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Original article

COMPARISON BETWEEN SOME BLOOD SERUM BIOCHEMICAL PARAMETERS OF HOLSTEIN-FRIESIAN AND GALLOWAY CALVES

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Summary

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The purpose of the study was to investigate the differences in the biochemical blood serum profiles of beef and dairy cows from two breeds: Galloway and Holstein-Friesian, to compare the biochemical parameters between the two coat colour variations of the Holstein-Friesian breed (black and white, red and white), and differences of the blood biochemical parameters between male and female Galloway calves. Thirty-six Galloway calves – 13 male and 23 female, 37 red and white female Holstein-Friesian calves, and 41 female black and white Holstein-Friesian calves were sampled for this research. The results of the present study showed that some blood biochemistry parameters displayed a significant difference between the two breeds, between male and female Galloway calves and between Holstein-Friesian colour patterns. In terms of breed, blood calcium (Ca), phosphorus (P), glucose, urea, total bilirubin, alkaline phosphatase (ALP), creatinine kinase (CK), and potassium (K) were significantly greater in Holstein-Friesian animals whereas magnesium (Mg), total protein (TP), creatinine, chlorides (Cl), aspartate aminotransferase (AST), ALP, gamma-glutamyl transferase (GGT), cholesterol, and sodium (Na) were higher in the Galloway breed. The mean cholesterol levels in Holstein-Friesian breed (2.01 mmol/L) exceeded significantly the mean serum concentrations in Galloway calves (3.61 mmol/L). The mean values of Ca, Cl, alanine aminotransferase (ALT), ALP, GGT, CK, cholesterol, triglycerides and K were higher in the blood of the red and white calves. In contrast, the total levels of bilirubin, albumin, urea, P, Mg, TP and Na were higher in the black and white coloured animals. The blood serum of female Galloway calves had higher levels of P, glucose, total bilirubin, ALT, ALP, CK, cholesterol, triglycerides and K compared to male Galloway calves. The results indicate that genetic and metabolic differences play a significant role in shaping the physiological characteristics of these cattle breeds. The determination of these blood variations is an important factor for better management and health monitoring strategies that could improve productivity and overall health of the animals. The results may also useful for future studies and comparative analysis of biochemistry in cattle.

Key words: biochemistry of calves, blood reference values, Galloway breed, Holstein-Friesian breed, serum biochemistry analysis

INTRODUCTION

Assessing the health, metabolic efficiency and general physiological condition of cattle requires an understanding of their blood biochemical and serological parameters. Despite the existing research data on cattle breeds, there is few specific information comparing meat and dairy breeds and their blood biochemical markers. The Holstein-Friesian cattle, one of the most popular dairy breeds worldwide, and the Galloway, a well-known meat breed originating from Scotland, are two production types of cattle with different metabolic and physiological needs. However, focused studies comparing their biochemical profiles, especially when it comes to health indicators and metabolic efficiency are important.

Environmental factors, age, gender, and diet can influence breed-specific differences in biochemical and serological parameters in meat and dairy cows. For example, although breeds such as have lower feed requirements and are efficient grazers, little is known about the underlying biochemical differences within the breed. 's grazing of all types of plants on hilly pastures also improves the grass quality by removing excess roughage (Yarkov, 2022). They are characterised by high endurance in mountainous regions with different altitudes and colder climates, due to the lipid layer and thick coat that contribute to the higher tolerance to variable temperatures. The Holstein-Friesian breed is reknown for producing large quantities of milk, however its susceptibility to stress and dietary changes increases the possibility of variability in blood biochemical markers depending on dietary intake and environmental conditions. The cows have a typical dairy cattle exterior with a pronounced body angularity and very little musculature. Research has also shown correlations between external body measurements and calving ease (Ali *et al.*, 1984).

This research aims to find out whether there are significant differences in the metabolic processes between meat and dairy cattle breeds, as well as the differences associated with sex and colour variations. Furthermore, sex differences in biochemical parameters within the Galloway and Holstein-Friesian breeds, for example between male and female Galloway calves have not yet been thoroughly studied. In addition, genetic variations can also lead to metabolic differences between red and white and black and white colour variations of the Holstein-Friesian breed. These results could provide important new information about optimum management of cattle from specific breeds and groups, including feeding schedules and environmental factors. It is postulated that there are significant differences in blood biochemical and serological parameters between beef and dairy cattle breeds and that genetic and gender differences also play a role in these biochemical changes.

MATERIALS AND METHODS

The research was conducted in the spring-summer season in the region of Stara Zagora, Bulgaria, at an altitude of 200 m above sea level and average temperatures ranging from 18–24 ^{o}C. Blood samples collected from 114 clinically healthy calves from the Galloway and Holstein-Friesian breeds, aged from 3 to 8 months, were analysed for nineteen blood serum parameters. The animals used in the research included 36 Galloway calves – 13 male and 23 female, 37 red and white female Holstein-Friesian calves and 41 black and white female Holstein-Friesian calves. Galloway calves (n= 36) lived on pastures with wired electricity defense systems, and Holstein-Friesian calves (n=78) were reared in barns at standard stall-housing conditions and fed a commercial milk replacer CONFOR, with 50% dried milk content, starting in the first week of life. In addition to milk, calves received a pre-starter (Microstart CCC, Alltech) and a structured feeding programme as solid feed until five months of age. Calves were provided *ad libitum* access to water and dry feed starting from the third week.

Blood samples of 2 mL were obtained from the jugular vein of each animal in 4-mL test plain tubes and stored at 4 °C in a refrigerating system during the transportation to the laboratory. The blood biochemical analysis was performed in blood serum using a Veterinary Automatic Biochemistry Analyzer Mindray Vetube 30 with the Health-Check option of the device, giving results after 10 minutes. The calibration ran automatically and included 19 parameters (calcium, phosphorus, magnesium, glucose, total protein, albumin, urea, creatinine, total bilirubin, chloride, aspartate transaminase, alanine aminotransferase, alkaline phosphatase, gamma-glutamyl transferase, creatine kinase, cholesterol, triglycerides, potassium and sodium). These parameters contribute to assessing the nutritional status, metabolic health, and overall physiological condition of the animals from the beef and dairy breeds. As a next step, the installed 'Mindray Data Management' software was used to record the results of the blood biochemistry components.

The data were processed with the software SPSS Statistics (SPSS-Inc., 2019, Chicago, USA). The results were presented as means ± standard deviation with minimum-maximum range. The difference was significant at $P<0.05$.

RESULTS

The comparison of the values of the 19 biochemical parameters in Galloway and Holstein-Friesian calves demonstrated interactions in terms of breed and sex, as and colour variation of the Holstein-Friesian breed. It needs to be taken in mind that in growing calves, the feeding changes have an important influence on the concentrations of different blood variables with these characteristics becoming more distinct after the 5th month of age, when the consumption of more food sources increases.

The blood serum biochemistry of the Galloway calves exhibited significant higher ($P<0.05$) levels of Mg, TP, creatinine ($P<0.05$), chlorides ($P<0.05$), AST ($P<0.05$), ALP ($P<0.05$), GGT ($P<0.05$), cholesterol ($P<0.05$), sodium ($P<0.05$), in comparison to the same parameters in Holstein-Friesian calves (Table 1). On the contrary, Holstein-Friesian calves showed higher blood concentrations of calcium ($P<0.001$), phosphorus ($P<0.001$), urea ($P<0.001$), ALP ($P<0.05$), CK ($P<0.05$). The level of triglycerides the same in both breeds.

The blood serum biochemical analysis also demonstrated differences between the two Holstein-Friesian color patterns. The red and white calves showed higher mean values of Ca, glucose, creatinine, Cl, AST, ALT, ALP, GGT, CK, cholesterol, triglycerides, and potassium. The serum of the black and white coloured calves had higher P, Mg, TP, albumin, urea, total bilirubin, and Na concentrations (Table 2).

The comparison of the blood serum biochemistry of female and male Galloway calves showed that female calves had

Table 1. Blood serum biochemical parameters in Red and Black Holstein-Friesian (HF) (n=78) and Galloway (n=36) calves

Parameter	Breed	Mean ± SD	95% CI for mean	Minimum-maximum range	P value
Ca, mmol/L	Red & Black HF Galloway	2.84 ± 0.12 2.75 ± 0.11	2.81–2.87 2.71–2.87	2.48–3.12 2.49–2.98	0.000
K, mmol/L	Red & Black HF Galloway	4.61 ± 0.36 5.09 ± 0.69	4.53–4.69 4.86–5.32	2.82–5.82 4.10–7.26	0.000
Na, mmol/L	Red & Black HF Galloway	135.33 ± 2.32 141.14 ± 3.39	134.80–135.85 139.99–142.28	128.50–141.30 132.60–148.70	0.000
P, mmol/L	Red & Black HF Galloway	2.71 ± 0.35 2.45 ± 0.27	2.63–2.79 2.36–2.54	0.87–3.24 1.90–2.98	0.000
Cl, mmol/L	Red & Black HF Galloway	101.55 ± 4.22 104.47 ± 3.82	100.60–102.50 103.18–105.770	89.00–118.00 98.00–114.00	0.001
Mg, mmol/L	Red & Black HF Galloway	0.90 ± 0.05 0.93 ± 0.07	0.89–0.91 0.90–0.95	0.78–1.08 0.79–1.08	0.028
Total protein, g/L	Red & Black HF Galloway	74.75 ± 4.15 72.79 ± 4.53	73.81–75.68 71.26–74.33	66.40–85.60 58.70–81.20	0.025
Albumin, g/L	Red & Black HF Galloway	38.31 ± 1.9 38.95 ± 2.32	37.89–38.74 38.16–39.73	32.80–42.50 33.80–42.30	0.126
Urea, mmol/L	Red & Black HF Galloway	4.25 ± 0.72 2.62 ± 0.5	4.09–4.42 2.45–2.79	2.40–6.60 1.70–3.60	0.000
Creatinine, µmol/L	Red & Black HF Galloway	84.1 ± 11.41 128.97 ± 11.25	81.53–86.68 125.17–132.78	62.00–109.00 106.00–151.00	0.000
Total bilirubin, µmol/L	Red & Black HF Galloway	7.27 ± 1.43 6.95 ± 1.7	6.95–7.59 6.37–7.53	4.30–11.30 3.90–11.20	0.293
AST, U/L	Red & Black HF Galloway	103.54 ± 20.83 126.92 ± 41.34	98.84–108.23 112.93–140.90	66.00–180.00 68.00–218.00	0.000
ALT, U/L	Red & Black HF Galloway	21.09 ± 4.39 30.17 ± 8.33	20.10–22.08 27.35–32.99	14.00–36.00 16.00–45.00	0.000
ALP, U/L	Red & Black HF Galloway	467.86 ± 184.76 401.97 ± 166.76	426.20–509.52 345.55–458.39	159.00–1285.00 95.00–923.00	0.071
GGT, U/L	Red & Black HF Galloway	19.95 ± 5.82 26.08 ± 7.62	18.64–21.26 23.51–28.66	7.00–32.00 16.00–45.00	0.000
CK, U/L	Red & Black HF Galloway	389.83 ± 214.87 344.17 ± 432.03	341.39–438.28 197.99–490.34	202.00–1969.00 179.00–2814.00	0.452
Cholesterol, mmol/L	Red & Black HF Galloway	2.01 ± 0.51 3.61 ± 0.64	1.89–2.12 3.39–3.82	0.83–3.25 2.37–4.75	0.000
Triglycerides, mmol/L	Red & Black HF Galloway	0.31 ± 0.14 0.31 ± 0.13	0.27 – 0.34 0.27–0.36	0.14–0.82 0.01–0.62	0.744
Glucose, mmol/L	Red & Black HF Galloway	4.50 ± 0.61 4.32 ± 0.77	4.36–4.63 4.06–4.58	3.05–6.35 3.23–7.66	0.195

Table 2. Blood serum biochemical parameters comparison between Red (n=37) and Black (n=41) Holstein-Friesian (HF) calves

Parameter	Breed	Mean ± SD	95% CI for mean	Minimum-maximum range	P value
Ca, mmol/L	Red HF	2.85 ± 0.14	2.80–2.89	2.48–3.12	0.706
	Black HF	2.84 ± 0.10	2.80–2.87	2.63–3.04	
K, mmol/L	Red HF	4.63 ± 0.49	4.46–4.79	2.82–5.82	0.755
	Black HF	4.60 ± 0.19	4.54–4.66	4.31–5.01	
Na, mmol/L	Red HF	135.06 ± 2.82	134.12–136.00	128.50–141.30	0.345
	Black HF	135.56 ± 1.76	135.01–136.12	131.90–139.60	
P, mmol/L	Red HF	2.68 ± 0.48	2.52–2.83	0.87–3.21	0.449
	Black HF	2.74 ± 0.18	2.68–2.80	2.25–3.24	
Cl, mmol/L	Red HF	101.78 ± 5.2	100.05–103.52	89.00–118.00	0.647
	Black HF	101.34 ± 3.15	100.35–102.34	96.00–111.00	
Mg, mmol/L	Red HF	0.88 ± 0.05	0.86–0.90	0.78–0.98	0.001
	Black HF	0.92 ± 0.05	0.90–0.93	0.80–1.08	
Total protein, g/L	Red HF	74.61 ± 4.55	73.09–76.12	66.40–85.60	0.774
	Black HF	74.88 ± 3.81	73.67–76.08	68.60–82.60	
Albumin, g/L	Red HF	38.17 ± 2.05	37.48–38.85	33.20–42.50	0.521
	Black HF	38.45 ± 1.76	37.89–39.00	32.80–41.30	
Urea, mmol/L	Red HF	4.18 ± 0.88	3.89–4.48	2.40–6.60	0.429
	Black HF	4.31 ± 0.56	4.14–4.49	2.50–5.60	
Creatinine, µmol/L	Red HF	86.08 ± 10.03	82.74– 89.43	66.00–109.00	0.147
	Black HF	82.32 ± 12.38	78.41–86.22	62.00–108.00	
Total bilirubin, µmol/L	Red HF	6.89 ± 1.41	6.42–7.36	4.30–10.20	0.023
	Black HF	7.62 ± 1.37	7.19–8.05	4.60–11.30	
AST, U/L	Red HF	105.35 ± 24.47	97.19–113.51	74.00–180.00	0.469
	Black HF	101.9 ± 17.03	96.53–107.28	66.00–136.00	
ALT, U/L	Red HF	21.35 ± 5.09	19.65–23.05	14.00–36.00	0.620
	Black HF	20.85 ± 3.7	19.69–22.02	14.00–32.00	
ALP, U/L	Red HF	478.46 ± 185.92	416.47–540.45	159.00–1285.00	0.633
	Black HF	458.29 ± 185.49	399.75–516.84	200.00–1202.00	
GGT, U/L	Red HF	20.24 ± 6.43	18.10–22.39	7.00–31.00	0.674
	Black HF	19.68 ± 5.27	18.02–8.00	8.00–32.00	
CK, U/L	Red HF	434.11 ± 285.65	338.87–529.35	202.00–1969.00	0.084
	Black HF	349.88 ± 109.51	315.31–384.44	226.00–802.00	
Cholesterol, mmol/L	Red HF	2.23 ± 0.57	2.04–2.42	1.04–3.25	0.000
	Black HF	1.81 ± 0.35	1.70–1.92	0.83–2.54	
Triglycerides, mmol/L	Red HF	0.32 ± 0.15	0.26–0.37	0.14–0.82	0.517
	Black HF	0.3 ± 0.12	0.26–0.33	0.17– 0.74	
Glucose, mmol/L	Red HF	4.73 ± 0.61	4.53–4.94	3.87–6.35	0.001
	Black HF	4.28 ± 0.53	4.11–4.45	3.05–5.21	

higher P, glucose, total bilirubin, ALT (P<0.01), ALP, CK, cholesterol, triglycerides, and K concentrations. Conversely, lower average levels were registered for Ca, Mg, total protein (P<0.05), albumin (P<0.01), urea, creatinine, Cl, AST, GGT and Na (Table 3).

Table 3. Blood serum biochemical parameters comparison between male (n=13) and female (n=23) Galloway calves

Parameter		Mean ± SD	95% CI for mean	Minimum- maximum range	P value
Ca, mmol/L	Female Male	2.74 ±0.09 2.75 ±0.14	2.71–2.78 2.67–2.84	2.65–2.98 2.49–2.96	0.80
P, mmol/L	Female Male	2.46 ±0.28 2.44 ±0.25	2.33–2.58 2.28–2.59	1.90–2.98 1.92–2.71	0.83
Mg, mmol/L	Female Male	0.92 ±0.06 0.93 ±0.07	0.90–0.95 0.89–0.97	0.80–1.08 0.79–1.03	0.86
Cl, mmol/L	Female Male	103.87 ±3.96 105.54 ±3.45	102.16–105.58 103.45–107.63	98.00–114.00 101.00–111.00	0.21
Total protein, g/L	Female Male	71.71 ± 5.03 74.72 ± 2.67	69.53–73.88 73.10–76.33	58.70–81.20 68.80–77.30	0.05
Albumin, g/L	Female Male	38.17 ± 2.5 40.32 ± 0.98	37.09–39.25 39.73–40.92	33.80–42.30 38.40–41.70	0.01
Urea, mmol/L	Female Male	2.58 ± 0.56 2.69 ± 0.39	2.34–2.82 2.46–2.93	1.70–3.60 1.90–3.30	0.54
Creatinine, µmol/L	Female Male	127.57± 11.37 131.46± 11.01	122.65–132.48 124.81–138.12	106.00–151.00 107.00–146.00	0.33
Total bilirubin, µmol/L	Female Male	7.05 ±1.68 6.78 ±1.80	6.32–7.77 5.69–7.86	4.10–11.20 3.90–10.20	0.65
AST, U/L	Female Male	123.74 ±37.98 132.54 ±47.81	107.31–140.16 103.65–161.43	68.00–208.00 86.00–218.00	0.55
ALT, U/L	Female Male	31.3 ±7.09 28.15 ±10.17	28.24–34.37 22.01–34.30	19.00–45.00 16.00–44.00	0.28
ALP, U/L	Female Male	457.22 ± 159.19 304.23 ± 135.82	388.38–526.06 222.16–386.31	218.00–923.00 95.0–609.00	0.01
GGT, U/L	Female Male	25.91 ±7.61 26.38 ±7.93	22.62–29.20 21.59–31.18	16.00–43.00 17.00–45.00	0.86
CK, U/L	Female Male	376.39 ± 533.56 287.15 ± 130.2	145.66– 607.12 208.48–365.83	179.00–2184.00 189.00–675.00	0.56
Cholesterol, mmol/L	Female Male	3.75 ± 0.70 3.36 ± 0.46	3.45–4.05 3.08–3.64	2.37–4.75 2.87–4.16	0.08
Triglycerides, mmol/L	Female Male	0.33 ± 0.10 0.28 ± 0.17	0.29–0.38 0.18–0.38	0.18–0.54 0.01–0.62	0.20
Glucose, mmol/L	Female Male	4.50 ± 0.85 4.00 ± 0.49	4.13–4.87 3.71–4.29	3.64–7.66 3.23–4.69	0.06

DISCUSSION

Regardless of the breed of cattle, serum Ca increases in summer (Saber *et al.*, 2020). Calcium levels in female Galloway calves were 2.74 mmol/L; and in males 2.75 mmol/L. The results in red and white and black and white variations of the Holstein-Friesian breed with respective values 2.84 mmol/L and 2.85 mmol/L, showed insignificant difference. The research indicates that Ca levels were statistically significantly higher in Holstein-Friesian (2.84 mmol/L) than in Galloway calves (2.75 mmol/L). Periodical measurements of blood P is necessary to improve cattle management and welfare. The two breeds exhibit a relevant in terms of P concentrations with values of 2.71 mmol/L and 2.45 mmol/L in Holstein and Galloway calves. In the latter, average P value was 2.44 mmol/L in male calves and 2.46 mmol/L in females. The serum P analysis of the Holstein-Friesian calves yielded phosphate concentrations of 2.68 mmol/L for the red and 2.74 mmol/L in the black colour variety . Serum Mg levels are a good way of assessing the nutritional status and the need for dietary changes in order to achieve optimum herd health. Holstein-Friesian calves with the recessive gene for red coat colour had average Mg of 0.88 mmol/L, while the black-coloured calves: higher levels of 0.92 mmol/L ($P<0,0001$). The testing showed little sex-related difference for the beef breed Galloway – 0.93 mmol/L in male and 0.92 mmol/L in female calves. Altogether, serum Mg of the red and black coloured calves from the dairy breed was 0.90 mmol/L vs 0.93 mmol/L in Galloway calves.

Only low glucose levels can lead to elevated levels of non-esterified fatty acids (NEFA), which can exert toxic effects on the follicle, oocyte, embryo and foetus in cows. In addition, low glucose levels are connected with malfunction of the hypothalamus resulting in a decreased secretion of gonadotropin-releasing hormone (Adewuyi *et al.*, 2005). The higher NEFA and beta-hydroxybutyrate (BHB), combined with reduced levels of glucose and insulin, indicate negative energy balance in cows (Han van der Kolk *et al.*, 2017). Moreover, glucose is a valuable parameter for determining dietary sufficiency (Hadžimusić & Hadžijunuzović-Alagić, 2024). The glucose concentrations in Holstein-Friesian and Galloway calves were comparable: 4.50 and 4.32 mmol/L, respectively. Female Galloway calves exhibited higher blood glucose (4.50 mmol/L) than males (4.0 mmol/L). The cattle with red and white variety had significantly higher ($P<0.001$) glucose levels of 4.73 mmol/L than the black and white coloured calves (4.28 mmol/L).

The concentration of total protein and the ratio between albumin and globulin varies with age, the calves generally have a lower concentration of TP than the adult cattle (Kraft *et al.*, 1999). They reflect the nutritional status of calves and the status of the liver. Compared to the dairy breed, the Galloway beef cattle had slightly lower TP levels of 72.79 g/L. Sex differences within the Galloway breed were noticeable: 74.72 g/L (males) vs 71.71 g/L (females). Lower albumin was established in calves with smaller amounts of amino acids (Whitaker, 1997). In newborn calves an increase in TP and albumin concentration was followed from birth to the age of two months, showing higher values than in calves fed limited amounts of milk (Steinhardt & Thielscher, 2000).

Increased concentration of urea can be monitored at longer cases of diarrhoea: a link between the amount of protein in forage and the serum urea quantity in calves at the age of 8 to 15 weeks was observed

(Steinhardt & Thielscher, 2000). The Holstein-Friesian calves had an average urea level of 4.25 mmol/L, while in the Galloway breed it was by approximately 61% lower: 2.62 mmol/L. The serum concentration of urea in red and white, compared to black and white Holstein-Friesian variety showed little difference: 4.18 mmol/L and 4.31 mmol/L. The blood serum content of creatinine is important for evaluating glomerular function of the kidneys, with significant increases observed only in cases of severe damage. In Holstein calves, creatinine concentration decreases from the first to the 70th day of age. The comparison between the two breeds demosntrated that the serum creatinine was considerably lower in the Holstein-Friesian breed (84.10 µmol/L) than in Galloway calves (128.97 µmol/L).

Abnormally increased concentration of total serum bilirubin in cattle are usually associated with cholestasis, fatty liver, or haemolytic anaemia, anorexia and rumen stasis (McSherry *et al.*, 1984), but can also be in connection with decreased appetite (Kraft *et al.*, 1999). Female and male Galloway calves, showed little difference in total bilirubin; a similar slight difference was identified between the two colour variations of the Holstein-Friesian breed. The comparison of the two breeds showed that the Holstein-Friesian breed has higher serum total bilirubin (7.27 µmol/L) than the Galloway (6.95 µmol/L).

Serum chlorides were 86.08 mmol/L in the red and white coloured Holstein-Friesian calves and 82.31 mmol/L in the black variety. Male and female Galloway calves had average chloride levels in blood of 131.46 and 127.57 mmol/L, respectively. The dairy Holstein-Friesian breed had significantly lower serum chlorides (84.10 mmol/L), compared to the beef Galloway breed (128.97 mmol/L).

AST activity is increased mainly by cell necrosis in smaller amounts and also by damage to the cell membrane (Kraft *et al.*, 1999). Measuring AST activity in combination with CK is used to diagnose muscle damage (Kaneko, 1997). When liver damage is present AST activity in blood serum is also elevated. The Holstein-Friesian calves presented a significanty lower AST activity (103.53 U/L), compared Galloway calves (126.92 U/L; P< 0.0001). The between AST levels in female and male Galloway calves were inconsistent 123.74 U/L and 132.54 U/L in males, respectively. Similar sex-associated differences were observed for ALT activities: 31.30 U/L (females) and 28.15 U/L in males. TThe Holstein-Friesian breed had lower ALT than the Galloway breed (21.09 U/L vs 30.17 U/L).

In calves until 6 months of age, the activity of ALP can reach 1800 U/L, while in animals up to 3 years, it decreases to 500 U/L (Kraft *et al.*, 1999). The activity of ALP can also be increased in acute and chronic liver diseases, such as cholestatic hepatopathy, as well as in pathological conditions of the skeleton, such as rachitis and periostitis. Holstein-Friesian calves showed higher blood activity of ALP, compared to Galloway with mean values of 467.86 U/L and 401.97 U/L. Average ALP in male Galloway was 304.23 U/L vs 457.22 U/L in females. The increased activity of gamma-glutamyl transferase (GGT) can be a sign of bile duct damage and cholestasis. By monitoring GGT levels in young calves, farmers and veterinarians can ensure that calves are getting the nutrition they need to grow (Steiner *et al.*, 2024a). Very high activity of GGT is also observed in the colostrum of cattle, sheep, and goats with GGT above 50 U/L in the serum indicating sufficient colostrum supply (Hammon & Blum, 1998). Moreover, the levels of GGT are higher in cattle at lower altitudes than those raised at higher altitudes (Tanuwiria *et al.*, 2022). The serum activity of GGT in the red and white Holstein-Friesian variety proved to be slightly higher than in the black and white variety. Breed comparison demonstrated that the Galloway serum GGT was higher (mean value 26.08 U/L) than that in the dairy breed (19.95 U/L).

The serum analysis of Holstein-Friesian cattle revealed cholesterol concentrations of 2.01 mmol/L vs 3.61 mmol/L in Galloway calves. Female beef breed calves had higher average blood cholesterol of 3.75 mmol/L than males (3.36 mmol/L). Red and white-colored Holstein-Friesian calves had significantly higher cholesterol (P<0.0001) than the black and white variety – 2.23 mmol/L and 1.81 mmol/L, respectively.

Blood electrolytes concentrations could help clinicians to interpret more accurate the clinical pathology data (Mohri *et al.*, 2007). In case of hypokalemia, the potential of the membrane is raised and thus the musculature lowers its tone, which leads to paralysis (Carlson, 1997). K levels in the Holstein-Friesian breed, proved to be lower than in the Galloway breed: 4,61 mmol/L and 5.09 mmol/L (P<0.0001). The rumen can store up to 50% of the total available sodium for the whole organism. Then, Na is excreted from the body through faeces, urine, and milk. Calves with acute diarrhoea had lower serum sodium concentrations (131.2 ± 7.2 mmol/L) compared to healthy calves of the same age (140.0 ± 9.9 mmol/L) (Underwood & Suttle, 2001). During the first three months of the life of calves, Na levels remained relatively stable at 145 mmol/L, decreasing slightly to approximately 136.6 ± 5.1 mmol/L by the age of 6 months (Maach *et al.*, 1991). Higher serum sodium concentrations were found in calves fed milk replacer compared to those fed whole milk (Bouda & Jagos, 1984). In our study, serum Na in the Holstein-Friesian breed was significantly lower (P<0.0001) than in the Galloway breed 135.33 mmol/L and 141.14 mmol/L respectively.

The serum biochemical analysis shows some key points for further research. The higher calcium (2.84 mmol/L) and phosphorus (2.71 mmol/L) levels in Holstein-Friesian calves suggest that more attention should be directed toward nutritional strategies for the dairy compared to beef cattle to minimise metabolic disorders. Galloway calves had lower total protein (72.79 g/L) and glucose levels (4.32 mmol/L), which indicated that dietary and protein energy supplies were deficient and, therefore, the diet needs to be optimised with higher energy content. It is important to note that there are nutritional factors associated with an increase in the quantity or quality of colostrum and food to calves (Abed *et al.*, 2020). Furthermore, the elevation of serum liver enzymes in Galloway calves may also indicate metabolic stress, prompting further studies on how this is influenced by diet composition and intake. Our findings showed higher albumin levels in both Holstein-Friesian and Galloway breeds (38.31 ± 1.9 g/L; 38.95 ± 2.32 g/L), when compared with the values of 36.6 g/l level of albumin in 3 months old calves (Mohri *et al.*, 2007), although it can be due to some of the calves being older than 3 months. In the same study, similarly, the TP in calves that were 3 months of age reached 61.8 g/L, and for 6 months old animals: 66.7 g/L. In our study the values were higher reaching 74.75 g/L for Holstein-Friesian calves and 72.79 g/L for

Galloway calves. In another study (Ježek *et al.*, 2006) with 36 dairy calves the following average serum concentrations were measured: Ca 2.64 mmol/L vs 2.84 mmol/L for the dairy breed; K 5.92 mmol/L vs lower values in our study (4.61 mmol/L); Na of 145 mmol/L vs 135,33 mmol/L in this research; Alb 32 g/L compared to 38.31 g/L in dairy calves in this research. Moreover, some findings suggest a big impact of different food mixtures on the biochemical parameters in calf plasma, measured four times during the initial growth phase (Steiner *et al.*, 2024b). It is also important to note that metabolic abnormalities are reflected by perturbations in serum electrolyte, protein and enzyme levels (Banwo *et al.*, 2024). For this reason it is crucial to bring forward the need for specific breed-oriented approaches for the optimal health and productivity of cattle.

CONCLUSION

This is the first scientific research in which the serum biochemical parameters of calves from the Holstein-Friesian and Galloway breed were compared and providing an in-depth analysis of how they could vary depending on the color variation and sex of the animals. There were differences in the blood biochemical constituents between the two types of cattle breeds, indicating that the values for one breed should not be considered directly for another breed. There were also some differences between males and females Galloway breed calves, suggesting that the gender also needs to be considered when using the serum components' reference values. Small differences were observed during the serum biochemistry analysis of the two colour variations of the Holstein-Friesian dairy breed, suggesting that blood serum biochemical components may vary between breed's different phenotypes.

The analysed values can be used in further research in the field of comparative biochemistry as part of the improvement of the management and cattle productivity. The results underscore the need for tailored benchmarks in productivity research and cattle management by highlighting notable breed and gender differences. Further research is required in order to obtain better understanding of within-breed and between-breed serum biochemistry changes.

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