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Research article

Effect of abiotic feeding factors on mineral metabolism in bulls

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Abstract

Importance of the work: The study of the combined effects of the wormwood plant (*Artemisia absinthium* L.) and trace elements is crucial for understanding their impact on cattle metabolic systems.

Objectives: To evaluate the effect of *Artemisia absinthium* L. and cobalt chelate compounds on the metabolic parameters and mineral metabolism of bulls.

Materials and Methods: The study was undertaken at the Federal Scientific Center for Biological Systems and Agrotechnology of the Russian Academy of Sciences using a sample of 16 Kazakh bulls (white-headed breed, aged 13−14 mth). The experiment used a 4 × 4 Latin square design, comprising four repetitions with four bulls per group, across 17 d periods (10 d of adaptation and 7 d of sampling). Blood samples were collected during each sampling period to determine biochemical indicators and trace elements. Biochemical analyses were performed using an automatic biochemical analyzer, while trace element levels in serum were assessed using inductively coupled plasma spectrometry.

Results: Alterations in feeding conditions significantly affected the metabolism of the Kazakh white-headed bulls. During the experimental period, incorporating a plant-based feed supplement derived from *Artemisia absinthium* L. was an optimal strategy for enhancing metabolic processes and promoting growth in the bulls. The combined introduction of wormwood and cobalt compounds into the diet resulted in increases in the levels of cobalt (Co) by 67% ($p = 0.002$), chromium by 80% ($p = 0.004$) and selenium by 12% ($p = 0.05$). Furthermore, when Co compounds were administered alone, there was a notable increase in Co levels by 100% ($p = 0.002$), accompanied by a decrease in iodine levels by 33% ($p = 0.007$). Additionally, groups receiving wormwood supplements had increased concentrations of heavy metals (nickel and lead) exceeding 10%.

Main finding: Feeding a plant-based additive comprising *Artemisia absinthium* L. and cobalt chloride ($CoCl_2$) compounds was optimal for cattle. This combined supplementation effectively enhanced protein, carbohydrate, lipid and mineral metabolism in the bulls.

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Introduction

High meat productivity of farm animals, achieved due to the success of genetics and breeding, has caused an increased load on these animals' metabolic processes (Mwangi et al., 2019). This has resulted in a decrease in their adaptive capabilities, a change in the degree of tension of regulatory processes and, consequently, depletion of functional reserves, which affects cattle health (Gaughan et al., 2018). In animal husbandry, it is known that the health of farm animals largely determines their productivity and the quality of their derived products (Tüfekci and Sejian, 2023). In this regard, it is relevant to search for new effective methods for optimizing the metabolic processes of the ruminants' organisms, as well as reducing any negative effects of stress on the physiological systems of the body.

Accumulated scientific and practical experience testifies to the key role of various nutritional factors in the work of the metabolic, endocrine and immune systems of the body (Kegley et al., 2016; Malau-Aduli et al., 2021; Liu et al., 2022). At present, there is extensive practical material on the use of feed additives, including phytobiotics and trace elements, in cattle diets in animal husbandry (Haug et al., 2018; Jahani-Azizabadi et al., 2022). Scientists have established the positive effects of their use, which is expressed in improvements to metabolic and digestive processes and reduced morbidity, as well as the realization of the productive qualities of farm animals (Budde et al., 2019; Wang et al., 2022).

In the search for new feed additives, scientists are increasingly turning to plants of the family *Asteraceae (*the Compositae*)*, with one species being *Artemisiae absinthium* L., commonly known as bitter wormwood (Beigh and Ganai, 2017; Mravčáková et al., 2020). Wormwood contains a high concentration of biologically active substances, including essential oils, alkaloids, flavonoids, glycosides, saponins, tannins and coumarins, due to which it has antimicrobial, antiviral, antiparasitic, anti-inflammatory, antioxidant and immunomodulatory properties (Mahmood and Abdullah, 2023; Koulu et al., 2016; Batiha et al., 2020). The use of *A. absinthium* in the diet of farm animals had a positive effect on digestion processes, enzyme synthesis, digestibility and assimilation of feed nutrients, as well as regulating and stimulating the activity of gastrointestinal tract microflora, thereby indirectly affecting the growth performance and carcass quality of beef cattle (Kim et al., 2012; Lee et al., 2020).

Notably, complex feed additives are widely used, combining the composition of several components, the use of which has a positive effect on a number of systems and subsystems of the animal body (Buryakov et al., 2023). However, published data on the combined use of phytobiotics and minerals are still scarce. The essential trace element cobalt (Co), which participates in many functional processes of the organism, plays an important role in the regulation of vital activity processes in the body (Strachan, 2010; Lison, 2015). A number of studies have demonstrated the importance of Co in ruminant nutrition and its key function in the synthesis of water-soluble vitamin B_{12} (cobalamin, cyanocobalamin) in the rumen (Stemme et al., 2008; Watanabe and Bito, 2018). Thus, this chemical element has a significant impact on the processes of hematopoiesis, as well as being a coenzyme of a number of vital enzymes affecting metabolic reactions in the body (González-Montaña et al., 2020; Jomova et al., 2022).

Currently, the available literature provides limited information on the state of mineral metabolism of cattle as background to the separate and combined applications of additives of bitter wormwood and cobalt chelate compounds. The current study hypothesized that supplementation with *A. absinthium* alone or in combination with cobalt chelate compounds could have major effects on the metabolic parameters and mineral metabolism of bulls, particularly in terms of glucose, total protein, cholesterol, triglycerides and certain trace elements. This hypothesis was tested in the current study through the investigation of the mineral metabolism of bulls when fed the herbaceous plant *A. absinthium* alone or in combination with cobalt chelate compounds.

Materials and Methods

The experimental design was approved by the Local Ethics Committee of the Federal Research Centre for Biological Systems and Agrotechnologies, Russian Academy of Sciences (Protocol No. No. 2/1 dated 30 April 2024). All animal studies complied with the ethical standards outlined in the 1964 Declaration of Helsinki and its later amendments. The research was conducted in 2024 at the physiological yard (vivarium; 51.777029°N, 55.237674°E) of the Federal Scientific Center for Biological Systems and Agrotechnologies of the Russian Academy of Sciences, Orenburg, Russia. The study involved clinically healthy bulls of the Kazakh white-headed breed ($n = 16$, with 4 animals in each experimental group), aged 13−14 mth, with an average live weight standard deviation (± SD) of 330 ± 1.65 to 335 ± 1.83 kg. Health status was confirmed based on anamnesis, including assessments of general condition, body temperature, arterial pulse, mucosa and lymph nodes.

The experiment was conducted in four replicates following a 4 × 4 Latin square design with four bulls per group. Each experimental period lasted 17 d, comprising 10 d of adaptation followed by 7 d of data collection, with a 1 wk rest period between each phase. The whole-plot factor was the type of supplementation, with four dietary treatments: 1) the control group received a basal diet (BD); experimental group I received the BD supplemented with *Artemisia absinthium* at a dose of 2.0 g/kg dry matter (DM); experimental group II received the BD supplemented with both *A. absinthium* (2.0 g/kg DM) and $CoCl_2$ (1.5 mg/kg DM); and experimental group III received the BD with $CoCl_2$ alone at a dose of 1.5 mg/kg DM. Each bull was housed individually in a pen measuring 125 cm in width and 210 cm in length, with *ad libitum* access to water. The diet was formulated to meet the nutrient requirements of Kazakh white-headed breed bulls following the guidelines provided by Kalashnikov et al. (2003).

Table 1 Composition of bull diet

Ingredient	%
Mixed grass hay	47.4
Legume hay	32.6
Grain mixture	19.0
Mineral	1.0
Total	100
(% DM)	
Dry matter	94.7
Crude protein	5.9
Crude fiber	36.75
Neutral detergent fiber	63.12
Acid detergent fiber	46.51
Hemicellulose	16.61
Crude fat	2.73
Organic matter	93.4
Calcium	0.51
Phosphorus	0.37
Crude ash	1.28
Nitrogen free extract	53.8

Artemisia absinthium L. (Asteraceae) plant material was supplied by the pharmaceutical company Krasnogorskleksredstva, located in Krasnogorsk, Moscow Region, Russia. The material, including stem, leaf and inflorescence fragments, was ground to a particle size of 2–4 mm,. Cobalt (II) chloride ($CoCl_2$) was provided by LLC NPK Ascont+, Moscow, Russia. The supplement was in tablet form, containing 40 mg of cobalt chloride as the active ingredient, with additional excipients up to a total weight of 1 g.

Blood samples were collected for biochemical and elemental analysis during each sampling period. Jugular vein blood was drawn into vacuum tubes containing a clot activator and a gel separator (Greiner Bio-One International AG; Kremsmünster, Austria), using a 14 G veterinary blood collection needle (Yangzhou Goldenwell Import and Export Co.; Ltd., Jiangsu , China). Samples were collected at the start and end of each period in the morning.

Following coagulation, samples were centrifuged at 1,600×*g* for 10 min. Then, the serum was divided into two aliquots, with only those without signs of hemolysis being used for subsequent analyses. Biochemical parameters (glucose, total protein, albumin, total cholesterol and triglycerides) were measured using a CS-T240 automated biochemical analyzer (Dirui Industrial Co., Ltd.; Changchun, China) with Commercial biochemical kits (Randox; Montgomery, USA). Serum aliquots were frozen at -70°C in an 803CV freezer (Thermo Fisher Scientific; Dreieich, Germany) until further analysis.

For elemental analysis, serum samples were diluted (1:15, weight per weight) in an acidified diluent (pH 2.0), composed of 1% 1-butanol (Merck KGaA; Darmstadt, Germany), 0.1% Triton X-100 (Sigma-Aldrich; St. Louis, MO, USA), and 0.07% HNO_3 (Sigma-Aldrich; St. Louis, MO, USA) in deionized water (18 MΩ/cm; Merck Millipore; Burlington, VT,USA). Macro-elements (Ca, K, Mg, Na, P), essential trace elements (Co, Cr, Cu, Fe, I, Li, Mn, Se, Si, V, Zn), and toxic trace elements (As, B, Cd, Hg, Ni, Pb, Sn, Sr) were quantified using a NexION 300D ICP-MS spectrometer (Perkin Elmer; Shelton, CT, USA) with single-element standards (Perkin Elmer Inc.; Shelton, CT, USA). Yttrium (10 μg/L) was used as an internal standard for online standardization.

Live weight was recorded monthly based on the individual bull weight before morning feeding and watering, with absolute and average daily weight gains subsequently calculated.

Statistical analysis

Statistical analysis was performed using the Statistica version 10 software (StatSoft Inc.; Tulsa, OK, USA), with preliminary data storage and processing in Microsoft Excel 2010 (Microsoft Corp.; Redmond, WA, USA). Data normality was assessed based on the Shapiro-Wilk test. Normally distributed data were presented as mean ± SD, while non-normally distributed data were reported as the median (Me) and 25th to 75th percentiles (Q25–Q75). The significance threshold was set at $p < 0.05$, with statistical differences evaluated using Student's t test, considering values of $p < 0.05$ as significant and $p < 0.01$ as highly significant. The hypothesis that the data belonged to a normal distribution was rejected in all cases with a probability of 95%, which justified the use of non-parametric procedures for downstream statistical analyses, with differences among group means tested based on Mann-Whitney U-tests.

Ethical statement

The experimental design was approved by the Local Ethics Committee of the Federal Research Centre for Biological Systems and Agrotechnologies, Russian Academy of Sciences (Protocol No. No. 2/1 dated 30 April 2024). All animal studies complied with the ethical standards outlined in the 1964 Declaration of Helsinki and its later amendments.

Results

The addition of wormwood and Co supplements, both individually and in combination, did not result in clinically significant deviations in blood biochemical parameters, with all measured values remaining within their reference ranges. Notably, experimental groups I, II and III had increases in the glucose, total protein, cholesterol and triglycerides contents, though these values remained within the physiological range (Table 2)

In the group receiving *A. absinthium* supplementation, there were significant increases in the levels of glucose by 4% ($p = 0.05$), total protein by 65% ($p = 0.02$), cholesterol by 18% ($p = 0.05$) and triglycerides by 55% ($p = 0.04$) compared to the control. In the group with combined supplementation of *A. absinthium* and $CoCl_2$, glucose levels increased by 5% ($p = 0.03$), total protein by 70% ($p = 0.02$), albumin by 6% ($p = 0.01$), and cholesterol by 16% ($p = 0.02$), while the triglyceride content decrease by 45% compared to the control. In the group supplemented solely with $CoCl_2$, there was an increase in the levels of glucose by 24% ($p = 0.05$), total protein by 42% ($p = 0.05$), cholesterol by 45% ($p = 0.02$), and triglycerides by 164% ($p = 0.02$) compared to the control.

Table 3 provides data on the macro and trace element contents in the blood serum of bulls across all groups. Comparative analysis of the macronutrient levels in the serum revealed no statistically significant differences between the experimental groups and the control. However, further analysis indicated that the addition of *A. absinthium* and $CoCl_2$, both individually and in combination, influenced the levels of several essential trace elements.

Table 2 Biochemical indicators of blood from bulls

Indicator	Control group	Experimental group I	Experimental group II	Experimental group III
Glucose (mmol/L)	3.81 ± 0.03	3.97 ± 0.05*	4.00 ± 0.04*	4.71 ± 0.09*
Total protein, (g/L)	67.65 ± 0.08	111.30 ± 0.17*	115.00 ± 0.12*	96.07 ± 0.11*
Albumin (g/L)	35.00 ± 0.06	36.00 ± 0.04	37.00 ± 0.05*	34.00 ± 0.08
Cholesterol, (mmol/L)	2.03 ± 0.06	2.39 ± 0.04*	2.36 ± 0.06[b]	2.94 ± 0.08*
Triglycerides, (mmol/L)	0.11 ± 0.04	0.17 ± 0.03*	0.06 ± 0.002	0.29 ± 0.01*

Control group received basal diet (BD); experimental group I received BD supplemented with *Artemisia absinthium* at 2.0 g/kg dry matter (DM); experimental group II received BD supplemented with both *A. absinthium* (2.0 g/kg DM) and $CoCl_2$ (1.5 mg/kg DM); and experimental group III received BD with $CoCl_2$ alone at 1.5 mg/kg DM.

* = significant ($p < 0.05$) difference compared to control group; ** indicates highly significant ($p < 0.01$) difference compared to control group.

Values shown as Mean ± SD.

Table 3 Elemental concentration in serum of bulls fed different nutrients in diet (μg/mL)

Indicator element	Control group	Experimental group I	Experimental group II	Experimental group III
		Macro elements		
Ca	117.0 (115.5–118.2)	114.1 (113.1–116.3)	120.0 (116.9–122.0)	115.2 (114.5–116.2)
K	184.0 (175.0–192.2)	174.0 (167.7–177.0)	192.5 (190.9–201.1)	190.0 (177.5–200.0)
Mg	26.4 (25.7–27.3)	23.7 (22.6–24.7)	21.0 (20.1–22.4)	22.3 (21.7–24.5)
Na	3231.0 (3228.0–3240.8)	3225.6 (3168.6–3330.3)	3220.0 (3157.0–3238.0)	3343.7 (3238.0–3483.0)
P	129.4 (127.8–130.9)	127.0 (120.2–128.6)	117.9 (106.8–124.1)	127.0 (124.8–143.2)
		Trace elements		
Co	0.0009 (0.0008–0.00099)	0.00069 (0.00058–0.00077)	0.0015** (0.0013–0.0017)	0.0018** (0.0014–0.0019)
Cr	0.0173 (0.0062–0.0224)	0.0299 (0.0292–0.0308)**	0.0312 (0.0276–0.0344)**	0.0224 (0.0172–0.0262)
Cu	0.486 (0.479–0.488)	0.535 (0.506–0.552)*	0.504 (0.437–0.509)	0.484 (0.4750–0.5104)
Fe	2.71 (2.63–2.78)	2.6 (2.55–2.72)	2.6 (2.47–2.83)	2.51 (2.37–3.01)
I	0.089 (0.078–0.092)	0.063 (0.06–0.069)*	0.079 (0.077–0.09)	0.06 (0.056–0.064)**
Mn	0.0029 (0.0026–0.0034)	0.0028 (0.0026–0.003)	0.0027 (0,0021–0.0031)	0.0029 (0.0022–0.0038)

Table 3 Continued

Indicator element	Control group	Experimental group I	Experimental group II	Experimental group III
Se	0.041 (0.037–0.044)	0.06 (0.054–0.068)**	0.046 (0.044–0.051)*	0.052 (0.043–0.056)
Zn	0.958 (0.757–0.969)	0.777 (0.745–0.861)	0.716 (0.596–0.753)*	0.855 (0.826–0.881)
Ni	0.0058 (0.0055–0.0061)	0.0076 (0.0068–0.0089)*	0.0065 (0.0058–0.0068)	0.0062 (0.0061–0.0065)
V	0.0023 (0.002–0.0025)	0.0023 (0.0021–0.0026)	0.0026 (0.0024–0.0032)	0.0026 (0.0024–0.0028)
As	0.0019 (0.0018–0.002)	0.002 (0.0019–0.0021)	0.0019 (0.0017–0.002)	0,0022 (0.0019–0.0023)
Toxic elements				
Pb	0.0004 (0.00035–0.00042)	0.00048 (0.0004–0.0005)*	0.00045 (0.00041–0.00046)	0.00042 (0.0004–0.00043)
Sr	0.136 (0.134–0.138)	0.12 (0.11–0.132)	0.116 (0.094–0.121)	0.133 (0.124–0.158)

Control group received basal diet (BD); experimental group I received BD supplemented with *Artemisia absinthium* at 2.0 g/kg dry matter (DM); experimental group II received BD supplemented with both *A. absinthium* (2.0 g/kg DM) and $CoCl_2$ (1.5 mg/kg DM); and experimental group III received BD with $CoCl_2$ alone at 1.5 mg/kg DM.
* = significant ($p < 0.05$) difference compared to control group; ** indicates highly significant ($p < 0.01$) difference compared to control group.

In experimental group I, which received *A. absinthium* alone, there were significant increases in Cr by 73% ($p = 0.003$), Cu by 10% ($p = 0.02$), and Se by 46% ($p = 0.002$) compared to the control. In comparison, I levels were 29% lower ($p = 0.02$). These results are illustrated in Fig. 2.

In experimental group II, which received both *A. absinthium* and $CoCl_2$, there was a significant increase in serum Co by 67% ($p = 0.002$) relative to control levels, along with increases in Cr by 80% ($p = 0.004$) and Se by 12% ($p = 0.05$). Notably, Zn levels were significantly lower than in the control group by 25% ($p = 0.03$), as shown in Figs. 1 and 2.

In experimental group III, which received $CoCl_2$ alone, the only significant differences from values in the control were for the serum Co levels (100% higher, $p = 0.002$) and I (33% lower, ($p = 0.007$).

Notably, the serum levels of the analyzed chemical elements remained within the physiological range for cattle, except for Cu, which was below the recommended levels in the control group. Supplementation with the studied additives contributed to an increase in serum Cu levels, enhancing the availability of this essential element.

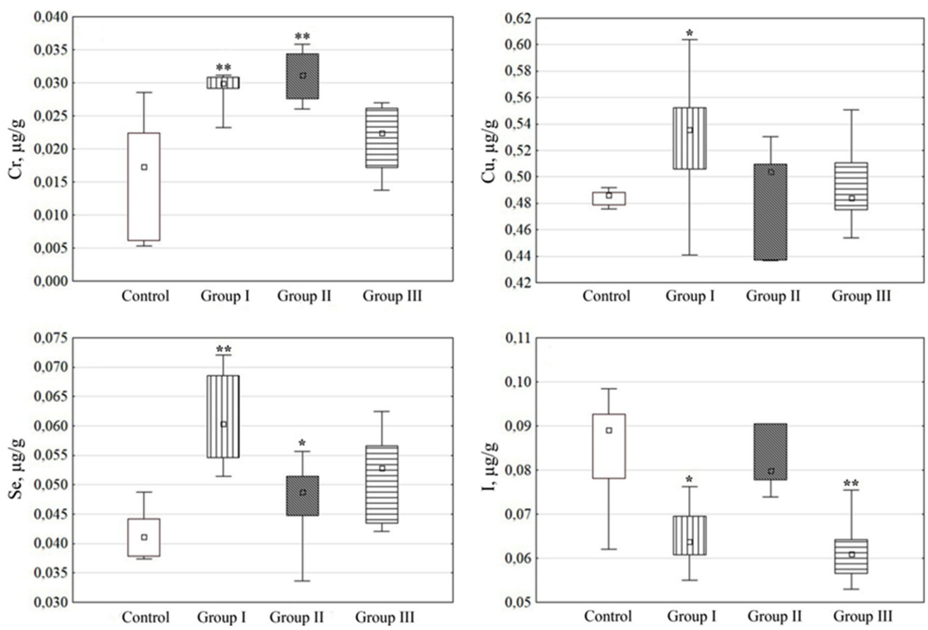

Fig. 1 Levels of chromium, copper, selenium and iodine in bull serum by experimental group, where control received basal diet (BD), group I received BD supplemented with *Artemisia absinthium* at 2.0 g/kg dry matter (DM), group II received BD supplemented with both *A. absinthium* (2.0 g/kg DM) and $CoCl_2$ (1.5 mg/kg DM), group III received BD with $CoCl_2$ alone at 1.5 mg/kg DM, vertical lines indicate an error, the box displays the interquartile range, and the point inside the box is the arithmetic mean of the sample, respectively, * = significant ($p < 0.05$) difference compared to control group and ** indicates highly significant ($p < 0.01$) difference compared to control group.

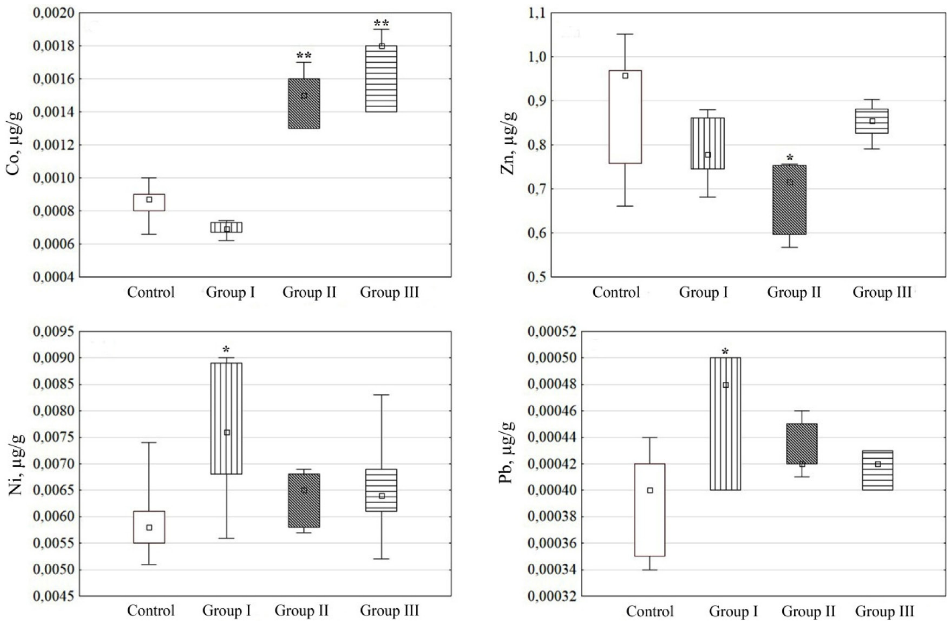

Fig. 2 Level of cobalt, zinc, nickel and lead in in bull serum by experimental group, where control received basal diet (BD), group I received BD supplemented with *Artemisia absinthium* at 2.0 g/kg dry matter (DM), group II received BD supplemented with both *A. absinthium* (2.0 g/kg DM) and $CoCl_2$ (1.5 mg/kg DM), group III received BD with $CoCl_2$ alone at 1.5 mg/kg DM, vertical lines indicate an error, the box displays the interquartile range, and the point inside the box is the arithmetic mean of the sample, respectively, * = significant ($p < 0.05$) difference compared to control group and ** indicates highly significant ($p < 0.01$) difference compared to control group

The study also examined the content of toxic elements. Concentrations of these elements were very low across all serum samples, posing no health risk to the cattle. However, the Ni and Pb levels in experimental group I, which received *A. absinthium* supplementation, were significantly higher than in the control group by 12% ($p = 0.02$) and 20% ($p = 0.05$), respectively. There were no significant differences in experimental group II, which received a combined supplement of *A. absinthium* and $CoCl_2$, though there was a trend toward increased levels of these elements (Fig. 2).

Discussion

This study provided a unique opportunity to assess the health status of Kazakh white-headed bulls after adding wormwood and Co supplements to their diet, both individually and in combination, using biochemical and elemental blood analyses. The biochemical blood analysis indicated that the glucose levels in all experimental groups were significantly higher than in the control, correlating with the supplementation of these additives. Notably, experimental group III, which received Co supplementation, had the most pronounced increase, with glucose levels rising by 24% ($p = 0.05$). These findings aligned with other studies reporting elevated glucose levels in lambs and steers upon dietary inclusion of Co compounds (Doornenbal et al., 1988; Tiffany and Spears, 2005; Bishehsari et al., 2010; Ryazanov et al., 2022). High dietary Co has been associated with increased propionate concentrations in the rumen, a primary gluconeogenic precursor, thereby explaining the observed rise in blood glucose levels in cattle (Dezfoulian and Aliarabi, 2017).

Based on the results of the current study, there was a significant increase in total protein levels across all experimental groups compared to the control. Notably, the group receiving the combined supplement of *A. absinthium* and $CoCl_2$ had the most substantial changes, with total protein and albumin levels exceeding their control values by 70% ($p = 0.02$) and 6% ($p = 0.01$), respectively. This increase in total protein and albumin levels could be attributed to several factors since the incorporation of Co into the diet is known to enhance rumen bacterial populations, improve nutrient absorption through the elongation of intestinal villi and increase the synthesis of vitamin B12-dependent enzymes, such as methylmalonyl-CoA mutase and methionine synthase, which are essential for protein synthesis and energy metabolism (Kadim et al., 2003). Furthermore, the literature indicates that *A. absinthium* may improve digestion in livestock, as studies have reported enhanced crude protein digestibility and growth performance in cattle when this phytobiotic is included in the diet (Kim et al., 2006; Ko et al., 2006). Other research related to the current project demonstrated that adding plant matter, in conjunction with micronutrients, positively impacted amino acid metabolism, thereby supporting the observed increase in total protein levels in the blood of the animals (Ryazanov et al., 2023).

In the bulls receiving *A. absinthium* and $CoCl_2$ supplements separately (experimental groups I and III, respectively), there were significant increases in their cholesterol and triglyceride levels compared to the control group. These findings could be considered somewhat controversial, as other studies have reported opposing effects. For example, researchers from the Republic of Korea indicated that extracts of *A. absinthium* lowered the total cholesterol and triglyceride levels in animal blood (Chu Park, 2022). Conversely, Iranian researchers reported no changes in lipid metabolism in animals receiving Co supplementation throughout their study (Dezfoulian and Aliarabi, 2017). The increase in cholesterol and triglycerides by more than 45% in experimental group III could be attributed to Co's ability to stimulate the production of reactive oxygen species (Simonsen et al., 2012). Notably, the current study identified that the combined use of bitter wormwood and Co resulted in a 45% decrease in triglyceride levels, alongside a modest increase in cholesterol levels by 16% (p = 0.02). Co's multifaceted effects on lipid metabolism involve influencing triglyceride synthesis, lipid transport and serum lipid levels. It is known that Co treatment can enhance triglyceride formation and alter lipoprotein composition, resulting in increased serum lipid concentrations, including cholesterol and triglycerides in experimental animals (Caplan et al., 1963; Vladov et al., 2020). However, the current results may have been due to the synergistic effects of combining wormwood and Co. Supplementation with *A. absinthium* had promising effects on improving lipid profiles and enhancing antioxidant activity. It appeared to improve nutrient digestibility, reduce harmful lipid fractions and increase beneficial lipid fractions, while demonstrating strong antioxidant properties that may protect against lipid peroxidation (Son et al., 2017; Beigh et al., 2019). These findings suggest that the combined use of *A. absinthium* and $CoCl_2$ may serve as a valuable dietary supplement for improving lipid metabolism and overall health.

The design of the current study in the form of a 4 × 4 Latin square scheme was chosen based on humane considerations and ethics to minimize the number of animals used in the experiment. Nevertheless, the Latin square model allowed for a full assessment of the impact of the studied feed additives. This model is often used in experiments on farm animals (Ahmed et al., 2017).

When evaluating the elemental status of the animals, it was found that in experimental groups I and II, which received *A. absinthium* supplementation in addition to their diet, the content of several trace elements in blood serum changed significantly. In group I, the intake of wormwood led to a significant increase in the levels of Cr by 73%, Cu by 10% and Se by 46% compared to the control group. In experimental group II, which received a combination of wormwood and Co compounds, there was an increase in the levels of Cr by 80% and of Se by 12%, similar to the findings in group I. Additionally, the Co levels increased by 67%, while Zn and I levels decreased by 25% compared to the control.

These results could be interpreted in light of the literature indicating that *A. absinthium* is a valuable source of essential elements, including Cu and Se (Brima, 2018). Furthermore, several studies have reported that wormwood can enhance the absorption of nutrients, including minerals (Nanon et al., 2014; Bisht et al., 2021). These facts support the increase in vital chemical element levels in the blood serum of animals receiving *A. absinthium* in their diet.

Notably, Cu and Se play critical physiological roles in living organisms, with Cu being a component of various vitamins, hormones and enzymes, participating in metabolic processes and tissue respiration (Tapiero et al., 2003; Puls, 2009). In addition, Cu is essential for maintaining the structure of bones, cartilage and tendons and is a part of the antioxidant defence system, serving as a cofactor for the enzyme superoxide dismutase, which neutralizes free oxygen radicals (Hara, 2022). Se is a crucial component of the enzyme glutathione peroxidase, which protects the body from harmful substances and enhances the immune defence (Zhang et al., 2023)

The least number of changes in elemental components were observed in experimental group III. However, there was a significant increase in the Co level (by 100%), accompanied by a decrease in the I level (by 33%), compared to the control group. The observed increase in serum Co is logical and could be attributed to the higher dietary intake of this element. It has been well documented that Co actively inhibits I metabolism, which explains the reduction in I in the bulls in experimental groups II and III that received Co compounds in their diet (Pronina et al., 2021).

Furthermore, it is noteworthy that in the animals in experimental groups I and II that received the herbaceous plant *A. absinthium* in conjunction with their diet, there was an increase in the concentrations of Ni and Pb in the blood. However, the levels of these heavy metals remained within reference values and did not pose a health risk to either the cattle or consumers of derived meat products (Suttle, 2010). Nonetheless, these results suggested a contaminated environment in which the plant had been cultivated. Research has indicated that plants belonging to the *Artemisia* genus could accumulate substantial amounts of heavy metals, particularly Cd, As, Pb and Hg, in their above-ground parts (stems, leaves and flowers) when grown in polluted soils and air (Mahmood and Abdullah, 2023).

An increase in the concentration of heavy metals such as Ni and Pb in the blood serum of cattle is influenced, among other things, by the environment of the animals that could have been polluted by anthropogenic factors; thus, the use of feed from such an area would also lead to an increase in the concentration of heavy metals in the blood serum. In this regard, it is worth subjecting the feed to a complete chemical analysis before harvesting or alternatively to source feed from ecologically clean regions (Tomza-Marciniak, et al., 2011).

The use of *A. absinthium* alone or in combination with chelated $CoCl_2$ compounds has been reported to change the bacterial structure in the rumen of cattle (Ryazanov et al., 2024), leaing to an increase in productive qualities due to changes in such indicators as the residual consumption of animal feed (Faryabi, et al., 2023) In this regard, reducing feed costs and improving their use with better maintenance of animal health will help to reduce the economic burden in this industry.

The results of the current study should contribute to the expansion of knowledge on the use of plant components based on *Artemisia absinthium* in combination with cobalt chloride in the diet of cattle Since published data on the individual use of these components are limited, the effectiveness of *Artemisia* or its components in combination with other chemical elements has been discussed earlier not only in relation to humans (Wang et al., 2017) and animals (Yang et al., 2022) but also regarding cultivated plants (Djeugapa et al., 2023). There is insufficient information in the scientific literature on the impacts on farm animals from the complex effects of plants containing trace elements of metals. Clearly, the combination of phytogenics and trace elements requires more detailed research.

Conclusion

The current results identified changes in the metabolism of bulls of the Kazakh white-headed breed that were connected to the transformation of feeding conditions. Feeding a plant feed supplement based on *A. absinthium* and $CoCl_2$ compounds was the best for cattle to improve protein, carbohydrate, lipid and mineral metabolisms in the animals, accompanied by a significant increase in the levels of glucose by 4%, total protein by 70% and albumin by 6%, as well as a decrease in triglycerides by 45% and an increase in the levels of Co, Cr, Cu and Se in the blood. The detected increases in the levels of heavy metals, particularly Ni and Pb, in the blood serum of animals against the background of receiving this feed additive indicated that it is necessary to use *A. absinthium* from ecologically cleaner areas. However, the results of the study indicated great potential for using bitter wormwood in combination with Co compounds in livestock production and may provide new opportunities for optimizing cattle feeding to improve metabolic processes that are related to animal growth.

Data Availability

The authors confirm that all relevant data are included in the article and its supplementary information files.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Authors' Contributions

All authors contributed to the study's conception and design. GD: Conception and design of the study. TK and OM: Material preparation, data collection, and analysis. VR, VK, AR: Supervision. All authors commented on previous versions of the manuscript. All authors have read and approved the final manuscript.

Conflict of Interest

The authors declare that they have no competing interests.

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