STUDIES ON SERUM BIOCHEMICAL PARAMETERS OF CAMELS (*Camelus dromedarius*) IN ETHIOPIA

BY

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LIST OF ABBREVIATIONS

°C	Degree Celsius
µl	microliter
ALP	Alkaline phosphatase
ALT	Alanine aminotransferase
AST	Aspartate aminotransferase
BUN	Blood urea nitrogen
CK	Creatine kinase
CSA	Central Statistics Authority
E	East
ECF	Extra cellular fluid
g/dl	gram per deciliter
GGT	Gamma glutamyl transferase
GOT	Glutamic oxaloacetic transaminase
GPT	Glutami pyruvic transaminase
kms	kilometers
LDH	Lactate dehydrogenase
mg/dl	milligram per deciliter
ml	milliliter
mm	millimeter
mmol/L	millimole per liter
N	North
nm	nanometer
NRCC	National research center on camel
SD	Standard deviation
U/L	Unit per liter

ABSTRACT

This study was conducted in Awash Fentale district of Afar region and Metehara town of Oromia region, Ethiopia, in an attempt to determine the serum biochemical parameters of camels as well as to observe the influence of age on the parameters. The mean values of serum enzyme levels of ALP, ALT, AST and GGT for the Borana origin camels were 106.77 ± 32.06 U/L, 12.54 ± 4.65 U/L, 75.16 ± 25.48 U/L and 15.06 ± 7.85 U/L, respectively. The mean concentrations of serum electrolytes were 146.83 ± 0.28 mmol/L, 5.27 ± 0.06 mmol/L, 112.6 ± 0.21 mmol/L and 0.59 ± 0.02 mmol/L for sodium, potassium, chloride and ionized calcium, respectively in the Borana origin camels. Whereas, the mean serum concentrations of total protein, urea, creatinine, total bilirubin, direct bilirubin and triglyceride were 6.67 ± 0.05 g/dl, 35.76 ± 0.74 mg/dl, 1.96 ± 0.02 mg/dl, 0.53 ± 0.01 mg/dl, 0.2 ± 0.01 mg/dl and 0.86 ± 0.02 mmol/L, respectively. In Afar camels, the mean values of serum enzyme levels of ALP, ALT, AST and GGT were 114.8 ± 6.83 U/L, 10.09 ± 0.73 U/L, 67.42 ± 3.5 U/L and 11.96 ± 0.83 U/L, respectively. The mean concentrations of serum electrolytes were 165.91 ± 1.38 mmol/L, 4.96 ± 0.09 mmol/L, 125.49 ± 0.58 mmol/L and 1.19 ± 0.04 mmol/L for sodium, potassium, chloride and ionized calcium, respectively for the Afar camels. Whereas, the mean serum concentrations of total protein, urea and creatinine were 6.39 ± 0.14 g/dl, 48.76 ± 1.25 mg/dl and 1.16 ± 0.02 mg/dl, respectively. The data analysis revealed that age had significant effect on some of the serum biochemical parameters. Afar camels up to the age of 5 years had significantly ($P< 0.05$) higher levels of ALP, whereas those above 5 years of age had significantly ($P< 0.05$) higher levels of urea. Borana origin camels up to the age of 5 years had significantly ($P< 0.05$) higher levels of ALT and AST, whereas those above 5 years of age had significantly ($P< 0.05$) higher levels of total protein. Thus, care should be taken during interpretation of serum biochemical values for disease diagnosis due to the influence of age.

Key words: serum biochemistry, age, camel, Ethiopia

1. INTRODUCTION

The dromedary camel, which totals almost 90 per cent of the genus *Camelus* in the world today, is distributed in Africa, Middle East and the Indian sub-continent with more than 80 per cent occurring in Africa (Lensch, 1999; Wilson, 1989). According to the animal population census (CSA, 2004), the camel population in Ethiopia is estimated to be 2.314 million. The major ethnic groups owning camels in Ethiopia are the Beja, Rashaida, Afar, Somali and Borana (Workneh, 2002).

The camel plays a significant role in the socio-economic affairs of the nomadic people by providing meat, milk and draught power. Wealth, status and subsistence of the nomadic people are based on their close association with camels (Abebe, 1991; Tegegne, 1991). Despite its significant contribution to the livelihood of the pastoralist society whose mode of production allows very limited choice, up until recently, the camel is one of the most neglected domestic livestock with regard to research (Yesihak and Bekele, 2003).

Although, the camels have been used and bred for several thousand years, the efforts to understand their biology and diseases in greater depth has been only been done fairly recently. Camels constitute the least researched domestic animal among others. Because camels are still such important animals in Africa, the Middle East and Asia, there has been more interest and need to understand their diseases and healthcare needs, nutritional requirements, reproduction, behavior, physiology, and adaptation (Jean and Judith, 2004).

Of the several production factors that have impact on the performance of animals, diseases are the most important. Appropriate diagnostic procedures are essential for any intervention programs. Similar to other livestock, hematological and serum biochemical tests are widely used and provide a good basis for judgment regarding the nature of a disease, the extent of tissue and organ damage, the response of the immune defense mechanism and selection of an appropriate treatment (Schalm *et al*., 1975; Jain, 1993). Hence, baseline data on normal hematological and serum biochemical parameters have paramount importance both for the

clinician and for researcher who envisage for clear understanding and interpretations of physiological and pathological conditions.

The normal blood values in apparently healthy animals are affected by several factors. These are age, sex, breed, nutritional status, physiological status, season, ambient temperature, altitude and others. It is also well known that variations exist in hematological and serum biochemical parameters with regard to sampling procedure and analytical techniques (Beaunoyer, 1992; Jain, 1993).

A potential difference in the types of breeds, management and local environmental factors indicates that data available for camels in other camel breeding regions cannot be reliably used elsewhere. This necessitates the establishment of all physiological parameters in breeds of camels present in Ethiopia. Though the need for reference values of hematological and serum biochemical parameters of camel breeds in Ethiopia is indisputable, very few attempts have been made so far to establish values for apparently healthy camels. It is high time that an objective detailed study be carried. The objectives of this thesis are therefore:

- To determine the level of serum enzymes of clinical significance in apparently healthy camels reared in Ethiopia
- To establish the concentrations of selected biochemical constituents in serum of the camels
- To assess the influence of age on the serum biochemical parameters of camels

2. LITERATURE REVIEW

2.1. Distribution of camels

Scientists believe that the Camelidae evolved in North America. Their ancestors migrated from North America across the Alaskan land bridge to Asia and down across Panama into South America. They eventually became extinct in North America, but adapted well and evolved to their current forms. Once in Asia, camels migrated through Eastern Europe, the Middle East and North Africa. In Asia, two groups separated to become the two chief types of camel known today: the dromedary, one-humped or Arabian camel (*Camelus dromedarius*) and the bactrian or the two-humped camel (*Camelus bactrianus*) (Graham, 1996; Jean and Judith, 2004).

It is believed that the dromedary camels were domesticated earlier than the bactrian camels, before 3000 B.C. in the Arabian peninsula, whereas bactrian camels are thought to have been domesticated prior to 2500 B.C. While Arabian camels are now all domesticated, some bactrian camels still live in the wild in the Gobi desert, between southwest Mongolia and northwest China (Graham, 1996).

The dromedarian camel is distributed in Africa, Middle East and the Indian sub-continent (Lensch, 1999). It is numerically far superior to the bactrian camel, and totals almost 90 per cent of the genus *Camelus* in the world today. More than 80 per cent of Arabian camels occur in Africa with Somalia and Sudan accounting for 70 per cent of camels in Africa while Ethiopia, Chad and Kenya contain a further 12 per cent (Wilson, 1989). According to the animal population census (CSA, 2004), the camel population in Ethiopia is estimated to be 2.314 million. The bactrian camel occupies Mongolia, Central Asia and China. It can withstand the very low temperatures of the winter as well as the high temperatures of the summer (Jean and Judith, 2004).

The distribution of camels is governed by environmental and social factors. With regard to the environment, the African and Asian tropical and subtropical dry areas are the convenient distributional range of the camel. The greatest social impact on the recent distribution of the

camel was the advent of Islam, as Arabs poured from their heartland to conduct their Holy Wars and spread their gospel they took their camels with them, consolidating its range northwards and eastwards in Asia and westwards along the Mediterranean littoral. In general, there has been a steady increase in camel population since about 1980s. However, in countries in which oil is now the principal commodity and where the nomadic way of life is no longer the major one, there has been a steady decrease in the numbers of camels (Wilson, 1998).

2.2. Dromedary's adaptation to heat and dehydration and its importance

The dromedary camel does not store water any more than does any other species, yet it does not need to drink water for days. It can lose safely body water equivalent to 40 per cent of its body weight, a loss that would be lethal in any other animal. Its success in climates hotter and drier than those, which other domestic animals can tolerate, is due to its different physiological adaptations to heat and dehydration. Some of the different adaptations are: plasma volume maintenance at the expense of tissue fluid, the ability of its small oval erythrocyte to continue to circulate in situations of increased blood viscosity, ability of the camel to take in a very large amount of water at one session to make up for previous fluid loss that would cause osmotic problems in other animals, ability to reduce water loss through respiration, ability of their kidneys to concentrate urine markedly to reduce water loss and efficient reabsorption of water in colon to reduce fecal water loss (Graham, 1996). A further adaptation solely for heat is the camel's ability to tolerate fluctuations of body temperature (from 34 - 42 ^{0}C); during the hot desert day it can increase its body temperature and store heat to conserve water that would otherwise be lost to evaporation and during the cool night of the desert, the stored heat in the camel dissipates by non-evaporative mechanisms so that its body temperature returns to a normal level (Graham, 1996; Schwartz and Dioli, 1992).

Dromedary camels, which are primarily the domestic animals of pastoral communities, produces milk, meat, wool, hair and hides, and serves for riding, as a beast of burden and as a draft animal for agriculture and short-distance transport. The camels are also used for driving oil mills, operating water wheels or drawing irrigation water from deep wells. Recently, camel racing and other sports and leisure activities, such as camel safaris and trekking have become a

tourist attraction in some parts of the world. In Ethiopia, the major camel product is milk followed by meat. Although hides, hair and draught power are recognized as potential products, they are not exploited to any significant extent (Schwartz and Dioli, 1992).

2.3. Importance of serum biochemical studies

Evaluation of chemical components of blood, particularly when combined with complete physical examination and history of the patient, becomes an important aid in formulation of an accurate diagnosis, prescription of proper therapy, and documentation of the response to treatment. Information received from such analyses is of value only if the proper studies have been requested and the clinician has the ability to interpret the results. Most chemical assays measure the level of a dissolved substance normally carried in blood or the amount of a substance not normally found in blood, which has been released into the blood from damaged or destroyed cells (Coles, 1986; Colville, 2003).

2.3.1. Importance of serum enzyme level determination

Importance of determining the level of serum alanine aminotransferase (ALT)

The enzyme alanine aminotransferase (ALT), previously known as serum glutamic pyruvic transaminase (GPT) is also correctly referred to as alanine transaminase. ALT is a cytoplasmic enzyme that catalyzes the transamination of alpha-ketoglutarate and L-alanine, forming glutamate and pyruvate (Bain, 2003; Kaufman and Greene, 1993). The highest levels of ALT are found in hepatocytes and striated (skeletal and cardiac) muscle cells. Therefore, increased serum ALT level can accompany hepatocellular injury or necrosis of striated muscle as aresult of escape from cytosol (Valentine *et al.,* 1990). Mechanisms of increased level of ALT in serum include enzyme release from damaged cells or increased enzyme synthesis (Stockham and Scott, 2002).

In dogs, cats, rats, rabbits, and primates, ALT level is highest in hepatocytes. Therefore, elevations in serum ALT level are considered relatively specific for liver disease. However, it

may also occur with striated muscle necrosis or injury. Ruminants, pigs, horses, and birds have a much lower level of hepatocellular ALT. The serum creatine kinase (CK) level should be measured to determine whether the increased ALT level is due to hepatocyte or muscular damage. Increased serum CK level indicates a muscular insult; however, increased ALT level without a concurrent increase in CK level suggests hepatocellular damage (Bain, 2003; Stockham and Scott, 2002; Valentine *et al.*, 1990).

Importance of determining the level of serum ***aspartate aminotransferase (AST)***

The enzyme AST is also known as serum glutamic oxaloacetic transaminase (GOT). AST occurs in a wide variety of tissues including liver hepatocytes, cardiac muscle, skeletal muscle, brain, kidneys, lungs, pancreas, erythrocytes and leukocytes, with highest concentrations found in liver and skeletal muscle. When disease or injury affects these tissues, the cells are destroyed and AST is released into the bloodstream. Since AST is present in several tissues, measurement of its serum level is not an organ-specific test and consequently may be utilized to detect destruction in a wide variety of tissues. However, the most common causes of increased blood levels of AST are hepatic disease, muscle inflammation or necrosis, and hemolysis (Schumann and Klauke, 2003; Colville, 2003).

Importance of determining the level of serum ***alkaline phosphatase (ALP)***

Phosphatases are agents that hydrolyze phosphoric esters with the liberation of inorganic phosphate (Coles, 1986). Alkaline phosphatase (ALP) is an enzyme found in high concentrations in liver, osteoblasts of bone, placenta, and intestine. Since ALP occurs as isoenzymes in these various tissues, the source of an isoenzyme or location of the damaged tissue may be determined by special analytic methods in commercial or research laboratories (Colville, 2003). ALP is found in small amount in serum, but when largely elevated it particularly indicates bone or liver disease or tumor. In liver, ALP is produced by the cells lining the small bile ducts. Therefore, if the liver disease is primarily of an obstructive nature (cholestatic), i.e. involving the biliary drainage system, the alkaline phosphatase will be the first and foremost enzyme to be elevated, unlike aminotransferases elevation that indicates

hepatocyte damage. In bone, elevated level signifies bone cancer or rickets (Coles, 1986; Colville, 2003).

Importance of determining the level of serum gamma glutamyl transferase (GGT)

Gamma glutamyl transferase (GGT), sometimes referred to as gamma glutamyl transpeptidase, is an enzyme that is found in many tissues but its primary source is the liver. Other sources of GGT include the kidneys, pancreas, intestine and muscle cells. Raised levels of GGT in the blood are a sensitive indicator of liver disease, especially obstructive liver disease. Together with alkaline phosphatase (ALP), GGT is a marker of cholestasis. Any blockage to the flow of bile, inside or outside the liver, will lead to induction of these enzymes and both tend to be elevated in blood to similar levels. Serum levels of GGT are commonly elevated in acute hepatitis although the rise in GGT is usually less than that of the transaminases (Ruppin *et al.*, 1982; Colville, 2003).

2.3.2. Importance of determining the concentration of serum electrolytes

The serum electrolytes concentrations are affected by body fluid problems, water deprivation, nutritional deficiency and other factors. Such factors cause disturbance of the electrolytes particularly sodium, chloride, calcium, potassium, phosphorous, iron and magnesium in the body of the animal. Thus, the disturbance of these electrolytes results in malfunctions of various organs and tissues and leads to clinical manifestations. Therefore, determination of serum electrolytes is needed for evaluating animals with a suspected electrolyte disorders and for treating them according to the standard reference values (Mohamed, 2006; Kerr, 1989).

Importance of determining the concentration of serum sodium

Sodium is the major cation of ECF whose primary functions in the body are to maintain osmotic pressure and acid-base balance. Sodium functions at the cell membrane level by creating an electrical potential between different cell membranes causing the transmission of

nerve impulses and neuromuscular excitability to be maintained. Sodium is also involved in some enzyme catalyzed reactions as a cofactor (Burtis and Ashwood, 1994; Norbert, 1990).

Low sodium values in blood, hyponatremia, usually reflect a relative excess of body water rather than a low total body sodium. Reduced sodium levels may be associated with: low sodium intake; sodium losses due to vomiting or diarrhea with adequate water and inadequate salt replacement or diuretics abuse; osmotic diuresis seen in diabetes mellitus; and lack of aldosterone during adrenocortical insufficiency (Addison's disease) (Burtis and Ashwood, 1994).

Elevated sodium values, hypernatremia, are associated with conditions with water loss in excess of salt loss through profuse sweating, severe vomiting or diarrhea or diabetes insipidus; increased renal sodium conservation in hyperaldosteronism; or advanced chronic renal failure with a low glomerular filtration rate (Coles, 1986; Norbert, 1990).

Therefore, the sodium value obtained may be used in the diagnosis or monitoring of all disturbances of the water balance, infusion therapies, vomiting, diarrhea, kidney insufficiency, central or renal diabetes insipidus, endocrine disturbances and primary or secondary cortex insufficiency of the adrenal gland or other diseases involving electrolyte imbalance (Norbert, 1990).

Importance of determining the concentration of serum potassium

Potassium is the major intracellular cation that has important role in normal muscular function, cardiac function, nerve impulse transmission, and helps maintain acid-base balance and osmotic pressure (Colville, 2003).

Hyperkalemia, an elevated blood potassium levels, occurs secondary to hypoadrenocorticism, renal failure particularly acute failure, diffuse cell necrosis or altered membrane permeability and during acidosis especially when there is concomitant kidney dysfunction. Factitious hyperkalemia (pseudohyperkalemia) may occur during delayed separation of serum from

clotted blood with extreme leukocytosis or thrombocytosis as well as during hemolysis (Meyer and Harvey, 1998).

Hypokalemia, low blood potassium levels, can be found in excessive loss of potassium through vomiting or diarrhea, inadequate intake of potassium, malabsorption, hyperadrenocorticism, and alkalosis where potassium is excreted in urine and hydrogen is retained (Burtis and Ashwood, 1994; Norbert, 1990; Meyer and Harvey, 1998).

High or low potassium levels may cause changes in muscle irritability and myocardial function. The potassium value obtained may be used to monitor electrolyte imbalance in the diagnosis and treatment of infusion therapies, heart or circulatory insufficiency, acid-base imbalance, therapy with diuretics, kidney problems, diarrhea and hyper- and hypo-function of adrenal cortex and other diseases involving electrolyte imbalance (Burtis and Ashwood, 1994; Norbert, 1990).

Importance of determining the concentration of serum chloride

Chloride is the predominant extracellular anion that plays an important role in maintenance of water distribution, osmotic pressure, and the normal anion: cation ratio. Its measurement provides the least clinical information of the electrolytes; but is usually included in electrolyte profiles because of its close relationship to sodium and bicarbonate levels (Meyer and Harvey, 1998).

Chloride alterations generally follow those of sodium. Thus, hypochloremia may occur with prolonged vomiting (hypokalemia, hypochloremic metabolic alkalosis), advanced renal failure and adrenal insufficiency; while hyperchloremia may occur with dehydration and Cushing's syndrome (Burtis and Ashwood, 1994; Norbert, 1990; Coles, 1986).

Importance of determining the concentration of serum calcium

Calcium in whole blood is almost entirely in plasma or serum, with erythrocytes containing only little calcium (Colville, 2003). The plasma calcium exists in three forms: ionized or free, bound to albumin and bound to anions. The pH of ECF and the plasma protein concentration can change its plasma concentration (Meyer and Harvey, 1998).

Hypercalcemia may be seen during primary hyperparathyroidism, pseudohyperparathyroidism, hypervitaminosis D, renal disease, hyperproteinemia, and osteolytic bone lesions. Hypocalcemia may be observed during hypoalbuminemia, alkalosis, hypoparathyroidism and dietary imbalances (Meyer and Harvey, 1998; Coles, 1986).

The ionized portion of the total calcium in serum or plasma can also be determined. Ionized and total calcium measurements have about equal utility. However, in certain disorders such as pancreatitis and hyperparathyroidism, ionized calcium is a better indicator for diagnosis than total calcium. Ionized calcium determination is also the preferred method for accurately monitoring calcium status in renal disease (Burritt *et al*., 1980; Norbert, 1990).

2.3.3. Importance of determining the level of serum bilirubin

When red blood cells die, the pigment portion of heme, or porphyrin, is metabolized by the macrophage system to bilirubin, which is pigmented compound considered a waste material. This bilirubin is uncojugated (indirect-reacting) and becomes conjugated after it is taken into hepatocytes, where it is then carried to the intestines by the bile (Meyer and Harvey, 1998).

Unconjugated bilirubin and conjugated bilirubin are found in plasma or serum, and assays can directly measure total bilirubin (conjugated bilirubin plus unconjugated bilirubin) and conjugated bilirubin (Colville, 2003).

Bilirubin is assayed to determine the cause of jaundice, to evaluate liver function, and to check the patency of bile ducts. Blood levels of conjugated (direct) bilirubin are elevated with

hepatocellular damage or bile duct injury / obstruction; whereas blood levels of unconjugated (indirect) bilirubin are elevated with excessive erythrocyte destruction or defects in the transport mechanism that allow bilirubin to enter hepatocytes for conjugation (Colville, 2003).

2.3.4. Importance of determining the level of serum creatinine

Creatinine is irreversibly formed from creatine that is found in skeletal muscle, as part of muscle metabolism. It rapidly diffuses out of the muscle cell into the blood. The creatinine in blood is filtered through the glomeruli and eliminated in urine without renal tubular reabsorption (Colville, 2003; Meyer and Harvey, 1998).

Blood creatinine levels are used to evaluate renal function, based on the ability of the glomeruli to filter creatinine from blood and eliminate it in urine. However, it is not accurate indicator of kidney function, because nearly 75 per cent of the kidney tissue must be nonfunctional before blood creatinine levels rise (Colville, 2003). Generally, causes of increased blood creatinine level are prerenal, like in case of dehydration and cardiac insufficiency; postrenal, subsequent to urethral obstruction; and renal, during glomerular damage (Meyer and Harvey, 1998).

2.3.5. Importance of determining the level of total serum protein

The total plasma protein measurements include fibrinogen values, whereas the total serum protein determinations measure all the protein fractions except fibrinogen, which is removed during the clotting process. The total protein concentration may be affected by altered hepatic synthesis, rapid albumin breakdown or excretion during disease, dehydration, or over hydration. Total protein concentrations are especially valuable in determining an animal's state of hydration. Total protein concentrations also are useful as initial screening tests for patients with edema, ascites, diarrhea, weight loss, hepatic and renal disease, and blood clotting problems (Colville, 2003; Coles, 1986).

2.3.6. Importance of determining the level of serum urea

Urea, a final degradation product of protein and amino acid metabolism, is assayed in blood to evaluate kidney function based on the ability of the kidney to remove urea from blood. However, this renal function test is not very sensitive since 75 per cent of kidney tissue must be non-functional before elevated values are detected (Colville, 2003).

Generally, increase in the blood urea concentration may be due to prerenal causes (dehydration and cardiovascular insufficiency), renal causes (renal diseases causing two thirds to three fourths of nephrons to be destroyed) or postrenal causes (urethral obstruction) (Meyer and Harvey, 1998).

Camels have special ability to recycle and utilize urea for microbial protein synthesis better than true ruminants, particularly when fed on low-protein forages (Gihad *et al*., 1988; Schwartz and Dioli, 1992).

2.3.7. Importance of determining the level of serum triglycerides

Triglycerides are simple lipids that may be ingested or synthesized in the liver. Their main storage site is adipose tissue. Triglycerides combine with cholesterol, phospholipids and plasma proteins to form protein-lipid complexes, known as lipoproteins, in plasma. Triglycerides are also known to be the major components of chylomicrons as well as very low density lipoproteins (Kaneko, 1980; Milne, 1990).

Assay of serum triglycerides is one of the best methods for diagnosing hyperlipemia, which is a syndrome characterized by negative energy balance and rapid mobilization of fatty acids derived from adipose tissue. The mobilized fatty acids ultimately result in fatty liver and subsequent hypertriglyceridemia. Fasting is the usual cause of hyperlipemia, since it results in mobilization of lipid stores more rapidly than the resulting very low density lipoprotein can be utilized by tissues (Forhead, 1994; Kaneko, 1980).

2.4. Factors affecting serum biochemical parameters

The blood values in apparently healthy animals are affected by several factors. These include age, sex, nutritional status, physiological status, season, ambient temperature, altitude and others. Serum biochemical values may also be affected by sampling procedure and analytical techniques (Beaunoyer, 1992; Jain, 1993).

2.4.1. Sex

Influence of sex on serum ALP level was reported in camels by NRCC (India) (1988) where males showed significantly higher level than females. In contrast, NRCC (India) (1986) and Chiericato *et al.* (1986b) could not establish a significant difference between sexes in alkaline phosphatase.

Sarwar *et al.* (2004) showed that sex had significant effect on serum concentration of sodium, with higher levels seen in female camels than in males; however, the author observed no significant effect of sex on the serum level of ALT, AST, potassium, chloride and calcium.

Chiericato *et al*. (1986a), Chartier *et al.* (1986), Badiei *et al*. (2006) and AL-Busadah and Homeida (2005) did not observe any significant sex related difference in concentration of several serum profiles in camels.

2.4.2. Age

Several researchers made age comparisons in terms of serum biochemical levels in camel. Kataria *et al.* (1991) observed total serum protein levels to differ significantly between age groups of < 4, 4-10 and > 10 years where the mean value was highest in young animals below 4 years of age and then gradually declined as the age advanced. However, Chartier *et al.* (1986) observed that the serum protein level was significantly low in camels below one year of age than from 1-7 years and older than 7 years age groups.

Vertor and Swaton (1969), Bissa (1993), NRCC (India) (1988) and NRCC (India) (1990) reported that the serum alkaline phosphatase level was considerably higher in young camels, where alkaline phosphatase level progressively declined with advancement of age. However, Halabi *et al.* (1982) did not observe significant difference in serum alkaline phosphatase level in camels of different ages.

Otesil and Kasali (1992) found significantly elevated levels of AST and ALT in young sheep than in adults. However, no differences for AST and ALT were observed among four age groups of Pakistan male camels (Sarwar *et al.*, 2004).

According to Mohamed (2006), age was found to be an important variable influencing blood iron level in *Camelus dromedaries* aged between 3 months to 7 years with higher levels occurring in neonates than in adults and yearlings. On the other hand, with increase in age, significant increase in serum triglycerides was observed in Iranian male dromedary camels (Nazifi *et al*., 2004).

2.4.3. Season

Seasonal influence on serum biochemistry of camels has been forwarded by several researches. Amin *et al.* (2007) revealed that the serum levels of total protein, globulins and triglycerides increased significantly during the dry season, while the concentrations of plasma glucose and serum urea, creatinine, phosphorous and calcium increased significantly during the green season. From the results obtained, they explained that the nutritional status could induce significant changes in the physiological responses of the dromedary camel, where the available forage during the green season improved the body condition, the blood metabolic and mineral profile in camels.

Statistically significant seasonal variations, in racing camels, were also observed in serum levels of GOT, LDH, BUN and iron; with GOT, BUN and iron levels being higher in winter while LDH was higher in summer (Salman and Afzal, 2004). Seasonal variations in enzyme pattern were attributed to difference in feeding, exercise and management of the racing camels

during the two seasons. The significantly higher BUN and serum iron levels in winter than summer were attributed to higher dietary protein and iron supplementation in the racing season (winter), respectively (Carlson, 1987; Emmanuel, 1984). Salman and Afzal (2004) observed no significant changes in total proteins in camels during the two seasons, but albumin levels were significantly lower in summer than winter, which might be attributed to temperature stress (Kaneko, 1980).

Mehrotra and Gupta (1989), Ghosal *et al.* (1973) and Mohamed *et al.* (1990) also reported seasonal variation in serum concentration of glucose, total protein and urea.

2.4.4. Pregnancy and lactation

The effect of lactation on serum electrolytes was observed by Sarwar *et al*. (2004) where serum potassium level was significantly higher in non-pregnant dry than in non-pregnant lactating camels. However, no significant effect of pregnancy and lactation was observed on serum levels of AST, sodium, chloride and calcium (Sarwar *et al.*, 2004).

Results obtained by Mohamed (2006) and Eltohamy and Salam (1986) indicate that blood iron level in *Camelus dromedarius* was higher in non-pregnant than pregnant and lactating ones. Furthermore, serum ALP level was found to be higher in lactating camels than the non-lactating adult ones (Elias and Yagil, 1984).

3. MATERIALS AND METHODS

3.1. Study area

The study was carried out at two sites, Awash Fentale district of Afar region, and Metehara town of Oromia region (Annex 1). Awash, the capital of Awash Fentale district is located at about 225 kms from Addis Ababa and lies at $8^0$59'N latitude and $40^0$09'E longitude. Awash Fentale district is a lowland area with an altitude of 739 to 931 meters above sea level. The average annual rainfall of the district is 450 mm. It has a mean minimum and maximum temperature of 21 ^{0}C and 38 ^{0}C, respectively. Three villages namely Hadiya Habur, Unda Boloyta and Hayukele Boloyta were selected from Awash Fentale district because of their greater number of camel population as well as based on willingness of the owners to be part of the study.

Metehara is a small town in the Fentale district of East Showa Zone, located 198 kms east of Addis Ababa. It lies at $8^0$54'N latitude and $39^0$54'E longitude. The specific site of data collection in Metehara was "Shag import and export enterprise", which brought the camels from Borana zone of southern Ethiopia.

Most parts of Fentale district are low-lying plains with elevations ranging from 900-1000 meters above sea level. The district is generally characterized by low rainfall of 200-700 mm and high temperature (mean annual of 25-35 ^{0}C). Livestock rearing is the main economic activity of the rural community in the district. The cultivated and grazing lands covered about 8.2 per cent and 7.6 per cent of the district, respectively. Forests and shrubs accounted for 28.8 per cent of the land, while 55.4 per cent is accounted for degraded land. Maize is the only cereal crop grown both by rain fed and irrigation whereas fruits and vegetables are the important cash crops.

3.2. Study animals

A total of 241 apparently healthy camels were selected based on purposive sampling for this study. Awash Fentale camels comprised 55 (10 males and 45 females) of the total while 186

camels (all males) were included from Metehara. The status of 'healthy' was assigned when a camel showed no clinically apparent sign of disease and was declared as being healthy by the herdsmen. The age of all the camels of Awash Fentale ranged from 1 month to 10 years with all the females being non-pregnant whereas the camels of Metehara were between 4 and 8 years of age. Camels of the Awash Fentale area belonged to the traditionally raised Afar types primarily kept for milk production while those of Metehara were animals purchased for export purpose from Borana zone (southern Ethiopia) and were Somali type camels with large body size mainly used for milk and some as pack.

The Afar type camels in Awash Fentale were traditionally managed; watered daily with no supplementation and often wander long distances for feeding. Whereas the Borana origin camels were kept in free stall in Metehara, regularly watered and supplemented with hay, cottonseed cake, and wheat bran for about three months until export time. As part of the routine activity, the Borana origin camels were dewormed and sprayed with acaricide.

3.3. Study design

A cross-sectional study was performed to determine the level of serum biochemical parameters.

3.4. Study methodology

3.4.1. Blood sample collection

Blood samples were collected from the camels by jugular vein puncture using 10 ml plain vacutainer tubes approximately the same time of the day, every morning. Each sample was handled gently to avoid haemolysis and was allowed to clot at room temperature by keeping it in a slant position. Serum was then harvested and stored at -20 ^{0}C until analysis for serum biochemical values using standard methods and procedures provided with the kits (Annex 2). Data pertaining to age (Annex 3) and sex of each camel was recorded at the time of sampling.

3.4.2. Serum biochemical assay

The levels of 13 serum biochemical parameters including enzymes, electrolytes, protein and other metabolites were determined. The levels of serum alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), gamma glutamyl transferase (GGT), urea, total and direct bilirubin, creatinine, triglyceride, and total protein were analyzed using photometer 5010 (Robert Riele GmbH & Co KG, Germany, 2002) and commercially available kits. The concentration of serum sodium, potassium, chloride and ionized calcium was determined using 9180 electrolyte analyzer (Roche Diagnostics Ltd., USA, 2002).

Quality control sera of known values, for the various serum parameters, were used to check the biochemical analyzers to ensure the accuracy of the test results. The quality controls were conducted before analysis of the samples, during maintenance, after replacement of reagents and when there was any doubt about the accuracy of the results.

The level of serum enzymes was expressed in U/L. The level of serum AST (GOT) and ALP was determined using kits (Biocon Diagnostik, Germany), whereas the level of serum GGT and ALT (GPT) was obtained using commercial (Human, Germany) kits. Kinetic method was employed for the determination of the level of AST, ALP, GGT and ALT. The absorbance of ALP and GGT were read at 400 nm wavelength, while that of AST and ALT were read at 340 nm wavelengths.

Determination of serum concentrations of sodium, potassium, chloride and ionized calcium using 9180 electrolyte analyzer was based on the of ion-selective electrode measurement principle. Sodium, potassium, chloride and calcium electrodes were used in the analyzer for the measurement of sodium, potassium, chloride and ionized calcium values, respectively. Each electrode has an ion-selective membrane that undergoes a specific reaction with the corresponding ions contained in the serum sample. The concentration of the electrolytes in the serum was read in terms of mmol/L.

Serum concentration of triglycerides (mmol/L), whose absorbance was read at a wavelength of 546 nm, was determined by enzymatic colorimetric test using a commercially available kit (Human, Germany). Colorimetric test using kits (Human, Germany) was performed to determine the levels of serum total and direct bilirubin (mg/dl). Their absorbance was read at 546 nm wavelength. Urea concentration in the serum (mg/dl), whose absorbance was read at 578 nm wavelength, was determined by enzymatic colorimetric method using a commercially available kit (Biocon Diagnostik, Germany). Total serum protein level (g/dl) read at a wavelength of 546 nm, was determined by colorimetric assay using a commercially available kit (Biocon Diagnostik, Germany). Serum creatinine concentration (mg/dl) was determined by kinetic colorimetric assay using a kit (Biocon Diagnostik, Germany). The absorbance was read at 492 nm wavelength.

3.5. Data analysis

All computations were performed using computer software Microsoft Excel (2003) and SPSS (Version 13.0, 2004). Descriptive statistics of each data on serum parameter was separately calculated for Afar camels as well as Borana origin camels. Comparison of mean values of serum parameters between age groups was separately conducted for Afar camels and Borana origin camels. For comparison between age groups, the serum parameters were checked for normality distribution, and those parameters that were normally distributed were compared with one-way ANOVA whereas those not normally distributed were compared with Mann-Whitney U test. The level of significance was set at 0.05.

4. RESULTS

The mean values of serum ALP, ALT, AST, GGT, sodium, potassium, chloride, ionized calcium, total protein, urea, creatinine, total and direct bilirubin, and triglycerides in the Borana origin camels are shown in Table 1.

Table 1: Mean, minimum and maximum values of serum biochemical parameters in camels of Borana origin (n=186).

Serum parameter	Mean ± SD	Minimum	Maximum
ALP	106.77 ± 32.06	35	184
ALT/GPT	12.54 ± 4.65	5	29
AST/GOT	75.16 ± 25.48	26	154
GGT	15.06 ± 7.85	3	39
Total protein [g/dl]	6.67 ± 0.73	5.05	8.45
Urea [mg/dl]	35.76 ± 10.04	15	63
Creatinine [mg/dl]	1.96 ± 0.33	1.35	2.97
Total bilirubin [mg/dl]	0.53 ± 0.14	0.2	1
Direct bilirubin [mg/dl]	0.2 ± 0.09	0	0.6
Triglycerides [mmol/L]	0.86 ± 0.27	0.5	1.8
Sodium [mmol/L]	146.83 ± 3.88	132	156
Potassium [mmol/L]	5.27 ± 0.76	3.6	7.2
Chloride [mmol/L]	112.6 ± 2.92	102	120
Ionized calcium [mmol/L]	0.59 ± 0.21	0.27	1.27

The mean values of serum ALP, ALT, AST, GGT, sodium, potassium, chloride, ionized calcium, total protein, urea and creatinine in the Afar camels are shown in Table 2.

Table 2: Mean, minimum and maximum values of serum parameters in Afar camels (n=55).

Serum parameter	Mean ± SD	Minimum	Maximum
ALP [U/L]	114.8 ± 50.66	27	205
ALT/GPT [U/L]	10.09 ± 5.4	3	27
AST/GOT [U/L]	67.42 ± 25.98	13	145
GGT [U/L]	11.96 ± 6.18	2	30
Total protein [g/dl]	6.39 ± 1.04	4.29	8.54
Urea [mg/dl]	48.76 ± 9.27	30	67
Creatinine [mg/dl]	1.16 ± 0.17	0.79	1.57
Sodium [mmol/L]	165.91 ± 10.27	151	204
Potassium [mmol/L]	4.96 ± 0.64	4	6.7
Chloride [mmol/L]	125.49 ± 4.32	118	141
Ionized calcium [mmol/L]	1.19 ± 0.29	0.41	1.74

The influence of age, in Afar camels, on the mean values of ALT, AST, GGT, creatinine, total protein, sodium, potassium, ionized calcium and chloride was not significant (P> 0.05). Age had significantly (P< 0.05) influenced mean values of ALP and urea. Afar camels up to the age of 5 years had significantly (P< 0.05) higher levels of ALP, whereas those above 5 years of age had significantly (P< 0.05) higher levels of urea.

Table 3: Mean ± SD values of serum parameters of Afar camels as affected by age.

Serum parameter	≤ 5 years of age	> 5 years of age
n	30	25
ALP [U/L]	146.57 ± 40.46*	76.68 ± 31.97*
ALT/GPT [U/L]	9.4 ± 4.58	10.92 ± 6.24
AST/GOT [U/L]	68.33 ± 28.09	66.32 ±23.73
GGT [U/L]	11.83 ± 6.63	12.12 ±5.72
Urea [mg/dl]	45 ± 9.45*	53.28 ±6.82*
Creatinine [mg/dl]	1.18 ± 0.16	1.14 ± 0.18
Total protein [g/dl]	6.3 ± 1.05	6.5 ± 1.03
Sodium [mmol/L]	166.13 ± 12	165.64 ± 7.94
Potassium [mmol/L]	4.98 ± 0.6	4.92 ± 0.69
Ionized calcium [mmol/L]	1.24 ± 0.31	1.13 ± 0.24
Chloride [mmol/L]	125.87 ± 4.5	125.04 ± 4.14

Row means with '*' differ significantly (P<0.05)

No significant (P>0.05) age influence was noted, in Borana origin camels, on the mean values of ALP, GGT, urea, creatinine, total and direct bilirubin, triglycerides, sodium, potassium, chloride and ionized calcium. Age had significantly (P< 0.05) influenced mean values of ALT, AST and total protein. Borana origin camels up to the age of 5 years had significantly (P< 0.05) higher levels of ALT and AST, whereas those above 5 years of age had significantly (P< 0.05) higher levels of total protein.

Table 4: Mean ± SD values of serum parameters of Borana origin camels as affected by age.

Serum parameter	≤ 5 years of age	> 5 years of age
n	102	84
ALP [U/L]	111.47 ± 34.21	101.07 ±28.41
ALT/GPT [U/L]	13.29 ± 5.02*	11.63 ± 4.01*
AST/GOT [U/L]	77.95 ± 23.32*	71.77 ± 27.65*
GGT [U/L]	14.38 ± 8.23	15.88 ±7.34
Total protein [g/dl]	6.54 ± 0.68*	6.82 ± 0.76*
Urea [mg/dl]	35.52 ± 9.07	36.05 ±11.16
Creatinine [mg/dl]	1.92 ± 0.32	2 ± 0.34
Total bilirubin [mg/dl]	0.54 ±0.14	0.51 ± 0.14
Direct bilirubin [mg/dl]	0.2 ± 0.08	0.21 ±0.09
Triglycerides mmol/L]	0.85 ± 0.25	0.88 ± 0.29
Sodium [mmol/L]	146.82 ± 4.04	146.83 ± 3.69
Potassium [mmol/L]	5.24 ± 0.75	5.3 ± 0.78
Chloride [mmol/L]	112.33 ± 3.2	112.92 ± 2.54
Ionized calcium [mmol/L]	0.57 ± 0.19	0.63 ± 0.23

Row means with '*'differ significantly (P<0.05)

5. DISCUSSION

Serum biochemical parameters of camels in Ethiopia have not yet been conducted. This study is the first to determine a wide range of serum constituents of camels in Ethiopia. All blood samples were collected, stored and analyzed with the same technical procedures in order to avoid variations in the biochemical parameters with regard to sampling procedures, analytical techniques and other factors (Beaunoyer, 1992).

The mean value of ALT in the Borana origin camels was 12.54 ± 0.34 U/L whereas that of Afar camels was 10.09 ± 0.73 U/L. Both values were in close agreement with the reports of Bogin (2000) (11 ± 3 U/L) and Al-Busadah and Homeida (2005) for three breeds of camels in Saudi Arabia (11.23 ± 1.6 U/L). However, both values were lower than the mean values reported by Mohamed and Hussein (1999) for 100 normal 'Hijin' racing camels in Kuwait (17.42 ± 4.08 U/L) and Osman and Al-Busadah (2003) for 5 adult she-camels in Saudi Arabia (17.2 ± 3.6 U/L). On the other hand, both values were observed to be higher than the reports of Sarwar *et al*. (2004) for 56 normal camels of both sexes in Pakistan (4.33 ± 0.12 U/L), Kouider and Kolb (1982) for 6 Syrian camels (3.5 ± 3.3 U/L) and Al-Amrousi and Wasfi (1984) for 40 Saudi Arabian camels of the two sexes (5.54 ± 0.51 U/L).

In the current study, the mean values of AST for Borana origin and Afar camels were 75.16 ± 1.87 U/L and 67.42 ± 3.5 U/L, respectively. The mean values of AST for both camels were close to the values of 69.8 ± 23.11 U/L reported for racing camels in Kuwait by Mohamed and Hussein (1999) and 71 ± 8 U/L observed for 28 adult racing camels in United Arab Emirates during summer season by Salman and Afzal (2004). In addition, an average of 81 ± 3.7 U/L found in Syrian camels by Al-Ali *et al*. (1988) was close to the mean of Borana origin camels. However, values of AST much higher than the averages of Borana origin and Afar camels were reported by Osman and Al-Busadah (2003) for she-camels in Saudi Arabia (164.6 ± 39.9 U/L) and Bogin (2000) (105 ± 17 U/L). On the contrary, lower means of AST were reported by Sarwar *et al*. (2004) for normal camels of both sexes in Pakistan (47.79 ± 2.58 U/L), Al-Amrousi and Wasfi (1984) for Saudi Arabian camels of the two sexes (44.22 ± 6.2 U/L), Al-

Busadah and Homeida (2005) for three breeds of Saudi Arabian camels (28.98 ± 3.1 U/L) and Kouider and Kolb (1982) for Syrian camels (24.6 ± 5 U/L).

The mean serum GGT level was 15.06 ± 0.58 U/L and 11.96 ± 0.83 U/L in Borana origin and Afar camels, respectively. Bogin (2000) reported a low average value of 10 ± 3 U/L. Although the minimum and maximum values reported by Mohamed and Hussein (1999) for 'Hijin' racing camels (12 U/L and 28 U/L) fall within those for Borana origin camels (3 U/L and 39 U/L) and Afar camels (2 U/L and 30 U/L), the mean value in the race camels (20.82 ± 3.34 U/L) was higher than both the Borana origin and Afar camels. Higher average than the Borana origin and Afar camels was also reported by Osman and Al-Busadah (2003) for she-camels in Saudi Arabia (25.6 ± 7.8 U/L).

The mean ALP level in Afar camels was 114.8 ± 6.83 U/L, while in Borana origin camels it was 106.77 ± 2.35 U/L. The higher value observed in Afar camels might be due to the high ALP level observed in young camels particularly less than 1 year of age. Increased levels of ALP may occur in young growing animals due to their higher metabolic and osteoblastic activities than other age groups (Coles, 1986; Elias and Yagil, 1984; Kerr, 1989). Both mean values observed in the present study were higher than the reports of Osman and Al-Busadah (2003) for she-camels in Saudi Arabia (60 ± 7.2 U/L), Mohamed and Hussein (1999) for normal 'Hijin' racing camels in Kuwait (95.12 ± 36.8 U/L) and Bogin (2000) (82 ± 13 U/L). On the other hand, very high mean values were reported by NRCC (India) (1988) for camels 2 to 3 years of age (184.8 ± 23.02 U/L), and Elias and Yagil (1984) for newborn calves (289.1 ± 43.2 U/L).

In the present study, the mean total serum protein concentration in Borana origin and Afar camels was 6.67 ± 0.05 g/dl and 6.39 ± 0.14 g/dl, respectively. Mean values very comparable to the Afar camels were reported by Mohamed and Hussein (1999) for racing camels (6.26 ± 0.6 g/dl), and Salman and Afzal (2004) for racing camels in United Arab Emirates during summer (6.36 ± 0.28 g/dl) and winter (6.33 ±0.27 g/dl). Higher means than both Borana origin and Afar camels were reported by Al-Busadah and Homeida (2005) for camels of Saudi Arabia (7.74 ± 0.68 g/dl), Osman and Al-Busadah (2003) for she-camels of Saudi Arabia (7.1 ± 0.3

g/dl) and Amin *et al*. (2007) for camels in Sudan during the green season (7.08 ± 0.08 g/dl) and dry season (8.43 ± 0.08 g/dl).

The mean urea concentrations in Afar camels and Borana origin camels were 48.76 ± 1.25 mg/dl and 35.76 ± 0.74 mg/dl, respectively. The mean urea value of Borana origin camels was in close agreement with the observation of Amin *et al*. (2007) for 210 camels of Sudan during the dry season (34 ± 1.8 mg/dl); while that of Afar camels was in close agreement with the finding of Osman and Al-Busadah (2003) for she-camels of Saudi Arabia (49.8 ± 5.5 mg/dl). Chavanne and Bone (1950) reported an average urea value of 40 mg/dl, which was in between the means of Afar and Borana origin camels. The mean urea concentrations of both Borana origin and Afar camels were higher than the reports of Bogin (2000) (30 ± 9 mg/dl), Koudier and Kolb (1982a) (25.7 ± 4.9 mg/dl) and Azwai *et al*. (1990) (31.72 mg/dl). However, a higher mean value than both was reported by Amin *et al*. (2007) (55.13 ± 1.74 mg/dl) during the green season that was attributed to availability and quality of forage during that season.

The mean serum creatinine concentration was determined in Borana origin camels (1.96 ± 0.02 mg/dl) and Afar camels (1.16 ± 0.02 mg/dl). The higher value seen in Borana origin camels may be attributed to their higher muscle mass. The mean creatinine value of Borana origin camels was in close agreement with the observations of Mohamed and Hussein (1999) for 'Hijin' racing camels in Kuwait (1.97 ± 0.33 mg/dl) and Salman and Afzal (2004) for racing camels in United Arab Emirates during summer season (1.87 ± 0.23 mg/dl) and winter season (1.9 ± 0.15 mg/dl). Average creatinine values were reported by Osman and Al-Busadah (2003) for she-camels (1.5 ± 0.1 mg/dl) and Amin *et al*. (2007) for camels in Sudan during the green season (1.54 ± 0.04 mg/dl) that were in between the means of Afar and Borana origin camels. Lower mean creatinine values of 0.8 ± 0.4 mg/dl and 0.84 ± 0.05 mg/dl were reported by Bogin (2000) and Amin *et al*. (2007) during dry season, respectively.

The study shows that Afar camels and Borana origin camels had mean serum sodium concentration of 165.91 ± 1.38 mmol/L and 146.83 ± 0.28 mmol/L, respectively. The lower sodium value seen in Borana origin camels might be attributed to relative excess of body water rather than a low total body sodium (Burtis and Ashwood, 1994) because of regular water

supply. The mean sodium value of Afar camels was close to the value of 168.2 ± 0.7 mmol/L reported by Osman and Al-Busadah (2003) for she-camels. On the other hand, the mean sodium value of Borana origin camels was close to the findings of Mohamed and Hussein (1999) for normal 'Hijin' racing camels (148.22 ± 17.42 mmol/L), Barakat and Fattah (1970) for 200 adult Egyptian camels of either sex (148.16 ± 2.05 mmol/L) and Al-Amrousi and Wasfi (1984) for 40 Arabian camels (146.06 ± 2.03 mmol/L). Sarwar *et al*. (2004) observed higher mean sodium concentration of 178.39 ± 2.86 mmol/L for normal camels in Pakistan.

The mean value of potassium was 5.27 ± 0.06 mmol/L and 4.96 ± 0.09 mmol/L for the Borana origin and Afar camels, respectively. The average value of potassium in Borana origin camels was very comparable with the value of 5.41 ± 0.1 mmol/L observed by Sarwar *et al*. (2004) for Pakistan camels; while that of Afar camels was comparable to the value of 4.7 ± 0.1 mmol/L found by Barakat and Fattah (1970) for adult Egyptian camels. Mean values lower than Afar and Borana origin camels were observed by Mohamed and Hussein (1999) for racing camels (3.96 ± 0.41 mmol/L), Osman and Al-Busadah (2003) for she-camels (4 ± 0.2 mmol/L), Al-Busadah and Homeida (2005) for camels in Saudi Arabia (4.3 ± 0.61 mmol/L) and Al-Amrousi and Wasfi (1984) for 40 Arabian camels (4.39 ± 0.13 mmol/L).

The mean serum chloride concentrations in Afar and Borana origin camels were 125.49 ± 0.58 mmol/L and 112.6 ± 0.21 mmol/L, respectively. The mean chloride value of Borana origin camels was comparable with the value of 115 ± 7 mmol/L reported by Bogin (2000). Average values higher than Borana origin and Afar camels were reported by Osman and Al-Busadah (2003) for she-camels (130.2 ± 1.9 mmol/L), Yousef and Abdelmalek (1980) for Egyptian camels (171.4 mmol/L) and Sarwar *et al*. (2004) for Pakistan camels (175.8 ± 2.26 mmol/L).

In the present study, the mean concentration of ionized calcium in Afar and Borana origin camels was 1.19 ± 0.04 mmol/L and 0.59 ± 0.02 mmol/L, respectively. The lower ionized calcium level in Borana origin camels might be attributed to low mineral calcium content of their feed. Mean serum concentration of calcium in camels was reported by Amin *et al*. (2007) (2.03 and 2.2 mmol/L in dry and green seasons), Sarwar *et al*. (2004) (5.64 mmol/L), Al-Amrousi and Wasfi (1984) (5.84 mmol/L), Barakat and Fattah (1970) (6.2 mmol/L) and

Mohamed and Hussein (1999) (2.25 mmol/L). However, unlike the current study that measured only the ionized (free) calcium in serum, the above authors determined the total calcium level in serum.

The mean serum triglycerides level observed for Borana origin camels (0.86 ± 0.02 mmol/L) was in accordance with the reports of Nazifi and Maleki (1998) (0.9 ± 0.1 mmol/L) for adult normal Iranian camels. However, the values were higher than the reports of Osman and Al-Busadah (2003) for she-camels in Saudi Arabia (0.36 ± 0.03 mmol/L) and Amin *et al*. (2007) for camels in Sudan during the green season (0.3 ± 0.02 mmol/L) and dry season (0.39 ± 0.02 mmol/L). This higher concentration of serum triglycerides could be related to inadequate feed intake. Reduced feed intake causes mobilization of fatty acids from adipose tissue that ultimately results in subsequent hypertriglyceridemia (Forhead, 1994; Kaneko, 1980).

The mean total bilirubin of Borana origin camels (0.53 ± 0.01 mg/dl) was very comparable to the value of 0.51 ± 0.3 mg/dl found in normal 'Hijin' racing camels by Mohamed and Hussein (1999). However, Bogin (2000) reported lower average bilirubin level of 0.3 ± 0.17 mg/dl.

The variations observed in the mean values of serum biochemical constituents between the present study and the previous other reports might be attributed to difference in methods of analysis, environmental conditions or nutrition (Beaunoyer, 1992).

In Afar camels, those up to the age of 5 years had significantly ($P< 0.05$) higher levels of ALP, whereas those above 5 years of age had significantly ($P< 0.05$) higher levels of urea. The increased levels of ALP in those up to 5 years of age might be due to the higher metabolic and osteoblastic activities in young growing ones than other age groups (Coles, 1986; Elias and Yagil, 1984; Kerr, 1989).

In Borana origin camels age had significantly ($P< 0.05$) influenced mean values of ALT, AST and total protein. Borana origin camels up to the age of 5 years had significantly ($P< 0.05$) higher levels of ALT and AST, similar to the finding of significantly elevated levels of AST and ALT in young sheep than in adults by Otesil and Kasali (1992). Borana origin camels

above 5 years of age had significantly ($P< 0.05$) higher levels of total protein. The increased concentration of total serum protein in camels above 5 years may be attributed to increased gamma globulin concentration in Adults than youngs (Jain, 1993).

6. CONCLUSIONS AND RECOMMENDATIONS

The present study has provided serum biochemical values for Borana origin camels as well as Afar camels of Ethiopia. The biochemical values of the camel serum were within the limits of several previous reports in other countries. The variations observed between the results of the current study and those from previous studies may be attributed to variation in nutrition, environmental conditions or analytical techniques.

In the present study, the influence of age on serum biochemical parameters was seen separately in Afar camels as well as in Borana origin camels. In Afar camels, age significantly affected the levels of ALP and urea, whereas in Borana origin camels the levels of ALT, AST and total protein were significantly affected by age.

Taking into account the above findings, the following recommendations are forwarded:

- Owing to the influence of age on serum parameters, care should be taken during interpretation of serum biochemical values for disease diagnosis

- Extensive and well-controlled studies should be conducted to assess the influence of sex, season, physiological conditions and other factors on the serum biochemical parameters of camel breeds of Ethiopia

- Further investigations should be undertaken to determine serum biochemical values of camel breeds in various regions of Ethiopia

- Although camels are neglected animals in terms of science and research, owing to their significant contribution to the livelihood of pastoral societies, special attention should be given on camel production

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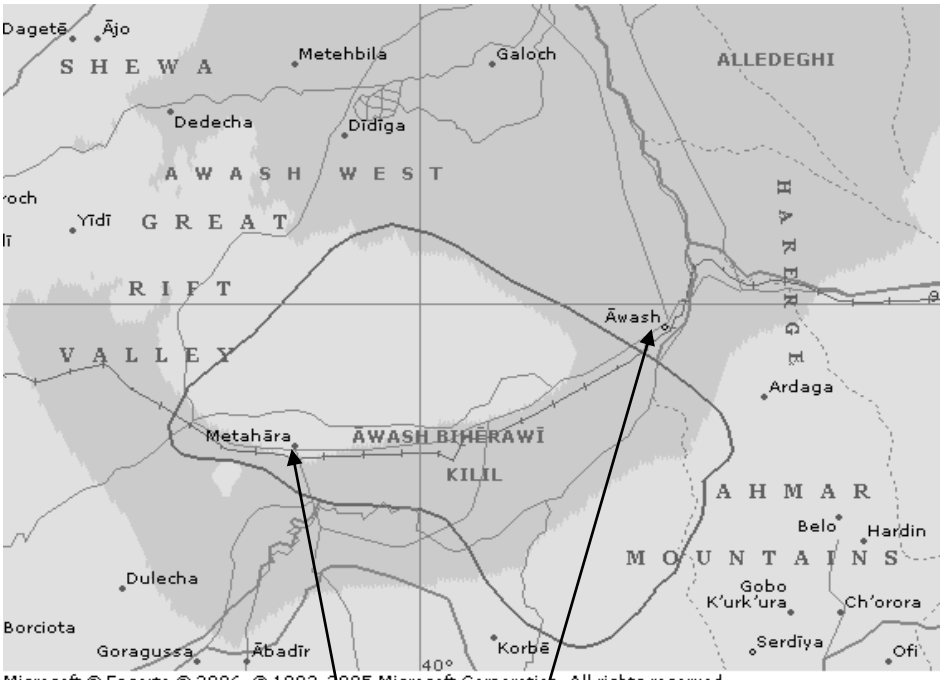
8. ANNEXES

Annex 1. Map of Awash (capital of Awash Fentale district) and Metehara (capital of Fentale district)



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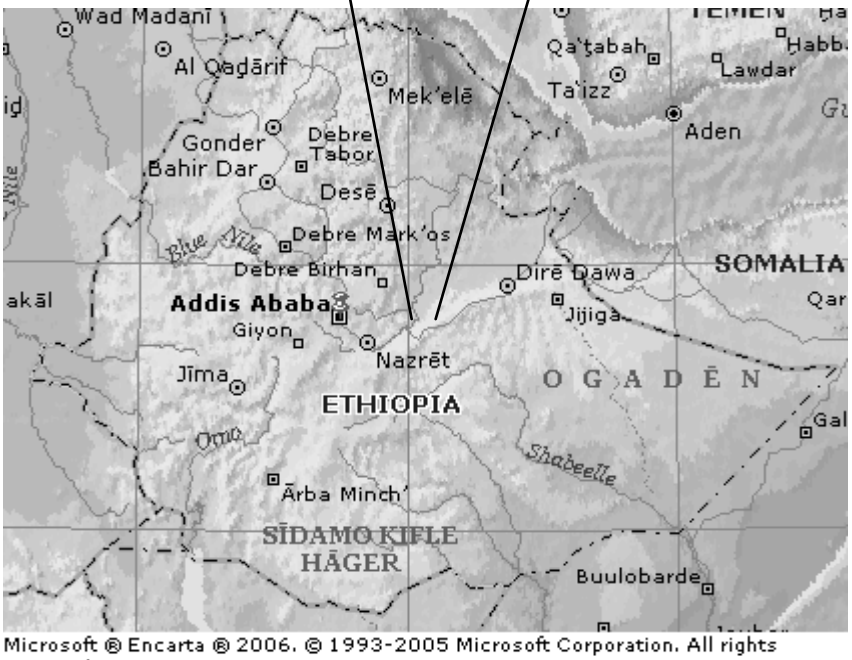

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Annex 2. Laboratory materials and procedures

Analysis of serum enzymes and other metabolites

Materials required

1. Micropipette of different capacity for measuring reagents as well as serum samples
2. Micropipette tips
3. Test tubes
4. Photometer
5. Incubator set at a constant temperature of 37 ^{0}C
6. Reagents for each analyte
7. Serum samples to be analyzed
8. Distilled water to wash the photometer after each analysis
9. Quality control sera for each analyte

Test for Direct and Total Bilirubin

Procedure for total bilirubin

1. Label two test tubes, one sample blank and one sample, for each test.
2. Add 1000 µl total bilirubin reagent (Sulphanilic acid, Hydrochloric acid, Caffeine [accelerator] and Sodium benzoate) to both sample blank and sample test tubes.
3. Add 40 µl T-Nitrite reagent (Sodium nitrite) to sample test tube.
4. Mix thoroughly and incubate for 5 minutes.
5. Add 100 µl of serum sample to both test tubes.
6. Mix well and incubate at 20-25 ^{0}C for 10 to 30 minutes.
7. Measure the absorbance of sample against sample blank at 546 nm wavelength using photometer.

Procedure for direct bilirubin

1. Label two test tubes, one sample blank and one sample, for each test.

2. Add 1000 µl direct bilirubin reagent (Sulphanilic acid and Hydrochloric acid) to both sample blank and sample test tubes.
3. Add 40 µl D-Nitrite reagent (Sodium nitrite) to sample test tube.
4. Mix thoroughly and within 2 minutes, add 100 µl of serum sample to each test tube.
5. Mix well and incubate at 20-25 ^{0}C for 5 minutes.
6. Measure the absorbance of sample against sample blank at 546 nm wavelength using photometer.

Test for Triglycerides

Procedure

1. Add 1000 µl of the reagent (PIPES buffer [pH 7.5], 4-chlorophenol, 4-aminoantipyrine, magnesium ions, ATP, lipases, peroxidase, glycerol kinase and glycerol-3-phosphate oxidase) to three test tubes labeled blank, sample and standard.
2. Add 10 µl of the standard to the standard test tube.
3. Add 10 µl of the serum sample to the sample test tube.
4. Mix each test tube and incubate for 5 minutes at 37 ^{0}C.
5. Measure the absorbance of the sample and the standard against the reagent blank at 546 nm wavelength using photometer.

Total Protein test

Procedure

1. Add 1000 µl of reagent (potassium iodide, potassium sodium tartrate, copper sulphate and sodium hydroxide) into three test tubes marked blank, standard and sample.
2. Add 20 µl of standard into standard labeled test tube.
3. Add 20 µl of serum sample into sample labeled test tube.
4. Mix and incubate at 37 ^{0}C for 10 minutes.
5. Measure the absorbance of sample and standard against reagent blank at 546 nm wavelength using photometer.

Creatinine test

Procedure

1. Prepare the working solution by diluting 1 volume of R1 solution (picric acid) with 1 volume of R2 solution (sodium hydroxide).
2. Add 1000 µl of the working solution to standard and sample test tubes.
3. Add 100 µl of the standard to the standard test tube.
4. Add 100 µl of the serum to sample test tube.
5. Mix, and immediately measure the absorbance of sample and standard at 492 nm wavelength using photometer.

Test for Urea

Procedure

1. Prepare the working solution by adding 1 vial R2 (urease) to 1 bottle of R1 (phosphate buffer [pH 6.7], EDTA, sodium salicylate and sodium nitroprusside).
2. Add 1000 µl of the working solution to three test tubes marked reagent blank, standard and sample.
3. Add 10 µl of standard to standard test tube.
4. Add 10 µl of serum sample to sample test tube.
5. Incubate at 37 ^{0}C for 5 minutes.
6. Then add 200 µl of R3 (sodium hypochloride and sodium hydroxide) to the three test tubes.
7. Mix, incubate at 37 ^{0}C for 5 minutes and read absorbance against reagent blank at 578 nm wavelength using photometer.

Test for AST/GOT

Procedure

1. Prepare the working solution by mixing 5 volumes of R1 (TRIS buffer (pH 7.8), L-aspartate, LDH and MDH) with 1 volume of R2 ($NADH_2$ and 2-oxoglutarate).
2. Add 1000 µl of the working solution to a test tube.

3. Add 100 µl of serum sample to the test tube containing the working solution.
4. Mix and read the absorbance at 37 ^{0}C at 340 nm wavelength using photometer.

Test for GGT

Procedure

1. Prepare the working reagent by pouring the entire contents of one bottle of substrate (L-gamma-glutamyl-3-carboxy-4-nitroanilide) into one bottle of buffer (TRIS buffer [pH 8.25] and glycylglycine), and mix thoroughly.
2. Add 1000 µl of the working reagent into a test tube.
3. Add 100 µl of serum sample to the test tube containing the working reagent.
4. Mix, and read the absorbance at 37 ^{0}C at 400 nm wavelength using photometer.

Test for ALT/GPT

Procedure

1. Prepare the working reagent by pouring the entire contents of one bottle of substrate (2-oxoglutarate and NADH) into one bottle of reagent (TRIS buffer [pH 7.5], L-alanine and LDH), and mix thoroughly.
2. Add 1000 µl of the working reagent into a test tube.
3. Add 100 µl of serum sample to the test tube containing the working reagent.
4. Mix, and read the absorbance at 37 ^{0}C at 340 nm wavelength using photometer.

Test for ALP

Procedure

1. Prepare the working reagent by mixing 5 parts of R1 (diethanolamine buffer [pH 9.8], magnesium sulfate, detergents and stabilizers) with 1 part of R2 (p-nitrophenylphosphate and stabilized liquid).
2. Add 1000 µl of the working reagent to a test tube.
3. Add 20 µl of serum sample to the test tube containing the working reagent.

4. Mix, and read the absorbance at 37 ^{0}C at 400 nm wavelength using photometer.

Serum electrolytes analysis

Materials required

1. Automated 9180 electrolyte analyzer
2. Snap pack reagent
3. Serum sample to be analyzed

Procedure

1. Perform daily maintenance, conditioning and cleaning of the analyzer.
2. Check the quality of the machine using the control sera solution.
3. Bring the reagents and fit into the electrolyte analyzer.
4. Bring the sample to room temperature.
5. Provide the serum sample to be analyzed to the analyzer.
6. Read the result after 56 seconds.

Annex 3. Ageing camels by examination of teeth

Estimated age	Teeth characteristic
14 days	-Eruption of central deciduous incisors
4 - 5 weeks	-Eruption of lateral deciduous incisors
6 – 12 weeks	-Eruption of corner deciduous incisors
6 months	-Deciduous canines and upper premolars 1, 2 & 3 and lower premolars 1 & 2 are all obvious -Some wear may be occurring commencing with the centrals
1 year	-A full set of deciduous teeth are present and all lower incisors are in wear
1.5 years	-All deciduous teeth are fully functional -Upper and lower molar 1's, that erupt between 12 and 15 months, are proud of the gums
2 - 2.5 years	-Deciduous incisor teeth show progressive wear and separation -All molar 1's come into wear and all molar 2's are about to erupt
3 - 3.5 years	-Deciduous incisors are well worn and separated and some may be loosening -All molar 2's have erupted
4 years	-Deciduous incisors have worn down to small irregularly shaped, loose stumps
4.5 - 5 years	-Lower deciduous premolars are shed and are usually not replaced -Permanent central incisors erupt behind the deciduous stumps (if the latter is still present and is not shed)
5 - 5.5 years	-Deciduous lateral incisors are shed -Upper permanent premolars 2 & 3's, and permanent lower premolar 2's erupt -Upper and lower molar 1's and 2's are in wear and molar 3's about to erupt
6 - 7 years	-Upper corner permanent incisors (not found in every camel), upper and lower permanent canines and upper permanent premolars have all become apparent

	-Permanent central and lateral incisors are in wear, and lower permanent corner incisors erupt and develop -All upper and lower permanent premolars and molars are in wear by 7 years
8 years	-All permanent teeth are present and in wear -Premolar 1's, when present, are darkly stained due to plaque and scale -Canines, particularly in males, are large and powerful
8 - 15 years	-Progressive wear of the teeth at a rate related to the food consumed and its content of abrasives -Definite separation of the permanent incisors usually commences at about 15 years

Source: CACIA (2003)

9. DECLARATION

This thesis is my original work, has not been presented for a degree in any other University and that all sources of material used for the thesis have been duly acknowledged.

Name: Eyob Ibrahim

Signature_____

Date of submission _____

This thesis has been submitted for examination with our approval as University advisors.

Signature

Dr. Gezahegne Mamo (DVM, MSc, Asst. Prof.) _____

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