Environmental Compliance and Nutritional Value of Yakutian Cattle Products

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Abstract. Due to the increasing anthropogenic pollution of the environment, the environmental compliance of agricultural and livestock products becomes increasingly important. This study discusses the materials on pollutant content in the Yakutian cattle products and includes the assessment of the nutritional value of meat and milk. The research objective is to determine the content of toxic metals, microelements, and the nutritional value of meat and milk of Yakutian cattle bred in Yakutia. Research methods. Sample material was analyzed for the content of toxic metals and microelements using atomic absorption spectroscopy. Milk productivity indicators and organoleptic properties of meat were determined by conventional methods. Results. The average value of lead content in meat was determined amounting to 0.1736±0.0076 mg/kg, mercury — 0.0156±0.0012 mg/kg, arsenic — 0.006±0.0007 mg/kg. No cadmium was not found in meat. Relatively high content of toxic metals was detected in liver. The content of microelements (Zn, Cu, Fe) satisfies regulatory requirements. Relatively high content of copper (83.3076±0.2342 mg/kg) and iron (97.4148±0.4412 mg/kg) was detected in liver. Conclusions. Analysis of research results showed that the average values of toxic metals content (mg/kg) (Pb, Cd, Hg, As) in meat and liver satisfy the regulatory requirements. Yakutian cattle meat contains a balanced full range of amino acids and is suitable for the production of high-quality meat products. Yakutian cattle milk has high fat content varying on average from 5.04% to 5.46%.

1. Introduction
Due to the increasing anthropogenic pollution of the environment, various pollutants enter agricultural ecosystems and, subsequently, with feed and water — into animal bodies and livestock products. Still, meat and milk are valuable traditional food products, while providing the population with high-quality and environmentally compliant meat and milk products is a relevant task in northern regions. Currently, the environmental situation is deteriorating in various parts of the Republic of Sakha (Yakutia), which is particularly associated with the territory's industrial development. According to environmental monitoring, the pollution of the atmosphere, water bodies, and soil by waste and drainage from the mining industry, various enterprises, and motor vehicles [1, 2, 3] continues with each year.

Yakutian cattle were bred by artificial selection by traditional breeders in the harsh conditions of the North. The population is only 1828 heads, including 726 cows (as of January 1, 2019) [4]. This cattle breed is highly adaptable to extreme climatic conditions and has some valued genetic
qualities — high butterfat content, beefiness, and disease resistance. Currently, the Yakutian Cattle is bred by agricultural companies of Yakutia and GKP RS (Ya) Yakutskiy skot. The latter company has gene pool breeding grounds and basic farms in seven districts of Yakutia and the city of Yakutsk.

2. Research purpose and objectives
The research purpose was to assess the environmental compliance, adequacy, and quality of products (meat and milk) of Yakutian cattle. The objective of our studies included the determination of the content of toxic metals and microelements in meat and liver, as well as the assessment of milk productivity, nutritional value of meat and milk.

3. Research materials and methods
The study was supported by the Department of Physiology of Farm Livestock and Ecology of the Federal State-Owned Publicly-Funded Institution Of Higher Education Arctic State Agrotechnological University, the Laboratory of Biochemistry and Bulk Analysis of the Federal State-Funded Research Institution Yakut Agriculture Research Institute, and the Yakut Republican Veterinary Testing Laboratory. Samples of meat and liver of bulls at the age of 2 were taken during slaughtering in November, milk samples from cows — in summer. All samples were taken at the livestock farm of State Unitary Enterprise Tuskul located in Central Yakutia. The assessment of organoleptic properties of bull meat was carried out according to the VNIIP method [5]. Milk productivity assessment was carried out by monthly control milking in various farms, while milk butterfat content was determined using the Laktan-Klever analyzer. The content of toxic metals (Pb, Cd, Hg, As) in meat and liver was determined by atomic absorption spectroscopy using the Spectrome-5 analyzer. The content of toxic elements (Pb, Cd, Hg, As) in meat and liver was assessed according to Sanitary Rules and Regulations SanPin 2.3.2.1078-01 [6].

4. Research results
Yakutian cattle belonging to a group of low-yield breeds are adapted to harsh climatic conditions of Yakutia, have low feeding requirements, and can give the maximum yield at the lowest feed cost, i.e. has high ecological efficiency [4]. According to some studies, Yakutian cattle cows yielded 6–8 kg of milk per day with a fat content of 5.0–5.5% [7]. Annual milk production can reach 2000 kg and more in favorable feeding and housing conditions [8, 9]. The high quality of meat and milk is one of the indicators of environmental compliance and nutritional value. Table 1 contains the data from our study of milk productivity of Yakutian cattle cows from various farms. For instance, the average fat content in milk of cows from various farms varies from 5.04±0.10% to 5.46±0.09%, butterfat — from 47.11±0.50 to 62.66±0.4 kg. Milk yield per lactation is low, on average ranging from 935±2.20 kg to 1146±1.6 kg, while the highest milk yield is observed in the summer months during the grazing period.

The obtained milk productivity data for Yakutian cattle are very close to the data obtained by other authors. For instance, G.P. Korotov (1983) stated that 55.7% of the studied cows gave milk with a fat content over 5%, including 3.8% of cows with fat from 6 to 7% [10]. Ye.I. Eliseyeva (2015) stated that the average content of fat in the milk produced by Yakutian cattle cows was 5.32±0.02% [11].

The results of a comparative assessment of organoleptic properties of boiled meat and broth from bulls of Yakutian cattle at the age of 18 months and 2.5 years showed no significant differences. Boiled meat of bulls of the age of 2.5 years is slightly better than the boiled meat of bulls at the age of 18 months by the aroma, taste, mellowness, and fat content in the broth.

According to A.F. Abramov, R.G. Popov, and others (2018), Yakutian cattle bull meat is better than bull meat of beef breeds of the Russian Federation (Kazakh Whiteheaded cattle, Russian polled cattle, Kalmyk cattle) by multiple indicators of chemical composition (fat, ash content) and the energy value. The high content of essential irreplaceable lysine and methionine amino acids in the Yakutian cattle meat characterizes its usefulness and balance of amino acid composition, as well suitability for the production of high-quality meat products [12].
Table 1. Milk productivity of Yakutian cattle cows per lactation III.

| S.N. | Indicator                          | Farms                      | Bytantay                  | Small house suburbs |
|------|------------------------------------|----------------------------|---------------------------|---------------------|
|      |                                    | Ulu Sysy (Gorny District)   | (Eveno-Bytantaysky National District) | (Eveno-Bytantaysky National District) |
|      |                                    | \( n = 33 \)              | \( n = 22 \)               | \( n = 65 \)         |
| 1    | Milk yield per lactation, kg       | 935±2.20                   | 998±2.95                  | 1146±1.6            |
| 2    | Fat content, %                     | 5.04±0.10                  | 5.25±0.12                 | 5.46±0.09           |
| 3    | Milk butterfat, kg                 | 47.11±0.50                 | 52.45±0.70                | 62.66±0.4           |
| 4    | Milking days                       | 247±2.21                   | 247±1.29                  | 240±0.76            |
| 5    | Live weight, kg                    | 294±0.86                   | 313±1.24                  | 319±0.86            |

Due to anthropogenic pollution, various toxic substances enter animal bodies along the food chain — from soil into plants — food — animal — animal products — humans, while the toxic effect can be direct or indirect. According to different authors, a significantly high content of heavy metals was found in meat and liver of cattle bred near industrial areas. It is known that certain elements from the heavy metals group (copper, zinc, manganese, cobalt, iron, etc.) are an integral part of enzyme systems and participate in vital metabolic processes of the body. But high concentrations of these elements have a synergistic effect, intensifying the toxic effect of other pollutants [13, 14]. The results of our research (Table 1) show that the content of toxic metals in meat and liver is minor and does not exceed the regulatory requirements. The highest content of toxic elements was detected in liver samples, which is due to the physiological functions of this organ and the possible accumulation of these elements in liver.

Table 2. The content of toxic metals and microelements in the Yakutian cattle bull meat, mg/kg.

| Heavy metals and microelements | MAC (meat), mg/kg, max | MAC (liver), mg/kg, max |
|-------------------------------|------------------------|-------------------------|
| Lead (Pb)                     | 0.5 \( M±m \)         | 0.6 \( M±m \)           |
| Cadmium (Cd)                  | 0.05 \( not found \)   | 0.3 \( M±m \)           |
| Mercury (Hg)                  | 0.03 \( 0.0156±0.0012 \) | 0.1 \( M±m \)           |
| Arsenic (As)                  | 0.1 \( 0.006±0.0007 \) | 1.0 \( M±m \)           |
| Zink (Zn)                     | 70.0 \( 55.0592±1.2594 \) | 100.0 \( M±m \)        |
| Copper (Cu)                   | 5.0 \( 1.8436±0.0830 \) | 20.0 \( M±m \)          |
| Iron (Fe)                     | - \( 24.851±0.3794 \)  | - \( M±m \)             |

The studies of certain authors conducted in various regions shows that the content of heavy metals in samples of meat of various cattle breeds was also lower than the maximum allowable concentrations [15, 16, 17].

5. Findings
To summarise the abovementioned, the productive indicators of Yakutian cattle are low, but at the same time, Yakutian cattle have the potential ability to increase their productivity in favorable housing and feeding conditions. The results of laboratory analyzes show that the studied meat and liver comply with the regulatory requirements for the content of heavy metals. Speaking of microelements, the content of copper of 83.173 (at MAC of 20.0 mg/kg) noticeably exceeds the regulatory indicators. The content of iron in liver is four times more than its content in meat. The literature sources contain an explanation that the amount of cadmium absorbed in the small intestine increases from 5% to 20% in...
case of a decreased iron content in the body [19]. Due to the protective function of iron, the absorption of cadmium in intestines can decrease to 80% [18]. Quite possibly, an increased amount of copper and iron content in liver implies that these microelements affect the intensity of various enzymatic metabolic processes and are required for the growth and development of the animal body. The amounts of heavy metals accumulated in cattle liver are also affected by the breed, age, and environmental conditions [20].

6. Conclusions
The content of toxic metals — lead, cadmium and mercury in meat and liver of Yakutian cattle has been determined to be low and not exceed the regulatory requirements of Sanitary Rules and Regulations. A significantly higher content of toxic metals was found in liver. Yakutian cattle meat contains a balanced full range of amino acids and is suitable for the production of high-quality meat products. Yakutian cattle is distinguished by milk with a high fat content varying on average from 5.04% to 5.46% (according to our data) to 6–7% (according to literature sources). Due to the continuing pollution of the environment, the content and accumulation of pollutants shall be regularly monitored in meat and milk products made of Yakutian cattle.

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