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The influence of breed's difference on the hemogram and biochemistry profile of goats raised in Libya during winter

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ABSTRACT

Background: In Libya, goats are considered as one of the most important livestock in which there are many breeds of goats such as Kurdi, Hegazi, Cyprus, Shami, and Mahali. A little hematological and biochemical information is known on these goat breeds raised in Libya.

Aim: The main purpose was to verify the effect of breed variations on the hematological and biochemical parameters of goat breeds raised in Libya.

Methods: The blood samples were collected in the winter season from 70 clinically healthy animals of different breeds for hematology and biochemical analysis.

Results: Regarding the effect of breeds on blood hematology, significantly higher number ($p < 0.01$) of Mid cells were found in Hegazi ($3.12 \pm 1.30 \times 10^3$/µl) and Cyprus ($2.41 \pm 1.69 \times 10^3$/µl) when compared to other goat's breeds including Kurdi ($2.28 \pm 0.95 \times 10^3$/µl), Shami ($1.90 \pm 0.84 \times 10^3$/µl), and Mahali ($1.37 \pm 0.88 \times 10^3$/µl). Moreover, the percentage of Mid cells was highest in Hegazi (22.34% ± 9.40%), 11.40% ± 4.34%), followed by Kurdi (17.71% ± 8.16%), Cyprus (15.84% ± 8.33%), Shami (13.38% ± 5.76%), and lowest in Mahali (11.40% ± 4.34%). There are significant differences ($p < 0.\ 01$) in hemoglobin (Hb), red blood cells (RBCs), hematocrit (HCT), mean corpuscular hemoglobin (MCH), red cell width distribution-coefficient of variation (RDW-CV, %), and red cell distribution width-standard deviation (RDW-SD, fl) values among all different breeds of Libyan goats. The results of biochemistry displayed significant changes among the studied goats' breeds, where the highest serum alanine aminotransferase (ALT, U/L) activity was observed in Cyprus (17.81 ± 7.95) and Shami (17.27 ± 1.15) compared with Hegazi (15.31 ± 6.13) and Mahali (14.60 ± 0.46), while Kurdi breed (11.68 ± 7.95) showed the lowest ALT activity. Moreover, significant differences ($p < 0.01$) in serum lactate dehydrogenase (LDH, U/l), total and direct bilirubin, glucose (GLU), creatinine, lipid profile, and electrolyte levels were recorded among different breeds used in this study. On the other hand, non-significant variations ($p > 0.\ 05$) are reported in aspartate aminotransferase (U/l), alkaline phosphatase (U/l), total protein (g/dl), albumin (g/dl), urea and magnesium (Mg, mg/dl) levels.

Conclusion: These results showed a significant difference between some blood parameters of goat breeds raised in Libya. This could aid veterinarians in interpreting laboratory data properly in order to improve the management and conservation of those breeds.

Keywords: Goat breed, Hematology profile, Enzymes, Lipids, Electrolytes.

Introduction

In the period of 9000–7000 BC, the goat (*Capra aegagrus*) was one of the ancient livestock first domesticated in western Asia (Zeuner, 1963). Libya has 2.5 million heads of goats and Libyan local goats (Mahali) represent more than 90% of the total goat population (Akraim, 2012). Generally, goat breeds are named by their places of origin and classified by their uses of products. As the effect of different ecological conditions and long-term artificial selection, goat breeds with different genetic characteristics and product orientations are formed (AL-Harbi and Amer,

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2012). Goats and other livestock may experience a range of behavioral, physiological, biochemical, hormonal, and molecular changes in response to various environmental stresses. These conditions include heat load and limitations on natural resources such as feed and water availability and the quality of grazing ground (Tadesse *et al.,* 2023) which results from a total heat load (internal production and environment.

The hematological and biochemical parameters are important to be determined because they provide valuable information about the breed, sex, and animal's health status (Madan *et al*., 2016). Additionally, these parameters can also be used to assess the immunity status in goats (Al-Seaf and Al-Harbi, 2012). Importantly, the seasonal variations may reflect an effect on these parameters (Abdelatif *et al*., 2009). In the same context, some investigations have studied the hematobiochemical indicators in healthy goats in relation to breeds (Tambuwal *et al*., 2002). Furthermore, a Turkish study reported significant changes in red blood cells (RBC), Hb, hematocrit (HCT), and erythrocyte indices (mean corpuscular volume (MCV), MCH, mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW) in Angora and Akkeçi goats (Aktaş and PehliVan, 2023). Moreover**,** another study recorded a significant difference in most of the biochemical analytes such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) activities, total protein (TP), albumin (ALB), creatinine, urea, and some electrolytes among indigenous breeds of goats in Nigeria (Olaogun and Esan, 2024). However, according to the present reports, there are great alterations among goat breeds concerning their hematological and biochemical profile. Based on this data, the aim of this study was to assess the effects of differences in goat breeds on the blood hematology and biochemistry.

Materials and Methods

Animals

The present study was approved by the Ethics Committee on Animal Care and used of the Faculty of Veterinary Medicine, University of Tripoli, Tripoli, Libya. Seventy goats of different breeds (Kurdi = 20, Hegazi n = 19, Cyprus n = 15, Shami n = 10, and Mahali n = 6) and ages (14 young animals from 10 to 16 months and 56 adults above 19 months old). The animal sample included 12 males and 58 females. The animals are owned by private farms located in Tripoli, Libya. The description of the study samples is illustrated in Table 1.

Blood collection and evaluation procedures

In this study, blood samples were collected from the jugular vein into the plain tube for serum analysis and another with K_3EDTA anticoagulant for whole blood analysis. The EDTA-anticoagulant tubes were analyzed using an automated hematology analyzer (Celltac α, Nihon Kohden, Tokyo, Japan). These samples were used for the determination of the following parameters: white blood cell (WBC), lymphocyte (Lymph), monocyte and eosinophil (Mid), granulocytes (Gran), hemoglobin (Hb), RBC, HCT, MCV, mean corpuscular hemoglobin (MCH), MCHC, and RDW. Moreover, the other blood samples were allowed to clot and centrifuged at 5,000 rpm for 15 minutes to obtain the serum. These samples were aliquoted in dry clean Eppendorf capped tubes and stored at –80°C for later biochemical analysis.

Table 1. Description of the study samples.

Item		n = 70	%
Breed	Kurdi	20	29%
	Hegazi	19	27%
	Cyprus	15	21%
	Shami	10	14%
	Mahali	6	9%

The serum alanine aminotransferase (ALAT), aspartate aminotransferase (ASAT), ALP, lactate dehydrogenase (LDH), TP, ALB, total bilirubin (T BIL), direct bilirubin (D BIL), glucose (GLU), triglycerides (TG), total cholesterol (TC), very low-density lipoprotein (VLDL), high-density lipoprotein (HDL), low-density lipoprotein (LDL), creatinine (Cr), urea, phosphorus (Phos), calcium (Ca), and magnesium (Mg) were estimated using an automatic analyzer (pz Cormay ACCENT M320). The serum concentrations of the sodium (Na), potassium (K), and chloride (Cl) electrolytes were determined by the ion-selective electrode method in the EasyLyte® Plus analyzer.

All analyses were accomplished at Esraa's and Al-shefaa's clinical laboratories, Tripoli, Libya. Importantly, the same analyses were performed manually by investigators using 15 random blood samples. They obtained the same findings as attained from clinical laboratories.

Statistical analysis

The data were analyzed using the SPSS Statistics software version 25, used to analyze the collected data; mean, standard deviation, and percentages. A non-parametric test was used because the data collected did not follow a normal distribution (Kolmogorov-Smirnov Test). To compare means, tests were used on independent two samples (Mann-Whitney test) and a one-way analysis of variances (Kruskal-Wallis test). Statistical significance happened when $p < 0.05$.

Ethical approval

The present study was approved by the ethics committee on animal care and use of the Faculty of Veterinary Medicine, University of Tripoli, Tripoli, Libya.

Results

The descriptive study for the breeds is presented in Table 1 and Figure 1, while the descriptive statistics (minimum, maximum, mean, and std. deviation) for

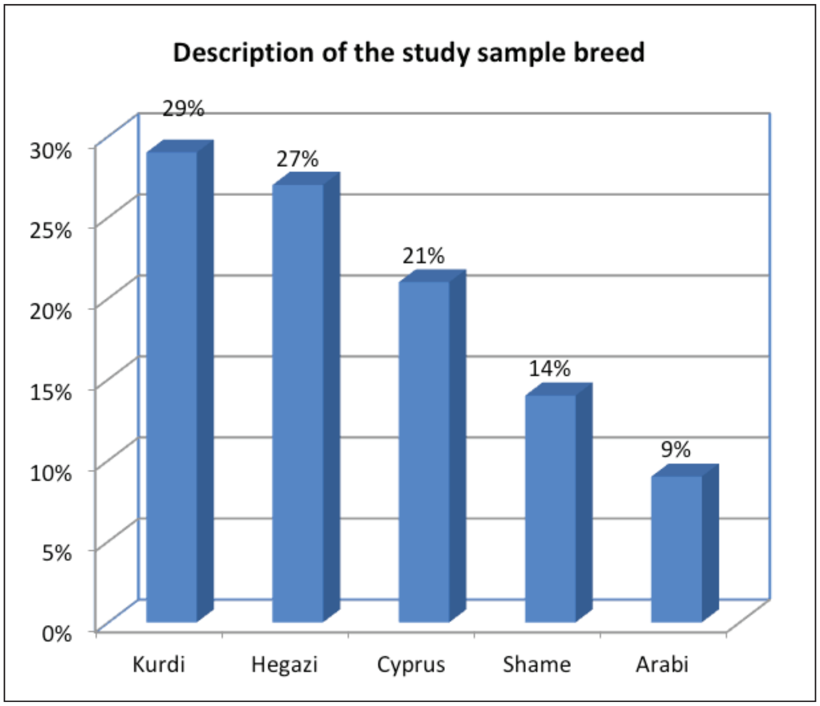

Fig. 1. The descriptive study for the goat's breeds.

Table 2. Descriptive statistics for the hematological parameters.

Parameter	Minimum	Maximum	Mean		Std. deviation
WBC (×10³/µl)	4.70	27.50	13.99	±	4.40
Lymph (×10³/µl)	2.20	13.10	7.70	±	2.53
Mid (×10³/µl)	0.30	6.80	2.40	±	1.30
Gran (×10³/µl)	0.60	8.60	3.60	±	1.94
Lymph (%)	19.80	92.10	55.66	±	16.81
Mid (%)	2.90	45.00	17.41	±	8.60
Gran (%)	5.00	56.10	25.82	±	12.64
Hb (g/dL)	1.60	10.10	6.42	±	2.45
RBC(×10⁶/µl)	0.03	2.03	0.52	±	0.40
HCT (%)	0.00	7.30	1.81	±	1.43
MCV(fl)	33.00	107.10	37.93	±	11.09
MCH (pg)	36.40	312.50	136.23	±	52.01
MCHC (%)	12.30	914.20	366.41	±	157.71
RDW-CV (%)	9.80	14.20	11.93	±	0.84
RDW-SD (fl)	11.20	15.90	13.76	±	1.00

the hematological parameters in Libyan goat are presented in Table 2. The minimum and maximum values for WBC, lymphocyte, and granulocytes are 4.70–27.50 × 10^3/µl, 2.20–13.10 × 10^3/µl, and 0.60–8.60 × 10^3/µl, respectively, while RBC, Hb, and HCT are 0.03–2.03 × 10^6/µl, 1.60–10.10 g/dl, and 0.00%–7.30%.

Table 3 shows the effect of different goat's breeds on the total and differential leukocyte parameters. Higher counts of WBC, Lymph, and Gran were seen in Kurdi (15.02 ± 5.88 × 10^3/µl), Mahali (8.18 ± 0.12 × 10^3/µl), and Cyprus (4.01 ± 2.03 × 10^3/µl), respectively, when compared with other breeds meanwhile this did not statistically significant (*p*

> 0.129). However, Shami and Mahali goat breeds showed significantly ($p < 0.01$) lower mean values of mid cells (1.90 ± 0.84 × 103/µl, 1.37 ± 0.88 × 10^3/µl), and their percentages (13.38 ± 5.76 × 103/µl, 11.40 ± 4.34 × 10^3/µl), respectively, than the other breeds.

There are significant differences in the Hb concentrations, RBC counts, and HCT values among all different breeds of Libya goats as illustrated in Table 4. The mean concentration value of Hb and RBC for Mahali, Kurdi, Cyprus, and Hegazi were 9.40, 6.68, 6.93, and 5.69 g/dl for Hb and 1.03 × 10^6/

Table 3. The total and differential leukocyte counts for goat's breeds (means values± SD). n = 20 Kurdi, 19 Hegazi, 15 Cyprus, 10 Shami, and 6 Mahali.

Parameter	Breed	Mean		Std. Deviation	Kruskal-Wallis test	
					Test statistics	*p*-value
WBC (×10^3/µl)	Kurdi	15.02	±	5.88	3.804	0.433
	Hegazi	14.23	±	3.93		
	Cyprus	14.34	±	2.98		
	Shami	12.43	±	4.03		
	Mahali	11.52	±	2.98		
Lymph (×10^3/µl)	Kurdi	7.39	±	2.75	0.922	0.921
	Hegazi	7.64	±	2.46		
	Cyprus	7.69	±	3.10		
	Shami	8.14	±	2.38		
	Mahali	8.18	±	0.12		
Mid (×10^3/µl)	Kurdi	2.28	±	0.95	12.850	0.012*
	Hegazi	3.12	±	1.30		
	Cyprus	2.41	±	1.69		
	Shami	1.90	±	0.84		
	Mahali	1.37	±	0.88		
Gran (×10^3/µl)	Kurdi	3.83	±	1.74	7.141	0.129
	Hegazi	3.47	±	1.73		
	Cyprus	4.01	±	2.03		
	Shami	3.90	±	2.41		
	Mahali	1.70	±	1.55		
Lymph (%)	Kurdi	51.41	±	12.23	8.225	0.084
	Hegazi	53.51	±	13.35		
	Cyprus	54.25	±	20.46		
	Shami	58.80	±	20.53		
	Mahali	75.00	±	13.94		
Mid (%)	Kurdi	17.71	±	8.16	14.253	0.007*
	Hegazi	22.34	±	9.40		
	Cyprus	15.84	±	8.33		
	Shami	13.38	±	5.76		
	Mahali	11.40	±	4.34		
Gran (%)	Kurdi	28.42	±	8.77	8.216	0.084
	Hegazi	23.36	±	7.48		
	Cyprus	29.56	±	16.97		
	Shami	27.22	±	17.27		
	Mahali	13.27	±	9.09		

µl, 0.60 × 10^6/µl, 0.56 × 10^6/µl, and 0.41 × 10^6/µl for RBC, respectively. These values were significantly ($p < 0.001$) greater than that of Shami (4.78 g/dl, 0.24×10^6/µl). The HCT value was significantly ($p < 0.001$) higher in Kurdi (2.10%), Cyprus (1.91%), Hegazi (1.39%), and Mahali (1.22%) compared with Shami (0.80%) (Table 4).
There are significant ($p < 0.05$) differences in the MCH, red cell width distribution coefficient of variation (RDW-CV), and red cell distribution width-standard deviation (RDW-SD) values among all different breeds of Libya goats as illustrated in Table 5. The highest significant ($p < 0.01$) value of MCH was recorded in Hegazi (162.02 pg), while RDW-CV (13.00%) and RDW-SD (14.90 fl) in Mahali in relation to other breeds. The lower values for MCH were detected in Mahali (91.87 pg), while RDW-CV in Cyprus (11.64%), and RDW-SD in Shami (13.24 fl) compared with others. Nevertheless, the MCV did not statistically ($p > 0.1$) change among all goat breeds (Table 5).
The multiple comparisons between the hematological parameters (Mid, Hb, RBc, HCT, RDW-CV, and RDW-SD) which have significant differences for the different goat's breeds were reported in Table 5. There are significant ($p < 0.05$) differences in the count of Mid cells between kurrdi and Hegazi, in Hb, RBc, HCT between Kurdi and Shami, in Mid, Hb, RBc, HCT, RDW-CV between kurrdi and Mahali (Table 6). Moreover, there are significant ($p < 0.05$) differences in all parameters between Hegazi and Mahali, as well as in all parameters except Mid between Cyprus and Mahali, and between Shami and Mahali.
Regarding the effect of variations in breed on the blood parameters, descriptive statistics of chemistry in goats including minimum, maximum, mean, and standard deviation (std. deviation) were illustrated in Table 7.
Table 8 compares the means of serum ALT, AST, ALP, LDH, TP, and ALB in this experiment for the different breeds of goats. The serum ALT activity showed significant differences ($p < 0.001$) and tended to be higher in Cyprus (17.81 ± 7.95) and Shami (17.27 ± 1.15) followed by Hegazi (15.31 ± 6.13) and Mahali (14.60 ± 0.46) compared with the lowest value in Kurdi (11.68 ± 7.39). The serum LDH activity showed a higher value ($p < 0.001$) in Hegazi (588.71 ± 188.87) and Cyprus (523.99 ± 170.32) when matched with Mahali (428.07 ± 32.74), Kurdi (353.25 ± 142.29) and Shami (261.66 ± 20.98). On the other hand, serum AST, ALP, TP, and ALB revealed non-significant change ($p > 0.05$) among the goat's breeds.
Table 9 revealed the mean values of total and D BIL, GLU, and lipid profiles in different breeds of goats. Significant differences in serum T BIL ($p < 0.001$), D BIL ($p < 0.01$), GLU ($p < 0.0001$), TG ($p < 0.01$), TC ($p < 0.01$), and LDL ($p < 0.001$) were recorded among all used goats' breed (Table 8). On the other hand, serum HDL, and VLDL levels revealed non-significant change ($p > 0.05$) among the goat's breeds.
Significant differences in serum Cr ($p < 0.01$), P, Ca, Na, K, and Cl among all used goats' breeds were observed as shown in Table 10. The Mahali breed

Table 4. The erythrocyte parameters in the goat's breeds (means values± SD). n = 20 Kurdi, 19 Hegazi, 15 Cyprus, 10 Shami, and 6 Mahali.

Parameter	Breed	Mean		Std. Deviation	Kruskal-Wallis test	
					test statistics	p-value
HGB (g/dl)	Kurdi	6.68	±	2.41	17.638	0.001*
	Hegazi	5.69	±	2.33		
	Cyprus	6.93	±	2.26		
	Shami	4.78	±	2.02		
	Mahali	9.40	±	0.62		
RBC (×10^6/µl)	Kurdi	0.60	±	0.50	20.649	0.000*
	Hegazi	0.41	±	0.31		
	Cyprus	0.56	±	0.28		
	Shami	0.24	±	0.26		
	Mahali	1.03	±	0.04		
HCT (%)	Kurdi	2.10	±	1.81	19.831	0.001*
	Hegazi	1.39	±	1.11		
	Cyprus	1.91	±	0.99		
	Shami	0.80	±	0.91		
	Mahali	1.22	±	0.86		

Table 5. The erythrocyte indices in the goat's breeds (means values± SD). *n* = 20 Kurdi, 19 Hegazi, 15 Cyprus, 10 Shami, and 6 Mahali.

Parameter	Breed	Mean		Std. deviation	Kruskal-Wallis test	
					Test statistics	*p*-value
MCV (fl)	Kurdi	36.34	±	3.37	7.345	0.119
	Hegazi	43.69	±	20.09		
	Cyprus	35.54	±	3.00		
	Shami	35.14	±	0.30		
	Mahali	35.60	±	0.46		
MCH (pg)	Kurdi	128.14	±	46.63	12.834	0.012*
	Hegazi	162.02	±	67.94		
	Cyprus	137.89	±	49.62		
	Shami	127.54	±	9.40		
	Mahali	91.87	±	9.50		
MCHC (%)	Kurdi	366.28	±	145.43	8.495	0.075
	Hegazi	369.71	±	214.55		
	Cyprus	404.36	±	165.82		
	Shami	367.20	±	26.98		
	Mahali	260.17	±	30.73		
RDW-CV (%)	Kurdi	11.94	±	0.70	12.861	0.012*
	Hegazi	11.86	±	1.00		
	Cyprus	11.64	±	0.94		
	Shami	11.82	±	0.25		
	Mahali	13.00	±	0.00		
RDW-SD (fl)	Kurdi	13.99	±	1.12	14.385	0.006*
	Hegazi	13.61	±	0.74		
	Cyprus	13.54	±	1.19		
	Shami	13.24	±	0.51		
	Mahali	14.90	±	0.15		

Table 6. Multiple comparisons between the statistically significant hematology in the different goat's breeds.

CBC	Kurdi				Hegazi			Cyprus		Shami
	Hegazi	Cyprus	Shami	Mahali	Cyprus	Shami	Mahali	Shami	Mahali	Mahali
Mid ($\times 10^3/\mu l$)	0.022	0.657	0.307	0.123	0.056	0.006	0.011	0.807	0.112	0.562
Mid (%)	0.035	0.419	0.307	0.046	0.021	0.005	0.006	0.765	0.381	0.428
HGB(g/dl)	0.194	0.730	0.049	0.009	0.071	0.247	0.001	0.026	0.002	0.000
RBC ($\times 10^6/\mu l$)	0.309	0.908	0.024	0.006	0.167	0.085	0.000	0.012	0.000	0.000
HCT (%)	0.309	0.961	0.024	0.006	0.167	0.085	0.000	0.016	0.000	0.000
MCH (pg)	0.204	0.831	0.948	0.028	0.228	0.195	0.000	0.892	0.005	0.000
RDW-CV (%)	0.380	0.382	0.779	0.002	0.918	0.377	0.006	0.397	0.001	0.000
RDW-SD (fl)	0.531	0.254	0.024	0.054	0.656	0.085	0.000	0.531	0.011	0.000

Table 7. Descriptive Statistics of chemistry in goats.

Chemistry	Minimum	Maximum	Mean		Std. deviation
ALT (U/l)	3.30	34.00	15.07	±	6.58
AST (U/l)	32.90	709.00	94.63	±	87.59
ALP (U/l)	13.70	621.90	92.00	±	118.87
LDH (U/l)	192.30	3168.40	446.37	±	408.78
TP (g/dl)	2.77	8.93	6.47	±	1.04
Alb (g/dl)	1.30	3.98	2.69	±	0.60
T BIL (mg/dl)	0.36	0.21	0.02	±	0.08
D BIL (mg/dl)	0.36	0.21	0.02	±	0.08
GLU (mg/dl)	12.00	58.60	36.92	±	12.05
TG (mg/dl)	7.30	75.80	22.56	±	10.50
TC (mg/dl)	16.80	89.50	57.24	±	19.15
VLDL	2.00	22.00	8.35	±	5.07
HDL (mg/dl)	11.30	53.50	33.07	±	10.37
LDL (mg/dl)	1.60	33.10	16.03	±	8.06
Cr (mg/dl)	0.47	1.22	0.74	±	0.15
Urea (mg/dl)	9.30	61.30	40.23	±	9.64
Phos (mg/dl)	1.41	8.84	4.68	±	1.71
Ca (mg/dl)	5.56	10.06	7.72	±	1.04
Mg (mg/dl)	1.74	3.18	2.34	±	0.28
Na (mEq/l)	133.00	164.10	145.89	±	6.97
K (mEq/l)	3.22	436.00	11.35	±	52.67
Cl (mEq/l)	104.50	130.70	116.07	±	6.12

showed lower concentrations of Cr (0.61 ± 0.01 mg/dl), P (3.90 ± 0.16 mg/dl), Na (154.60 ± 8.68 mEq/l), and Cl (125.23 ± 7.54 mEq/l) than other breeds. In addition, higher levels of Ca (8.46 ± 0.64 mg/dl) and K (7.60 ± 0.90 mEq/l) were observed in Shami and Kurdi, respectively, when compared with other breeds. On the other hand, serum urea, and Mg revealed non-significant change ($p > 0.05$) among the goat's breeds (Table 10).

Table 11 shows the multiple comparisons between the statistically significant biochemical parameters for the different goat's breeds. The statistically significant differences were at $p < 0.05$, 0.01, and 0.001.

Discussion

In order to improve the productivity of goat breeds, landowners have used special goat breeds, such as the Kurdi, Hegazi, Cyprus, Shami, and Mahali breeds, and it is important to understand the physiological characteristics of their animals, particularly the hemato-biochemical parameters, when raised in these problematic conditions. Goats can be stressed by a variety of things, including being in a restricted cage, managing their hosting, traveling, changing seasons, heat, strange places, and others (Ungerfeld *et al*., 2021; Rosenberger *et al*., 2022). After prolonged exposure to stress, goats generate physiological mechanisms that confer them the potential to tolerate stress (So-In and Sunthamala, 2023). Hematological qualities are broadly used to decide methodical connections and physiological adjustments, including evaluating the general wellbeing state of a creature (Mohammed *et al*., 2021). The examined breeds differed in several hematological parameters mainly related to the leukogram and erythrogram. Regarding the leukogram, higher counts of WBC, Lymph, and Gran were seen in Kurdi, and Cyprus breeds when compared with other breeds, meanwhile this was not statistically significant. The WBCs are the soldiers of the body and their high counts may also be due to the increase of the complement in the immune systems of the animals. It may also be attributed to physiological phenomena, i.e., excitement or strenuous exercise during handling (Weiss and Wardrop, 2011). However, the absolute and percentage count of mid cells were significantly ($p < 0.01$) lower in Shami and Mahali or Mahali goat breeds when matched with the other goats' breed (Kurdi, Hegazi, and Cyprus). The increased values of mid cells, mainly monocytes in some goat's breed of the present study suggested that the immune system of these breeds was well developed

Table 8. The means values ± SD of some biochemical parameters in goat's breeds as Kurdi (*n* = 20), Hegazi (*n* = 19), Cyprus (*n* = 15), Shami (*n* = 10), and Mahali (*n* = 6).

Chemistry	Breed	Mean		Std. deviation	Kruskal-Wallis	
					Test statistics	*p*-value
ALT (U/l)	Kurdi	11.68	±	7.39	15.606	0.001*
	Hegazi	15.31	±	6.13		
	Cyprus	17.81	±	7.95		
	Shami	17.27	±	1.15		
	Mahali	14.60	±	0.46		
AST (U/l)	Kurdi	76.47	±	32.89	5.212	0.266
	Hegazi	135.43	±	161.25		
	Cyprus	80.78	±	26.19		
	Shami	79.12	±	11.47		
	Mahali	90.27	±	5.06		
ALP (U/l)	Kurdi	82.21	±	134.68	6.074	0.194
	Hegazi	94.12	±	132.00		
	Cyprus	119.60	±	138.94		
	Shami	82.11	±	60.99		
	Mahali	64.10	±	15.80		
LDH (U/l)	Kurdi	353.25	±	142.29	19.229	0.001*
	Hegazi	588.71	±	188.87		
	Cyprus	523.99	±	170.32		
	Shami	261.66	±	20.98		
	Mahali	428.07	±	32.74		
TP (g/dl)	Kurdi	6.25	±	0.84	4.850	0.303
	Hegazi	6.52	±	0.98		
	Cyprus	6.74	±	1.64		
	Shami	6.28	±	0.33		
	Mahali	6.64	±	0.55		
ALB (g/dl)	Kurdi	2.42	±	0.61	5.904	0.206
	Hegazi	2.75	±	0.70		
	Cyprus	2.78	±	0.66		
	Shami	2.81	±	0.31		
	Mahali	2.91	±	0.10		

compared to another breeds (Shami and Mahali). These results and explanations were in agreement with those obtained by (Mohammed *et al*., 2021)**.**

The values of the RBC, HCT, HBG, MCV, MCHC, MCH, WBC, and white blood differential count in Shami goats were reported in this study and found to be in general agreement with previously published values in healthy goats of different breeds (Mohammed *et al*., 2016; Al-Bulushi *et al*., 2017; Al-Rukibat and Ismail, 2019)concentrations for glucose ranged from 60.75 to 71.76 mg/dl, for blood urea nitrogen (BUN**.** Compared with other ruminants, more lymphocytes exist in circulation than neutrophils (Latimer, 2011). However, the total WBC, lymphocytes, and granulocytes did not differ in different breeds (Gorkhali *et al*., 2017). A study reported that the breed differences were observed in TP where Lampuchhre sheep (lowland sheep) showed a lower value than hill sheep breeds (Baruwal and Kage sheep). There was, however, some variation in a few values between our results and previously reported values that could be attributed to differences in nutritional status, geographical location, the physiologic status of the animals, and other genetic factors (Opara *et al*., 2010; Al-Rukibat and Ismail, 2019)WBC (X 109/l. Additionally, reported that the discrepancies in hematological parameters may be

Table 9. The means values± SD of some biochemical parameters in goat's breeds as Kurdi (*n* = 20), Hegazi (*n* = 19), Cyprus (*n* = 15), Shami (*n* = 10), and Mahali (*n* = 6).

Chemistry	Breed	Mean		Std. deviation	Kruskal-Wallis	
					Test statistics	*p*- value
T BIL (mg/dl)	Kurdi	0.10	±	0.10	25.925	0.000*
	Hegazi	0.10	±	0.08		
	Cyprus	0.05	±	0.02		
	Shami	0.04	±	0.02		
	Mahali	0.14	±	0.05		
D BIL (mg/dl)	Kurdi	0.04	±	0.11	12.354	0.015*
	Hegazi	0.05	±	0.10		
	Cyprus	0.03	±	0.04		
	Shami	0.01	±	0.01		
	Mahali	0.07	±	0.04		
GLU (mg/dl)	Kurdi	36.28	±	11.72	22.241	0.000**
	Hegazi	32.24	±	11.52		
	Cyprus	44.61	±	10.22		
	Shami	27.44	±	5.47		
	Mahali	49.57	±	5.06		
TG (mg/dl)	Kurdi	23.07	±	15.95	13.997	0.01*
	Hegazi	19.05	±	6.47		
	Cyprus	22.93	±	8.58		
	Shami	20.94	±	3.76		
	Mahali	33.20	±	1.55		
TC (mg/dl)	Kurdi	51.62	±	20.57	13.174	0.010*
	Hegazi	55.91	±	20.41		
	Cyprus	57.18	±	16.63		
	Shami	55.26	±	12.27		
	Mahali	82.50	±	5.42		
VLDL (mg/dl)	Kurdi	7.35	±	6.62	8.864	0.065
	Hegazi	9.24	±	5.18		
	Cyprus	6.60	±	4.12		
	Shami	9.20	±	2.57		
	Mahali	11.67	±	3.61		
HDL (mg/dl)	Kurdi	30.69	±	11.02	5.044	0.283
	Hegazi	32.32	±	11.36		
	Cyprus	35.07	±	10.59		
	Shami	31.98	±	7.39		
	Mahali	39.67	±	7.85		
LDL (mg/dl)	Kurdi	13.83	±	8.50	16.408	0.001*
	Hegazi	14.64	±	6.53		
	Cyprus	15.49	±	6.11		
	Shami	14.24	±	4.74		
	Mahali	31.50	±	1.24		

Table 10. The means values± SD of creatinine, urea, and electrolytes in different goat's breeds as Kurdi (*n* = 20), Hegazi (*n* = 19), Cyprus (*n* = 15), Shami (*n* = 10), and Mahali (*n* = 6).

Chemistry	Breed	Mean		Std. deviation	Kruskal-Wallis	
					Test statistics	*p*-value
Cr (mg/dl)	Kurdi	0.70	±	0.09	12.055	0.017*
	Hegazi	0.78	±	0.19		
	Cyprus	0.78	±	0.16		
	Shami	0.78	±	0.12		
	Mahali	0.61	±	0.01		
Urea (mg/dl)	Kurdi	38.41	±	10.90	5.530	0.237
	Hegazi	41.94	±	10.22		
	Cyprus	37.80	±	10.13		
	Shami	43.41	±	7.76		
	Mahali	41.63	±	1.76		
P (mg/dl)	Kurdi	4.14	±	1.51	10.552	0.032*
	Hegazi	4.81	±	1.60		
	Cyprus	5.66	±	1.82		
	Shami	4.46	±	2.11		
	Mahali	3.90	±	0.16		
Ca (mg/dl)	Kurdi	7.35	±	0.89	12.445	0.014*
	Hegazi	8.05	±	0.96		
	Cyprus	7.36	±	1.37		
	Shami	8.46	±	0.64		
	Mahali	7.55	±	0.23		
Mg (mEq/l)	Kurdi	2.39	±	0.33	1.378	0.848
	Hegazi	2.29	±	0.32		
	Cyprus	2.35	±	0.24		
	Shami	2.37	±	0.14		
	Mahali	2.29	±	0.34		
Na (mEq/l)	Kurdi	144.01	±	7.02	12.832	0.012*
	Hegazi	144.15	±	6.13		
	Cyprus	148.75	±	6.15		
	Shami	142.90	±	1.58		
	Mahali	154.60	±	8.68		
K (mEq/L)	Kurdi	7.60	±	0.90	11.186	0.025*
	Hegazi	5.16	±	0.62		
	Cyprus	4.57	±	0.64		
	Shami	5.14	±	0.35		
	Mahali	4.78	±	0.43		
Cl	Kurdi	113.50	±	5.79	13.546	0.01*
	Hegazi	115.51	±	4.12		
	Cyprus	117.97	±	5.92		
	Shami	113.53	±	2.78		
	Mahali	125.23	±	7.54		

Table 11. Multiple comparisons between the statistically significant biochemical parameters for the different goat's breeds.

Chemistry	Kurdi				Hegazi			Cyprus		Shami
	Hegazi	Cyprus	Shami	Mahali	Cyprus	Shami	Mahali	Shami	Mahali	Mahali
ALT	**0.049**	**0.013**	**0.001**	0.013	0.347	0.068	0.688	0.739	0.482	**0.001**
D BIL	0.460	0.646	0.169	0.029	0.231	0.661	**0.006**	**0.049**	**0.017**	**0.001**
T BIL	0.635	**0.026**	0.166	0.001	**0.005**	0.360	**0.001**	**0.000**	**0.004**	**0.001**
Ca	**0.018**	0.903	**0.003**	0.339	0.096	0.361	0.255	**0.035**	0.815	**0.004**
Chol	0.466	0.367	0.358	**0.004**	1.000	0.597	**0.001**	0.824	**0.004**	**0.001**
Crea	0.132	0.092	0.167	**0.030**	0.828	0.773	**0.011**	0.824	**0.012**	**0.001**
GLU	0.181	0.056	**0.019**	**0.009**	**0.010**	0.150	**0.005**	**0.000**	0.241	**0.001**
LDH	0.378	**0.002**	0.748	**0.026**	**0.047**	0.084	0.181	**0.000**	0.138	**0.001**
LDL	0.447	0.331	0.462	**0.001**	0.814	0.597	**0.000**	0.956	**0.000**	**0.001**
P	0.236	**0.006**	1.000	0.307	0.206	0.564	0.285	0.085	**0.002**	0.185
TG	0.670	0.395	0.382	**0.009**	0.107	0.124	**0.002**	0.617	**0.002**	**0.001**
Na	0.788	**0.039**	0.613	**0.035**	**0.011**	0.687	**0.009**	**0.026**	0.159	**0.047**
K	0.303	**0.017**	0.251	0.848	**0.007**	0.580	0.527	**0.003**	0.390	0.508
Cl	0.325	**0.019**	0.646	**0.009**	0.117	0.580	**0.009**	**0.026**	0.138	**0.015**

probably due to nutritional variation and breed of goats (Mohammed *et al*., 2021). In the present study, the mean concentration value of Hb and RBC for Mahali or Mahali, Kurdi, Cyprus, and Hegazi was significantly ($p < 0.001$) greater than that of Shami. These discrepancies agreed with the documentation by various researchers in different livestock (Piccione *et al*., 2007). These findings suggest that Mahali, Kurdi, Cyprus, and Hegazi goats have a greater propensity to transport oxygen and in situations of oxygen starvation, these breeds survive better (Okonkwo *et al*., 2011).

The HCT value was significantly ($p < 0.001$) higher in Kurdi (2.10%), Cyprus (1.91%), Hegazi (1.39%), and Mahali (1.22%) compared with Shami (0.80%). The high HCT values in all breeds in comparison to the lowest values in the Shami breed may be attributed to either an expansion in the quantity of increasing RBC or decrease in flowing plasma volume or an increase in environmental temperature (Isidahomen *et al*., 2010). Furthermore, it was reported that the increased hemoglobin or HCT values might probably be a sign of healthy goats (Muayad *et al*., 2018). However, other authors illustrated that the high values of Hb and HCT could be related to the high altitude of the originated place of these breeds and their need for oxygen (Al-Bulushi *et al*., 2017). Generally, an increase in the concentration of erythrocyte parameters is associated with a greater ability to resist disease infection and a low level is an indication of disease infection and poor nutrition (Tambuwal *et al*., 2002). In contrast, the values of RBCs, Hb, and HCT were within the normal range that was reported formerly (Al-Bulushi *et al*., 2017).

The highest significant ($p < 0.01$) value of MCH was recorded in Hegazi, while RDW-CV and RDW-SD in Mahali in relation to other breeds. However, the lower values for MCH were detected in Mahali, while RDW-CV in Cyprus and RDW-SD in Shami compared with others. Other studies showed higher values of MCV and MCH and lower values of MCHC in other goat breeds (Piccione *et al*., 2012; Arfuso *et al*., 2016). In addition, erythrocyte values were observed differently in the present study than those previously reported (Rice and Hall, 2007; Olayemi *et al*., 2009; Piccione *et al*., 2010). Finally, Mahali goat breeds showed higher mean values for RBC, HGB, RDW-CV, and RDW-SD, while HCT and MCH were significantly lower in Shami and Mahali breeds, respectively, than other goat's breeds. These differences could be partly due to subclinical anemia caused by the higher average gastrointestinal nematode infections as reported by previous reports Gastrointestinal nematode infections in goats: Differences between strongyle faecal egg counts and specific antibody responses to Teladorsagia circumcincta in Nera di Verzasca and Alpine goats (Zanzani *et al*., 2020; Agradi *et al*., 2022).

In the blood chemistry parameters of the Libyan goat breeds in this study, there are significant variations ($p < 0.05$) in serum ALT, LDH, total and direct BIL, GLU, TG, TC, LDL, Cr, and electrolytes (P, Ca, Na, K, and Cl) were recorded among all goats' breed (Table 6). The Mahali breed showed higher concentrations of all previous variables with the exception of lower concentrations of Cr, P, Na, and Cl, and higher levels of Ca and K were observed in the Shami and Kurdi breeds. A previous study on Kanni goats reported that the calcium mean value (7.60 ± 0.05 mg/dl) was comparable with our finding, while the phosphorus mean value (3.58 ± 0.02 mg/

dl) was lower (Ramprabhu *et al*., 2010). Moreover, a study carried out on West African pygmy goats found that the P mean value (8.02 ± 2.03 mg/dl) was higher than our finding (3.90–5.66mg/dl) (Tahas *et al*., 2012). Earlier reports stated that the serum liver enzymes and electrolytes are correlated with hormones during the different seasons and pregnancy and healthy status (Sarıbay *et al*., 2020). However, it was recorded that data exhibited no significant season and pregnancy status interaction on serum levels of Na, K, and iron concentrations in goats (Al-Sobaiyl, 2010). The significant dissimilarities in these parameters in the present study between different breeds were in agreement with other studies in different experimental goat breeds in Oman, Sudan, Kuwait, Nigerian, and Nepal (Oramari *et al*., 2014; Mohammed *et al*., 2016; Al-Bulushi *et al*., 2017; Parajuli, 2020). This could be due to differences in breed, climate, animal housing, nutrition, and subclinical diseases. Serum biochemical parameter concentrations in this study were similar to the values obtained previously in Shami goats (Al-Rukibat and Ismail, 2019)the establishment of breed-specific hematologic reference intervals (RIs.

The ALT is an enzyme found in the highest amount in the liver and is typically used to detect liver injury. The values of ALT of goat breeds in this ranged from 14.60 ± 0.46–17.81 ± 7.95 U/l. These values were lower than those reported for goats in Pakistan (77.1 ± 74.2 U/l) and higher than those reported for West African Dwarf goats (8.9 ± 0.9 U/l) and the difference was highly statistically significant (Kiran *et al*., 2012). Another study carried out in wild goats demonstrated higher/or comparable ALT concentration (48.4 ± 52.3 U/l) to the present study (Pérez *et al*., 2003). Indeed, a great variation stated in ALT activity among different small ruminants was based on different geographical distributions (Kiran *et al*., 2012)**.**

The AST is an enzyme abundantly found in liver and heart muscles and plays an important role in amino acid metabolism (Kaneko *et al*., 1997). Additionally, the ALP is an enzyme produced by the liver and along with other enzymes such as ALT, AST, and GGT, can be used as an indicative of liver diseases and can also be a predictive of the health status of goats (Gwaze *et al*., 2012). There was no significant difference in AST and ALP levels among goats during the present study. In the study on different goat breeds in Sudan, the mean level of ALP was 104.7 IU/l with no significant difference between breeds (Elnasri, 2015).

The LDH is an enzyme that catalyzes the conversion of lactate into pyruvate which is an important step in energy production in cell. The value of the LDH is higher in Hegazi (588.71 ± 188.87 U/l) than those of the Shami breed (261.66 ± 20.98 U/l) and this difference is statistically highly significant ($p < 0.001$). Increased activity of LDH is probably due to vascular thrombosis, hemorrhage, and tissue breakdown, especially in the liver and kidney of infected animals (Kaneko *et al*., 1997).

The levels of T BIL, and D BIL in the present study were in the range of 0.04–014 and 0.01–0.07, respectively, in Libyan goat breeds. Higher mean values of T BIL of 0.1 mg/dl were recorded in Saanen goats and 0.22 mg/dl in Omani goat breeds (Elitok, 2012; Al-Bulushi *et al*., 2017). These higher values were more than those obtained in this study and could be attributed to different breeds, environmental conditions, feeding, and others.

The blood GLU concentrations are indicators of energy status in animals. In domestic animals, blood GLU is regulated by the hypoglycemic and hyperglycemic hormones, but may be related to genetic predisposition (Antunović *et al*., 2022). A blood GLU level in the studied Libyan goat's breed was in the range of 27.44–49.57 mg/dl and the highest level was observed in the Mahali breed (49.57 mg/dl). Several studies reported GLU level in the range of 29-35 mg/dl for breeds raised in Nigeria, 31.8 g/dl for Saanen goats raised in Turkey, 47mg/dl for Kanni goats, while higher blood GLU concentration was reported in wild goat (126.1 ± 66.0 mg/dl) than the values reported in the existing study (Pérez *et al*., 2003; Ramprabhu *et al*., 2010; Opara *et al*., 2010; Njidda, 2013). The difference in GLU concentration may be due to levels of nutrition and the metabolic activity of individual animals or to greater ruminal microbial propionate production because of different diets, but relatively high variability reflects the influence of many other factors (Jawasreh and Ismail, 2012; Wang *et al*., 2020; Belkasmi *et al*., 2023)non-pregnant Awassi ewes. Blood samples for hematology and blood biochemical analyses were withdrawn from 92 (30 Local Awassi; Lo-A, 34 Improved Awassi; Im-A, 28 Afec-Awassi; Af-A.

Serum values of Cr and urea are used clinically to determine the integrity of urinary function, hydration, and nutritional status (Kaneko *et al*., 1997). The Cr is formed in skeletal muscle by the degradation of phosphocreatine to produce energy. Serum creatinine concentration has been observed to be proportional to muscle mass (Latimer, 2011). This explains the higher Cr content recorded in some breeds (Hegazi, Cyprus, and Shami) compared to others in the present study. Increases in creatinine levels are associated with a reduction of serum thyroxine levels (Yokus *et al*., 2006)early pregnancy (October. The blood urea is an indirect indicator of the protein composition of feed. Higher levels of urea in Shami than others although not significant are associated with greater ruminal degradation of protein with a concurrent increase in ammonia production (Kaneko *et al*., 1997).

In the present study, the TG concentration was a very important variable probably because of differences in energy metabolism and breed. The highest serum TG level was observed in the Mahali breed but the lowest value was seen in Hegazi goat. Serum TG concentration was the most significant indicator followed by cholesterol concentration for feed restriction. Under severe feed restriction, TG concentration may increase to compensate for the maintenance energy deficit via the mobilization of fat reserve. Body condition score and body fatness under feed restriction are reported to affect TG concentration (Caldeira *et al*., 1999)creatinine, non-esterified fatty acids, globulins, glucose, total lipids, total protein, triglycerides, urea, β-hydroxybutyrate, and in the activity of alkaline phosphatases, aspartate aminotransferase, glucose-6-phosphate dehydrogenase, glutamate dehydrogenase, isocitrate dehydrogenase and pyruvate kinase were evaluated in the serum or plasma of ewes fed 30, 100 and 200% of theoretical maintenance energy requirements. A daily profile was observed in almost all variables, which may be of importance when interpreting data for these blood indicators. Daily variations were found even for albumin and total protein serum concentrations, showing a significant decrease of their levels after the meal. In order to maximize the diagnostic value of these indicators, the most suitable times for blood collection seem to be 16 h after the meal and (or. An increase in the level of serum TG has been reported under conditions of feed restriction because of reduced lipoprotein lipase (which transfers TG-derived fatty acids to adipose tissues for storage) activity and its mRNA expression in adipose tissues (Tadesse *et al*., 2023)**.**

The level of TC can differ between different animal breeds, Mahali for example was found to have a higher mean value (82.50 mg/dl) compared to Kurdi which has the lowest level of TC (51.62 mg/dl). These results disagree with the lower TC level reported in Saanen goats (45.34 mg/dl) and goat's breeds of Northern Nigeria (2.9 ± 0.02 mmol/l), but are similar to those stated in goat breeds in Nigeria.

There were no significant differences ($p > 0.05$) in some biochemical analytics (AST, ALP, TP, ALB, HDL, VLDL, urea, and Mg) observed among all the breeds of goats. This is in synchronization with the earlier reports which reported no significant differences in all biochemical parameters analyzed in Saanen goats breed or lame indigenous breeds of goats in Nigeria (Elitok, 2012; Olaogun and Esan, 2024). The non-significant differences in blood TP and ALB concentrations are indicators of no differences in dietary protein intake between the breed groups because serum TPs, particularly ALB, are good indicators for predicting protein status in animals (Sitaresmi *et al*., 2020). A high intake of grains and high temperatures were the cause of high blood TP as reported previously (Sandabe, 2000). Other reports displayed that lower protein and ALB values occurred because animals did not consume any considerable amount of grain or liver dysfunction. Similar findings reported that there was no significant difference in TP (Elnasri, 2015; Soul *et al*., 2019)one-year-old, of average live weight 14.13 ± 0.24 kg were assigned, in a completely randomized design, to three treatment diets. Animals were housed individually and sex was equally represented among treatments with 6 animals per treatment. Weights and blood samples were taken every fortnight. A pair of blood samples (5 ml each.

Conclusion

The results obtained from this study showed a significant difference between some blood parameters of different goat breeds. This can add some knowledge to the definition of the health status of the five breeds raised in Libya. Moreover, it may serve as reference intervals for hematology and biochemistry analytes of goat breeds which could aid veterinarians to interpret laboratory data properly in order to improve the management and conservation of these breeds.

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Authors' contributions

Conceptualization and design: F.M.B; Practical work: F.M.B, F.A.A, A.M.G, M. A. A, and A.O.B: formal analysis and interpretation of data: M.M.A and M. E.S; writing-original draft preparation: F.M.B and F.A.A; all authors revised and approved the final manuscript for publication.

Conflict of interest

The authors declare that there is no conflict of interest.

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Data availability

All data supporting the findings of this study are available within the manuscript.

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Please provide the expansion for the Abbreviation "EDTA and SPSS."