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# Effect of breed factor on urea level and blood biochemical parameters in dairy cattle

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**Abstract.** Dairy cattle breeding has achieved great success due to the targeted improvement of dairy and combined breeds in different climatic and agroecological zones of the world. The level of urea and other biochemical parameters of cows' blood indicates the peculiarities of carbohydrate and protein balance, its impact on reproductive functions, health, feed efficiency, and methane emissions. The aim of the study was to determine the effect of the breed factor on urea levels and

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other biochemical parameters of blood in cows of different breeds. The research was conducted on cows of three contrasting breeds. The first breed is a combined (cross-border) Simmental, the last two are local – Ukrainian Red and White dairy (created by crossbreeding Simmental with Ayrshire, Montbéliard, Holstein) and Ukrainian Black and White dairy (created by crossing local Black and White with Holstein). The experiment was conducted under standard conditions when feeding cows "without restrictions" with the analysis of productive indicators and blood biochemical parameters. The most significant factor influencing the productive and biochemical parameters was the breed factor, which accounted for 14.6% and 51.2%, respectively, in terms of fat content in milk and milk yield in terms of total energy value. A significant influence of the breed was noted in blood biochemical parameters such as total bilirubin 24.7%, urea 33.2%, creatinine 49.8%, alanine aminotransferase 10.4%, aspartate aminotransferase 46.3%, albumin 35.1% and total protein 13.2%. A significant correlation between the concentrations of urea and creatinine, creatinine and aspartate aminotransferase, and albumin in the blood plasma of the studied animal groups was established. A preliminary conclusion was made about the presence of a significant genetic component of influence on the level of urea, blood biochemical parameters and productivity traits. The analysis of the manifestation of such traits in different breeds can be taken into account in selection programmes and the creation of appropriate feeding conditions, taking into account the peculiarities of protein nutrition

**Keywords:** blood urea level; blood urea nitrogen; dairy breeds of Ukraine; Simmental breed; degree of breed influence

## Introduction

In management or herd management programmes, much attention is paid to assessing the genetic predisposition of animals to certain abnormalities or health problems. Urea, as a product of protein metabolism, in combination with other biochemical indicators, is an important indicator of dietary balance for managing nutrition strategy, health status, and controlling nitrogen emissions to the environment (Ruban *et al.*, 2021). Blood urea levels are related to urine and milk nitrogen levels, which makes these indicators, when abnormal, accurate predictors of certain problems (Hossein-Zadeh, 2024). Given the agro-climatic conditions of Ukraine and the breeding of local dairy breeds (Black and White and Red and White) and such cross-border breeds as Simmental, there is a need to test both the level of manifestation and the possibilities of using such biochemical indicators in animal breeding and herd management (Dymchuk & Ponko, 2023). The work is based on the data obtained from the results of biochemical blood tests. According to V. Kondratiuk *et al.* (2024), the value of milk urea (MU) is a useful tool for monitoring the protein nutrition of dairy cows, as it is closely correlated with the level of blood urea (BU). Depending on farms and feeding conditions, this correlation ranged from +0.7543 to +0.9017, with more accurate blood tests being performed when blood samples were taken two hours after feeding. Thus, these indicators serve as a certain indicator of the peculiarities of the manifestation of biochemical processes. In addition, MUN values tend to be higher in the summer months (Webb & de Bruyn, 2021). The University of Pennsylvania's practice guidelines for urea nitrogen values suggest that the observed differences may not be so much related to the breed as to their live weight (Ishler, 2023). For example, large Holsteins tend to have lower MUN and BUN than medium-sized Jerseys.

In the experiments of M. Prahl *et al.* (2022), high-yielding cows had higher plasma levels of urea, uric acid and hypuric acid. These differences were not associated with changes in gene expression and urea cycle or nitrogen metabolism, but were primarily due to hepatic metabolism. According to the authors, feeding a low diet led to an increase in the expression of enzymes that catabolise fatty acids, but the reason for this remains to be determined in future studies. Thus, studies on the influence of genetic and organised (environmental) factors on the characteristics of biochemical processes in cows make it possible to use certain forecasts and select optimal solutions in modern production conditions. The aim of the study was to evaluate and compare the level of urea and basic biochemical parameters of blood of cows of different breeds under similar feeding and housing conditions.

## Literature Review

Urea is the end product of protein metabolism, a marker of cow health and an indicator of the balance of cattle rations. The average protein value in milk ranges from 3.0 to 3.9%, with a urea concentration of 8-25 mg/100 ml (Ruban *et al.*, 2021). Any deviations in urea content indicate a carbohydrate-protein imbalance in the diet, which affects reproductive function, hoof problems, reduced feed efficiency, etc. In addition, the level of urea nitrogen in blood (BUN), milk (MUN) or urine (UUN) is used as a control for certain environmental problems associated with methane emissions in ruminants (Zhao *et al.*, 2025). Urea has a low molecular weight, which allows it to rapidly cross the blood-brain barrier into milk, resulting in a strong association between blood urea nitrogen (BUN) and milk urea nitrogen (MUN) concentrations. Although MUN is a minor component of milk, it is an effective tool to identify potential problems in dairy herds (Sosa *et al.*, 2010). Many studies have shown that the intake of plant protein and energy and their synchronised interaction in the rumen are the main factors affecting MUN concentrations. Thus, MUN measurement can serve as a reliable indicator for improving nutrition management.

The urea nitrogen concentration in milk can also be used as an indicator in managing the nutrition strategy on dairy farms to increase the protein utilisation efficiency of dairy cows. Recent studies show that the nitrogen content of milk urea depends mainly on the nitrogen to energy ratio in the diet, but many other factors can influence ureogenesis. According to N. Munyaneza *et al.* (2017), measuring milk urea nitrogen can serve as a control for nitrogen use efficiency in dairy cows and optimise milk nitrogen levels. However, the reference values of milk urea nitrogen for optimising nitrogen use efficiency are different from the required level for milk protein production. Thus, an increase in milk protein production can be expected at milk urea nitrogen levels > 11 mg/dl (Ruban *et al.*, 2021), while protein utilisation efficiency is below this level (< 11 mg/dl). Optimal MUN values range from 10 to 14 mg/dl, but for many countries, the recommended milk urea nitrogen values for cow's milk range from 10 to 16 mg/dl milk. The studies by S. Nozad *et al.* (2012) showed that the highest blood concentrations of blood urea nitrogen (BUN), serum protein (SPtn), creatinine, triglycerides (TG), cholesterol and beta-hydroxybutyric acid (BHB) were found in high-yielding cows. Finally, to ensure a balance between milk protein production and reduced urinary and milk urea nitrogen excretion, recent evidence suggests that dairy cows should be fed a crude protein diet of 16.5%.

M. Štolcová *et al.* (2020) monitored changes in the protein status of the parameters of energy metabolism of the Holstein and Fleckvih breeds by urea and other blood biochemical parameters. At the beginning of lactation, changes in key metabolic parameters were faster and more pronounced in Holstein cows, and the dynamics of these parameters indicated the levels of adaptive performance and processes of body energy mobilisation in the two breeds as a whole. Complex processes occur in the ruminant rumen with additional formation of microbial nitrogen and nucleic acids, circulation of such a toxic compound as hydrogen nitrite and subsequent neutralisation (conversion) into urea. Urea is hydrolysed into carbon dioxide and ammonia by the urease enzyme. The activity of urease increases the pH of the environment, as ammonia is formed (Ruban & Vasilevsky, 2015). In the 50s of the last century, M. Wall & K. Laidler (1953) studied the hydrolysis of urea catalysed by urease. The work was carried out in trihydroxymethylaminomethane-$H_2SO_4$ buffer, which was shown to have no activating or inhibitory effect on the reaction. It was found that the reaction passes through a sharp maximum pH of 8.00 at a wide range of substrate concentrations and temperatures, which, in the case of ruminant digestion, leads to certain complications in microbial processes (Ruban & Vasilevsky, 2015).

In the convincing opinion of P. Gregorini *et al.* (2013), the improvement of the functional version of Molly to Molly84 and Molly85, where the biochemical processes of digestion in the cow were described in a comprehensive and interdependent manner, led to a reduction in the proportion of the average relative prediction error and better predictions of methane production ($CH_4$) in ruminants. Further development of such a mathematical model should focus on potentially improving the prediction of rumen FFA production, as well as the intake pattern and associated changes in rumen nutrient excretion and the model of fermentation itself.

According to A. Bedford *et al*. (2020) investigated the effect of short-term elevated ambient temperature on rumen volatile fatty acid (VFA) dynamics and gene expression (the process where hereditary information from a gene (DNA nucleotide sequences) is converted into a functional product – RNA or protein) of the rumen epithelium associated with VFA transport and metabolism. The results show that under low feed intake and heat stress, there are shifts in the dynamics of rumen VFA and the ability of the rumen epithelium to absorb and transport acids of this series. During protein digestion, ammonia is released in the rumen, and if it is in excess, it is absorbed through the rumen wall into the bloodstream and converted to urea in the liver. Most of the urea is excreted in the cow's urine, although some of it passes into the milk. If the diet lacks nitrogen, the urea is not excreted, but returns to the rumen and is converted back to ammonia (Zhao *et al.*, 2025). G. Cozzi *et al.* (2011) observed that the production season significantly impacts several blood parameters, including total protein, globulin, creatinine, alkaline phosphatase, phosphorus, sodium, and chloride. They propose that these values can be used by dairy farmers to evaluate the metabolic health of lactating cows. Given the kidneys' continuous filtering function, stable blood creatinine levels are expected in healthy individuals, and deviations can indicate kidney problems. X. Du *et al*. (2017) found notably elevated levels of aspartate aminotransferase (AST), a marker of liver damage, in cows experiencing ketosis compared to healthy cows. They suggested that AST levels in blood tests could serve as an indicator of apoptosis, or programmed cell death, in liver cells.

R. Danielsson *et al.* (2017) discovered that despite consistent dietary intake, individual animals exhibited variations in methane (CH4) output. To examine the microbial makeup of the rumen, they performed 16S rRNA gene sequencing on the V4 region of rumen fluid. The study revealed that lower methane levels were associated with a greater abundance of the Methanobrevibacter ruminantium clade, a group of archaea within the Methanobacteriaceae family that produces methane primarily through the reduction of carbon dioxide with hydrogen. Archaea, a specialised group of unicellular organisms found in oxygen-deprived environments such as the rumen, are responsible for methane production (methanogenesis). Within the rumen, these microorganisms primarily utilise hydrogen (H2) and carbon dioxide (CO2) as fuel for methane synthesis, thus occupying a vital ecological role. Animal waste, including urine and feces, contributes to global nitrogen emissions. Milk urea nitrogen (MUN) levels in dairy cows are directly linked to urinary urea nitrogen (UUN) emissions; both diminish when crude protein intake is reduced. However, even with consistent feeding, MUN levels can vary among individual cows. Furthermore, research by Y. Yao *et al*. (2018) has demonstrated that, in the pursuit of sustainable biogas energy, pre-treating wheat straw with urea allows for substantial methane generation.

C. Müller *et al.* (2021) proposed that variations in internal nitrogen processing lead to differing urinary urea nitrogen (UUN) excretion, with cows exhibiting higher milk urea nitrogen (MUN) levels releasing more UUN than those with lower MUN. Their research examined nitrogen distribution and urea metabolism in dairy cows with varying MUN concentrations, comparing a diet with optimal crude protein (NP) to one with low crude protein (LP). The LP diet resulted in reduced total nitrogen (N) and UUN excretion, as well as lower ammonia emissions from feces. However, methane emissions, urinary nitrogen excretion, and ammonia excretion remained relatively consistent across the groups. Notably, cows with high MUN (HMU) showed lower renal creatinine and uric acid levels and excreted less uric acid (specifically on the LP diet) and creatine in their urine. The authors' initial prediction that cows with high milk urea (HMU) would excrete more urinary urea nitrogen (UUN) than those with low milk urea (LMU) was not supported by their findings. The reduced urinary creatine excretion in HMU cows suggests a potentially smaller environmental nitrogen impact from these animals. J. Spek *et al*. (2012) propose that milk urea nitrogen (MUN) levels in dairy cows can be used on farms to guide dietary adjustments and strategies for minimising environmental nitrogen (N) emissions. While urinary urea nitrogen excretion (UUN) is generally correlated with MUN, this relationship is highly variable. The reliability of MUN as a UUN predictor could be enhanced by considering several influencing factors. These include variations in water consumption, urine production, protein levels, body weight, and the timing and frequency of feeding and milking. Incorporating these factors into the MUN-UUN relationship can significantly improve the accuracy of MUN as a marker for protein utilisation efficiency and UUN.

Therefore, a complicated yet interconnected dynamic exists between milk yield and composition (specifically protein content) and urea concentrations in blood, urine, and milk. Current models that describe nitrogen digestion, absorption, and metabolism, often utilising urea analysis, facilitate the creation of more precise animal diets. However, further investigation is needed to fully optimise not only animal nutrition but also health, reproduction, and methane reduction. These investigations are, in part, influenced by the ecological and genetic features of the research locations.

## Materials and Methods

The research was conducted in the conditions of the farm "Grigorovich S.A." Kyiv region in the winter period of 2022-2023 on cows of combined Simmental, dairy Ukrainian Red-White and Black-White breeds. The Ukrainian Red-and-White dairy cow was created by crossbreeding Simmental with Ayrshire, Montbéliard and Holstein, and the Ukrainian Black-and-White dairy cow was created by crossing the local Black-and-White with Holstein. Each of the groups of animals in the experiment consisted of 33 heads. During the experimental studies presented in this paper, all manipulations with the cows involved in the research were carried out taking into account the basic principles of bioethics, in accordance with Article 26 of the Law of Ukraine No. 3447 "On the Protection of Animals from Cruelty" (2006), the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (1986) and the Procedure for Conducting Experiments and Experiments on Animals by Scientific Institutions (2012). Automated milking took place twice a day. The daily mixed diet of the cows consisted of the following feed components: alfalfa haylage – 3.3 kg; corn silage – 21 kg; mixed fodder – 9.7 kg; grass haylage – 5.5 kg; beet pulp – 3 kg; corn – 2.5 kg, straw – 0.5 kg; vitamin and mineral supplements. The level of feed dry matter intake was within 21.5 kg with a content of 15% crude protein, 17% acidic detergent fibre and 26% neutral detergent fibre. The general characteristics of the studied groups are given in Table 1.

***Table 1.*** *General characteristics of the studied groups of cows during standard lactation (305 days) and blood biochemical parameters at the time of the experiment*

| Indicator | Breed | | |
|---|---|---|---|
| | **Simmental (n = 33)** | **Ukrainian Red-White (n = 33)** | **Ukrainian Black-and-White (n = 34)** |
| Hope for 305 lactations | 4,359.7 ± 39.15 | 7,320.9 ± 47.24 | 8,617.1 ± 85.96 |
| Fat content in milk, % | 4.30 ± 0.059 | 3.82 ± 0.443 | 3.48 ± 0.043 |
| Protein content in milk, % | 3.29 ± 0.019 | 3.28 ± 0.014 | 3.25 ± 0.025 |
| ECM(1), kg | 4,487.8 ± 65.40 | 7,094.5 ± 296.86 | 7,969.2 ± 109.11 |
| Total bilirubin, µmol/l | 6.12 ± 0.749 | 3.43 ± 0.160 | 2.75 ± 0.157 |
| Direct bilirubin, µmol/l | 1.67 ± 0.096 | 1.74 ± 0.101 | 1.39 ± 0.075 |
| Urea, mmol/l | 2.91 ± 0.046 | 3.41 ± 0.058 | 3.06 ± 0.047 |
| Creatinine, µmol/l | 86.54 ± 1.699 | 111.16 ± 2.436 | 86.31 ± 2.016 |
| ALT[2], units/l | 37.16 ± 0.625 | 34.81 ± 1.012 | 33.44 ± 0.697 |
| AST[3], units/l | 34.24 ± 3.344 | 48.39 ± 1.900 | 18.43 ± 1.251 |
| Glucose, mmol/l | 2.59 ± 0.079 | 2.83 ± 0.077 | 2.74 ± 0.096 |
| Albumin, g/l | 31.30 ± 0.241 | 34.45 ± 0.473 | 31.67 ± 0.222 |
| Total protein, g/l | 67.46 ± 0.743 | 72.02 ± 1.247 | 72.12 ± 0.917 |
| GGT[4], units/l | 13.22 ± 0.424 | 16.15 ± 1.096 | 15.04 ± 1.005 |

**Note:** ECM(1) – milk fat and protein corrected milk yield; ALT[2] – alanine aminotransferase; AST[3] – aspartate aminotransferase; GGT[4] – gamma glutamyl transferase
**Source:** developed by the authors on the basis of research

Milk production (milk yield, fat and protein content) was monitored according to the requirements of ICAR (n.d.). The value of ECM – Energy-corrected milk or milk yield adjusted for fat and protein content was calculated using the formula (1):

$$\text{ECM} = (\text{milk fat, kg} \times 38.3 + \text{milk protein, kg} \times 24.3 + \text{milk yield} \times 0.7832)/3.14. \quad (1)$$

The analysis of serum biochemical parameters was measured on an automatic biochemical analyser HTI BioChem FC-120 (High Technology, Inc., USA) using reagents from this company in the Educational and Scientific Laboratory of Veterinary Diagnostic Research of the Faculty of Veterinary Medicine of the National University of Life and Environmental Sciences of Ukraine.

The analysis of variance of the effect of breed, month of lactation and month of pregnancy on the studied traits of cows was carried out using a linear model (2):

$$y_{ijk} = a_i + b_j + c_k + e_{(ij)(k)}, \quad (2)$$

where $y_{ijk}$ is the trait under study, $a_i$ is the effect of the i-th breed, $b_j$ is the effect of the j-th month of lactation, $c_k$ is the effect of the k-th month of pregnancy, and $e_{(ij)(k)}$ is the residual.

The degree of influence of factors on the studied traits of beef cattle was calculated by the ratio of variances according to formula (3):

$$\eta 2 = (SSA/SSD)\ 100\%, \tag{3}$$

where SSA is the sum of squared deviations due to the influence of factor A; SSD is the total sum of squared deviations.

Statistical analysis (descriptive statistics, analysis of variance, and correlation analysis) was performed using RStudio software. The following were selected as the main biochemical characteristics:

➤ total bilirubin – a breakdown product of haemoglobin (red blood cells), myoglobin and cytochromes in the form of direct (bound, conjugated) and indirect (free, unbound or unconjugatedfractions, as an indicator for the diagnosis of liver diseases;

➤ direct bilirubin as a sensitive marker of liver pathology, which provides a connection of total bilirubin with glucuronic acid (a low-toxic fraction of total bilirubin) in hepatocytes (liver cells);

➤ urea is the end product of the breakdown of proteins and amino acids, which accounts for more than 50% of residual nitrogen in the body;

➤ creatinine, a byproduct of protein breakdown, supplies energy to muscles. Blood creatinine levels are directly related to an individual's muscle mass and body weight;

➤ alanine aminotransferase (ALT) is an enzyme primarily located in liver and kidney tissues, with smaller quantities present in heart and muscle tissues;

➤ aspartate aminotransferase (AST) is an enzyme distributed throughout the body's cells, with the highest concentration in the liver;

➤ gamma-glutamyl transferase (GGT) is an enzyme found in liver cells and the bile ducts, where it facilitates specific biochemical processes;

➤ glucose – blood glucose analysis is considered a useful tool for rapid diagnosis and differentiation of ketosis (Mair *et al.*, 2016);

➤ albumin – their balance is necessary to prevent fluid loss through blood vessels. Normal levels of total protein, albumin and globulin were 6.70-9.40 g/dl, 2.87-4.29 g/dl, and 3.03-5.73 mg/l, respectively;

➤ total protein – shows the concentration of proteins in the blood plasma, which consists of three main groups of components: albumin, globulins and fibrinogen.

Blood samples for subsequent analysis were taken two hours after feeding.

***Table 2.*** *Influence of the breed factor on the main productive indicators*

| Factor, indicator | Middle square | Fisher's F-test | $\eta^2$, % |
|---|---|---|---|
| Fat content | 18.132 | 8.089*** | 14.6 |
| ECM | 95,921,886.182 | 49.790*** | 51.2 |

**Note:** ECM – total energy content of milk; *** – P > 0.999; ** – P > 0.99; * – P > 0

**Source:** developed by the authors on the basis of research

## Results and Discussion

The general results of the impact of such a variable as breed are presented in Table 2.

The breed factor played a significant role in influencing the traits of fat content in milk and ECM, the values of which were 14.6% and 51.2%, respectively (Table 2). Significant differences in the performance data between the combined Simmental, Ukrainian Red-and-White and Black-and-White dairy breeds were caused by their production orientation, which affected the digestion characteristics in general and especially nitrogen digestion.

To accurately describe the characteristics of nitrogen digestion, absorption and metabolism, urea levels, as well as nitrogen utilisation efficiency and profit maximisation, M. Meng *et al.* (2019) recommend using the "Molly the Cow Model" (Fig. 1).

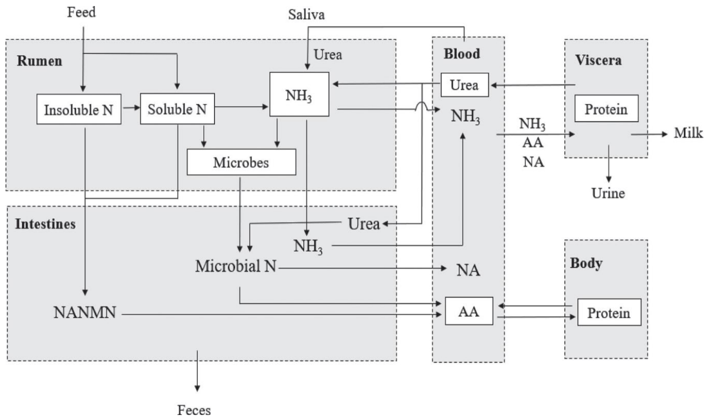


**Figure 1.** Conceptual diagram of nitrogen metabolism in ruminants – the "Molly model"
**Note:** NANMN – nonammonia, nonmicrobial nitrogen; NA – nucleic acids; AA – amino acids; N – nitrogen; $NH_3$ – hydrogen nitrite (ammonia). The darkened areas represent organs and tissues where biochemical processes take place, and arrows indicate the direction of movement of these processes
**Source:** M. Meng *et al.* (2019)

According to P. Gregorini *et al.* (2013), this model is a deterministic, mechanistic, dynamic model that represents the digestion, metabolism and production of a dairy cow based on mathematical equations. The authors compared the predictions of enteric (when the feed substrate passes through the entire gastrointestinal tract) methane production with the original mathematical version of Molly Origin and two updated versions based on a number of biochemical and genetic parameters that correspond to the design of this experiment. Thus, these versions included the effect of scar tissue, digestive parameters and hormonal parameters (Molly84) with a revised version of digestive and ruminal parameters (Molly85). This model was partly used to explain the influence of genetic (breed) and organisational factors (month of lactation, month of pregnancy), the results of which are shown in Table 3.

***Table 3.*** *Effect of breed, month of lactation and month of pregnancy on the studied blood traits of cows*

| Factor, indicator | Sum of squared deviations | Number of degrees of freedom | Mean square of deviations | Fisher's F-test | $\eta^2$, % |
|---|---|---|---|---|---|
| **Total bilirubin, μmol/l** | | | | | |
| Breed | 212.0 | 2 | 106.02 | 15.566*** | 24.7 |
| Month of lactation | 56.6 | 7 | 8.09 | 1.187 | 6.6 |
| The month of pregnancy | 24.9 | 6 | 4.15 | 0.610 | 2.9 |
| Balance | 565.3 | 83 | 6.81 | | |
| **Direct bilirubin, μmol/l** | | | | | |
| Breed | 2.261 | 2 | 1.1303 | 3.857* | 7.7 |
| Month of lactation | 0.507 | 7 | 0.0725 | 0.247 | 1.7 |

Table 3. Continued

| Factor, indicator | Sum of squared deviations | Number of degrees of freedom | Mean square of deviations | Fisher's F-test | $\eta^2$, % |
|---|---|---|---|---|---|
| The month of pregnancy | 2.086 | 6 | 0.3477 | 1.187 | 7.1 |
| Balance | 24.324 | 83 | 0.2931 | | |
| **Urea, mmol/l** | | | | | |
| Breed | 4.060 | 2 | 2.0300 | 25.506*** | 33.2 |
| Month of lactation | 0.950 | 7 | 0.1357 | 1.704 | 7.8 |
| The month of pregnancy | 0.625 | 6 | 0.1042 | 1.310 | 5.1 |
| Balance | 6.606 | 83 | 0.0796 | | |
| **Creatinine, µmol/l** | | | | | |
| Breed | 13,632 | 2 | 6,816 | 57.393*** | 49.8 |
| Month of lactation | 1,719 | 7 | 246 | 2.068 | 6.3 |
| The month of pregnancy | 2,167 | 6 | 361 | 3.041** | 7.9 |
| Balance | 9,857 | 83 | 119 | | |
| **ALT, U/l** | | | | | |
| Breed | 236.1 | 2 | 118.06 | 5.569** | 10.4 |
| Month of lactation | 157.3 | 7 | 22.47 | 1.060 | 6.9 |
| The month of pregnancy | 120.2 | 6 | 20.04 | 0.945 | 5.3 |
| Balance | 1,759.6 | 83 | 21.20 | | |
| **AST, U/l** | | | | | |
| Breed | 14,964 | 2 | 7,482 | 38.432*** | 46.3 |
| Month of lactation | 578 | 7 | 83 | 0.424 | 1.8 |
| The month of pregnancy | 618 | 6 | 103 | 0.529 | 1.9 |
| Balance | 16,158 | 83 | 195 | | |
| **Glucose, mmol/l** | | | | | |
| Breed | 0.811 | 2 | 0.4054 | 1.713 | 0.004 |
| Month of lactation | 0.742 | 7 | 0.1061 | 0.448 | 0.004 |
| The month of pregnancy | 2.386 | 6 | 0.3977 | 1.680 | 0.01 |
| Balance | 19.646 | 83 | 0.2367 | | |
| **Albumin, g/l** | | | | | |
| Breed | 191.34 | 2 | 95.67 | 28.461*** | 35.1 |
| Month of lactation | 36.48 | 7 | 5.21 | 1.550 | 6.7 |
| The month of pregnancy | 37.63 | 6 | 6.27 | 1.866 | 6.9 |
| Balance | 279.00 | 83 | 3.36 | | |
| **Total protein, g/l** | | | | | |
| Breed | 479.7 | 2 | 239.87 | 7.809*** | 13.2 |
| Month of lactation | 514.8 | 7 | 73.54 | 2.394* | 14.2 |
| The month of pregnancy | 86.7 | 6 | 14.45 | 0.470 | 2.4 |
| Balance | 2,549.7 | 83 | 30.72 | | |
| **GGT U/l** | | | | | |
| Breed | 135.8 | 2 | 67.90 | 1.855 | 3.5 |
| Month of lactation | 246.2 | 7 | 35.18 | 0.961 | 6.3 |
| The month of pregnancy | 504.9 | 6 | 84.16 | 2.298* | 12.9 |
| Balance | 3,039.0 | 83 | 36.61 | | |

**Note:** *** – P > 0.999; ** – P > 0.99; * – P > 0.95

**Source:** developed by the authors on the basis of research

A significant influence of the breed factor was noted in such blood biochemical parameters as total bilirubin 24.7%, urea 33.2%, creatinine 49.8%, alanine aminotransferase (ALT) 10.4%, aspartate aminotransferase (AST) 46.3%, albumin 35.1% and total protein 13.2% (Table 3). The influence of the breed factor had a significant impact due to the contrasting performance indicators between the compared groups for the entire lactation period (Table 2), which was implemented under the same feeding conditions and carried out on the principle of "no restrictions".

According to DairyNZ (2023), a New Zealand livestock breeding website aimed at farmers, milk urea "indicates" the level of crude protein in a cow's diet, which is produced by the metabolism of amino acids and protein in the body. If a cow's diet is rich in protein, she can produce more urea, which is usually excreted in urine and milk. On the other hand, when the diet lacks nitrogen, the cow's body redirects the urea back into the rumen. Urea levels in milk have been shown to differ in early, mid and late lactation (Table 4).

***Table 4.*** *Recommended nutritional requirements for cows in crude protein (CP) and MUN levels at different stages of lactation*

| Indicators | Early lactation | Mid-lactation | Late lactation |
|---|---|---|---|
| Minimum CP*% in the diet | 18 | 16 | 14 |
| Approximate MUN (mg/dl) | 25-40 | 25-30 | 20-25 |

**Note:** * – crude protein
**Source:** DairyNZ (2023)

In New Zealand's pasture-based systems, MUN levels are higher than where cows are fed a general mixed diet (i.e. USA, Western Europe, the conditions of this study). This is due to the high amount of crude protein (around 20 and sometimes 30 mg/dl) that cows receive on good quality pasture, travelling long distances. Other factors include water intake, cow condition, lactation stage, season, genetics, milking frequency, rumen health and liver function. Table 5 shows the degree of correlation between biochemical parameters.

A correlation was established between the concentrations of urea, which is the main nitrogenous end product of protein and amino acid catabolism, and creatinine, a product of creatine phosphate breakdown in muscles, including Simmental, Ukrainian Red-White, and Ukrainian Black-White dairy cows (Table 5). The total correlation coefficient for plasma urea and creatinine is 0.552, which shows a positive relationship with the value of $m_r = 0.000$ ($p \leqslant 0.01$), indicating an increase in the level of creatinine in the blood plasma of the studied groups of cows with an increase in the value of urea and vice versa. As in the work of M. Edvardsson *et al.* (2018), a positive correlation was established between creatinine and aspartate aminotransferase, which characterises the functional state of the liver, as well as albumin in the blood plasma of the studied animal groups. The total correlation coefficient is 0.457 and 0.744, respectively, with a value of $m_r = 0.000$ ($p \leqslant 0.01$) and is consistent with changes in the level of these indicators in each of the studied groups of cows. A negative correlation was observed between the concentration of urea and the level of alanine aminotransferase in the blood plasma of cows with a correlation coefficient $r = 0.229$, $m = 0.022$ ($p \leqslant 0.05$). The total correlation coefficient for urea, albumin and total plasma protein is 0.454 with a value of $m_r = 0.000$ ($p \leqslant 0.01$) and 0.0234 with a value of $m_r = 0.019$ ($p \leqslant 0.05$), respectively.

***Table 5.*** *Matrix of correlation coefficients between biochemical parameters of cows' blood (total sample – 100 cows)*

| Indicators | Total bilirubin, μmol/l | Direct bilirubin, μmol/l | Urea, mmol/l | Creatinine, μmol/l | ALT, U/l | AST, U/l | Glucose, mmol/l | Albumin, g/l | Total protein, g/l |
|---|---|---|---|---|---|---|---|---|---|
| Bilirubin total | 1.00 | - | - | - | - | - | - | - | - |
| Bilirubin direct | 0.336 ± 0.001** | 1.00 | - | - | - | - | - | - | - |
| Urea | -0.171 ± 0.091 | 0.111 ± 0.272 | 1.00 | - | - | - | - | - | - |
| Creatinine | -0.089 ± 0.384 | 0.103 ± 0.306 | 0.552 ± 0.000** | 1.00 | - | - | - | - | - |
| ALT | 0.114 ± 0.263 | 0.183 ± 0.068 | -0.229 ± 0.022* | -0.008 ± 0.937 | 1.00 | - | - | - | - |
| AST | 0.333 ± 0.001** | 0.238 ± 0.017* | 0.182 ± 0.071 | 0.457 ± 0.000** | 0.144 ± 0.152 | 1.00 | - | - | - |
| Glucose | -0.021 ± 0.838 | -0.301 ± 0.002** | 0.098 ± 0.331 | 0.110 ± 0.276 | -0.129 ± 0.200 | 0.001 ± 0.996 | 1.00 | - | - |
| Albumin | -0.140 ± 0.168 | -0.002 ± 0.986 | 0.454 ± 0.000** | 0.744 ± 0.000** | 0.112 ± 0.268 | 0.368 ± 0.000** | 0.211 ± 0.035* | 1.00 | - |
| Total protein | -0.152 ± 0.133 | -0.126 ± 0.211 | 0.234 ± 0.019* | 0.024 ± 0.812 | -0.548 ± 0.000** | -0.016 ± 0.873 | -0.005 ± 0.958 | 0.064 ± 0.527 | 1.00 |
| GGT | -0.192 ± 0.058 | -0.048 ± 0.637 | 0.125 ± 0.217 | -0.053 ± 0.604 | -0.108 ± 0.286 | -0.184 ± 0.069 | -0.149 ± 0.141 | -0.086±0.397 | 0.189 ± 0.061 |

**Note:** significance level where $^{*}p \leqslant 0.05$, $^{**}p \leqslant 0.01$

**Source:** developed by the authors on the basis of research

A positive correlation was found between the concentration of direct bilirubin, which is an endogenous antioxidant and the level of glucose and AST in the blood of the studied groups of cows, the correlation coefficient of which is 0.301 with a value of $m_r = 0.002$ ($p \leqslant 0.01$) and 0.238 with a value of $m_r = 0.017$ ($p \leqslant 0.05$). The values of the correlation coefficients are consistent with changes in the level of indicators in each of the studied groups of cows (Table 1).

Thus, the breed factor introduces significant differences in a wide range of biochemical parameters, which can be used for targeted selection programmes and achieving positive results in improving both health and reducing methanogenesis in ruminants. Both excessively high and low values of BUN and MUN are undesirable for dairy cows due to their negative impact on reproductive performance, health and nitrogen use efficiency (Fig. 2).

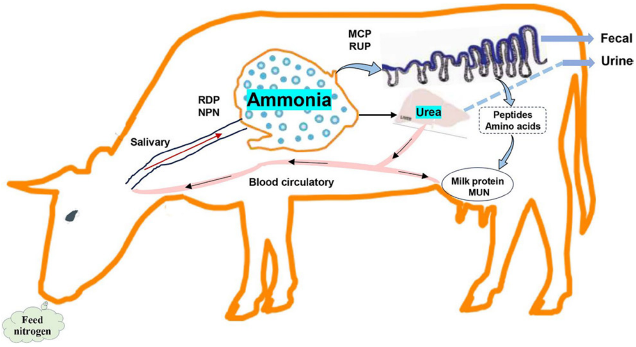


**Figure 2.** The process of nitrogen metabolism in cattle
**Note:** RDP – rumen degradable protein; RUP – rumen unprocessable protein; MCP – microbial protein; NPN – non-protein nitrogen; MUN – milk urea nitrogen
**Source:** X. Zhao *et al*. (2025)

Studies have shown that MUN, like BUN, is a trait with low to moderate heritability and is positively correlated with nitrogen release. According to X. Zhao *et al.* (2025), there are still inconsistencies in the selection of cows with low MUN values, which can effectively reduce nitrogen excretion and affect other economic parameters of dairy cows, as well as reduce nitrogen emissions. In addition, O. Fedota *et al.* (2020; 2022) proved that changes in blood parameters may depend on the body's response to xenobiotics, depending on the genotype, in particular on liver enzyme genes, which was observed both in animals and in medical practice. Thus, the analysis of correlations between biochemical blood parameters in cows of different breeds suggests the existence of breed specificity of metabolic processes, which should be taken into account when developing breeding programmes and animal breeding technologies.

## Conclusions

A significant influence of the breed factor (Simmental, Ukrainian Red-and-White dairy and Ukrainian Black-and-White dairy breeds) on the fat content in milk (14.6%), total energy value of milk (51.2%), urea level (33.2%) and blood biochemical parameters was established. Breed or breed factor has a significant impact on blood chemistry parameters such as total bilirubin (24.7%), urea (33.2%), creatinine (49.8%), alanine aminotransferase (ALT) (10.4%), aspartate aminotransferase (AST) (46.3%), albumin (35.1%) and total protein (13.2%). This relationship indicates the possibility of using these indicators in selection programmes aimed at reducing nitrogen emissions and the use of certain biochemical indicators to monitor animal health and welfare.

The correlation between the concentrations of urea and creatinine in the blood plasma of the studied groups of animals was established. The general correlation coefficient for plasma urea and creatinine indicates an increase in the level of creatinine in the blood plasma of the studied groups of cows with an increase in the value of urea and vice versa. A positive correlation is observed between creatinine and aspartate aminotransferase, as well as albumin in the blood plasma of the studied groups of animals. A negative correlation was observed between the concentration of urea and the level of alanine aminotransferase in the blood plasma of cows. A positive correlation was found between the concentration of direct bilirubin and the level of glucose and AST in the blood of the studied groups of cows, and between the content of urea and albumin, urea and total plasma protein. The values of the correlation coefficients are consistent with changes in the level of indicators for each of the studied groups of cows - Simmental, Ukrainian Red-and-White dairy, Ukrainian Black-and-White dairy breeds.

In order to correctly describe the peculiarities of ruminant digestion, assimilation and metabolism of feed resources, urea levels and a wide range of biochemical parameters of blood and milk, it is necessary to use the "Molly the Cow Model". Building experiments on this principle to assess the effect of a wide range of genetic and organised (non-genetic) factors on nitrogen digestion opens up the possibility of a systematic view of solving environmental, economic and biological problems. Further research should be aimed at a comprehensive assessment of the factors influencing the peculiarities of nitrogen metabolism, which finds its application not only in the agricultural sector but also in medicine.

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## Conflict of Interest

The authors declare no conflict of interest.

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# Вплив породного фактору на рівень сечовини та біохімічні показники крові в молочному скотарстві

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**Анотація.** Молочне скотарство досягло великих успіхів завдяки цілеспрямованому удосконаленню молочних та комбінованих порід у різних кліматичних і агроекологічних зонах світу. Рівень сечовини та інших біохімічних показників крові корів свідчить про особливості вуглеводно-білкового балансу, його вплив на відтворювальні функції, стан здоров'я, ефективність використання корму, інтенсивність викидів метану. Мета дослідження полягала у визначенні впливу породного фактору на рівень сечовини та інші біохімічні показники крові корів різних порід. Дослідження проведені на коровах трьох контрастних між собою порід. Перша порода – комбінована (транскордонна) симентальська, дві останні місцеві – українська червоно-ряба молочна (створена шляхом комбінаційного схрещування симентальської породи з айрширською, монбельярдською, голштинською) та українська чорно-ряба молочна (створена на основі схрещування місцевої чорно-рябої з голштинською). Дослід проведено у стандартних умовах при годівлі корів «без обмежень» з аналізом продуктивних показників та біохімічних показників крові. Найбільш суттєвим фактором впливу на продуктивні та біохімічні показники був фактор породи, який склав за ознаками вмісту жиру в молоці та надою в перерахунку на загальну енергетичну цінність відповідно 14,6 % та 51,2 %. Вірогідний вплив породи відзначено за такими біохімічними показниками крові, як рівень загального білірубіну 24,7 %, сечовини 33,2 %, креатиніну 49,8 %, аланінамінотрансферази 10,4 %, аспартатамінотрансферази 46,3 %, альбуміну 35,1 % та загального білка 13,2 %. Встановлена вірогідна кореляційна залежність між концентраціями сечовини та креатиніном, креатиніном та аспартатамінотрансферазою, а також альбуміном у плазмі крові досліджуваних груп тварин. Зроблено попередній висновок про наявність суттєвої генетичної компоненти впливу на рівень сечовини, біохімічних показників крові та ознак продуктивності. Аналіз прояву таких ознак у різних порід можна враховувати в програмах відбору та створенні відповідних умов годівлі, враховуючи особливості білкового живлення

**Ключові слова:** рівень сечовини в крові; азот сечовини крові; молочні породи України; симентальська порода; ступінь впливу породи