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PHYSIOLOGICAL FEATURES OF THE HORMONAL STATUS OF THE THYROID GLAND IN BEEF COWS

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An evaluation of the correlation between AST enzymatic activity as a marker of mitochondrial function and the concentration of thyroid hormones present in the bloodstream of Kazakh white-headed cattle is presented. It was observed that the requirement for the physiological effects of triiodothyronine in the organism diminishes from the onset to the conclusion of the first month of lactation, which is substantiated by a reduction in the hormone concentration in the blood ranging from 1.89 to 4.02 times. Conversely, the mitochondrial activity within the cells of these animals exhibits an increase of 9.21 to 35.74%, which underscores the adaptive potential of energy-producing mechanisms.

This inverse relationship highlights a complex metabolic adaptation. While thyroid hormones are key metabolic regulators, the observed dynamics suggest a shift in energy substrate utilization. The rising AST activity indicates enhanced cellular respiration efficiency, possibly compensating for the lower hormonal stimulation. This ensures stable energy production for lactation demands. Further research should focus on the molecular mechanisms behind this mitochondrial compensation and its long-term impact on cattle

productivity and health in the postpartum period. Understanding these processes is crucial for optimizing animal husbandry practices.

Keywords: cows; lactational physiology, aspartate aminotransferase, triiodothyronine hormone.

ЕТТІ СИЫРЛАРДАҒЫ ҚАЛҚАНША БЕЗІНІҢ ГОРМОНАЛДЫ КҮЙІНІҢ ФИЗИОЛОГИЯЛЫҚ ЕРЕКШЕЛІКТЕРІ

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Митохондриялық функцияның маркері ретінде АсАт ферментативті белсенділігі мен қазақтың ақбас ірі қара малының қанында болатын қалқанша безінің гормондарының концентрациясы арасындағы корреляцияны бағалау ұсынылған. Триодотирониннің организмдегі физиологиялық әсеріне деген қажеттілік лактацияның бірінші айының басынан аяғына дейін төмендейтіні байқалды, бұл қандағы гормон концентрациясының 1,89-дан 4,02 есеге дейін төмендеуімен негізделген. Керісінше, бұл жануарлардың жасушаларында митохондриялық белсенділік 9,21-ден 35,74% – ға дейін артады, бұл энергия өндіретін механизмдердің бейімделуіне әлеуетін көрсетеді.

Бұл кері байланыс метаболизмнің күрделі бейімделуін көрсетеді. Қалқанша безінің гормондары метаболизмнің негізгі реттеушілері болғанымен, байқалған динамика энергетикалық субстраттарды пайдаланудың өзгеруін көрсетеді. АсАТ белсенділігінің жоғарылауы жасушалық тыныс алу тиімділігінің жоғарылауын көрсетеді, мүмкін гормоналды ынталандырудың төмендеуін өтейді. Бұл лактация талаптары үшін тұрақты энергия өндіруді қамтамасыз етеді. Әрі қарайғы зерттеулер осы митохондриялық компенсацияның негізінде жатқан молекулалық механизмдерге және оның босанғаннан кейінгі кезеңдегі ірі қара малдың өнімділігі мен денсаулығына ұзақ мерзімді әсеріне бағытталуы керек. Бұл процестерді түсіну мал шаруашылығы тәжірибесін оңтайландыру үшін өте маңызды.

Түйінді сөздер: сиырлар, лактация физиологиясы, аспартаминотрансфераза, трийодтиронин гормоны.

ФИЗИОЛОГИЧЕСКИЕ ОСОБЕННОСТИ ГОРМОНАЛЬНОГО СОСТОЯНИЯ ЩИТОВИДНОЙ ЖЕЛЕЗЫ У МЯСНЫХ КОРОВ

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Представлена оценка корреляции между ферментативной активностью АсАТ как маркера функции митохондрий и концентрацией гормонов щитовидной железы, присутствующих в крови казахского белоголового крупного рогатого скота. Было замечено, что потребность организма в физиологическом воздействии триодотиронина уменьшается с начала и до конца первого месяца лактации, что подтверждается снижением концентрации гормона в крови в диапазоне от 1,89 до 4,02 раза. Напротив, митохондриальная активность в клетках этих животных увеличивается с 9,21 до 35,74%, что подчеркивает адаптивный потенциал механизмов производства энергии.

Эта обратная зависимость указывает на сложную метаболическую адаптацию. Хотя гормоны щитовидной железы являются ключевыми регуляторами обмена веществ, наблюдаемая динамика свидетельствует о сдвиге в использовании энергетических субстратов. Повышение активности АсАТ указывает на повышение эффективности клеточного дыхания, что, возможно, компенсирует снижение гормональной стимуляции. Это обеспечивает стабильную выработку энергии для удовлетворения потребностей в период лактации. Дальнейшие исследования должны быть сосредоточены на молекулярных механизмах, лежащих в основе этой митохондриальной компенсации, и её долгосрочном влиянии на продуктивность и здоровье крупного рогатого скота в послеродовой период. Понимание этих процессов имеет решающее значение для оптимизации методов ведения животноводства.

Ключевые слова: коровы, физиология лактации, аспаратаминотрансфераза, гормон трийодтиронин.

Introduction. The transition from gestation to lactation in bovine species represents a critical phase characterized by the initiation of profound metabolic adaptations [1, p. 1-2; 2, p. 9602-9603]. This period is associated with a significant escalation in energy and protein requirements to support the onset of milk synthesis. The successful metabolic acclimatization to lactation depends on a complex cascade of endocrine-regulated physiological transformations, which progress gradually and exhibit considerable variation depending on genetic lineage, productivity level, and parity, suggesting a substantial influence of hereditary determinants on these adaptive mechanisms [1, p. 1-2; 2, p. 9602-9603; 5, p. 4-5].

Thyroid hormones, particularly triiodothyronine (T3), play a pivotal role in orchestrating these adaptive processes by modulating cellular metabolism through genomic influences mediated by nuclear transcription factors [3, p. 236-238; 4, p. 1382–1383; 5, p. 4-5]. These transcription factors, in turn, regulate mitochondrial function and biogenesis, thereby governing energy production and thermogenesis, which is reflected in the rate of endogenous heat production [6, p. 545-547; 7, p. 336-338]. Studies in dairy cows have confirmed that regulative processes within thyroid hormone metabolism occur during early lactation, with T4 concentrations decreasing after calving and milk yield negatively correlated with T3 and T4 levels [14, p. 100-105]. Additionally, the number of lactations and total milk yield correlate with blood thyroid hormone concentrations, indicating that the reproductive history of the animal influences its hormonal status.

However, while these foundational concepts are well-documented in dairy cattle [1, p. 1419; 2, p. 9602-9603], it is critical to recognize that beef cattle, particularly breeds managed under suckling systems, exhibit fundamentally distinct metabolic characteristics. In dairy cows, the onset of lactation is accompanied by a pronounced negative energy balance, intensive lipolysis, and high growth hormone levels primarily to support maximal milk synthesis. In contrast, beef cows are selected for efficient weight gain and calf growth rather than high milk yield. Under natural suckling conditions, the metabolic load is distributed differently: calves consume milk in frequent small portions, providing a physiological stimulation of the mammary gland distinct from machine milking, while the cow's energy is partitioned between lactation and maternal investment [5, p. 4-5]. Furthermore, in Kazakh White-headed cows, calving typically occurs in February-March, coinciding with the cold season, which imposes additional energy demands for thermoregulation [5, p. 4-5]. This implies that beef cows rely more heavily on mobilization of body fat reserves to meet energy needs during early lactation, making thyroid hormones – key regulators of thermoregulation and intracellular metabolism – particularly important for resource distribution [10, p. 295; 11, p. 103-105; 12, p. 141-143].

To evaluate the functional status of mitochondrial energy metabolism, the activity of aspartate aminotransferase (AST) is commonly employed as a marker. AST is a key enzyme involved in amino acid metabolism and gluconeogenesis, and its activity is closely linked to mitochondrial functional capacity [8, p. 625-627; 9, p. 4-6; 10, p. 295]. Previous studies have demonstrated that AST activity reflects the efficiency of cellular respiration and energy synthesis, making it a valuable indicator of the adaptive potential of energy-producing mechanisms under conditions of metabolic stress [8, p. 625-627; 9, p. 4-6; 10, p. 295].

Despite the recognized importance of thyroid hormones and mitochondrial function in metabolic adaptation, the specific interplay between these systems in beef cows during early lactation remains insufficiently explored. The majority of existing research focuses on dairy breeds, while the physiological features of hormonal regulation in beef cattle under suckling management are poorly characterized [5, p. 4-5; 11, p. 103-105]. This knowledge gap underscores the need for breed-specific investigations that consider the unique metabolic demands and environmental conditions faced by beef cows in the postpartum period.

Therefore, the objective of our study was to assess the correlation between aspartate aminotransferase (AST) activity, serving as a marker for mitochondrial function, and the concentration of circulating thyroid hormones in the bloodstream of Kazakh White-headed cattle during the first month of lactation, with particular attention to the influence of parity on these parameters.

Although the general principles of metabolic adaptation during lactation are known from dairy studies, the specific physiological features of thyroid regulation in beef cows under suckling management remain poorly understood, necessitating breed-specific investigation.

Objective, tasks. The aim of this study was to investigate the adaptive metabolic interplay between thyroid hormonal regulation and mitochondrial energy metabolism in beef cattle during the critical transition to lactation.

To achieve this aim, the following specific objectives were set:

1. to determine the dynamics of blood serum triiodothyronine (T3) concentration in Kazakh white-headed cows from parturition to the end of the first month of lactation.
2. to assess the activity of aspartate aminotransferase (AST) as a marker of mitochondrial function in the blood serum of the same animals over the same postpartum period.
3. to analyze the correlation and inverse relationship between the circulating levels of thyroid hormone (T3) and AST activity in relation to the stage of early lactation.
4. to evaluate the influence of parity (number of calvings) on the investigated parameters of hormonal status and mitochondrial activity.

Materials and methods. The investigation was conducted in 2025 at Olzha-Borovskoye LLP and involved the formation of three experimental groups (n=10) from recently calved cows of the Kazakh White-Headed breed. The first group included animals after their second calving at the age of 3 years; the second group consisted of cows after their third calving at the age of 5 years; and the third group comprised cows after their sixth calving at the age of 8 years.

All cows post-calving were engaged in suckling and were provided with a complete mixed feed ration bi-daily. They had unrestricted access to water, which was maintained at a temperature of 15 °C.

Blood samples for analytical purposes were procured from the cows in the morning prior to feeding, from which blood serum was derived; in this serum, the activity of aspartate aminotransferase and the levels of triiodothyronine were quantified utilizing commercially available reagent kits. Blood samples were collected immediately post-calving and at the conclusion of the first month of lactation.

Statistical data processing was carried out using the Microsoft Excel spreadsheet processor and the «Biometrics» application software packages. To assess the relationship between the variables, the Pearson correlation coefficient (r) was calculated.

Results and discussion. The biologically active thyroid hormone triiodothyronine is pivotal in the metabolic acclimatization of cows to lactation by modulating the rate of nutrient assimilation [1, p. 1419; 2, p. 9602-9603]. The findings regarding the concentration of triiodothyronine in the bloodstream of Kazakh white-headed cows during the early postpartum phase are illustrated in Figure 1. Consequently, in cows during the early lactation phase, specifically immediately following calving, the concentration of triiodothyronine in the blood exhibited an increase correlated with the number of reproductive cycles previously experienced. The disparity between the first and third groups was observed to be 1.56 times. This suggests that with advancing age, the requirement for the biological actions of the hormone in the development of lactation metabolism escalates. This phenomenon may be attributed to an augmentation in the quantity of target cells and triiodothyronine receptors within the organisms of these animals, potentially resulting from an increase in their overall body weight [7, p. 337-338].

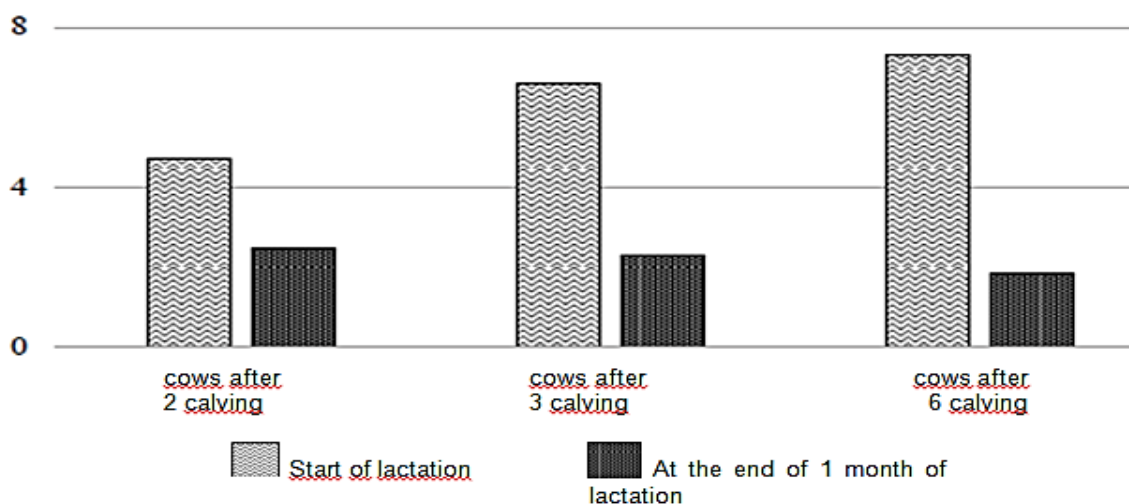


Fig.1. Triiodothyronine (nmol/l) levels in the blood of cows in the early postpartum period depending on the number of calvings

At the termination of the first month of lactation, the concentration of triiodothyronine in the blood of the cows exhibited a decline ranging from 1.89 to 4.02 times. Concurrently, an inverse correlation with the frequency of calvings was noted: the greater the number of reproductive cycles experienced, the lower the concentration of the hormone in the bloodstream. This may suggest an enhancement in the organism's

capacity to adapt to metabolic fluctuations associated with the influences of thyroid hormones, potentially attributable to improved regulation of heat production.

To evaluate the mitochondrial activity of cells within the bovine organism, the activity of aspartate aminotransferase (AST) was assessed [8, p. 628-630; 9, p. 6-8; 10, p. 3-5; 11, p. 105-106; 12, p. 142-143; 13, p. 85-87]. The variability in its concentration within the blood of the animals is depicted in Figure 2. Thus, the activity of AST, similarly to triiodothyronine, was higher at the commencement of lactation in the blood of cows that had a greater number of reproductive cycles. The differences observed between the groups amounted to 29.37%.

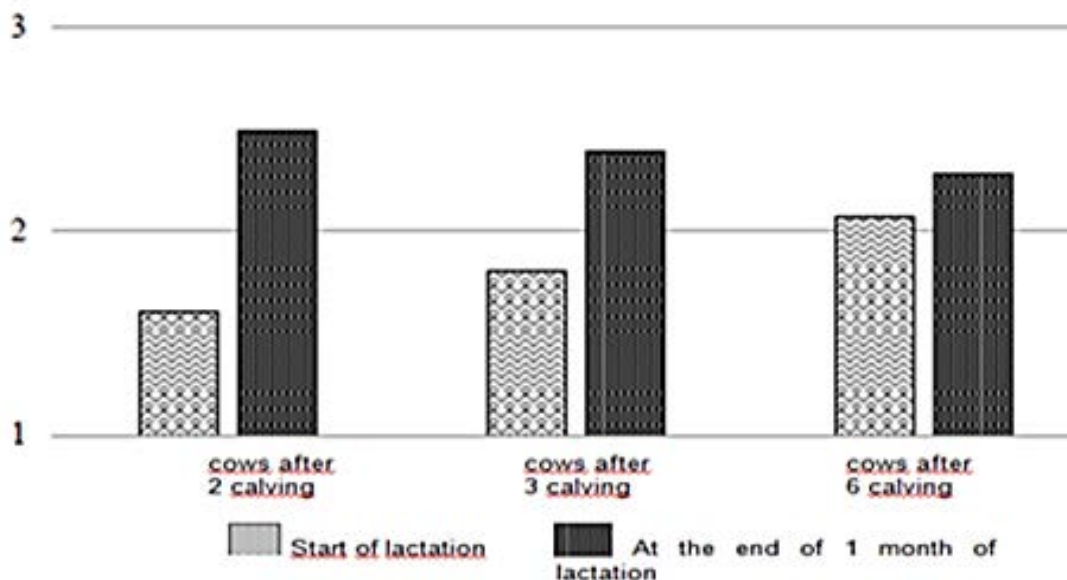


Fig. 2. AST activity (U/L) in the blood of cows in the early postpartum period depending on the number of calvings

During the lactation period, the activity of aspartate aminotransferase (AST) exhibited an augmentation ranging from 9.21% to 35.74% (refer to Fig. 2), indicative of enhanced mitochondrial functional capacity and subsequent energy synthesis, respectively [8, 628-630; 9, p. 6-8; 10, p. 3-5]. Concurrently, the elevation in catalytic activity was observed to be diminished in bovine subjects with extended histories of reproductive cycles.

While the foundational concepts of metabolic adaptation during the transition period and the regulatory role of thyroid hormones have been extensively documented in dairy cattle [1, p. 1-2; 2, p. 9605-9607], it is critical to acknowledge that beef cattle, particularly the Kazakh White-headed breed under suckling management, exhibit fundamentally distinct metabolic characteristics.

In dairy cows, the onset of lactation is accompanied by a pronounced negative energy balance, intensive lipolysis, and a pronounced shift in endocrine profiles, with high growth hormone and low insulin levels, primarily to support maximal milk synthesis [1, p. 1-2; 2, p. 9605-9607]. In contrast, beef cows are selected for efficient weight gain and calf growth rather than high milk yield. Under natural suckling conditions, the metabolic load is distributed differently: calves consume milk in frequent small portions, providing a physiological stimulation of the mammary gland distinct from machine milking, while the cow's energy is partitioned between lactation and maternal investment.

Classic comparative studies by Hart et al. (1975) have demonstrated that lactating beef cows (Hereford) maintain positive body weight gain during early lactation, with significantly higher serum insulin (28.8 vs. 9.5 μ U/mL) and glucose (0.705 vs. 0.654 mg/mL) levels compared to dairy cows (Friesians), indicating a fundamentally distinct nutrient partitioning strategy.

Our study extends these earlier observations by revealing a novel adaptive mechanism in Kazakh White-headed beef cows: a 1.89- to 4.02-fold decline in circulating triiodothyronine (T3) during the first month of lactation is counterbalanced by a 9.21% to 35.74% increase in aspartate aminotransferase (AST) activity, a marker of mitochondrial function. This inverse relationship suggests a unique compensatory upregulation of mitochondrial respiration efficiency, which likely compensates for diminished hormonal stimulation and ensures stable energy production to meet lactation demands under conditions of restricted nutrient intake typical of pasture-based suckling systems.

These findings highlight the remarkable metabolic plasticity of beef cattle and underscore the importance of breed-specific and management-specific adaptations. While the general principles of neuroendocrine regulation derived from dairy studies remain valid as a conceptual framework, direct extrapolation of metabolic thresholds or hormonal reference ranges from dairy to beef cattle is inappropriate and may lead to misinterpretation.

tation. Our work therefore contributes to filling a critical knowledge gap regarding the physiological features of thyroid hormonal status specifically in beef cows during the suckling period, an area that remains insufficiently explored in the existing literature.

Conclusions

1. The concentration of triiodothyronine (T3) in the blood serum of Kazakh White-headed cows decreases from the onset to the end of the first month of lactation by a factor of 1.89 to 4.02, indicating a diminishing physiological demand for thyroid hormone stimulation as lactation progresses.

2. Mitochondrial activity, assessed by serum aspartate aminotransferase (AST) activity, increases during the same postpartum period by 9.21% to 35.74%, reflecting enhanced functional capacity of energy-generating cellular mechanisms. Our findings highlight the metabolic specificity of beef cattle compared to dairy breeds, emphasizing the need for breed-adapted reference values and management strategies.

3. A clear inverse correlation was established between circulating T3 levels and AST activity during early lactation: the decline in hormonal stimulation is counterbalanced by a compensatory upregulation of mitochondrial respiration, ensuring stable energy production to meet lactation demands.

4. The number of calvings (parity) significantly influences both hormonal and mitochondrial parameters. Cows with a higher parity (sixth calving) exhibited lower T3 concentrations and a less pronounced increase in AST activity by the end of the first month of lactation compared to cows with fewer calvings, suggesting improved metabolic adaptation and more efficient energy homeostasis with advanced reproductive experience.

Conflict of interest: The authors declare no conflict of interest.

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