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Blood profile in normal one humped dromedary (*Camelus dromedarius*) camel breeds in Libya. Part 1: Determination of biochemical and haematological blood profile

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1. Abstract

As little is known about the blood profile of camels in Libya, this article is the first of a 4-part series describing the biochemical and haematological blood profile in Libyan camels. Part 1 of these manuscripts determines the values of enzymes, metabolites, electrolytes and haematological indices in the blood of Libyan camels, parts 2-4 evaluates the effects of breed, gender and age respectively on these values. In this study, blood samples were collected from sixty six camels of three different breeds, different ages and with both sex. The blood of the studied camels showed (*i*) average values of Potassium (K), Calcium (Ca), Magnesium (Mg), Phosphorus (Ph), Haemoglobin (Hb), Packed Cell Volume (PCV) and White Blood Cell (WBC) counts (*ii*) low values of Sodium (Na), Iron (Fe), total proteins, albumin, globulin, creatinine, cholesterol, triglycerides, Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), and low serum activity of aspartate aminotransferase (AST), alanine aminotransferase (ALT), lactate dehydrogenase (LDH), alkaline phosphatase (ALP), gamma glutamyl transferase (GGT) and amylase (AMS) enzymes and (*iii*) high values of glucose, urea, Red Blood Cell (RBC) counts, Erythrocyte Sedimentation Rate (ESR) and Mean Corpuscular Haemoglobin Concentration (MCHC). The finding of this study was documented and compared with the findings of similar studies performed elsewhere.

Key words: Camel, blood profile, biochemistry, haematology, Libya

2. Introduction

Camel is a one of the ruminant animals that is well adapted to the harsh environment of desert and is used for transportation, racing, show and considered as a source of meat, milk and wool (Kamal, 2008; Meiloud et al., 2011). According to the FAO, there are approximately 28 million camels worldwide of which 24 million camels in Africa, 4 million in Asia and only 7 thousand in Europe (FAO, 2018). Approximately 94% of the estimated world's camel population are one-humped or dromedary camels while the remained 6% comprises the two-humped bactrian camel which is located in Asia (Yam and Khomeiri, 2015).

The quantitative analysis of blood constituents can often assist the clinician by providing normal reference values for easy evaluation of the health and sickness of animals (Nyangao et al., 1997; Osman et al., 2015). The blood profile of camels in Libya is poorly documented and little is known about the normal ranges of the biochemistry and haematology blood references (سلامه et al., 2016; Abdoslam et al., 2018) compared to the extensive studies conducted in other countries such as Tunisia (Ben Romdhane et al., 2003), Algeria (Aichouni et al., 2010; Ahmed et al., 2013; Aichouni et al., 2013), Morocco (Bengoumi et al., 1997a), Egypt (Abd-El-Salam et al., 2008; Saleh et al., 2009; El-Harairy et al., 2010; Osman et al., 2015), Sudan (Omer et al., 2006; Amin et al., 2007; Dowelmadina et al., 2012; Babeker et al., 2013), Nigeria (Mohammed et al., 2007), Kenya (Kuria et al., 2006), Saudi Arabia (Al-Ali et al., 1988; Haroun, 1994; Al-Busadah and Osman, 2000; Chaudhary and Iqbal, 2000; Al-Busadah, 2003; Muna et al., 2003; Osman and Al-Busadah, 2003; AL-Busadah, 2007; Ali et al., 2010; Jalal et al., 2010; Al-Mujalli et al., 2011; Ghoneim et al., 2013; El-Bahr et al., 2015; Ghoneim et al., 2016; Al-Busadah et al., 2017), United Arab Emirates (Abdalla et al., 1988; Chaudhary and Iqbal, 2000; Ayoub et al., 2003), Iraq (Abdalla et al., 1988), Iran (Ghodsian et al., 1978; Nazifi and Maleki, 1998; Nazifi et al., 1998; Nazifi et al., 2000; Radfar and Iranyar, 2004; Badiei et al., 2006; Sazmand et al., 2011; Ahmadi-hamedani et al., 2014), Kuwait (Eissa and Abdel-Fattah, 1974; Mohamed and Hussein, 1999), Oman (Eltahir et al., 2010), India (Kataria and Bhatia, 1991; Patodkar et al., 2010; Saini et al., 2014), Pakistan (Ahmad et al., 2007; Ali et al., 2008; Farooq et al., 2011; Durrani et al., 2017), Australia (Little et al., 1970) and France (Faye et al., 1995).

The aims of this study series are (*1*) to establish a base line reference values for blood biochemical and haematological parameters in normal, healthy, one humped camels in Libya and (*2*) to highlight the effect of breed, sex and age on these parameters. In this first part of study series, the mean values of selected biochemical and haematological blood parameters in sixty six Libyan camels are presented and compared with the findings of similar studies conducted elsewhere.

3. Materials and Methods

3.1 Animals

Camels were randomly chosen from three breeds, different ages and of both sexes with a total of sixty six apparently healthy camels were involved in this study. Forty two camels were chosen from Fakhreya breed, from a farm located in Tarhuna city in the north west of Libya. Thirteen camels were chosen from Mahari breed, from a farm located in Obari city in the south west of Libya. Eleven camels were chosen from Sirtaweya breed, from a farm located in Wadi Alrabee area in the suburban area of Tripoli, in the north west of Libya.

3.2 Blood collection

Blood samples were collected in the summer time of the year. Thirteen millilitre of blood were collected from the jugular vein of each camel by disposable plastic syringe and a 19G needle. Three millilitre of blood were distributed into EDTA anti coagulant containing tubes for haematological analysis while the remained ten millilitre of blood were distributed into clean dry plain tubes for serum analysis. All blood samples were transferred on ice to laboratory at the Faculty of Veterinary Medicine, University of Tripoli, Tripoli, Libya. The blood allowed to clot and after centrifugation at 5000rpm for 15 min, the serum samples were aliquoted in dry clean Eppendorf capped tubes and stored at -80^{o} C for later analysis.

3.3 Biochemical analysis

The serum activity of aspartate aminotransferase (AST, L-aspartate/2-oxoglutarate as a substrate), alanine aminotransferase (ALT, L-alanine/2-oxoglutarate as a substrate), lactate dehydrogenase (LDH, Pyruvate/NADH+H^{+} as a substrate), alkaline phosphatase (ALP, p-nitrophenylphosphate as a substrate), gamma glutamyl transferase (GGT, Gulpa

Carboxy/glycyglycine as a substrate), amylase (AMS, 2-chloro-4-nitrophenyl α-D-maltotriose as a substrate) and the concentration of glucose (glucose oxidase method, GOD-PAP), cholesterol (cholesterol oxidase method, CHOD-PAP), cholesterol-High Density Lipoprotein (HDL, cholesterol oxidase method after precipitation by phosphotungstic acid/magnesium chloride, CHOD-PAP), triglyceride (glycerol-3-phosphate oxidase method, GPO-PAP), urea (Berthelot modified method), creatinine (kinetic test without deproteinization), total protein (biuret method), albumin (bromocresol green method), calcium (O-cresolphtaleine method), inorganic phosphorus (ammonium molybdate method), magnesium (calmagite method) and iron (ferrozine method) were measured by commercial kits (Biomaghreb, Ariana, Tunisia) and the values were calculated according to the manufacturer instructions using Jenway spectrophotometer, Model 6500 (Bibby Scientific Ltd, Stone, Staffordshire, United Kingdom). Sodium and potassium were measured using EasyLyte analyser that uses ion selective electrode technology. Globulin levels were calculated by subtraction of albumin content from the total protein value, cholesterol-Very Low Density Lipoprotein (VLDL) level was calculated by dividing triglyceride level on 5 while cholesterol- Low Density Lipoprotein (LDL) level was calculated by subtraction of the cholesterol-VLDL and cholesterol-HDL from the total cholesterol value.

3.4 Haematological analysis

The EDTA- anti coagulated blood was used to determine the haemoglobin concentration (Hb, g/dl), packed-cell volume (%), Fragility (% of haemolysis), Erythrocyte sedimentation rate (ESR, mm/hr), counts of red blood cells (RBC, $x10^6/mm^3$) and white blood cells (WBC, $x10^3/mm^3$). Haemoglobin concentration was determined following Sahli's method (Van Kampen and Zijlstra, 1961). Packed–cell volume was estimated by haematocrit capillary tube and centrifuged at 600 *g* for 20 minutes. Haematocrit value was read and recorded according to Schalm *et al.* (Schalm et al., 1975). Red blood cells and white blood cells were counted using haemocytometer and counted at x40 objective of phase contrast microscope according to Schalm *et al* (Schalm et al., 1975). The haematological indices mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC), were calculated from the erythrocytic series values. The differential cell count was enumerated on slides with

Giemsa stain and performed counting a minimum of 100 cells under a light microscope according to Schalm *et al.* (Schalm et al., 1975). Erythrocyte sedimentation rate (ESR) was determined by Westergren Method according to Bull *et al.* (Bull et al., 1993). Fragility was determined according to Benson and Swallen (Benson and Swallen, 1964).

3.5 Statistical analysis

Data were analysed using GraphPad Prism statistical software (version 6.0b; GraphPad Software Inc, La Jolla, CA, USA) and the results are expressed as mean ± SEM.

4. Results

The serum enzyme activities of ALT, AST, ALP, LDH, GGT and AMS measured in the serum of the camels involved in this study are shown in table 1. Camels had LDH with the highest enzyme activity and GGT with the lowest enzyme activity among the measured enzymes. The mean ± SEM concentrations of glucose, total proteins, albumin, globulin, urea, creatinine, triglycerides, cholesterol and lipoproteins measured in the serum of the camels involved in this study are shown in table 2. Albumin was the predominant serum protein and the Albumin/Globulin (A/G) ratio was more than one. The urea level was nearly 30 times higher than the creatinine level. The total cholesterol was higher than the triglycerides level and the HDL level was the highest among the measured lipoproteins. The mean ± SEM concentrations of Na, K, Ph, Ca, Mg and Fe measured in the serum of the camels involved in this study are shown in table 3. Calcium level was the highest in the serum of camel while iron was the lowest among the electrolytes measured in this study.

The mean ± SEM values of the investigated haematological parameters are shown in tables 4 and 5. The RBC and total WBC counts were $11.79x10^6/mm^3$ and $10.89x10^3/mm^3$ respectively. The lymphocytes were the predominant cell type among the leukocytes and were around two times of the neutrophils and six times of the monocytes. The basophils and eosinophils were very low in number and almost with the same frequency.

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Table 1. Mean ± SEM activities of ALT, AST, ALP, LDH, GGT and AMS enzymes in the serum of 66 camels

Parameter	Unit	Mean ± SEM	Range
ALT	UL^{-1}	5.37±0.62	0.00-25.55
AST	UL^{-1}	11.96±1.47	0.00-57.05
ALP	UL^{-1}	4.26±0.48	0.00-17.05
LDH	UL^{-1}	33.96±5.86	0.00-257.4
GGT	UL^{-1}	1.78±0.12	0.47-5.71
AMS	UL^{-1}	1.78±0.28	0.00-0.28

Table 2. Mean ± SEM concentrations of glucose, total proteins, albumin, globulin, urea, creatinine, triglycerides, cholesterol and lipoproteins in the serum of 66 camels

Parameter	Unit	Mean ± SEM	Range
Glucose	mg dl^{-1}	111.8±5.36	26.14-240.9
Total proteins	g l^{-1}	50.98±0.91	31.09-67.82
Albumin	g l^{-1}	30.58±0.63	17.51-39.52
Globulin	g l^{-1}	20.40±0.83	4.42-46.05
A/G	g l^{-1}	1.69±0.09	0.47-6.02 1
Urea	mg dl^{-1}	43.31±1.39	17.00-69.00
Creatinine	mg dl^{-1}	1.50±0.02	1.00-2.10
Triglycerides	mg dl^{-1}	31.60±1.81	8.14-82.22
Total cholesterol	mg dl^{-1}	36.39±1.72	5.72-77.60
HDL-cholesterol	mg dl^{-1}	15.91±1.23	0.00-37.50
LDL-cholesterol	mg dl^{-1}	14.16±1.97	0.00-46.83
VLDL-cholesterol	mg dl^{-1}	6.32±0.36	1.63-16.44

Table 3. Mean ± SEM concentrations of Na, K, Ph, Fe, Ca and Mg in the serum of 66 camels

Parameter	Unit	Mean ± SEM	Range
Na	mmol/l	148.4±0.71	116.8-158.5
K	mmol/l	4.98±0.10	3.11-7.39
Ph	mg dl^{-1}	5.20±0.24	1.75-8.89
Ca	mg dl^{-1}	9.87±0.08	7.65-12.81
Mg	mg dl^{-1}	2.51±0.05	1.58-3.81
Fe	mg l^{-1}	0.84±0.11	0.00-3.49

Table 4. Mean ± SEM values of erythrocytes in 66 camels

Parameter	Unit	Mean ± SEM	Range
PCV	%	33.47±1.01	16.00-50.00
Hb	g/dl	12.55±0.27	7.28-17.70
Fragility	%	0.77±0.01	0.00-0.90
ESR	mm/hr	30.73±2.93	10.00-130.00
RBC count	$10^6/mm^3$	11.79±0.36	7.53-30.88
MCV	fL	29.24±0.93	7.10-48.70
MCH	pg	11.06±0.32	3.30-18.60
MCHC	g/dl	39.38±1.30	21.60-87.30

Table 5. Mean ± SEM values of leukocytes in 66 camels

Parameter	Unit	Mean ± SEM	Range
Total WBC count	10^3/ mm^3	10.98±0.50	4.75-21.20
Lymphocytes	10^3/ mm^3	6.73±0.38	2.60-18.05
Neutrophils	10^3/ mm^3	2.96±0.23	0.59-9.46
Monocytes	10^3/ mm^3	1.14±0.07	0.06-3.18
Eosinophils	10^3/ mm^3	0.03±0.00	0.00-0.19
Basophils	10^3/ mm^3	0.03±0.00	0.00-0.19

5. Discussion

The lack of published biochemical and haematological reference values for camels in Libya make it inevitable to establish a blood profile reference of normal apparently healthy camels for both clinician and researchers in Libya. The present study series, in this part, attempt to determine the normal values of some biochemical and haematological blood constituents in Libyan, healthy camels and compare its finding with the other studies conducted elsewhere. Blood collection, storage and analysis were performed with the same technical procedures to minimize the variation that could affect the accuracy of the obtained data.

The serum enzyme activities of AST and ALT in this work were in agreement with the values reported by (Haroun, 1994; Nazifi and Maleki, 1998) and (Kataria and Bhatia, 1991; Aichouni et al., 2010), respectively. However, the serum enzyme activities measured in this study were lower than the values cited earlier (Abdalla et al., 1988; Bengoumi et al., 1997b; Nazifi et al., 1998; Mohamed and Hussein, 1999; Chaudhary and Iqbal, 2000; Osman and Al-Busadah, 2003; Jalal et al., 2010; Sazmand et al., 2011; Osman et al., 2015; Durrani et al., 2017), although LDH had a higher activity in this study than that determined by (Faye et al., 1995). Camels had a significantly lower enzyme activities when compared with sheep and goats born and reared in the same tropical area (Haroun, 1994). However, the effect of season, age, physiological status on the serum enzyme activities in camels have contradictory results in the literature (Ateeq et al., 1984; Eltohamy et al., 1986; Kataria and Bhatia, 1991; Kataria et al., 1991; Bengoumi et al., 1997a). In addition, the variations due to the geographical or nutritional factors or due to the differences in the used analytical procedures cannot be ruled out.

The electrolytes measured in this study showed average levels of Ca, K, Ph and Mg; and low levels of Na and Fe when compared with studies conducted earlier. The mean serum concentration of Ca (9.87±0.08 mg dl^{-1}), Ph (5.20±0.24 mg dl^{-1}), and Mg (2.51±0.05 mg dl^{-1}) were in accordance with studies of (Nazifi et al., 1998; Mohamed and Hussein, 1999; AL-Busadah, 2007; Aichouni et al., 2010), although Eltahir et al., reported higher values of these electrolytes (Eltahir et al., 2010). The mean serum concentration of Na (148.4±0.71 mmol/l) and K (4.98±0.10 mmol/l) reported in this study were in line with those reported by (Nazifi and Maleki, 1998; Mohammed et al., 2007; Jalal et al., 2010). However, these values were lower than those documented by (AL-Busadah, 2007; Aichouni et al., 2010; Eltahir et al., 2010). The mean concentration of Fe (0.84±0.11mg l^{-1}) in this study was in line with studies of (Nazifi and Maleki, 1998; Osman and Al-Busadah, 2003) but lower than studies of (Abdalla et al., 1988; Haroun, 1994; Chaudhary and Iqbal, 2000; Badiei et al., 2006; Eltahir et al., 2010).

The serum of camels have higher levels of Na, chloride (Osman and Al-Busadah, 2003) and Ph (Kamalu et al., 2003) and lower levels of Fe, Mg (Osman and Al-Busadah, 2003) and K (Kamalu et al., 2003) when compared with the other ruminants. The literature variation in the serum electrolytes concentrations in the camels could be attributed to many factors such as season, nutrition and age. Amin et al., reported an increase in Ph and Ca values in the serum of dromedary camels in the wet season due to the availability of plants rich in minerals (Amin et al., 2007). Other authors recorded an increase in Na, Ca but decrease in K and Ph in the summer season compared to the other seasons (El-Harairy et al., 2010). The high serum values of Na and low serum values of K was attributed to the high level of aldosterone hormone in the summer which causes an increase in Na reabsorption by the kidney and balance plasma K through its effect on renal reabsorption of Na in exchange for K and hydrogen ion (El-Harairy et al., 2010). Moreover, the iron level was higher in camels over 8 years of age compared with 3-7years of age and was higher in the dromedary camels than the bactrian camels (Eltahir et al., 2010).

The metabolites values in this work showed an agreement with previous studies in the mean serum concentrations of glucose (Faye et al., 1995; Jalal et al., 2010), urea (Osman and Al-Busadah, 2003), total proteins (Nazifi and Maleki, 1998), albumin (Haroun, 1994;

Mohammed et al., 2007), creatinine (Abdalla et al., 1988; Osman and Al-Busadah, 2003), total cholesterol (Al-Ali et al., 1988; AL-Busadah, 2007; Sazmand et al., 2011) and triglycerides (Osman and Al-Busadah, 2003). In general, the mean serum concentrations of glucose (111.8±5.36 mg dl^{-1}) and urea (43.31±1.39 mg dl^{-1}) reported in this study were high when compared with the literature. On the other hand, the mean serum concentrations of total proteins (50.98±0.91 g l^{-1}), albumin (30.58±0.63 g l^{-1}), cholesterol (36.39±1.72 mg dl^{-1}), triglycerides (31.60±1.81 mg dl^{-1}) and creatinine (1.50±0.02 mg dl^{-1}) were low when compared with the literature. Unfortunately, there is no much data in the literature about the lipoproteins levels in the serum of camels, however, the mean values of HDL (15.91±1.23 mg dl^{-1}), LDL (14.16±1.97 mg dl^{-1}) and VLDL (6.32±0.36 mg dl^{-1}) documented in this study were higher than those recorded by Nazifi et al., for camels over 3 years of age (Nazifi et al., 2000) and lower than values reported by (Jalal et al., 2010).

The variation in the blood metabolites levels seen in the literature could be attributed to the availability of food and water, and the remarkable adaptive mechanisms of camels to thirst and lack of food. The glucose level in camel's blood increases from 20 to 80% after 10 days of water deprivation (Ouajd and Kamel, 2009; Aichouni et al., 2013). This hyperglycemia is accompanied with no glucosuria to reduce moisture loss, and with low insulin level that inhibit lipolysis and lower the basic metabolism to decrease the glucose use (Ouajd and Kamel, 2009; Aichouni et al., 2013). The plasma concentration of glucose in camels decreases with the reduction in the available food during dry season (Aichouni et al., 2013) and feeding of camels after fasting was reported to increase the plasma glucose level (Amin et al., 2007).The lipids concentration in liver decreases by 13-25% after dehydration and the concentration of triglycerides, free fatty acids, phospholipids and cholesterol increased after 14 days of water deprivation (Ouajd and Kamel, 2009; Aichouni et al., 2013). Moreover, the poor dietary condition during the dry season was related to the observed high concentration of serum triglycerides in camels (Amin et al., 2007; Aichouni et al., 2013). In addition, lipid profile, like human, is influenced by age where it is higher in older animals and in advanced age (Nazifi et al., 2000). Camels are also well adapted to lower nitrogen diets by limiting the urinary excretion of urea and increasing the nitrogen recycling in the case of lower proteins in diet and/or dehydration (Gihad et al., 1989). Camels have high level of blood urea nitrogen when compared to the

other livestock due to the ability of camels to utilize urinary nitrogen at times of poor grazing or water deprivation (AL-Busadah, 2007; Aichouni et al., 2010; Patodkar et al., 2010) and the urea is efficiently utilized for microbial protein synthesis (Abdalla et al., 1988; Haroun, 1994). The total protein values were higher in summer season compared to the other seasons in camels (El-Harairy et al., 2010). This increase was attributed to the stimulation of growth releasing hormone that cause increase in the plasma proteins which are important to maintain plasma water (Horowitz and Adler, 1983). The dehydrated camels also showed a decrease in creatinine clearance and high level of albumin that maintain high colloid osmotic pressure needed for storing water in blood (AL-Busadah, 2007; Amin et al., 2007; Ouajd and Kamel, 2009; Aichouni et al., 2013).

The haematological indices investigated in this study had similar values of PCV and Hb, high values of the RBC count, MCHC and ESR and low values of MCV, MCH when compared with the literature. The mean RBC counts ($11.79x10^6/mm^3$), PCV (33.47 %) and Hb (12.55 g/dl) were in agreement with those reported by (Eissa and Abdel-Fattah, 1974; El-Harairy et al., 2010) , (Eissa and Abdel-Fattah, 1974; Abdalla et al., 1988; Chaudhary and Iqbal, 2000; Aichouni et al., 2010; El-Harairy et al., 2010) and (Eissa and Abdel-Fattah, 1974; Chaudhary and Iqbal, 2000; El-Harairy et al., 2010; Eltahir et al., 2010; Al-Mujalli et al., 2011), respectively. However, the counts ($11.79x10^6/mm^3$), MCHC (39.38g/dl) and sedimentation rate (30.73mm/hr) of erythrocytes were high when compared to the values reported by (Abdalla et al., 1988; Chaudhary and Iqbal, 2000; Jalal et al., 2010; Al-Mujalli et al., 2011; Farooq et al., 2011; Ahmadi-hamedani et al., 2014) for the RBC counts and MCHC; and (AL-Busadah, 2007; Babeker et al., 2013; Osman et al., 2015; Durrani et al., 2017) for the ESR. The MCV (29.24fL) and MCH (11.06 pg) were low when compared to studies of (Mohamed and Hussein, 1999; Chaudhary and Iqbal, 2000; Jalal et al., 2010; Babeker et al., 2013).

The RBC counts are higher in camels when compared to horses and cattles but a lower PCV values as camels erythrocytes are smaller in size and have elliptical shape make them pack tighter (Schalm O. W., 1975; Singh et al., 1997; Jain, 1998; AL-Busadah, 2007). The variations in the reported RBC counts in camels could be attributed to the age, health and physiological status of camels rather than stress as camels, like human, do not have splenic

reserve for RBC as indicated by a minimal increase in haemoglobin concentration and haematocrit after 4 or 5km maximal exercise (Snow et al., 1988). Babeker et al. showed that the ESR level is elevated in camels during the dry hot season as a result of the increase in RBC release from the spleen because of the dehydration or asphyxia (Babeker et al., 2013). Moreover, the latter authors showed that the dry season cause elevation in MCHC and drop in the MCV and MCH levels. This might explain the high level of ESR and MCHC and the low level of MCV and MCH observed in the present study which was performed in the summer season of the year. The MCHC reflects the potential oxygen carrying capacity of RBC in camels (Al-Busadah and Osman, 2000). In regard to osmotic fragility of erythrocytes, unfortunately, there are no comprehensive reports on this parameter in the camel to compare our results with. The erythrocytes of camels in this study started to haemolyse when suspended in hypotonic NaCl solutions of 0.7 % onward. The osmotic fragility of camel's erythrocytes studied by Amin et al., shown to be seasonal affected where RBC commenced haemolysis at 0.4% NaCl in blood samples collected during the dry season and at 0.3% NaCl in blood samples collected during the green season (Amin et al., 2007). The latter authors related that to the dehydration which increases survival and half-life of erythrocytes in camels. Having said that, the variation in various erythrocytic indices may also be attributed to the effect of age and physiological status on RBC size and its oxygen carrying capacity, and to the techniques variance (Farooq et al., 2011).

The mean total leukocyte counts ($10.98x10^3/mm^3$) in this study was in accordance with the previous values reported by (Mohamed and Hussein, 1999; El-Harairy et al., 2010; Farooq et al., 2011; Osman et al., 2015; Durrani et al., 2017). Also, the leukocyte differential cell counts obtained in the present study were similar to many studies in that the lymphocytes were the predominant cell types of leukocytes with neutrophils being the next one (Nazifi et al., 1998; AL-Busadah, 2007; Aichouni et al., 2010; Farooq et al., 2011; Durrani et al., 2017). In addition, the monocyte numbers were higher than eosinophils as shown by (AL-Busadah, 2007; Aichouni et al., 2010; Durrani et al., 2017). However, the WBC counts were higher than the studies of (Eissa and Abdel-Fattah, 1974; Jalal et al., 2010; Al-Mujalli et al., 2011; Babeker et al., 2013; Ahmadi-hamedani et al., 2014) and lower than the other studies of (Nazifi et al., 1998; Chaudhary and Iqbal, 2000; AL-Busadah, 2007;

Aichouni et al., 2010). Also, some studies showed that neutrophils as the predominant cell types followed by lymphocytes (Chaudhary and Iqbal, 2000; Ali et al., 2010; Babeker et al., 2013; Osman et al., 2015) and the eosinophils numbers more than monocytes (Nazifi et al., 1998; Chaudhary and Iqbal, 2000; Ali et al., 2010; Farooq et al., 2011; Babeker et al., 2013) unlike the finding of this study. The variation of white blood cell values could be attributed to the breed variations and stress accompanied the blood sampling (Higgins and Kock, 1984).

The current study has documented the normal values of many blood constituents in Libyan camels. These values were within the physiological range reported in other studies and the variations observed between this study and the previous studies could be attributed to many factors. The biochemical and haematological values obtained in this first part of the present study series may form a baseline reference for subsequent blood studies on the dromedaries in Libya. The effects of breed, gender and age on these values are investigated in the following three parts of this series.

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