Review Paper

Handling, reference value and usefulness of blood biochemical of indigenous pastoral cattle in tropical Africa: A review

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ABSTRACT

The objective of the study, therefore, is to review and package the current reference values of some haematological and serum biochemical of indigenous pastoral cattle in tropical Africa. Haematological investigation has gained a global popularity as a prime diagnostic and management tool in veterinary practice. It ascertains the physiological, nutritional and pathological status of an animal and helps distinguish the normal state from the state of stress, which can be nutritional, physical or environmental. The blood examination gives the opportunity to investigate the presence of several metabolites and other constituents in the body of animals and it plays a vital role in determining the physiological, nutritional and pathological status of an animal. Blood examination for their constituents can provide important information for the diagnosis and prognosis of diseases in animals. Blood constituents change in relation to the physiological conditions of health. These changes are of value in assessing response of animals to various physiological situations. The knowledge about normal values of biochemical variables in blood serum and other physiological variables of cattle is important for assessment of damage of organs and tissues in different disease conditions and for assessment of developmental stages as well as welfare of the animal. Precaution should be taken during handling and processing of blood and serum samples for laboratory analysis. This is to ensure accuracy in determination of haematological and serum biochemical indices.

Keywords: Current, Physiological, Value, Pastoral, cattle, Tropical, Africa.

Abbreviations: EDTA, ethylene-diamine-tetra-acetate ; PCV, Packed cell volume; RBC, red blood cells; WBC, white blood cells; HB, haemoglobin; MCV, mean corpuscular volume ; MCH, mean corpuscular haemoglobin; MCHC, mean corpuscular haemoglobin concentration ; TEC, total erythrocyte count ; TLC, total leukocyte count and DLC, differential leukocyte count; HT, haematocrit or EVF, erythrocyte volume fraction ; BUN, blood urea nitrogen ; NEFA, Non-esterified fatty acids ; VLDL, very low density lipoproteins; BHB, beta-Hydroxybutyrate; ERDP, effective rumen degradable protein ; AST, Aspartate Aminotransferase ; CK, creatinine kinase ; ALT, Alanine aminotransferase ; ALP, Alkaline Phosphatase ; GGT, Gamma – glutamyl Transpeptidase ; LDH, Lactate Dehydrogenase.
INTRODUCTION

Haematological studies are of ecological and physiological interest in helping to understand the relationship of blood characteristics of the environment and so could be useful in the selection of animals that are genetically resistant to certain diseases and environmental conditions (Ovuru and Ekweozor, 2004; Mmereole, 2008; Isaac et al., 2013). According to Afolabi et al. (2010), changes in haematological parameters are often used to determine various status of the body and to determine stresses due to environmental, nutritional and/or pathological factors. The haematology of indigenous cattle and other livestock species have also been well investigated (Oladele et al., 2001). Similarly, the haematology of some of these species has been investigated in important livestock diseases such as trypanosomiasis (Bawa et al., 2005). Investigation has also been made into the haematology of exotic cattle and their crosses with Zebu under the tropical conditions (Saror and Coles, 1975).

The value of haematological parameters and serum biochemical of cattle in the evaluation of the physical and health status of animals and birds (Zvorc et al., 2006), the diagnosis, prognosis, treatment and prophylaxis of many livestock diseases (Klinkon and Zadnik, 1999) have been widely reported but scattered. The objective of the study, therefore, is to review and package the current reference values of some haematological and serum biochemical of indigenous pastoral cattle in tropical Africa.

Methods of Blood Collection, Management and Analysis

Studies have shown that, blood is usually obtained from various veins of animals such as the jugular vein, saphenous, tail, wing, abdominal and pineal into sample bottles. Two methods are applicable in determining the number of concentrations of cells in suspension: total and differential cell counts. The total measure the total number of all types of cells in a unit volume of fluid, while the differential, measures the number of a given type of cell either as a proportion of the whole cell population or as an absolute number per unit volume (Coles, 1974). Blood samples that are either used for laboratory analysis or blood transfusion are usually anti-coagulated. Recommended anti-coagulants are ethylene-diaminetetra-acetate (EDTA), oxalate and heparin (Coles, 1980).

EDTA has the advantage of preserving cells as well as their stainability and morphological characteristics, but care must be taken not to exceed the recommended level as excess of it adversely affects the determination of PCV. Packed cell volume decreases when EDTA is present in excess, as a consequence of cell shrinkage (Penny, et al., 1970 and Coles, 1980). For reliable haematological data, a blood sample should be stored at refrigeration temperature (4°C) for a short time. In over stored blood, there is the tendency for red blood cells (RBC) to swell and haemolysate, while the white blood cells (WBC) undergo alteration in morphology and lyses (Schalm et al., 1975).

Storage of blood with EDTA in a refrigerator at (4°C) for 24 hours produces little effect on the PCV of bovine blood (Fisher, 1962). The tendency of RBC to swell slowly after 24 hours of storage and by six days of storage leading to about 7-10% increase in PCV also increases the tendency of haemolysis (Penny et al., 1970). Complete haemolysis will start to occur in a sample on days 17 and 28 in all samples, on days 24 and 41 in blood with EDTA and oxalate anti-coagulants respectively (Igbokwe and Sanu, 1992). Swelling of the RBC depends on the cell membrane permeability and elasticity and the failure of bovine RBC to swell may probably be due to its peculiar cell membrane properties.

Red blood cell (RBC) and white blood cell (WBC) counts could be determined using a haemocytometer. The packed cell volume (PCV) could be estimated by the microhaematocrit method and the haemoglobin (Hb) concentration by the cyaemethaemoglobin method. The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) are calculated from the Hb, PCV and RBC values (Jain, 1986). In recent studies, red blood cell counts, total white blood cell counts, haemoglobin, packed cell volume, MCV, MCH and MCHC are determined by an automated haematological analyzer, Coulter SPKS, PCL holding company, Germany (Matwichuk et al., 1999; Aengwanich et al., 2007; Farooq et al., 2012).

Blood smear is used with Wright-Giemsa in differential WBC count (Matwichuk et al., 1999; Aengwanich et al., 2007). Blood samples are, also, analyzed for Hb, total erythrocyte count (TEC), PCV, total leukocyte count (TLC) and differential leukocyte count (DLC) using an automated haematology analyzer (Sysmex K21, Kobe, Japan) which is off-hand calibrated with human and bovine blood using multiple samples.

Red Blood Cells (RBC)

Red blood cells (erythrocytes) serve as a carrier of haemoglobin. It is this haemoglobin that reacts with oxygen carried in the blood to form oxyhaemoglobin during respiration (Johnston and Morris, 1996; Chineke et al., 2006). According to Isaac et al. (2013), red blood cell is involved in the transport of oxygen and carbon dioxide in the body. Thus, a reduced red blood cell count implies a reduction in the level of oxygen that would be carried to the tissues as well as the level of carbon dioxide returned to the lungs (Ugwuene, 2011). The quality and amount of red blood cells in the animal's body depends on nutrient availability, state of health and physiological status of such animal (Soetan et al., 2013). Animals with sound health that are provided with good feeding, environmental conditions and other management welfare would always have a good amount of RBC (Isaac et al, 2013). Isaac et
also reported that, cattle with good haematological composition are likely to exhibit better performance and productivity. Studies conducted by Olayemi et al. (2007) reported the red blood cells of Sokoto Gudali and White Fulani cattle to be 9.63 and 8.63 × 10^12 mm^-3, respectively while Merck (2012) reported his own to be 5 to 10 × 10^12 mm^-3 which were within the normal values.

**Packed Cell Volume (PCV)**

Packed Cell Volume (PCV), which is also known as haematocrit (Ht) or erythrocyte volume fraction (EVF), is the percentage (%) of red blood cells in the blood (Purves et al., 2003). According to Isaac et al. (2013), PCV is involved in the transport of oxygen and absorbed nutrients. Increased Packed Cell Volume shows a better transportation and thus results in an increased primary and secondary polycythemia (Ndlovu et al., 2007). Furthermore, Chineke et al. (2006) reported that, high PCV reading indicated either an increase in number of Red Blood Cells (RBCs) or reduction in circulating plasma volume. It is the most accurate means of determining red blood cell volume and can be used to deduce total blood volume and haemoglobin levels.

According to Coles (1974), since packed cell volume is the proportion of blood volume occupied by cells, blood cell counts have major clinical, diagnostic, nutritional and environmental significance; indicating loss, destruction or under production of cells (e.g. leucopenia or anaemia), as unusual demand for cells as in leukocytosis or neoplastic proliferation as in leucosis. Farooq et al. (2012) reported mean PCV values of Cholistani breeding bulls in Pakistan to be 37.18 %, while Jain (1998) reported PCV range of 24-46% for cattle. Their results were in line with the work of Aengwanich et al. (2009), who reported a mean PCV of 36.50 % for crossbred male beef cattle in Thailand showing positive relationship with management and environmental conditions.

**Haemoglobin (Hb) Concentration**

Haemoglobin is the iron-containing oxygen-transport metallo-protein in the red blood cells in animals. Decrease in haemoglobin, with or without a decrease in red blood cells leads to symptoms of anaemia. Anaemia has many different causes, although iron deficiency is the most common cause. As absence of iron decreases heme synthesis, hypochromic red blood cells (lacking the red hemoglobin pigment) and microcytic red blood cells (smaller than normal) (Kneipp et al., 2006). Haemoglobin has the physiological function of transporting oxygen to tissues of the animal for oxidation of ingested food so as to release energy for other body functions as well as transport carbon dioxide out of the body (Ugwuene, 2011; Omiyale et al., 2012; Soetan et al., 2013; Isaac et al., 2013).

According to Peters et al. (2011), previous reports stated that, Packed Cell Volume, haemoglobin and mean corpuscular haemoglobin are major indices for evaluating circulatory erythrocytes, and are significant in the diagnosis of anaemia and, also, serve as useful indices of the bone marrow capacity to produce red blood cells as in mammals (Awodi et al., 2005; Chineke et al., 2006). Mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration indicate blood level conditions. A lower level is an indication of anaemia (Aster, 2004). Olayemi et al. (2007) reported the Hg of Sokoto Gudali and White Fulani cattle to be 11.18 and 9.31, MCV of 38.20 and 43.58, MCH of 12.36 and 11.66, MCHC of 32.42 and 26.28, respectively. In similar studies, RAR (2009) reported normal Hg reference values of cattle to be 8 to 15g/dl, MCV (40 to 60 fl), MCH (11 to 17pg) and MCHC (30 to 36 g/dl), while Merck (2012) reported Hg (10 to 15), MCV (39 to 55), MCH (13 to 17) and MCHC of 30 to 36 which are directly proportional to feeding, health care delivery and environmental management given to the animal.

**White Blood Cells (WBC)**

The other major type of blood cells is the white blood cells (WBC), which are, also, referred to as leucocytes (Iwuji and Herbert, 2012; Isaac et al., 2013). For every leucocyte present in a sample there will normally be 600 to 700 RBC. The major functions of the white blood cells are to fight infections, defend the body by phagocytosis against invasion by foreign organisms and to produce and transport and distribute antibodies in immune response. Thus, animals with low white blood cells are exposed to high risk of disease infection, while those with high counts are capable of generating antibodies in the process of phagocytosis and have a high degree of resistance to diseases (Soetan et al., 2013) and enhanced adaptability to local environmental and disease prevalent conditions (Kabir et al., 2011; Okunlola et al., 2012). RAR (2009) reported a normal WBC value of 4 to 12 × 10^3 as a function of good and proper management practices.

**Blood Metabolites**

To develop organized markets for promoting indigenous cattle products, there is a need to develop parameters that objectively assess nutritional and health status of the animals, while they are still growing. For example, there is a need to determine desirable breeds that maintain the least blood cholesterol levels (Ndlovu et al., 2007). Breed differences and genetic variation within breeds in rate and efficiency of growth, disease resistance and tolerance, and meat quality can be assayed using blood metabolites so as to establish genetically superior animals adapted to harsh environmental conditions. Although body weight measurement and body condition scoring are easier to perform and are cheaper to determine, they have limitations that can be complemented by the use of blood metabolites and haematology.
Metabolite profiling provides useful information such as the occurrence of negative energy balance, under-nutrition and the presence of disease. These profiles need to be established in animals destined for sale or export, as they also determine the quality of the meat produced. Similarly, frequent monitoring of blood parameters, once in every season, assists in diagnosing metabolic problems and determining animals that are metabolically superior on veld or to identify animals that require supplementary feeding (Otto et al., 2000).

In practice, metabolite herd testing has a number of constraints that need to be overcome. The major challenges include, highly skilled labor required for blood sampling, availability of sampling ingredients, expertise in processing and storing blood and, perhaps, the most important, the high cost of analyzing the samples. There is, for example, need to use friendly and appropriate techniques for restraining and bleeding that minimize stress. Appropriate infrastructure, such as strong cattle handling facilities are also needed. Many pastoral communities lack such facilities. Communities and the farmers, thus, need to be educated on the need for determination and application of blood parameters as a tool to aid beef cattle management. This should destroy the generally held myth that, animals are only handled when they are clinically sick or when they are ready for slaughter. Such costs of analyzing for blood samples are, however, in most cases, beyond the reach of many farmers, especially the resource-limited farmers in rural areas.

Again, blood metabolite concentrations represent an integrated index of the adequacy of nutrient supply in relation to nutrient utilization of cattle (Chester-Jones et al., 1990). They give an immediate indication of an animal’s nutritional status at any point in time (Pambu-Gollah et al., 2000). In the dairy industry, the use of metabolic profiles for assessing the nutritional and health status of cows is widespread (Doornenbal et al., 1988; Grunwaldt et al., 2005).

(a) Blood glucose: Blood glucose, hydroxy butyrate and non-esterified fatty acids are the most common metabolites used to assess the energy status of cattle (Ndluvu et al., 2007). Blood glucose has a moderate diagnostic value in the assessment of nutritional status of cattle as it varies moderately in blood. Insufficient nutrient intake can reduce circulatory glucose and cholesterol levels. In conditions of under-nutrition, the blood levels of propionate and other precursors derived from the diet decreases, thus, causing a reduction in the rate of glucose synthesis (Reynolds et al., 2003).

Glucose levels in calves are lower than those for mature animals (Doornenbal et al., 1988). In growing animals, glucose requirement is determined by growth rate, which is set by metabolizable energy intake (Reynolds et al., 2003), whereas in mature animals only maintenance energy is required. The physiological status of an animal, also, affects the glucose concentration (Otto et al., 2000). Glucose concentrations were higher in non-pregnant and non-lactating cows as compared to lactating cows due to the high energy demand in lactating cows for milk products. Previous studies have shown that, the percentage of total glucose supply oxidized is reduced in lactating compared to dry cows and tissue utilization of glucose decreases while there is an increase in use of lipid for energy (Reynolds et al., 2003).

Grunwaldt et al. (2005), reported an effect of season on glucose levels shown by a significant increase in blood glucose levels in autumn (February) as compared to summer (May). Glucose levels decreases with an increase in body temperature and respiration rate of animals normally experienced in hot summer season. Feed quality also affects blood glucose levels. For example, Chimonyo et al. (2000), observed a significant reduction of the levels of plasma glucose in winter in cows.

(b) Blood protein: At present there is no single metabolite that can be measured, which directly reflects protein status. As a result, a combination of parameters need to be utilized, including blood urea nitrogen (BUN), creatinine, and total protein, albumin, and creatinine levels. Albumin and total protein have low variability in blood. As a result, they both have a high diagnostic value in the assessment of nutritional status as compared to creatinine which has low diagnostic value due to its high variability in blood. Serum albumin is a very sensitive and early nutritional indicator of protein status (Agenas et al., 2006) because its turnover is only 16 days. Deficiency of protein impairs both humoral and cell mediated immunity, thus predisposing an animal to diseases (Titgemeyer and Loest, 2001).

Total protein levels are lower in young animals and higher in mature animals, whilst albumin levels are lower at birth, but increases with age (Doornenbal et al., 1988; Otto et al., 2000). Total protein and albumin reflect availability of protein and their concentration declines in the face of protein deficiency. Total protein levels are low in non-pregnant and non-lactating cows (Otto et al., 2000).

(c) Blood lipids: Lipids are of importance in the assessment of nutritional status of cattle and include non-esterified fatty acids, cholesterol, hydroxybutyrate and lipoproteins. There is low variability in the blood levels of non-esterified fatty acids as compared to cholesterol which has moderate variability. Non-esterified fatty acids, therefore, have a high diagnostic value in the assessment of nutritional status as compared to cholesterol. The reason for moderate variability of cholesterol is probably attributed to its metabolic variation with the blood glucose levels. Effect of season on cholesterol levels is also not clear. Elevated levels of cholesterol, triglycerides and phospholipids are indicative of copper deficiency. The essential nature of copper is due to its co-factor role at the active site of a number of enzymes (Engle and Spears, 2000).

Non-esterified fatty acids (NEFA) are released into the circulation as a direct result of lipid catabolism. Their concentrations are commonly used in assessing energy status of dairy cows. Mayes (2000), Adewuyi et al. (2005)
and Chimonyo et al. (2000), observed elevated NEFA levels in undernourished cows that were used for draught power. High NEFA values result in either elevated ketones or fat production by the liver (Oikawa and Katoh, 2002). Associated with fat in the very low density lipoproteins (VLDL) structure is a substantial amount of cholesterol. As a result, it has been suggested that NEFA to cholesterol ratio is more appropriate in assessing the energy status of animals.

Serum NEFA concentrations are more sensitive to changes in energy balance than body condition scoring in transition cow situations. Hydroxybutyrate (BHB) and NEFA elevated concentrations indicate short-term negative energy balance and adipose tissue catabolism (Reist et al., 2002; Agenas et al., 2006). At present, measurement of beta-hydroxybutyrate concentration is most commonly used. However, beta-hydroxybutyrate concentrations may not be sensitive enough and can come from dietary sources (Agenas et al., 2006).

(d) Urea nitrogen: No marked age differences have been detected in albumin levels (Otto et al., 2000). Dietary protein nutrition or utilization and the associated effects on ovarian or uterine physiology have been monitored with urea nitrogen in plasma. Concentrations above 19 mg/dl have been associated with altered uterine pH and reduced fertility in dairy cows (Butler et al., 1998). Monitoring of blood urea levels can be used for measuring protein status in cattle from different feeding regimes and seasons (Hammond, 2006). Values for urea within the optimum range (< 3.6 mmol/l) in cattle indicate that the effective rumen degradable protein (ERDP) is adequate. High blood urea levels could indicate a high protein intake or the excessive mobilization of muscle (Chimonyo et al., 2002). In ruminants, a decrease in the blood urea concentration is related to low dietary intake of protein due to the recycling of urea from blood back to the rumen when dietary protein intake is low (Oulun, 2005). Grunwaldt et al. 2005 observed similar levels of urea nitrogen in summer and in autumn.

The most common application of the use of blood urea nitrogen is as a retrospective diagnostic tool to analyze biological responses to protein or energy supplementation, change in pasture or forage on offer, or change in pasture management (Hammond, 2006). Serum urea concentration may also increase despite low-protein feeding if energy intake is restricted, which is thought to reflect increased breakdown of endogenous proteins for energy production, a decrease in renal re-absorption of urea and/or haemo-concentration (Oulun, 2005). High dietary protein (nitrogen) intake resulting in blood urea nitrogen of greater than 19 to 20 mg/dl has been associated with an altered uterine environment and decreased fertility (reduced conception rate, decreased pregnancy rate) in lactating dairy cows and heifers (Elrod and Butler, 1993; Butler et al., 1998).

(e) Creatinine: Creatinine, a by-product of the breakdown of creatinine and phosphocreatinine in muscle, is most commonly used as an indirect indicator of renal function and its impact on blood urea nitrogen. Serum creatinine concentrations vary due to an animal’s diet, breed, muscle mass and sex (Otto et al., 2000; Miller et al., 2004; Hammond, 2006). Grunwaldt et al. (2005), also, showed lower creatinine levels during the summer than in autumn. Reduced concentrations of creatinine indicate prolonged active tissue protein catabolism (Agenas et al., 2006). An increasing muscle mass from animal walking long distances in search of pasture can increase serum creatinine levels (Otto et al., 2000).

**Serum Enzymes**

Information from literature has revealed considerable differences in the activity of enzymes. There are, also, considerable differences between reference values of enzyme activity claimed by different authors. Enzymes are very sensitive indicators of cell damage, their activities are changed by tiny alternations so that enzyme activity could differ among individual animals resulting in different results between studies. Reasons for these differences are partly differences between breeds and breeding conditions where the results were obtained. Analytical procedures and temperatures at which the activity of enzymes was measured also influence results. In majority of literature, the mentioned analytical procedures are deficiently described, so it is very difficult to compare the data, because it is not clear at which temperature the activity of enzyme was measured (Otto et al., 2000).

(a) The enzyme Aspartate Aminotransferase (AST): AST is present in different tissues of animals and is a sensitive indicator of soft tissue damage (Otto et al., 2000). In heart and skeleton musculature as in liver, there is high activity of AST. The AST is present in cytoplasm and in mitochondria, so its activity is increased chiefly by cell necrosis in smaller amount and also by damage of the cell membrane (Kraft and Dürr, 1999). Measuring of AST activity in combination with creatinine kinase (CK) is used for diagnostics of muscle damage (Kaneko, 1997). There is also a high activity of AST in the liver, therefore, in the case of liver damage, AST activity in the serum increases.

Liver enzymes have low diagnostic value of nutritional status due to their high blood variability. Red blood cells contain AST which can leak into plasma before there is any visual evidence of haemolysis (Abutarbush and Radostits, 2003). Many conditions that produce a significant rise in creatinine kinase (CK) activity will also produce elevated high levels of AST (Abutarbush and Radostits, 2003). Vitamin E and selenium deficiency in diet cause nutritional muscular dystrophy and diagnosis is usually based on elevated levels of the muscle enzymes, CK and AST (Abutarbush and Radostits, 2003). Vitamins C, E and selenium are important in the protection of cellular membranes from free radicals that cause peroxidation of the membrane lipids (Abutarbush and Radostits, 2003; Karakik, et al., 2005).

In healthy cows, the serum enzyme activity is low or absent. Neither seasonal nor physiological variations have
been reported on AST (Yokus and Cakir, 2006). In contrast, there are higher AST levels during the rainy season than in the dry season (Ndlouvou et al., 2007). More significantly, Grunwaldt et al. (2005) observed breed differences in AST levels, where the Criollo Argentino had almost twice the amount of AST as compared to that of Aberdeen Angus cows.

In calves, after first colostrum intake the AST activity in serum increased from 23 U/L before intake, to 38 U/L at the age of 3 hours. This is most likely due to absorption from colostrum or because of activation of enzymes in calf intestine as a consequence of colostrum intake (Kurz and Willet, 1991). However, Hammon and Blum (1998) established that, in calves that received only milk replacer instead of colostrum, activity of AST increased on the second day after birth, so they are of the opinion that other factors may be influencing the increased activity of some enzymes. Specifically, the activity of AST decreased after the first week, and from 42nd to 84th day of life, it increased slowly (Egli and Blum, 1998). Mohri et al. (2007), also observed an increase of AST activity from the 14th to the 84th day of age.

(b) Alanine aminotransferase (ALT): ALT activity in cattle is not specific for the liver, in order to have a diagnostic significance (Kramer and Hoffman, 1997). Serum ALT has been reported (Otto et al., 2000; El – Sherif and Assad, 2001) to be affected by physiological status of cattle. ALT activity in the blood plasma is also influenced by age and muscle activity (Weigert et al., 1980). The serum ALT creates the structural components of the body of the foetus in pregnant animals, hence it is important for pregnancy. According to Milinkovic – Tur et al., (2005), the activities of ALT in the blood are associated with implantation, embryo survival, growth, uterine carbohydrate metabolism, amino acid metabolism and glycogen deposition. Adedibu et al. (2013) reported serum ALT of lactating and non-lactating cows to be 28.70 and 28.40 U/L, respectively in Zaria, Kaduna State, Nigeria.

(c) Alkaline Phosphatase (ALP): For a long time the enzyme Alkaline Phosphatase (ALP) has been used in diagnostics as an indicator of liver damage. The ALP is important also in diseases of the skeleton and is usually found in the intestine, liver, kidney and bones. Serum activity of ALP is thus higher in young animals than in adult ones and it decreases with age. After first colostrum intake, serum activity of ALP increased from 235 U/L before intake to 364 U/L at the age of 3 hours, most likely due to absorption from colostrum and activation of enzymes in the calf’s intestine resulting from colostrum intake (Kurz and Willet, 1991). The activity of ALP was highest in calves after birth, then decreased and remained stable until the age of 60 days, after which it decreased slightly more (Knowles et al., 2000). In calves to the age of 6 months the activity of ALP can reach 1800 U/L, while in young cattle to the age of 3 years, it has been shown to decrease to 500 U/L (Kraft and Dürr, 1999).

In adult animals activity of ALP can increase with increased activity of osteoblasts. Activity of ALP is also increased during acute and chronic liver diseases (especially cholestatic hepatopathies) and in diseases of bones (rachitis, periostitis).

(d) Creatinine Kinase (CK): The highest activity of creatinine kinase (CK) is in the skeleton and heart musculature. Measuring of the activity of CK in serum is first of all used for diagnostics of skeletal musculature damage. The activity of CK could be increased also after effort, long-lasting lying of the animal or convulsions. Miopathias as a consequence of vitamin E and Selenium deficiency which usually appear inveal animals (calves, lambs), sometimes also in adult animals, have been found to cause increased activity of CK (Smith et al., 1994).

The activity of CK in calves is high after birth, but later it decreases rapidly and stabilizes by the age of 60 days, but may again increase slightly by 80th day of age (Knowles et al., 2000). The mean activity of CK in calves of Simmental breed was 11.2 ± 2 μ/L (671.8 ± 119.9 U/L) at birth, then it begins to decrease at age of 7 days, thereafter it continued to increase up to the 84th day to read 21.3 ± 10.7 μ/L (1277.7 ± 641.8 U/L) (Egli and Blum, 1998). Increased activity of CK after birth have been associated with parturition and adaptation to the stress of extra uterine life. The increasing of CK activity with age has also been attributed to the growth and gaining of muscle mass, and partly also to the increased activity of the calves. At this age, they are in group pens where they have enough space for movement.

(e) Gamma – glutamyl Transpeptidase (GGT): The highest activity of gamma – glutamyl transpeptidase (GGT) is in bile duct epithelium and in kidney. The enzyme is found in membrane structures of the cells. The increased serum activity of GGT is usually associated with cholestasis and bile ducts damage. Very high activity of GGT is also in colostrum of cattle, sheep and goats. Hammon and Blum (1998) measured colostrum GGT in cows and found mean activity to be 22.432 U/L. After colostrum intake, the enzyme is absorbed through intestinal wall, consequently the GGT activity is increased at this period and can be used for indirect estimation of colostrum supply (Bostedt, 1983). The GGT activity in newborn calves was 10-31 U/L, after colostrum intake it increased to 370-5000 U/L, then it slowly decreased until the age of 20 days when it stabilized (Braun et al., 1982). In calves that received only milk or milk replacer instead of colostrum, the GGT activity did not increase (Boediker, 1991). In the first week of life GGT activity was high later it decreased rapidly (Knowles et al., 2000; Egli and Blum, 1998).

The GGT activity below 100 U/L at the age of 2 days indicates insufficient colostrum supply or disturbed absorption (Klee, 1985). Tyler et al. (1999b), claimed that activity of GGT above 50 U/L in the calves serum indicates sufficient colostrum supply, while Perino et al. (1993) stated that, 200 U/L should be regarded as the boundary value.

(f) Lactate Dehydrogenase (LDH): Enzyme lactate dehydrogenase (LDH) catalyses reversible oxidation of
pyruvate to lactate. The enzyme is present in numerous organs and tissues. The activity of LDH in calves increases slowly in the first 24 hours of life, from 421 U/L immediately after birth to 759 U/L at the age of 24 hours. This increase is more likely a physiological event than due to absorption from colostrum (Kurz and Willet, 1991). The LDH activity increased slowly until the age of 56 days and thereafter remained at the same level up to the age of 84 days (Egli and Blum, 1998).

Serum Electrolytes

To promote normal tissue growth, homeostasis, enzyme function, cell regulation and immune function, it is imperative that minerals be maintained within normal concentrations in the body (Underwood and Suttle, 1999). Minerals play vital roles in forage digestion, reproductive performance and the development of bones, muscle and teeth. Sub-clinical trace mineral deficiencies occur more frequently than recognized by most livestock producers (Underwood and Suttle, 1999). Mahussoon et al. (2004) observed marked breed differences in mineral metabolism in goats. Mineral levels have been shown to vary with seasons (Yokus and Cakir, 2006), however, Grunwaldt et al. (2005) showed no significant differences in autumn and summer for inorganic phosphate and calcium levels. Mineral absorption increases in the gastrointestinal tract, while mobilization is increased in the bones (Invartsen and Andersen, 2000).

Calcium, phosphorus and magnesium have high diagnostic value in determining the nutritional status of animals due to their low variability in blood. Calcium is the most abundant mineral in the body; approximately 98% functions as a structural component of bones and teeth (Ndlovu et al., 2007). The remaining 2% is distributed in extracellular fluids and soft tissues, and is involved in such vital functions as blood clotting, membrane permeability, muscle contraction, transmission of nerve impulses, cardiac regulation, secretion of certain hormones and activation and stabilization of certain enzymes, whereas, phosphorus on the other hand is involved in every metabolic reaction and energy transfer within the body (Invartsen and Andersen, 2000). Phosphorus is required for normal milk production, growth and efficient use of feed and by the rumen micro-organisms in the digestion of cellulose and synthesis of microbial protein (Ndlovu et al., 2007).

Physiological status affects calcium levels in cattle, where highest levels were obtained in non-pregnant and non-lactating dairy cows (Otto et al., 2000). Season was also reported to have no effect on inorganic phosphate and calcium levels (Yokus and Cakir, 2006). Magnesium is an essential cation involved in many enzymatic reactions as a co-factor to adenosine triphosphatases. It is critical in energy-requiring metabolic processes, in protein synthesis, membrane integrity, nervous tissue conduction, neuromuscular excitability, muscle contraction, hormone secretion and in intermediary metabolism (Laires et al., 2004). Serum magnesium concentration is maintained within a narrow range by the small intestine and kidney, which both increase their fractional magnesium absorption under conditions of magnesium deprivation (Ghamdi et al., 1994). If magnesium depletion continues, the bone store helps to maintain serum magnesium concentration by exchanging part of its contents with extracellular fluid (Laires et al., 2004). In dairy cows, magnesium levels are dependent on both physiological and seasonal variations (Yokus and Cakir, 2006). Serum magnesium levels reflect current daily intake rather than reserves, thus cattle are affected by low magnesium dietary content (Whitaker et al., 1999). Grass tetany occurs when the level of magnesium in blood falls below a critical threshold (below 1.2 mg/100 ml) (Herdt et al., 2000).

CONCLUSION AND RECOMMENDATIONS

Review and packaging of current reference values of haematological and serum biochemistry is paramount to the farmers and stakeholders who may use them for critical decision making on the farm. Since determination of haematological parameters and biochemical constituents of serum can provide valuable information in respect to nutrition, sex, age and physiological and health status of the animal. It is also a well known fact that variations exist in haematological parameters and biochemical constituents of serum with regards to sampling procedure, analytical technique, physical factors, environmental conditions and variation in species and breeds. High professionalism should be strictly adhered to during handling and processing of blood and serum samples for laboratory analysis. This is to ensure accuracy in determination of haematological and serum biochemical indices.

REFERENCES


