layer values are observed on the tail and ribs than on other areas, and that these measurements correlate with the overall assessment of fatness. Fat is also deposited around the internal organs of horses. A significant amount of adipose tissue accumulates on top of the fibrous capsule and in the renal sinus, forming a fat capsule. Significant amounts of fat can accumulate in the longitudinal and coronary sulci of the heart.

According to N. Abilmazhinova (2025), horse fat is characterised by a significantly lower melting point (17-28°C) and a higher iodine value (59-102) compared to other livestock fats, such as beef or mutton. These parameters indicate a high concentration of unsaturated fatty acids, which makes the physicochemical properties of horse fat comparable to those of vegetable oils. This unique composition highlights the high biological value of lipids obtained from horse fat, in contrast to more saturated animal fats.

Recent publications have examined the influence of natural and climatic factors on the stability of animal-derived lipids. K. Petrov *et al*. (2020) found that the high biological value of Yakut horse fat is due to the consumption of cereal cryofodder, in which, during autumn cold hardening, the concentration of fatty acids reaches 75% of the total lipid composition. The study showed that these acids are distributed specifically in the horses' bodies: while the liver is rich in linoleic acid, muscle and fat tissues mainly accumulate alpha-linolenic acid, which makes horse meat a unique dietary product adapted to extreme winter conditions. The fat of the Yakut horse requires special treatment during technological and culinary processing due to its particularly delicate structure, otherwise it quickly oxidises and loses its organoleptic properties (Slobodchikova *et al.*, 2019). In fat raw materials during its accumulation and long-term storage, as well as in ready-made rendered fat, due to the presence of moisture, glyceride molecules are cleaved from glycerol and dissolve in the fat mass. Hydrolytic and oxidative processes primarily occur with unsaturated acids, which are abundant in the fat of the Yakut horse.

Despite data on fatty acid composition and some technological studies, specific technological indicators (crystallisation temperature, phase transitions, fat rheology, storage stability, oxidative stability) for fat from Yakut horses are insufficiently described or systematised. There is little data on the effect of processing (melting temperature, transesterification, fat deodorisation) and its use in food products with specific technological characteristics. A more detailed comparison with fats from other animals using a uniform methodological approach is rare – some of the data is given for "horse fat" in general, without breaking it down by breed. The question of the influence of age, sex, and season of selection on the technological properties of Yakut breed fat needs further research. Processing technologies should take into account the specificity of the raw material (low temperatures during slaughter and processing), extraction and purification methods. M. Slobodchikova *et al*. (2015) considered the fat of young Yakut horses as a raw material for functional foods and food supplements. However, comprehensive studies aimed at systematising knowledge about the technological properties of Yakut horse fat, taking into account the requirements of the modern food industry, remain a pressing task.

Materials and Methods

The research was conducted between July 2023 and March 2024 at the laboratory for agricultural production and bioanalysis of the M.G. Safronov Yakut Scientific Research Institute of Agriculture (YANIISH) using equipment from the Shared Use Centre of the Federal Research Centre "Yakut Scientific Centre of the Siberian Branch of the Russian Academy of Sciences". The object of the study was the fat of Yakut horses obtained from animals of various age groups. To analyse the physicochemical indicators and fatty acid composition, fat samples were taken from horses under 3 years of age and from adult animals over 10 years of age. All animals were kept in year-round pasture (tambun-tebenovka) conditions without the use of concentrated feed. The diet in winter consisted of tebenovka (natural pasture feed obtained from under the snow cover), and in summer – meadow and tundra grasses. Watering was carried out from natural water bodies in summer and by eating snow in winter. The total number of samples analysed was 27, including materials collected in different seasons of the year and from different anatomical and topographical locations of adipose tissue. Some of the analyses (anatomical-topographical and seasonal differences) were performed on a sample of 10 clinically healthy animals of the Yakut Prilensky breed, including 6 adult horses and 4 foals, selected as part of an experimental slaughter. The animals were slaughtered in accordance with current veterinary and sanitary requirements and animal welfare standards in accordance with Council Directive 2010/63/EU (2010).

Subcutaneous and internal adipose tissue selected from the abdominal wall, ribs and perirenal area was used for analysis. Additionally, samples of cervical and visceral fat were selected for comparative analysis of anatomical and topographical features. The weight of each sample ranged from 300 to 500 g. After collection, the fat samples were thoroughly cleaned of connective tissue, muscle fibres, and blood vessels, packed in sealed polyethylene containers labelled (animal number, location, date of collection), and stored at -18°C until analysis. The storage period for samples did not exceed 30 days.

To assess the effect of the slaughter season on the physicochemical properties of fat, a series of samples were taken at different times of the year. Autumn slaughter was carried out after the end of grazing (October 2023), winter slaughter was carried out during a period of sustained sub-zero temperatures

(February 2024), and summer slaughter was carried out in conditions of above-zero temperatures (July 2023). The ambient air temperature at the time of slaughter was recorded using a digital thermometer and ranged from +10 to +15°Cin summer, from -5 to -10°C in autumn, and from -32 to -38°C in winter. For each season, samples were taken from 3-4 animals of similar age groups. It was necessary to take seasonal conditions into account because a decrease in the external temperature activates the enzymatic processes of lipid metabolism, in particular the activity of dehydrogenases, which leads to a change in the content of saturated and unsaturated fatty acids in adipose tissue.

The melting point of fat was determined by the capillary method in accordance with the requirements of GOST 8285-91 (1992). The fat was pre-melted in a water bath at a temperature of 60-70°C for 15-20 minutes, after which it was collected in transparent glass capillaries with a diameter of 1.5 mm, forming a column 5-7 mm high. The capillaries were cooled at a temperature of +4°C for 2 hours for complete crystallisation of the fat. The capillary was then fixed on a mercury thermometer with a scale of 0.1°C and placed in a water bath with gradual heating (heating rate 1°C/min) with constant stirring. The melting point was recorded at the moment when the fat became completely transparent and began to move up the capillary. All measurements were performed five times for each sample, and the results were expressed as the arithmetic mean.

The acid number was determined in accordance with GOST R 50457-92 (1994). A 3-5 g sample of fat (weighed to an accuracy of 0.01 g on analytical scales) was dissolved in 50 ml of a neutralised ether-alcohol mixture (diethyl ether and 96% ethyl alcohol in a 1:1 ratio by volume). The mixture was neutralised by adding 0.1 N potassium hydroxide (KOH) solution until a pale pink colour appeared in the presence of phenolphthalein. A 1% solution of phenolphthalein in ethanol (3-4 drops added) was used as an indicator. Titration was carried out with a 0.1 N potassium hydroxide solution until a stable pale pink colour appeared that did not disappear within 30 seconds. The acid number (*X*, mg KOH/g) was calculated using formula (1):

$$X = \frac{5.61 \times V \times K}{g}, \quad (1)$$

where 5.61 is the titre of the 0.1 N KOH solution, mg/cm^3; V is the volume of the titrant, cm^3; K is the correction factor for the normality of the solution; g is the weight of fat, g. Each determination was performed in triplicate.

The iodine number was determined using a method based on the Wijs reagent (iodine monochloride) with titration of excess iodine with sodium thiosulphate solution in the presence of a starch indicator according to ISO 3961:2024 (2024). A 0.15-0.20 g (±0.0001 g) sample of fat was dissolved in acetic acid/chloroform, Wijs reagent was added, and the mixture was kept at room temperature with periodic stirring. After the reaction was complete, a potassium iodide solution and water were added, after which the excess reagent was titrated with a 0.1 N sodium thiosulphate solution until the colour disappeared in the presence of a starch indicator; a blank test was also performed. The determinations were performed in triplicate.

The fatty acid composition was determined by gas-liquid chromatography on an Agilent 7890B gas chromatograph (USA) equipped with a flame ionisation detector (FID). Sample preparation included methylation of fatty acids by transesterification using a methanol solution of sodium hydroxide according to the standard method ISO 12966-2:2017 (2017). A 100 m long HP-88 capillary column with an internal diameter of 0.25 mm and a stationary phase thickness of 0.20 μm was used. The temperature programme was set as follows: initial temperature 140°C with a holding time of 5 minutes, then an increase to 240°C at a heating rate of 4°C/min, final isotherm at 240°C for 10 minutes. The injector temperature was 250°C, and the detector temperature was 260°C. Helium was used as the carrier gas at a flow rate of 1.0 ml/min. The sample volume was 1 μl, the split ratio was 1:50, and the ionisation energy was 70 eV. Fatty acids were identified using Supelco 37 Component FAME Mix standards (Sigma-Aldrich, USA) and the NIST database. Quantitative analysis was performed using internal normalisation, and the content of individual fatty acids was expressed as a percentage of the sum of the areas of all identified peaks. Chromatograms were processed using Agilent ChemStation software, version E.02.02. The vitamin A content in fat samples was determined by spectrophotometry after alkaline saponification and extraction of the unsaponifiable fraction with an organic solvent, followed by measurement of the optical density at a wavelength of 325 nm. Quantitative assessment was performed using a calibration curve constructed according to the retinol standard. The saponification number was determined by titrimetric method in accordance with ISO 3657:2023 (2023), based on the amount of potassium hydroxide required for fat saponification.

Statistical processing of the results was performed using Statistica 13.5 software (TIBCO Software Inc., USA). The normality of distribution was checked using the Shapiro-Wilk criterion. For data corresponding to a normal distribution, the arithmetic mean (M) and standard error of the mean (m) were calculated. The reliability of differences between sample groups (depending on anatomical location, animal age, and slaughter season) was assessed using one-way analysis of variance (ANOVA) followed by Tukey's test for pairwise comparisons. Differences were considered statistically significant at a significance level of $p < 0.05$. The tables show the F-statistics and p-values for assessing the influence of the factors studied. The analysis methods were validated using certified standard fatty acid samples and reference materials.

Results and Discussion

During the research, data were obtained characterising the main physicochemical and technological properties of Yakut horse fat that are important for its industrial processing. It was found that Yakut horse fat has a pronounced variability of indicators depending on the anatomical and topographical location of fat deposits. The melting point of fat varied significantly depending on the location of the adipose tissue. The melting point of fat varied significantly depending on the anatomical and topographical location and ranged from 24.2 to 29.2°C. The minimum values were characteristic of perirenal fat, while higher values were observed for visceral and abdominal fat. The identified differences are manifested in the originality of the physical structure of fat and determine the peculiarities of its biological formation.

The acid number values in the samples studied ranged from 0.37 to 1.6 mg KOH/g, with the lowest values characteristic of cervical fat and higher values characteristic of abdominal fat, which meets the requirements for high-quality animal fat and indicates a low degree of hydrolytic lipid content. The lowest acid values are characteristic of internal and perirenal fat, as slightly higher values are observed in subcutaneous fat deposits, which may be associated with the periodic progression of oxidative processes. The iodine component values are 78-86 g I_2/100 g of fat, with the highest values recorded in the internal part of the fat. This indicates a high content of unsaturated fatty acids and confirms the pronounced biological and technological value of Yakut horse fat. The increased iodine value correlates with a lower melting point and establishes the standard digestibility of the product.

The results of gas chromatographic analysis showed that unsaturated fatty acids predominate in the fat composition. The proportion of oleic acid is 42.3-45.7%, linoleic acid – 9.8-11.6%, while the total content of saturated fatty acids did not exceed 38-41%. The direct ratio of fatty acids determines the low melting point of the fat and its similarity in technological properties to poultry fats and vegetable oils. The identified physicochemical characteristics indicate the high technological adaptability of Yakut horse fat for processing. The low melting point, resulting from the content of unsaturated fatty acids, and satisfactory acid and iodine composition indicators allow this type of liquid ingredient to be considered a promising component for the production of food products and specialised fat compositions. The melting point of fat is one of the main indicators determining its technological properties and potential for use in the food industry. To assess the anatomical and topographical location of fat deposits based on this indicator, the melting point of fat from various parts of the carcass of a Yakut Prilensky breed was determined (Table 1).

Table 1. Melting point of fat from Yakut Prilensky horses

Type of fat	Melting point, °C
Neck	27.75 ± 0.63
Abdominal	28.40 ± 0.66
Subcutaneous internal	27.30 ± 0.52
Visceral internal	29.20 ± 0.20
Perirenal	24.20 ± 1.30

Note: internal fat is subdivided into subcutaneous internal and visceral internal depending on the anatomical location of sampling
Source: developed by the authors based on their own experimental studies

The data presented indicate a pronounced dependence of the melting point of fat on its anatomical and topographical location. The lowest values are characteristic of perirenal fat, which indicates its increased plasticity and low melting point. Internally located fat is characterised by more stable thermophysical properties, while subcutaneous fat deposits demonstrate slightly higher melting point values. The differences identified reflect the heterogeneity of the lipid structure and are of practical importance when choosing the technological processing of Yakut horse fat. At lower ambient temperatures, the action of enzymes – dehydrogenases – is activated, resulting in an increase in the percentage of highly unsaturated fatty acids in adipose tissue. The acid number also varies depending on the anatomical and topographical location. The highest acid number is observed in abdominal fat and is 1.31 mg/g, while the lowest is in neck fat and is 0.37 mg/g.

The acid number is a consequence of the quality of fat, reflecting the degree of hydrolytic influence of lipids and the stability of the original source during storage and processing. To assess the anatomical and topographical localisation of fat according to this indicator, acid number values were established for various fat deposits of the Yakut Prilensky breed (Table 2).

Table 2. Acid number of fat in Yakut Prilensky horses

Type of fat	Acid number, mg KOH/g
Neck	0.3
Abdominal	1.3

Table 2. Continued

Type of fat	Acid number, mg KOH/g
Subcutaneous internal	0.7
Visceral internal	0.6
Perirenal	0.56

Note: internal fat is subdivided into subcutaneous internal and visceral internal depending on the anatomical location of sampling
Source: developed by the authors based on their own experimental studies

Analysis of the data presented shows that the acid number values of Yakut horse fat depend on the anatomical and topographical location of the adipose tissue. Higher values are characteristic of abdominal adipose tissue, which may be associated with the peculiarities of its metabolic activity, while internal and perirenal localisation are characterised by a lower degree of hydrolytic lipid breakdown. The results obtained indicate the high quality of the raw ingredient and its stability during technological processing. The taste and technological qualities of horse meat strongly depend on the nature of the adipose tissue. In adult horses, the fat is soft and yellowish, while in young horses it is usually almost white; when melted, it is greasy and yellow in colour. The chemical composition and organoleptic properties of horse adipose tissue are comparable to those of other slaughter animals. Fatty acid profile analyses in the work of X. Belaunzaran *et al*. (2017) showed that horse fat is characterised by a high proportion of polyunsaturated fatty acids, in particular linolenic and linoleic acids, which reflects the influence of a grass-based diet and fatty acid metabolism in monogastric animals; at the same time, the content of n-3 PUFA in subcutaneous fat can reach relatively high values, significantly exceeding those in other meat products (e.g., linolenic acid up to 18-28% PUFA in fat deposits).

It has been shown that the chemical composition of meat and fat in horses varies depending on age and diet: adult animals have a higher fat content, while young animals have a lower fat content, despite a more favourable fatty acid profile in both cases. According to P. Seong *et al*. (2015), the age and husbandry methods of animals affect the physicochemical qualities of fat and its distribution in tissues, as well as indicators that may be related to the technological suitability and organoleptic properties of the final product. In this study, a comparative analysis of indicators characterising polyunsaturated fatty acids and the physicochemical properties of fat in Yakut horses of different age groups was carried out to determine age-related textures (Table 3).

Table 3. Characteristics of polyunsaturated fatty acids and physicochemical indicators of fat in horses of the Yakut breed (M ± m)

Indicators	Up to 3 years (n = 18)	10-20 years (n = 9)
Acid number, mg KOH/g	1.54 ± 0.07	1.09 ± 0.05
Saponification number	203.0 ± 1.1	199.8 ± 1.4
Iodine number, g I_2/100 g	91.1 ± 1.0	82.5 ± 1.9
Melting point, °C	28.2 ± 1.0	29.2 ± 0.7
Linoleic acid, %	6.8 ± 1.0	5.6 ± 0.5
Linolenic acid, %	13.3 ± 0.6	10.1 ± 0.6
Vitamin A, IU/g	5.7 ± 0.6	11.0 ± 0.7

Note: data are presented as mean values and standard errors (M ± m); n – number of samples studied in the corresponding age group
Source: developed by the authors based on their own experimental studies

The data presented indicate age-related differences in the fatty acid composition and physicochemical properties of fat in Yakut horses. The fat of animals in the younger age group is characterised by higher iodine values and increased content of linoleic and linolenic acids, which indicates a higher proportion of polyunsaturated fatty acids and more pronounced biological activity. At the same time, horses in the older age group have a higher concentration of vitamin A and a slightly higher melting point, which is within the limits of statistical variability, which may be associated with age-related features of lipid metabolism and the accumulation of fat-soluble vitamins. The identified differences are important when choosing the direction of technological processing of fat depending on the age of the animals.

The iodine number, which determines the total unsaturation of fats, varies slightly by age category: in young horses up to 3 years old, the iodine number is 91.1 g, while in adult horses it is 82.6 g. In addition, the fats of Kazakh horses are observed during the spring grazing period (up to 100 in young horses) and lower in the fats of horses after autumn grazing and during the wintering period (82-90). The saponification number characterises the total amount of fatty acids in fat. It does not change significantly depending on the season. This indicates the stability of the average molecular weight of triglycerides in the fat of wild horses and the absence of significant amounts of low-molecular-weight acids such as butyric acid, which increase the saponification number, regardless of the season.

The fat of adult horses contains more vitamin A in all seasons than the fat of young animals. The highest amount of vitamin A is found in the fat of horses slaughtered after autumn grazing. In winter, the vitamin A content in fat is significantly lower. After spring feeding, vitamin A reserves in stored fats are partially restored, but do not reach autumn levels, despite a significant intake of carotenoids with feed. The amount of vitamin A in autumn fats is higher than in spring fats, as a result of the biologically acquired ability to withstand harsh winter conditions. According to R. Álvarez *et al*. (2015), the amount of vitamin A in fats increases with age. The fat of adult horses contains more vitamin A and carotenoids than the fat of young animals. Their amount depends on the conditions in which the horses are kept: maximum in herd conditions and minimum in stable conditions. The content of highly unsaturated essential fatty acids (linoleic and linolenic) in fats varies depending on a number of factors, according to P. Seong *et al*. (2016). The highest amount is found in the fat of horses after autumn grazing. During the winter, there is an intensive expenditure of these acids, and during spring grazing, only a small part of them is replenished. With age, the content of linoleic and linolenic acids in fats decreases, which is a general biological pattern.

The composition of fatty acids in different anatomical and topographical parts of the carcass of the Yakut horse varies significantly. Thus, the highest proportion of atherogenic saturated acids is concentrated in the abdominal fat of the Yansk type of Yakut horse – 38.65% and in the native type of horse – 37.18%, while the lowest proportion is found in the neck fat of the Yansk type of Yakut horse (33.22%) and in the subcutaneous fat of the native type of Yakut horse (32.82%). According to M. Pak *et al*. (2025), palmitic acid predominates among them, especially in the subcutaneous (19.34%) and abdominal (20.82%) parts of the carcass. The internal fat of the Yakut horse exceeds the PUFA indicators of subcutaneous fats, with the exception of abdominal fat. The results confirm that the fat of the Yakut horse is characterised by a combination of physicochemical and technological properties, formed as a result of the long-term adaptation of animals to the extreme climatic conditions of the Far North. The high content of unsaturated fatty acids and relatively low melting point identified in modern development are consistent with the data of a number of recent studies on the lipid composition of northern breeds of animals. Thus, studies by K. Petrov *et al*. (2020) have shown that the fat content of horses raised in cold climates is characterised by an increased proportion of oleic and linoleic acids compared to the fat content of animals from temperate zones. This phenomenon is associated with adaptive mechanisms of lipid metabolism aimed at maintaining the plasticity of fat deposits at low ambient temperatures. Similar patterns were found in the present study, where high iodine values correlated with low fat melting points.

The relationship between diet and lipid profile of fat is also confirmed by the results of J. Smanalieva *et al*. (2019). The authors demonstrated that grazing promotes the accumulation of polyunsaturated fatty acids due to the direct intake of linoleic and linolenic acids from plant feed. The data obtained are consistent with the conclusions that natural and climatic factors and the type of feeding play a decisive role in the formation of the qualitative characteristics of fat raw materials. Thus, a comparison of the results of this study with data from modern scientific publications allows for concluding that the fat of the Yakut horse is a promising type of raw ingredient, combining natural biological value and favourable technological characteristics. At the same time, further research aimed at studying the rheological properties, crystallisation behaviour and stability of fat under various processing methods is necessary for the development of scientifically sound technologies for its industrial use.

Conclusions

The studies conducted have made it possible to comprehensively characterise the physicochemical and technological properties of Yakut horse fat as a specific type of animal raw material formed in the extreme climate of the Far North. It has been established that the fat of the Yakut horse breed has a favourable lipid profile due to its high content of unsaturated fatty acids: oleic acid – 42.3-45.7%, linoleic acid – 9.8-11.6%, with a total content of saturated fatty acids of no more than 38-41%. The melting point of the fat was 28.5-31.2°C, depending on the anatomical location, which determines its high plasticity and low melting point. Analysis of fat quality indicators showed that the iodine number values are at the level of 78-86 g I_2/100 g of fat, which indicates a significant proportion of polyunsaturated fatty acids and high biological value of the product. The acid number in all samples studied was 1.2-1.6 mg KOH/g, which indicates satisfactory fat quality and its resistance to hydrolytic processes when stored under optimal conditions. The differences in melting point depending on the anatomical and topographical location of adipose tissue (minimum values for perirenal fat – 24.20 ± 1.30°C, maximum for visceral internal fat – 29.20 ± 0.20°C) confirm the heterogeneity of the lipid structure and the need for a differentiated approach to their processing.

It has been established that the internal and perirenal fat of the Yakut horse is characterised by a higher content of unsaturated fatty acids compared to subcutaneous fat deposits, which makes them most promising for use in the food industry and in the creation of functional foods. Age characteristics also affect the properties of fat: in , young animals up to 3 years of age have a higher iodine number (91.1 ± 1.0 g I_2/100 g) and an increased content of linoleic (6.8 ± 1.0%) and linolenic (13.3 ± 0.6%) acids compared to animals aged 10-20 years (iodine value 82.5 ± 1.9 g I_2/100 g, linoleic acid 5.6 ± 0.5%, linolenic acid 10.1 ± 0.6%), while in adult animals, the fat is more stable during storage and has a higher vitamin A content (11.0 ± 0.7 IU/g versus 5.7 ± 0.6 IU/g in young animals).

The results confirm the possibility of using Yakut horse fat as a dietary product, as well as a valuable raw material for the production of food supplements and fat compositions with increased biological activity. The practical significance of the study lies in expanding the raw material base of the food industry in northern regions by involving previously underutilised slaughter products. Prospects for further research are related to the study of the rheological and crystallisation properties of Yakut horse fat, the assessment of its oxidative stability under various processing methods, as well as the development and testing of optimal technological modes that ensure the preservation of biologically active components and increase the shelf life of finished products.

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Conflict of Interest

None.

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Аннотация. Бул изилдөөнүн актуалдуулугу Крайний Түндүктүн өтө төмөн температура шарттарында калыптанган жана өзгөчө физика-химиялык касиеттерге ээ болгон якут жылкысынын майынын технологиялык потенциалын илимий негиздөө зарылдыгы менен шартталат. Иштин максаты – якут жылкысынын майынын физика-химиялык жана технологиялык мүнөздөмөлөрүн комплекстүү баалоо жана аны тамак-аш өнөр жайында жана айрым азык-түлүк продуктыларын иштеп чыгууда колдонуу мүмкүнчүлүктөрүн аныктоо. Изилдөөнүн жүрүшүндө май кислоталарынын курамын талдоо үчүн газ-суюктук хроматография ыкмасы, эригичтик температурасын, йоддук жана кычкылдык көрсөткүчтөрдү аныктоонун стандарттык физика-химиялык ыкмалары, ошондой эле майдын консистенциясын жана пластикалуулугун баалоонун инструменталдык ыкмалары колдонулду. Натыйжада якут жылкысынын майында каныкпаган май кислоталарынын жетиштүү үлүшү бар экени аныкталды: олеин кислотасынын курамы 42,3-45,7 %, линол кислотасыныкы 9,8-11,6 % түздү, бул башка жылкы тукумдарын өстүрүү үчүн көрсөткүчтөрдү салыштырууга мүмкүндүк берет. Үлгүлөрдүн эригичтик температурасы негизинен 28,5-31,2 °C болду, бул майдын жогорку пластикалуулугун жана жакшы сиңимдүүлүгүн көрсөтөт. Йоддук көрсөткүчтөр 78-86 г I_2/100 г майды, кычкылдык көрсөткүчтөр 1,2-1,6 мг KOH/г түзүп, майдын жогорку сапатын жана сактоо учурунда туруктуулугун тастыктайт. Көрсөтүлгөн көрсөткүчтөрдүн жыйындысы майдын айкын эмульгирлөөчү касиеттерин жана технологиялык иштетүүгө туруктуулугун камсыз кылаары аныкталды. Иштин практикалык мааниси – алынган натыйжаларды түндүк аймактардагы эт кайра иштетүүчү жана кондитердик өнөр жай ишканалары жылкы майын кайра иштетүү технологияларын иштеп чыгууда жана биологиялык баалуулугу жогору натыйжалуу азык-түлүк продуктыларын алууда колдоно алышында

Негизги сөздөр: жылкы эти; кулун эти; май тканы; союу продуктыларынын экинчи чийки заты; көп каныкпаган май кислоталары

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Аннотация. Актуальность данного исследования обусловлена необходимостью научного обоснования технологического потенциала жира якутской лошади как уникального исходного детского мяса, формирующегося в условиях экстремально низкой температуры Крайнего Севера и обладающего отличительными физико-химическими явлениями. Целью работы стала комплексная оценка физико-химических и технологических характеристик жира якутской лошади с точки зрения возможностей его использования в пищевой промышленности и при разработке определенных продуктов питания. В ходе исследований были использованы методы газожидкостной хроматографии для анализа жирнокислотного состава, стандартные физико-химические методы определения температуры плавления, йодного и кислотного чисел, а также инструментальные методы оценки консистенции и пластичности жира. В результате установили, что жир якутской лошади содержит необходимую долю ненасыщенных жирных кислот, при этом содержание олеиновой кислоты составило 42,3-45,7 %, линолевой – 9,8-11,6 %, что позволяет рассчитывать показатели для роста других пород лошадей. Температура плавления образцов составляла в основном 28,5-31,2 °C, что свидетельствует о высокой пластичности и хорошей усвояемости изделия. Значения йодного количества составили 78-86 г I_2/100 г жира, кислотное количество – 1,2-1,6 мг KOH/г, что свидетельствует о высоком качестве и выдержке жира при хранении. Установлено, что совокупность указанных показателей обеспечивает выраженные эмульгирующие свойства жира и его технологическую устойчивость к обработке. Практическая ценность работы заключается в возможности использования результатов предприятиями мясоперерабатывающей и кондитерской промышленности северных регионов при разработке технологий переработки конского жира и получения эффективных пищевых продуктов с повышенной биологической ценностью

Ключевые слова: конина; жеребятина; жировая ткань; вторичное сырье продуктов убоя; полиненасыщенные жирные кислоты