CHAPTER I

Introduction

Camels provide meat, milk and wool to the rural society, also for transporting goods and crops. Camel export in some countries began to participate substantially to national economy. Camel racing practiced in some Arab countries has furnished new and extra proportion in camel industry. In Sudan the efficiency of the camel to thrive in the arid and semi-arid areas western and eastern Sudan made it an important source of livelihood to nomadic people in these parts of the country (Hashim *et al*., 2015).

Animals' performance is a bear by interaction between genotype and environment (Ouajd and Kamel, 2009). Due to their physiological attributes, camels are the most convenient species of domestic mammals to be used under extremely arid conditions (Yagil, 1985 and Ouajd and Kamel, 2009). All the functions of the camel organism are conceived to be physiologically adapted to “water and food restrictions” and to a very hot climate (Ouajd and Kamel, 2009). The unique characteristics of camel physiology pose an exciting challenge to interested research workers (Hashim *et al*., 2015).

Temperature, respiratory and pulse rates in farm animals have been used as indicators of environmental stress (Hafez, 1968). It has been increasingly realized that more essential knowledge of haemogram, blood metabolites and hormones in the camel contributes greatly to the understanding of the physiology of this species (Al-Busadah, 2007). Hematology is an important diagnostic and management tool in veterinary medicine. The blood picture provides an opportunity to clinically investigate the presence of different metabolites and other constituents in the body of the animal and it plays a lusty role in the assessment of physiological, nutritional and pathological status of an organism. It also helps in distinguishing the normal status from the state of stress, which can be nutritional, environmental or physical (Aderemi, 2004).

The climate influences both distribution of animals and the nutritive value and chemical composition of pasture plants (Parker and Plowey, 1976). Changes in rainfall during seasons of the year have influence on pasture quantity and quality. Therefore, could influence the nutritional status and subsequently the blood constituents of camels (Amin *et al*., 2007).

The knowledge in blood constituents is important for assessing the health and the physiological status of animals (Omidi *et al*., 2014).

Studies determining normal values of blood constituents in camels are limited and the way they are affected by nutritional status and other factors seem to be limited (Omer *et al*., 2007). Comparison of blood values under different managemental systems seems to be essential as these values may reflect the well-being of the animal and could be used as diagnostic tools in disease and health of animals (AL-Shami, 2009). Since the camel is an adaptable species, the standard serum biochemical and haematological values need to be determined in a number of animals in variable environmental conditions (AL-Busadah, 2007). Minerals has long been known to be important in animal nutrition as they may be dietary essential and vital to enzyme processes of living cells or have some metabolic activity.

The objectives of this study:

The general objective of this study is to find out the physiological status of camels in the Butana region and study the effects of the environment and management, so the specific objectives of this study is

1- To determine the seasonal variations of the clinical parameters, haematological values, blood metabolites, blood minerals and thyroid hormones of camels.
2- To know the effect of pregnancy on the clinical parameters, haematological values, blood metabolites, blood minerals and thyroid hormones.
3- To know the effect of management system on the clinical parameters, haematological values, blood metabolites, blood minerals and thyroid hormones.
4- To contribute to data base available on the haematological values, blood metabolites, blood minerals and thyroid hormones of Sudanese camels.

CHAPTER II
LITERATURE REVIEW

2.1 Camels

The dromedary (*Camelus dromedarius*), also called one humped camel or Arabian camel, was domesticated some 5,000 years ago (3,000 years B.C.) in the Arabian Peninsula. The name dromedary is derived from dromos (road in Greek) in relation with first use of camel in transportation (Ouajd and Kamel, 2009).

The family camelidae is divided in to genera, llama and Camelus. The genus camelus includes two species: *Camelus dromedaries*, the dromedary or the one-humped and *camelus bactrianus*, the Bactrian or the two- humped camel. The genus llama includes four species, *llama glama*, *llama pacos*, *Alpaca* which are domesticated and *llama guanaco* (Simpson, 1945).

2.2 Importance of camels

Reproduction is an important factor in the economics of the animal production. The camel is a domesticated animal whose full agricultural reproductive potential has not yet been achieved. It is fully adapted to the harshness of the extreme diurnal variations of

temperature of the arid zones of Asia and Africa and requires little expenditure in terms of housing or shelter (El-Harairy *et al*., 2010).

Camels play a very important role in the economy and social life of a large sector of pastoralists in arid and semi-arid regions in several countries in the world (Kadim *et al*., 2006). The one humped camel is an essential source of milk and meat in many parts of the world and especially in the developing countries in Africa and Asia (Ouajd and Kamel, 2009).

Camels are an excellent source of high quality animal protein, especially in areas where the environment adversely affects the performance of other meat animals. This is due of their unique physiological characteristics, including a great tolerance to high temperatures, solar radiation, water scarcity, rough topography and poor vegetation (Kadim *et al*., 2008).

Historically, camel milk, due to its unique composition, has been used as a remedy for a number of medical problems (Dickson 1951). For instance, it has been used in different parts of the world including India, Russia, Sudan, Libya, in the treatment of a series of diseases such as jaundice, tuberculosis, asthma, dropsy and leishmaniasis (Shalash, 1984; Abdelgadir *et al*, 1998; Shabo and Yagil 2005). Recently, camel

milk was also reported to have other potential therapeutic properties, such as anti-diabetic (Agrawal, *et al*., 2007), anti-carcinogenic (Magjeed, 2005), anti-hypertensive (Quan *et al*., 2008) and in the treatment of immunity deficiencies. This last property of the camel milk might be very useful in the treatment of AIDS (Alwan *et al*., 2014).

The position of the camel in the modern world is changing as pastoral societies evolve or decline and the traditional use of camel, primarily, as transport animal is diminishing. Camels, however, continue to be an important component of ecosystem in which the plant of marginal land can be converted to human food. The importance of camel meat in human nutrition has been emphasized by nutritionists as it is an excellent source of meat (Dickson 1951).

The methods of camel keeping are now fast changing due to the shrinkage of natural pasture land as a result of the establishment of mechanized irrigated or rain-fed agricultural schemes in parts of the natural camel range lands as well as the very severe and historical drought that hit several camel producing countries, particularly during 1983-1984. These natural disasters had aggravated the situation and compelled many camel herders to start settling since these periods (Abbas and Omer, 2005).

Camels are now converted from the position of subsistence to one of production, this lead camel to be an important animal in Arabian culture. Raising edible animals with low-price meat such as camels is one way of bridging the gap between the demand for meat and the poor purchasing power in the less developed countries (FAO, 1995).

In Sudan, due to the effects of desertification, many of pastoralists in Northern Kordofan and Darfour started to raise camels in place of cattle due to their ability to live in a hard conditions, thus more consumption of camel meat will be expected (Elshrif, 2008).

2.3 Camels in world

The habitat of the one humped camel is the dry hot zones of North Africa, Ethiopia, the Near East and West Central Asia. Bactrian camel occupies the cold deserts of Southern areas of the former Soviet Union, Monogolia, East Central Asia and Latin America (Wilson, 1998). Jeblawi, (2005) reported that the dromedary camel is distributed in Africa, Middle East and Indian subcontinent.

World Camel numbers have increased from 10.7 million in 1980, 11.9 in 1989, 19.0 in 2003, 24.2 in 2009 and about 24.7 million 2010 (FAO, 2010). Their relative importance has relation to total animal units enhanced from 14.3 to 19.0 and 21.8% during the same period.

From about 24.730.320 camels worldwide, the dromedary accounts for 95%. The Near East, North Africa and the Sahel region have about 70% of the world's dromedary population (FAO, 2010).

2.4 Camels in Sudan

The main livestock in Sudan are sheep, goats, cattle, camels, donkeys, horses, and poultry. Livestock are vital to the welfare of large numbers of poor Sudanese by serving as a source of food, source of revenue, store of wealth, mode of transport, and aid in crop farming. Livestock are also central to the identities of many Sudanese tribes (FAO, 2007). In Sudan the ability of the camel, to thrive in the arid and semi-arid areas western and eastern Sudan, facilitated the sustenance to nomadic people in these parts of the country (Hashim *et al*., 2015).

Sudan holds the second largest camel population in the world (about 4.4 million), after Somalia (FAO, 2010). More than 80 percent of the camel population is found in the States of Kordofan and Darfur in Western Sudan and in the Eastern States. Kordofan States have 37 percent, Darfur States 17 percent and 27 percent in the Eastern States (Elshrif, 2008).

In Sudan, camel breeds are classified into pack and riding camels. The new classification system aims at establishing foundations for selection of camels on the basis of their performance as meat, dairy, dual purpose and race animals. Such system of classification will fit the requirements for the development of camel production and the importance of the standard of their herders (Kalafalla, 1999 and Wardeh, 2004). Ishag *et al*. (2010) found that the camel ecotypes in Sudan serve numerous functions in their respective production systems (e.g. milk, meat, racing, riding, packing) and are bred and selected for sustainable performance.

Camels' population is found in two main regions, the Butana in the East and the states of Darfur and Kordofan in the West of Sudan. These regions differ in their soil, temperature, rainfall and pasture (Ishag *et al* 2011). The methods of camel keeping are now fast changing due to the shrinkage of grazing land (Omer *et al*., 2008) and camel farms are now growing in Sudan rapidly.

2.5 Clinical parameters

The environment surrounding animals affects the amount of heat exchange between them. If the environment is not within the zone of comfort, the animal is said to be under environment stress, which is

reflected in its performance, growth rate and health status since active animal life is limited to a narrow range of temperatures (Mount, 1974).

Physiologically, the camel is strange among other domestic animals in that it is homeothermic since it can maintain a constant body temperature independent of large variation in the temperature of its environment through a balance of heat gain and loss (Schmidt-Nielsen, 1985).

Evaluation of adaptability to hot environments has been studied using physiological adaptation tests involving heart rate, respiratory rate and body temperature (Abdoun *et al*., 2012). Temperature, heart and respiratory rates in farm animals have been used as indicators of environmental stress (Hafez, 1968).

2.5.1 Rectal temperature

The body temperature of most domestic animals does not vary much unlike that found in camel. The camel's ability to allow its body temperature to fall and rise is exceptional with extremes outside the range of comfort for most mammals while maintaining its normal homeokinesis (Kamal, 1972). The variations in camel's body temperature were formerly thought to be an indication of poor thermoregulation, but it is now believed that the temperature

fluctuations indicate a sophisticated control mechanism (Wilson, 1984). The ability of the camel to raise its body temperature has the advantage of reducing heat gain; this is because the raised temperature reduced the heat gradient between the body and the air and heat flow is proportional to the gradient. Heat gained during the day can be dissipated at night when the ambient temperature lower (Yagil, 1985; Bengoumi *et al*, 1999, 2003).

Temperature when used as an indicator of the status of health of camels must be with caution because average (normal) values are not absolute (Schmidt-Nielsen, 1985).

The increases in rectal temperature during the hot conditions may be minimized temperature gradient between the body and the environment, that resulted in reduce of body heat gain (Abdel-Samee and Marai, 1997), this could be minimized the heat-stress on animals (El-Harairy, 2010).

Rectal temperature was significantly lower in the cold season than in the hot season (Wilson, 1998; Al-Haidary, 2006 and Abdoun *et al*., 2012).

The highest value (38.83ºC) of the rectal temperature was recorded during summer and the lowest value (36.33ºC) during winter season (El-Harairy, 2010).

Pregnancy did not show any influence on body temperature (Sarwar *et al*., 1998)

2.5.2 Respiratory rate

Respiratory rate increases very little with an increase in ambient temperature in camels unlike in other domestic animals that respond to hot environment by resorting to an increased respiratory rate and, in some cases, by panting (Kelly, 1974). Respiratory rates also vary considerably in the healthy camel in response to heat stress and the need to conserve or lose water (Schmidt-Nielsen, 1985).

The respiratory rate did not fluctuate as the main mechanism for heat dissipation in camels, is sweating rather than panting (Schmidt-Nielson *et al*., 1985).

The effect of different seasons of the year on respiratory rate was significant, being higher during summer (23.66) than in winter (12.73), spring (14.66) and autumn (14.70) (El-Harairy *et al*., 2010)

Respiratory rate was significantly lower in the cold season than in the dry season (Wilson, 1998; Mohammed *et al*., 2007b).

Pregnancy did not show any influence on respiration rate (Sarwar et al., 1998)

Mohammed *et al*. (2007b) reported that the respiration rate range was 13.61to 14.52, while Wilson (1998) found it was 8 – 16 breaths per min.

2.5.3 Pulse rat

Pulse rates vary considerably in the healthy camel in response to heat load and the need to conserve or lose water (Schmidt-Nielsen, 1985).

In females, pulse rate was highest in non pregnant lactating females. It might be the higher basal metabolic rate which affects the pulse rate in both young male and lactating female camels (Sarwar *et al*., 1998).

The effect of different seasons of the year on pulse rate was significant, being lower (49.66) during winter than summer (52.41), autumn (52.30) and spring (52.26). The highest value of the pulse rate

was recorded during summer and the lowest value during winter season (El-Harairy *et al*., 2010).

Pulse rate was significantly lower in the cold season than in the hot season (Wilson, 1998; Mohammed *et al*., 2007b).

Pregnancy did not show any influence on pulse rate (Sarwar *et al*., 1998)

The overall mean of pulse rate was 51.66 (El-Harairy *et al*., 2010), however, Sarwar *et al*. (1998) reported that, mean pulse rate was 43.46 (counts/minutes) for dromedaries during the summer season.

2.6 Blood constituents

Evaluations of the physiological status of the animal have been traditionally accomplished with the analysis of blood and serum parameters to evaluate the physiological or pathological status of the animal. Observation of a deviation of certain blood parameters from their normal limits could be a use for diagnosis or differential diagnosis of a disease condition (Omer *et al*., 2007). The study of blood constituents can provide valuable indication about the general health of animals. It has been increasingly realized that additional fundamental

knowledge of understanding of the physiology of this species (Al-Harbi, 2012).

The pasture quantity and quality are influenced by the seasonal changes in rainfall (Lebon, 1956). This in turn could influence the nutritional status and so the blood constituents of camels (Amin *et al*., 2007).

The pattern of blood biochemical changes in pregnant buffalo, cattle, sheep and goat has been well-documented but less is reported in camel (Deen *et al*, 2010).

2.6.1 Haematological values

Haematology is becoming an increasingly important management and diagnostic tools in veterinary medicine, globally. The blood picture provides an opportunity to clinically investigate the presence of different metabolites and other constituents in the body of the animal and it plays a vital role in the evaluating of physiological, nutritional and pathological status of an organism (NseAbasi *et al*., 2014). It also helps in distinguishing the normal status from the state of stress, which can be nutritional, environmental or physical (Aderemi, 2004).

In order to explicate the haematological data correctly, the results obtained in the laboratory have to be compared with normal reference values of clinically healthy animals, which serve as a yardstick to the clinician. Improper reference values may increases the risk of either unnecessary additional investigations or failure to detect underlying disease (Tsang *et al*., 1998).

It is well known that a variety of factors such as sex, age, species, breed, nutrition, illness, stress, exercise, transport, and seasonal variations can affect the profile of these values (Jain, 1998).

Changes in the environmental factors were found to exert pronounced effects on the blood constituents to maintain the animal health and help animal to survive the adverse effects (Al-Arfaj *et al*., 1992). Hematological variation may have an important role in adjusting the different functions of the animal's body to existing environmental conditions especially under stressful ones (Nazifi *et al*., 1999 and Nyang-ao, *et al*., 1997). Exposure to heat stress leads to variation in cellular properties of blood, these changes aim in its entirety to make the animal more adapted to changes in its environment (AL-Haidary, 2006).

Comparison of blood constituents under different management systems seems to be important as these values reflect the well-being of the animal and are used extensively as diagnostic tests (Barakat *et al*., 2007).

2.6.1.1 Erythrocyte count

Protein is an essential for production of erythrocytes in mammals (Williams *et al*., 1972). AL-Busadah (2007) reported that there was no significant effect of sex or breed on erythrocytic indices.

Al Sultan (2003), Ayoub *et al*. (2003) and Badaway *et al*. (2008) obtained that the red blood cells count (RBCs) decreases during summer season. Al-Haidary (2006), El-Harairy *et al*. (2010) and Babeker. *et al* (2013) recorded that the effects of seasons on red blood cells count was highly significant, being higher during summer than winter. Al Sultan (2003), Ayoub *et al*. (2003) and Badaway *et al*. (2008) attributed changes to the haemodilution phase resulting from increasing water intake during summer, where a considerable part is retained particularly in the extracellular compartment. Amin *et al*. (2007) obtained in RBCs an increases during dry season compared with the green season. Amin *et al*. (2007) found the highest value of RBCs

during summer due to the longer half-life and survival time of red blood cells during dehydration.

Erythrocyte count levels did not show any significant differences between winter and summer (Salman and Afzal, 2004).

Hyperthermia during transport under heat may stimulate a water loss caused by thermo regulation and urination, then contribute to dehydration and increase in RBC. These increases may be due to a contraction of spleen rather than to dehydration (Carlson, 1990). In fact, acute exposure of animals to stressful stimulation is accompanied by a significant activation of the sympathetic-adrenal medullary system, including increased synthesis, circulating levels and release of catecholamines into the circulation (McCarty *et al*., 1988), resulting in splenic contraction and the release of RBC into the circulation. This mechanism is stimulated by the action of catecholamines on α-adrenergic receptors located in the splenic capsule (Tauler *et al*., 2003).

In Sudan, Barakat et al. (2007) recorded that Management system did not affect the red blood cells count.

Pregnancy did not influence red blood cells count. The slight increases in RBC obtained on pregnant compared to non-pregnant she-

camels could be attributed to physiological status due to corpus luteum and fetal development (Muhammad *et al*., 2011).

The overall mean of RBC count reported in Previous publications were 6.1, 7.36, 9.45, 7.7, 10.9, 10.58, $(x10^6/mm^3)$ which had found in Sudan (Amin *et al*., 2007; Barakat *et al*., 2007), Suadi Arabia (AL-Busadah, 2007), Egypt (Badaway *et al*., 2008 and El-Harairy *et al*., 2010), Pakistan (Faroog *et al*., 2011), respectively.

2.6.1.2 Packed cell volume (PCV)

Ghosal *et al*. (1973) in camels and Mehrovta and Gupta, (1989) in sheep, found that PCV significantly increases during summer which was attributed to either the limited availability of oxygen to tissues that might stimulate haematopiosis resulting in increased PCV % and better oxygen-carrying ability. The effect of heat stress which may cause a great mobilization of erythrocytes from spleen, lungs and liver is also a possible reason for increased PCV % during hot seasons (Badawy *et al*., 2008). There is another possibility that the plasma value is reduced under heat stress.

Salman and Afzal, (2004), Al-Haidary (2006) and El-Harairy *et al*. (2010) found that the effect of the different seasons on camel PCV significantly increases during summer and decreases during autumn and

winter. El-Harairy *et al*. (2010) attributed this increases in PCV during summer to a reduced oxygen intake.

Badaway *et al*. (2008) observed that PCV% decreases in summer (31.6) and increases during autumn (34.4) and winter (34.9). The relative reduction in PCV values during summer might be attributed to the reduction in circulating erythrocyte and increases the rate of destruction in red blood cells of cattle (Shaffer *et al*., 1981).

Amin *et al*. (2007) reported that season had no significant effect on PCV.

PCV in penned camels was significantly higher (26.34) than in grazing camels (24.87) (Barakat *et al*. 2007). They explained that penned animals were de-wormed against both internal and external parasites as Tartour and Idris (1968) found that many of the clinically healthy Zebu cattle were actually sub-clinically infected with parasites.

Ayoub *et al*. (2003) and Muhammad et al. (2011) found that pregnancy did not influence PCV.

The overall mean of PCV available from Sudan (Amin *et al*., 2007 and Babeker *et al*., 2013) and several African and Asian countries (Al-Haidary, 2006; AL-Busadah, 2007; El-Harairy *et al*., 2010 and

Faroog *et al*., 2011) which were 25.55, 20.15, 29.09, 25.85, 31.61, 35.2(%), respectively.

2.6.1.3 Haemoglobin concentration (Hb)

There was no significant effect of seasons (dray and green season) on haemoglobin concentration (Amin *et al*., 2007). Haemoglobin level did not show any significant differences between winter and summer (Salman and Afzal, 2004).

Al-Haidary (2006) and El-Harairy *et al*. (2010) reported that the Hb concentration decreases during winter season while Badaway *et al*. (2008) found that Hb concentration decreases during summer season.

Hb in penned camels was significantly high (11.48) compared with grazing one (10.62), this may be due to the fact that penned animals were de-wormed against both internal and external parasites as Tartour and Idris (1968) found that many of the clinically healthy zebu cattle were actually sub-clinically infected with parasites (Barakat *et al*. 2007).

Ayoub *et al*. (2003) and Muhammad *et al*. (2011) found that pregnancy did not influence camel haemoglobin concentration.

The slight increase in haemoglobin concentration found on pregnant camels compared to non-pregnant ones attributed to physiological status due to corpus luteum and fetal development (Muhammad *et al*., 2011)

Normal values of Hb have been reported from different geographic zone of the world, Sudan (Amin *et al*., 2007; Barakat *et al*., 2007 and Babeker *et al*., 2013), Egypt (El-Harairy *et al*., 2010), Pakistan (Faroog *et al*., 2011) were 10.7, 11.05, 8.08, 11.42, 11.67 (g/dl), respectively.

2.6.1.4 Mean corpuscular volume (**MCV)**

The mean value of MCV for autumn (27.4) was a lower than the values obtained for winter (29.5) and summer (33.2) (Badaway *et al*., 2008). Amin *et al*. (2007) and Babeker *et al*., (2013) reported higher MCV during autumn than that of summer, and they attributed that to the negative correlation between the size and count of erythrocytes.

Mean values of MCV were significantly higher in summer (39.9) than winter (34.9) (Salman and Afzal, 2004).

MCV in penned camels (36.94) was higher than in grazing ones (33.65) (Barakat *et al*. 2007).

Muhammad *et al*. (2011) found that MCV did not influence by pregnancy.

The standard of MCV in camels determined in Sudan (Amin *et al*., 2007 and Babeker *et al*., 2013), Saudi Arabia (AL-Busadah, 2007), Egypt (Badaway *et al*., 2008), and Pakistan (Faroog *et al*., 2011) were 43.26, 76.4, 31.46, 31.8, 53.69, (fl), respectively.

2.6.1.5 Mean corpuscular hemoglobin (MCH)

Badaway *et al*. (2008) reported that there was no significant seasonal variation in MCH (summer, autumn and winter), but Al-Haidary (2006) obtained high values during summer season. Amin *et al*. (2007) and Babeker *et al*. (2013) reported that the MCH was increase in the autumn season.

MCH in penned camels (15.46) was higher than that found in grazing camels (14.23) (Barakat *et al*. 2007).

Muhammad *et al*. (2011) found that pregnancy did not influence MCH.

Overall mean of MCH in camel has taken place in Sudan (Amin *et al*., 2007 and Babeker *et al*., 2013), Suadi Arabia (Al-Haidary, 2006 and AL-Busadah, 2007), Egypt (Badaway *et al*., 2008), Pakistan

(Faroog *et al*., 2011) which were 18.22, 28.11, 14.85, 16.71, 11.48, 18.69 (pg), respectively.

2.6.1.6 Mean corpuscular hemoglobin concentration (MCHC)

Amin *et al*. (2007) did not found any seasonal variation on MCHC due to the constant value of PCV and Hb concentration which were found in their study. Badaway *et al*. (2008) found that MCHC increased during autumn season but Babeker *et al*. (2013) found it was increased during summer season.

Barakat *et al*. (2007) recorded that MCHC did not vary with the management system.

Muhammad *et al*. (2011) found that MCHC higher in pregnant camels compared with non-pregnant ones.

Data of MCHC are available in Sudan (Amin *et al*., 2007 and Babeker *et al*., 2013), Suadi Arabia (AL-Busadah, 2007), Egypt (Badaway *et al*., 2008), Pakistan (Faroog *et al*., 2011) were 42.06, 39.53, 49.1, 36.93, 34.21, (g/dl) respectively.

2.6.1.7 Total leukocyte count (TWBCs)

The leukocytes are the mobile units of body protective system. The TWBCs was the highest in camel among several other domestic animals (Sarwar *et al*., 1993).

TWBCs count did not show significant differences between winter and summer (Salman and Afzal, 2004).

White blood cells count increases during winter (16.87) and decreases during summer (9.60) (Badaway *et al*. 2008) and they attributed this to a reduction in corticosteroids secretion due to prolonged exposure to high environmental temperature during the summer season. Babeker *et al*. (2013) found that TWBCs increases during summer. El-Harairy *et al*. (2010) obtained that total TWBCs count decreases during autumn.

TWBCs in penned camels (11.54) were higher than that found in grazing camels (8.47) (Barakat *et al*. 2007).

Mean values of TWBCs recorded by Sarwar *et al*. (1993) Muhammad *et al*. (2011) at different physiological status in females were not different from each other. Muhammad *et al*. (2011) found slight increases in TLC on pregnant compared to non-pregnant she-

camels and they attributed to physiological status due to fetal development.

The overall mean of TWBCs were 10.01, 19.6, 15.97, 10.85, 19.04, 12.68, ($x10^3/mm^3$) which reported in previous publications, in Sudan (Barakat *et al*., 2007), Suadi Arabia (AL-Busadah, 2007), Egypt (Badaway *et al*., 2008 and El-Harairy *et al*., 2010), and Pakistan (Sarwar *et al*. 1993 and Faroog *et al*., 2011), respectively.

2.6.1.8 Differential leukocyte count (DLC)

Neutrophils were the major type of leukocytes in camels with an overall mean of 48.3 % (Badaway *et al*. 2008)

Neutrophils were decreased during winter (44.1) and increased during autumn (15.44) (Badaway *et al*., 2008). Neutrophils were increased during summer season (Babeker *et al*., 2013) but Amin *et al*. (2007) reported that neutrophils were increased in autumn (47.35) compared with summer (32.49); they explained that by the improvement of the nutritional status of camel. Higher dietary protein content was reported to increases the neutrophils percentage in ewes (Thomas and Chiboka, 1984).

El-Banna *et al*. (1981) and Al-Arfaj *et al*. (1992) explained the elevated level of neutrophils during summer in camels due to exposure to the dusty polluted warm environmental conditions.

The overall mean of neutrophils is available from Sudan (Amin *et al*., 2007 and Babeker *et al*., 2013) and several African and Asian countries (Rezakhani *et al*., 1997 and Badaway *et al*., 2008; and Faroog *et al*., 2011) which were 39.92, 38.45, 46.41, 48.33, 44.15 (%), respectively.

Badaway *et al*. (2008) found that lymphocytes increases during winter. Lymphocytes increases during autumn (47.10) compared to summer (40.24) and winter (41.60) Babeker *et al*. (2013), but Amin *et al*. (2007) reported that the lymphocytes decreases during autumn (34.93) compared with summer (56.24).

Camels' erythrocytes do not synthesize heat shock protein (hsp73) after temperature elevation and camel's lymphocytes exhibited strong production of constitutively expressed heat shock protein (hsp73), providing thermotolerance to camel's blood cells, because lymphocytes have a higher resistance of general protein synthesis to elevated temperature (Guerriero and Raynes 1990 and Ulmasov *et al*., 1993).

Normal percentage of Lymphocytes have been reported from different geographic zone, Sudan (Babeker *et al*., 2013), Suadi Arabia (AL-Busadah, 2007), Egypt (Badaway *et al*., 2008), Pakistan (Faroog *et al*., 2011) and Iran (Rezakhani *et al*., 1997), 42.25, 50.13, 44.93, 48.05, 46.67 (%), respectively.

Amin *et al*. (2007) reported that there was no significant seasonal variation in eosinophils and monocytes but they found that basophils increases during summer.

Eosinophils percentage in camels were determined in Sudan (Babeker *et al*., 2013), Suadi Arabia (AL-Busadah, 2007), Pakistan (Sarwar *et al*., 1993 and Faroog *et al*., 2011) and Iran (Rezakhani *et al*., 1997) were 7.48, 4.86, 5.63, 7.1, 4.53 (%), respectively.

The overall mean of basophils has taken place in Sudan (Amin *et al*., 2007 and Babeker *et al*., 2013), Suadi Arabia (AL-Busadah, 2007), Pakistan (Sarwar *et al*., 1993 and Faroog *et al*., 2011) and Iran (Rezakhani *et al*., 1997) which were 0.28, 1.37, 0.52, 0.61, <0.1, 0.00 (%), respectively.

Monocytes percentage was found to be 4.55, 10.85, 6.99, 1.1, 2.07 (%) in Sudan (Amin *et al*., 2007 and Babeker *et al*., 2013),

Pakistan (Faroog *et al*., 2011) and Iran (Rezakhani *et al*., 1997), respectively.

There was no significant difference amongst differential leukocyte count means recorded in various physiological statuses in females (Sarwar *et al*., 1993). Muhammad *et al*. (2011) found that pregnancy did not influence lymphocytes and neutrophils.

Ayoub *et al*. (2003) reported that neutrophils, lymphocytes and eosinophils higher in pregnant camels than that in non-pregnant ones. They attributed that to age differences and to the stress of pregnancy.

2.6.2 Blood Metabolites

Investigation determining normal values of blood constituents in camels is limited (AL-Shami, 2009).

The concentration of blood metabolites is sensitive to seasonal changes in nutrient supply. Therefore, they could be used as indicators of nutritional status in goat (Pambu-Gollah *et al*., 2000).

Comparison of blood values under different managemental systems is essential as these values may reflect the well-being of the animal and could be used as diagnostic tools in health and disease of animals (AL-Shami, 2009).

Compared to other domestic animals such as dairy cattle, sheep, and goats, our understanding about the physiological and hormonal changes that the camel undergoes during pregnancy is inadequate. Because of the long pregnancy period of camels, it was assumed that energy requirements of pregnant camels increase rapidly during the heavy pregnancy. This may affect the concentration of some biochemical parameters (Omidi *et al*., 2014). Also, during pregnancy some metabolic changes occur that may alter blood constituents in goat (Khan and Ludri, 2002).

Pregnancy is a dynamic process characterized by dramatic physiological changes that may influence biochemical values in human and animal (Aziz khan *et al*., 2014).

2.6.2.1 Total protein

Serum total protein and albumin levels are usually considered as useful indices of the nutritional status of animals (Lynch and Jackson, 1983).

Salman and Afzal, (2004), El-Harairy *et al*. (2010) and Javad *et al*. (2013) reported that no significant changes were seen in total proteins with the season. Al-Haidary (2006) and Abdoun *et al*., (2012) reported that total protein increases in the summer compared with

winter. Amin *et al*. (2007) recorded that total protein and globulin increases during summer season. Badawy *et al*. (2008) found that the total protein decreases during winter (6.59) compared to summer (7.33) and autumn (7.25). Amin *et al*. (2007) suggested that the increases in the concentration of serum globulin and total protein during the dry season could be attribute to the stresses to which camels were subjected under dry condition. Abokouider *et al*. (2001) reported that increases in serum total protein level during the dry season in camels kept under natural condition.

Muhammad *et al*. (2011) and Omidi *et al*. (2014) did not observe any significant difference in serum total protein between non-pregnant and pregnant. However, the values were lower in pregnant camels than those of non-pregnant (AL-Zamely 2011).

The overall mean of total protein available from Sudan (Babeker *et al*., 2013), Saudi Arabia (Osman and Al-Busadah, 2003 and AL-Shami, 2009), Egypt (Badaway *et al*., 2008 and El-Bahrawy and El Hassanein, 2011) and Iran (Omidi *et al*., 2014) were 6.75, 7.32, 6.74, 6.85, 6.45, 5.78 (g/dl), respectively.

2.6.2.2 Albumin

Albumin has the water attracting/holding property and its high value in camel probably indicates specific adaptation for the desert environment (Salman and Afzal, 2004).

Controversial results were found by different researchers with regard to the effect of the season in camel plasma albumin concentration. Amin *ea al*. (2007) and El-Harairy *et al*. (2010) did not find variation in albumin values with the seasons. Al-Haidary (2006) and Abdoun *et al*., (2012) reported that albumin increased in summer compared with winter, also Badawy *et al*. (2008) found a decrease during winter (3.98) compared with autumn (4.37) and summer (4.47) values. Mohammed *et al*. (2007a) found that the albumin increase during autumn compared with summer, while Salah El Din *et al*. (2005) found a decrease in autumn. Salman and Afzal (2004) reported that albumin levels were lower in summer (4.14) than winter (4.22) which they attributed to temperature stress.

In Buffalo, Heat stress induced a reduction of plasma albumin concentration could be due to the incapability of protein synthesis to counteract the protein catabolism which leads to negative nitrogen balance under such conditions (Marai and Habeeb, 2010).

Muhammad *et al*. (2011) and Omidi *et al*. (2014) obtained that there was no significant difference in serum albumin between non-pregnant and pregnant; however, the values were lower in pregnant camels than those of non-pregnant.

Saeed *et al*. (2009) AL-Zamely (2011) found that albumin concentration higher in non-pregnant camels than that in pregnant ones.

AL-Zamely (2011) attribute this decrease in pregnant camels to reduction of albumin biosynthesis due to increase pregnancy hormones especially progesterone which is rise in pregnant camels, this increases may effect on liver and cause decreasing of albumin production (Pineda and Doole, 2003), also increases of albumin elimination by kidney during pregnancy play a role in a decreases of albumin level (Halliwell, 1988).

Normal values of albumin concentration have been reported from different geographic zone of the world, Sudan (Amin *et al*., 2007 and Babeker *et al*., 2013), Suadi Arabia (AL-Shami, 2009), Egypt (Badaway *et al*., 2008), Iran (Omidi *et al*., 2014), India (Patodker *et al*., 2010) and USA (Dierenfeld *et al*. 2014) 3.13, 2.75, 3.26, 4.17, 2.96, 4.13, 3.6 (g/dl).

2.6.2.3 Cholesterol

Mean value of cholesterol determined during autumn (75.25) increased significantly compared to winter (65.63) and summer (62.85) values (Badawy *et al*., 2008). El-Harairy *et al*., (2010) obtained that the concentration of cholesterol was significantly different during winter (78.65) season compared to summer (72.66) and autumn (74.33). Javad *et al*., (2013) reported that there was no variation with the season on serum cholesterol. Ahmed *et al*. (2013b) recorded that the cholesterol concentration determined during summer was significantly increased compared with winter. An increase in serum cholesterol level during starvation has been reported by Mirghani (1982).

The increases in the concentration of cholesterol of serum during the dry season may be related to low dietary requirements (Ahmed *et al*., 2013b). Moreover, it was reported that reduced glucose metabolism is reflected on the performance of free fatty acids (Mayes and Bothman, 2003). This increased concentration of serum cholesterol during the dry season is in agreement with the bibliographic data (Mirghani, 1982; Wasfi *et al*., 1987 and Abokouider *et al*., 2001).

In goat, El-Masry *et al*. (1989) reported that the increase in cholesterol and total lipids under hot months could be attributed to the

increased non-esterified fatty acids and fat catabolism occurring in heat-stressed animals. However, Nazify *et al*. (1999) reported that cholesterol concentration was higher in winter than in summer in dromedary camels. It was suggested that the seasonal changes in blood lipids and proteins might result from changes in the nutritional and energy balances or changes in environmental temperature, humidity and day length.

Serum concentration of cholesterol was significantly higher in indoor camels compared to free grazing camels (AL-Shami, 2009). Higher level of cholesterol in indoor over that of grazing camels indicate that nutritional factor can influence normal values of blood constituents of metabolites (Mokhtar, 1998).

Cholesterol concentration in camels were determined in Sudan (Salah ElDin *et al*., 2005), Suadi Arabia (Al-Sultan 2003), Egypt (Badaway *et al*., 2008 and El-Bahrawy and El Hassanein (2011), Iran (Omidi *et al*., 2014) 139.49, 53.89, 65.08, 21.62, 31.96 (mg/dl), respectively.

2.6.2.4 Triglycerides

Serum triglycerides concentration was higher in she-camels than that of cows and ewes (Osman and Al-Busadah, 2003). In camels,

serum triglycerides concentration has been reported to be affected by the diet (Wasfi *et al*., 1987).

Amin *et al*. (2007) found that the triglyceride increases significantly during summer compared with autumn. Ahmed *et al*. (2013b) and Javad *et al*. (2013) found that the triglyceride increases significantly during summer compared with winter.

The increases in the concentration of triglycerides of serum during the dry season may be related to low dietary requirements (Ahmed *et al*., 2013b). Triglycerides are known to provide the metabolic fuel for most tissues when the animal is in energy deficit (Beitz, 1993). Moreover, it was reported that reduced glucose metabolism is reflected on the performance of free fatty acids (Mayes and Bothman, 2003).

The effect of dehydration on lipid metabolism is not well studied in camels. The camel's hump has long been considered a lipid reserve mobilized to release water during dehydration. However, the size of the hump is not affected by water deprivation. The decrease in basal metabolism inhibits lipolysis (Yagil, 1985).

Serum concentration of triglyceride was significantly higher in indoor camels compared to free grazing camels (AL-Shami, 2009). Higher level of triglyceride in indoor over that of grazing camels indicate nutrition is a factor that can influence normal values of blood metabolites (Mokhtar, 1998). Omidi *et al*., (2014) found that there was no significant deferent in triglycerides concentration between pregnant and non-pregnant she camels.

Data of triglycerides are available, 30.48, 36.52, 31.4, 77.8, 31.49 (mg/dl) such as in Sudan (Amin *et al*., 2007), Suadi Arabia (Al-Sultan, 2003; Osman and Al-Busadah, 2003 and AL-Shami, 2009) and Iran (Omidi *et al*., 2014) respectively.

2.6.2.5 Glucose

Badawy *et al*. (2008) reported that the plasma glucose level in true ruminants is lower than in simple stomached mammals. However, Dahlborn *et al*. (1992) reported that normally camels have a glucose level similar to simple stomached mammals.

Glucose concentration was increased during winter compared with summer (Al-Haidary, 2006; Abdoun *et al*., 2012 and Ahmed *et al*., 2013b). Badawy *et al*. (2008) found it was increased during winter compared to autumn and summer. However, Nazifi *et al*. (1999) found

that the concentration of serum glucose was significantly higher in summer than in winter. Amin *et al*. (2007) and Mohammed *et al*. (2007a) reported that the glucose concentration increased significantly during autumn season compared with summer season.

The decreases in plasma glucose concentration during the dry season can be attributed to the decreases in available forage (Amin *et al*., 2007 and Ahmed *et al*., 2013b). Food deprivation decreases the level of glucose in ruminants and simple stomached mammals (Evans, 1971). Moreover, the supply of camels after fasting increases the level of plasma glucose (Wensvoort *et al*., 2004). There are also reports indicating the decrease of plasma glucose level during the dry season in camels (Wilson, 1984 and Abokouider *et al*., 2001).

Food deprivation decreases plasma glucose levels in both simple stomached mammals and ruminants of similar size as the camel (Evans, 1971 and Rule *et al*., 1985). However, serum glucose level of camels was maintained during fasting and was increased after feeding had commenced (Wensvoort *et al*., 2004)

This discrepancy in effect of the season on blood glucose in camels may be due to breed differences and to the environmental conditions particularly feeding and watering systems. The increased

blood glucose level during summer may be due to a decreased basal metabolic rate reducing the use of glucose for energy production under hot climatic conditions (Badawy *et al*. 2008).

The Islet camels have more cells secreting glucagon than insulin secreting cells (Charnot, 1967). The proportion of these cells decreased in the dehydrated camel. However, after water deprivation for 10 days, blood glucose increased from 20 to 80% according to (Banerjee and Bhattacharjee, 1963 and Macfarlane *et al*., 1968), whereas glucosuria is zero. This hyperglycemia is due to the absence of renal excretion of glucose and a decrease in its use. During dehydration, insulin decreased more than 30% (from 20 to 14 IU/L). However, the administration of a glucose solution leads to a sharp increase in insulin which reaches 40 IU/L. Injection of glucose promotes glucosuria higher animals hydrated (0.36 mmol/L) than in dehydrated animals (0.18 mmol/L) (Yagil and Berlyne, 1977). Insulin acts mainly on the storage and use of tissue glucose, but it would have no effect on the renal reabsorption. The urinary excretion of glucose is accompanied by huge water loss, as is the case in diabetics. The dehydrated dromedary reduces water loss by maintaining its high glucose and glucosuria practically zero. The hypo-

insulinemia would maintain a low basal metabolism by decreasing glucose utilization (Ahmed *et al*., 2013b).

Serum concentration of glucose was significantly higher in indoor camels compared to free grazing one, rich source of sugars like dried dates may explain the significant increase of serum glucose concentration in indoor compared to free grazing one (AL-Shami, 2009). Higher level of glucose in indoor over that of grazing camels indicate that nutritional factor can influence normal values of blood constituents of metabolites (Mokhtar, 1998).

El Khasmi *et al*. (2013) reported that transportation increase plasma glucose levels in camels. This hyperglycaemia may be primarily might be due to an activation of the sympathetic nervous system, catecholamines secretion (Sanders and Straub, 2002) which is able to decrease the glycogen reserves by stimulating glycogenolysis in rat (Dronjak *et al*., 2004).

The levels of glucose in the sera of pregnant camels were significantly lower than non-pregnant camels (Omidi *et al*., 2014), this is in agreement with the findings of Khan and Ludri (2002) and Saeed *et al*. (2009); they found significantly lower concentrations of glucose in pregnant goats than in non-pregnant ones.

The low level of glucose in pregnant camels may be due to the developing fetuses and mobilization of glucose from the mother for providing adequate energy of the fetus (Omidi *et al*., 2014).

The overall mean of glucose concentration reported in Previous publications were 58.57, 53.03, 134.4, 117.6, 93.78, 108.63, 93.4 (mg/dl) which had found in Sudan (Babeker *et al*., 2013) Suadi Arabia (Al-Sultan, 2003; Osman and Al-Busadah, 2003; and AL-Shami, 2009), Egypt (Badaway *et al*., 2008 and El-Bahrawy and El Hassanein, 2011) and Iran (Omidi *et al*., 2014), respectively.

2.6.3 Thyroid hormones

Thyroid hormones are known as important modulators of general metabolism (Kaneko *et al*., 2008). In dairy cows, these hormones regulate energy metabolism in which carbohydrates and lipids are the major constituents (Mohebbi-Fani *et al*., 2009). Thyroid hormones affect lipid metabolism by increasing lipolysis in adipose tissue and stimulating lipogenesis by increasing the activities of some enzymes. Serum levels of thyroid hormones are mainly affected by general body metabolism, season and water availability (Nazifi *et al*. 2009).

Serum levels of thyroid hormones are mainly affected by general body metabolism (Yagil and Gannani, 1978), season (Nazifi *et al*., 1999) and the water availability (Yagil and Gannani, 1978).

The serum cholesterol level generally changes inversely with thyroid activity (Bruss, 2008), however, there are some contradictory findings regarding the relationship of serum thyroid hormones with cholesterol and triglycerides in camels (Javad *et al*., 2013). Some studies showed that the serum concentration of thyroid hormones were not related to cholesterol levels in male camels (Wasfi *et al*., 1987), however, Nazifi *et al*. (2009) found a significant positive correlation between serum thyroid hormones and cholesterol in male dromedary camels.

The net effect of thyroid hormones on the cholesterol metabolism is to increase the rate of cholesterol catabolism by liver (Bruss, 2008 and Mansourian, 2010).

Javad *et al*. (2013) and Nazifi *et al*. (2009) reported that Triiodothyronine (T_3) and thyroxin (T_4) increases during winter compared to summer. Serum concentrations of T3 and T4 in goats are higher in winter than in summer and it is believed that a cold environment increases the secretion of thyrotrophic hormone, which

results in a higher serum concentration of thyroid hormones (Prakash and Rathore, 1991). Yagil and Gannani (1978) reported that camel thyroid was inhibited in summer due to dehydration, this inhibition assists in the preservation of body water by decreasing pulmonary water loss and reducing the basic metabolism. Similarly, Khanna *et al*. (1996) reported that during summer, T_4 levels fell gradually in dehydrated dromedary camels and increases after rehydration, whereas in winter, T_4 levels increases in dehydrated camels.

Pregnancy is a dynamic process characterized by dramatic physiological changes that may influence hormonal functions in human and animal. Thyroid function regulates a wide range of metabolic activities (Aziz khan *et al*., 2014). Appropriate thyroid gland function and its hormonal activity are crucial to sustain the reproductive performance, healthy pregnancy outcomes, and successful brain development in the fetus of animals (LaFranchi *et al*., 2005). Thyroid function significantly affects lipoprotein metabolism (Duntas, 2002).

Rahman *et al*. (2007) and Omidi *et al*. (2014) found that T_3 and T_4 were not vary with pregnancy. Nazifi *et al*. (2003) found that the concentrations of serum T_4 and T_3 were higher in non-pregnant goats than those of the pregnant ones.

2.6.4 Blood mineral

Serum biochemical parameter can provide valuable information regarding health, sex, age, nutritional and physiological status of the animals (Osman and Al-Busadah, 2000, 2003).

Serum electrolytes that are Na^{+}, K^{+} and Ca^{++} take part in some reactions which are critical to life (Church, 1988). An unusual fluctuation in them is almost invariably indicative of an abnormal condition (Coles, 1967).

2.6.4.1 Magnesium concentration (Mg^{+})

There was no effect of season on Mg^{+} level (Ahmed *et al*., 2013a).

Magnesium in grazing camels was higher than that found in penned camels (Barakat *et al*., 2007 and AL-Shami, 2009). The higher values for serum Mg^{+} in free grazing camels compared to indoor camels could be due to the free grazing camels graze an plants rich in this mineral (Barakat *et al*., 2007) and (AL-Shami, 2009) or/ and may be contaminated with the soil (Barakat *et al*., 2007).

The overall mean of Mg^{+} was 2, 1.25, 2.16, 2.2, 1.04 (mg/dl) which found in Sudan (Barakat *et al*., 2007), Suadi Arabia (Al-Sultan,

2003; Osman and Al-Busadah, 2003 and AL-Shami, 2009) and Algeria (Ahmed *et al*., 2013a), respectively.

2.6.4.2 Sodium concentration (Na^+)

Sodium level was increased during summer compare with winter (Ahmed *et al*., 2013a). Mohammed *et al*. (2007a) reported that Na^+ did not vary with season.

The effect of different seasons of the year on sodium concentration of the dromedary she-camels was significantly higher during summer compared to spring, winter and autumn. The highest value of sodium was recorded during summer and the lowest value obtained during autumn (El-Harairy *et al*., 2010). These results may be attributed to the combined effect of both absorption and reabsorption of sodium and chloride from the alimentary tract and kidney, under the effect of aldosterone which show high level in summer and this was accompanied by an increase of plasma sodium level (Yagil and Etzion, 1979).

Barakat *et al*. (2007) and AL-Shami (2009) recorded that Na^+ level was not different between grazing and penned camels. The camel homeostatic mechanism may have kept a similar concentration of Na^+ for the grazing and penned camels (Barakat *et al*., 2007).

Sarwar *et al*. (2004) reported that serum Na^+ concentration did not vary with pregnancy in she camels.

The overall mean of Na^+ were 126.15, 168.2, 150.9, 153.5, 144.57, 157.91 (mEq/L), which were reported in Previous publications, Sudan (Barakat *et al*., 2007), Suadi Arabia (Osman and Al-Busadah, 2003; Al-Sagair *et al*., 2005 and AL-Shami, 2009), Nigeria (Mohammed *et al*., 2007a) and Algeria (Ahmed *et al*., 2013a) respectively.

2.6.4.3 Potassium concentration (K^+)

Potassium level was increased during summer compared to winter (Ahmed *et al*., 2013a) when Babeler *et al*. (2013) found marked increases of K^+ during winter.

The effect of the seasons of the year on potassium concentration of the dromedary she-camels was significantly higher during spring copared to winter, autumn and summer (El-Harairy *et al*., 2010).

The decreases of potassium concentration during summer may be attributed to an increases of aldosterone secretion in hot and dry climate which was enhanced by renin-angiotensin system in response to changes in effective circulating fluid volume where aldosterone balance

largely plasma potassium, through its effect on renal reabsorption of sodium in exchange for potassium and hydrogen ion (Kaneko,1980).

Potassium concentration in grazing camels was higher than that found in pennedcamels (Barakat *et al*., 2007) and (AL-Shami, 2009). The higher values for serum K^+ in free grazing camels compared to indoor camels could be due to the free grazing camels graze on plants rich in this mineral (Barakat *et al*., 2007 and AL-Shami, 2009) or/ and may be contaminated with the soil (Barakat *et al*., 2007).

Serum K^+ level was found to be significantly higher in non-pregnant than in pregnant females (Sarwar *et al*., 2004), However, Antunovic *et al*. (2011) reported that there was no variation in Serum K^+ with pregnancy in ewes.

The overall mean of K^+ available from Sudan (Barakat *et al*., 2007), Suadi Arabia (Osman and Al-Busadah, 2003; Al-Sagair *et al*., 2005 and AL-Shami, 2009), Nigeria (Mohammed *et al*., 2007a) and Algeria (Ahmed *et al*., 2013a) were 3.97, 4, 4.26, 5.5, 5.03, 5.67(mEg/dl) respectively.

2.6.4.4 Calcium concentration (Ca^{++})

The effect of the season of the year on calcium concentration of the dromedary she-camels was significantly increased during summer and spring than winter and autumn. The highest value of calcium concentration of the dromedary she camel was recorded during summer and the lowest value during autumn (El-Harairy *et al*., 2010).

Amin *et al*. (2007) observed marked increases in the concentration of serum Ca^{++} during the green season and they attributed that to the availability of plants rich in minerals (ash content) during the wet season. Rainfall can affect the mineral composition of pasture herbage (McDonald *et al*., 1995)

Calcium level was increased during winter compared with summer (Ahmed *et al*., 2013a). The rises in serum concentrations of calcium and phosphorus during the wet season can be attributed to the availability of plants rich in minerals during the rainy season (Ahmed *et al*. 2013a).

Barakat *et al*. (2007) and AL-Shami (2009) recorded that Ca^{++} was not different between grazing camels and penned ones, the camel homeostatic mechanism may have kept a similar concentration of Ca^{++} for the grazing and penned camels (Barakat *et al*., 2007).

There was no significant difference in Ca^{++} level due to pregnancy (Sarwar *et al*., 2004). Saeed *et al*. (2009) and Muhammad *et al*. (2011) reported that serum Ca^{++} level higher in non-pregnant camels compared to pregnant ones.

The overall mean of Ca^{++} have been reported from different geographic zone, Sudan (Barakat *et al*., 2007 and Babeker *et al*., 2013), Suadi Arabia (Osman and Al-Busadah, 2003 and AL-Shami, 2009), Nigeria (Mohammed *et al*., 2007a) and Algeria (Ahmed *et al*., 2013a) were 10.93, 7.46, 9, 10.05, 2.39, 5.67 (mg/dl), respectively.

CHAPTER III
MATERIALS AND METHODS

3.1 Study area and Study Duration

This study was done in Butana area, Sudan, which it lays approximately between latitude 14º-16º N and longitude 33º-36º E, between March (2013) and February (2014).

3.2 Animals

This study was carried out on sixty one-humped she-camels (*Camelus dromedarius*) aged between 6 and 9 years. Animals were divided into four groups: group (1) penned camels, group (2) grazing camels, group (3) pregnant camels and group (4) non-pregnant camels. All the camels were clinically healthy and free from any physical abnormalities.

3.3 Housing and Feeding

Thirty camels were free grazing in pasture and the other thirty camels were housed at open partially shaded yard in Tambol Camel Research Centre. Stockyard dimensions are 30 m wide and 54 m long. Shade dimensions are 6 m wide, 18 m long with 4 m high North side and 4.5 m high South side.

The penned animals were fed twice daily, sorghum straw and a concentrate composed of molasses 30%, bagasse 20%, sorghum grain 15%, groundnut cake 17%, wheat bran 15%, urea 2% and salt 1%.

The most available grasses for free grazing camels are (Tabar) *Ipomoea cardofana*, (Hantout) *Ipoboea blepharosepala*, (Sharia) *Indigofera hochstetteri*, (Um assabi) *Dactyloctenium aegyptiacum*, (Taffa) *Urochloa trichopus*, (Gubbein) *Solanum dubium* , (Rihana) *Ocimum basilicum* and (Um Galagil) *Aristolochia bracteolate*.

3.4 Meteorological data

Meteorological data during the study period, which are ambient temperature (Ta) and relative humidity (RH), were provided monthly for Butana area (14°-16°N, 33°-36°E) by the Meteorological Unit, Wad-Medani city.

3.5 Clinical parameters

3.5.1 Rectal temperatures (Tr)

The rectal temperature (Tr) of the camel was measured by using a digital thermometer (ACON). The animals were handled gently and the probe was inserted into the rectum 5cm touching the wall of the rectum for two minutes.

3.5.2 Respiration rate (RR)

The respiration rate (RR) was obtained visually by counting the frequency of flank movement per minute using a stopwatch.

3.5.3 Pulse rate

The pulse rate was determined by counting the frequency of the jugular vein with hand per minute using a stopwatch.

3.6 Blood collection

Blood samples (10ml) were collected monthly from jugular vein using 5 ml plastic disposable syringes and 6ml vacutainers tube with gel. Immediately, 3ml of the blood were delivered into vials containing di-soduim ethylenediamine-tetra-acetate (Na_2 EDTA) as an anticoagulant for the haematological analyses and 1ml was delivered into vials containing sodium fluoride for the determination of glucose.

Blood were taken by jugular venipuncture into vacutainers tube without any anticoagulant used for serum separation. The rest of blood was allowed to clot at room temperature and then centrifuged at 600rpm for 15 minutes for the separation of serum and stored in a deep freezer at –20°C for later analysis of total protein, albumin, globulin,

cholesterol, triglyceride, Triiodothyronine, thyroxin, sodium, potassium, calcium, magnesium and iron.

3.7 Blood analysis

3.7.1 Haematological values

The methods described by Jain (1998) was used for determination of erythrocyte count, packed cell volume (PCV), haemoglobin concentration (Hb), total leukocyte count (TWBCs) and differential leukocyte count (DLC). The erythrocytic indices, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC), were calculated according to formulae of Dacie and Lewis (1991).

3.7.1.1 Erythrocyte count

Red blood cells were determined by diluting blood sample with physiological solution (hayem's solution), and counting the number of RBCs using an improved Neubaur haematocytometer (Neubaur improve – Germany) (Jain, 1998).

3.7.1.2 Packed cell volume (PCV)

Capillary tubes were used for measuring packed cell volume; tubes were filled with blood above 3/4 and sealed with cristaseal, then

were centrifuged at 12000 rpm for 5 minutes by a micro-haemotocrit centrifuge (Hettich, Tuttlingen - Germany). Haemotocrit reader was used for determines the percentage of PCV (Jain, 1998).

3.7.1.3 Haemoglobin concentration (Hb)

Spin react Haemoglobin Drabkin kit (SPINREACT, Spin) was used for determining haemoglobin concentration using colorimetric method. Haemoglobin was oxidized by potassium ferric oxide into cyanomethaemoglobin by potassium cyanide. The intensity of absorbance of cyanomethaemoglobin is proportion to haemoglobin concentration.

The optical density was read at a wavelength of 540 nm using a calorimeter (Jenway, USA).

$$\text{Hb (g/dl)} = \frac{\text{Test optical density}}{\text{Standard optical density}} \text{ X } 14.5$$

3.7.1.4 Total leukocyte count (TWBCs)

Total leukocyte count was determined by diluting blood sample with physiological solution (Turk’s solution) and the count of the leukocyte was done by an improved Neubaur haematocytometer (Neubaur improve – Germany) (Jain, 1998).

3.7.1.5 Differential leukocyte count (DLC)

Neutrophils, eosinophils, basophils, lymphocytes and monocytes were determined by the microscope (Olympus, Japan) from a count of leukocytes in thin smears using Giemsa-May-Griinwald stain (Dacie and Lewis, 1991).

3.7.1.6 The erythrocytic indices

These values were calculated according to Dacie and Lewis (1991).

3.7.1.6.1 Mean corpuscular volume (MCV)

The MCV, in flemtoliters (fl) was calculated from the PCV and RBC count as follows:

$$\text{MCV (fl)} = \frac{\dfrac{\text{PCV\%} \times 10}{\text{RBC}}}{(\times 10^6 \text{mm}^3)}$$

3.7.1.6.2 Mean corpuscular hemoglobin (MCH)

The MCH, in picogram (Pg) was calculated from the Hb and RBC count as follows:

$$\text{MCH (Pg)} = \frac{\text{Hb (g/d)}}{\text{RBC}} \text{ X } 10$$

3.7.1.6.3 Mean corpuscular hemoglobin concentration (MCHC)

The MCHC, in (g/dl) was calculated from the Hb and PCV count as follows:

$$\text{MCHC (g/dl)} = \frac{\text{Hb (g/d)}}{\text{PCV\%}} \text{ X } 100$$

3.7.2 Blood metabolites

3.7.2.1 Total protein

Plasma total protein concentration was determined by spectrophotometric method using a commercial kit (SPINREACT, Spin).The method is based on that the peptide bonds of plasma proteins diluted with isotonic solution of sodium chloride react with alkaline copper sulphate to give a violet color. The optical density was read at a wavelength of 540 nm using a spectrophotometer (6305, Jenway, U.K).

$$\text{Plasma total protein (g/dl)} = \frac{\text{Sample optical density}}{\text{Standard optical density}} \text{ X } 7$$

3.7.2.2 Albumin

Plasma albumin was determined by spectrophotometric method using a commercial kit (LINEAR CHEMICALS, BARCELONA, Spin). The method is based on that the specific binding to the indicator 3, 5, 5, 5, tetrabromocresol (Bromocresol green, BCG), an anionic dye and protein at acid pH 4.2 with the formation of colored complex. The optical density was determined at a wavelength of 630 nm by using spectrophotometer (6305, Jenway, U.K).

$$\text{Plasma albumin (g/dl)} = \frac{\text{Sample optical density}}{\text{Standard optical density}} \times 5$$

3.7.2.3 Globulin

Plasma globulin was obtained by the difference between plasma total protein and plasma albumin (King and Wooton, 1956).

3.7.2.4 Cholesterol

Serum cholesterol concentration was measured by enzymatic hydrolysis to release cholesterol and it's esters from lipoprotein by cholesterol esterase (CHE) using commercial kit (SPINREACT, Spin). The method is based on that the cholesterol esters are hydrolyzed by

cholesterol esterase giving free cholesterol and fatty acids. This free Cholesterol is oxidized by cholesterol oxidase to cholesterine with the simultaneous production of hydrogen peroxide. Hydrogen peroxide in the presence of peroxidase, result in the formation of a quinonimine derivative, with a red coloring. The optical density was determined at a wavelength of 450 nm by spectrophotometer (6305, Jenway, U.K).

$$\text{Serum Cholesterol (mg/dl)} = \frac{\text{Sample optical density}}{\text{Standard optical density}} \text{ X } 100$$

3.7.2.5 Triglycerides

Triglycerides were determined by spectrophotometeric method using a commercial kit (SPINREACT, Spin). The method is based on the sample incubated with lipoproteinlipase (LPL), liberate glycerol and free fatty acids. Glycerol is converted to glycerol-3-phosphate (G3P) and adenosine-5-diphosphate (ADP) by glycerol kinase and ATP. Glycerol-3-phosphate (G3P) is then converted by glycerol phosphate dehydrogenase (GPO) to dihydroxyacetone phosphate (DAP) and hydrogen peroxide (H_2O_2). In the last reaction, hydrogen peroxide (H_2O_2) reacts with 4-aminophenazone (4-AP) and p-chlorophenol in presence of peroxidase (POD) to give a red colored dye. The intensity

of the color measured at a wavelength of 505 nm by spectrophotometer (6305, Jenway, U.K).

$$\text{Serum triglycerides (mg/dl)} = \frac{\text{Sample optical density}}{\text{Standard optical density}} \text{ X } 200$$

3.7.2.6 Glucose

Glucose concentration was determined by spectrophotometeric method using a commercial kit (SPINREACT, Spin). The method is based on the enzymatic oxidation in the presence of glucose oxidase, glucose is oxidized to gluconic acid and hydrogen peroxide. Hydrogen peroxide reacts with o-dianisidine in the presence of peroxidase form a colored product. The intensity of the color measured at a wavelength of 540 nm using a spectrophotometer (6305, Jenway, U.K).

$$\text{Plasma glucose (mg/dl)} = \frac{\text{Sample optical density}}{\text{Standard optical density}} \text{ X } 100$$

3.7.3 Blood hormones

3.7.3.1 Serum triiodothyronine (T_3) concentration

Triiodothyronine ($T_{3)}$ concentration was determined by RIA-Spec MIS kit (Hungary). The assay is based on the competition between

unlabeled T_3 and fixed quantity of ^{125}1-labeled T_3 for a limited number of binding sites on T_3 specific antibody. The concentration of antigen is inversely proportional to radio-activity measured in test tubes by plotting binding values against a series of calibrations, which contain known amount of T_4. Acalibration curve was constructed from which the unknown concentration of T_3 in sample was determined.

3.7.3.2 Serum thyroxin (T4) concentration

Thyroxin (T_4) concentration was determined using ^{125}1-T_4 RIA-Spec MIS kit (Hungary). The assay is based on the competition between unlabeled T_4 and fixed quantity of ^{125}1-labeled T_4 for a limited number of binding sites on T_4 specific antibody. The concentration of antigen is inversely proportional to radioactivity measured in test tubes by plotting binding values against a series of calibrators, which contain known amount of T_4. A calibration curve was constructed from which the unknown concentration of T_3 in sample was determined.

3.7.4 Serum minerals

3.7.4.1 Magnesium (Mg^+)

According to the method described by Fernandez and Khan (1971) Mg^+ concentration was determined by atomic absorption

spectrophotometer (3110, Germany), using a commercial kit (Fortress, diagnostics. Spin). The method is based on that magnesium ions react with calmagite indicator at alkaline pH to form a chromophore, the rate of formation of which can be measured at a wavelength 520 nm.

$$\text{Mg concentration (mg/dl)} = \frac{\text{Sample optical density}}{\text{Standard optical density}} \text{ X Standard concentration}$$

3.7.4.2 Sodium (Na^+)

Plasma sodium (Na^+) concentration was determined by flame photometer technique according to Wootton (1974). A stock solution of NaCl (1000mEg/L) was prepared by dissolving 58.56g of dry analar NaCl in one liter of distilled water. Standard solution was prepared by diluting the stock solution with deionized and distilled water 1:50.

A volume of 0.1ml of serum was diluted with 9.9 ml deionized water in a test tube. Zero reading was adjusted by ionized water and standard solution was used to adjust upper setting of 100. Then the standard solution and the samples were measured by the flame-photometer. Plasma (Na^+) concentration was measured in mEq/L. The values then read from the standard curve.

3.7.4.3 Potassium (K^+)

The concentration of plasma K^+ was measured by a flame photometer technique according to Wootton (1974). Stock solution of KCl (100mEg/L) was prepared by dissolving 7.46g analar KCl in one liter of distilled water. A standard solution was prepared by diluting stock solution with deionized and distilled water 1:50.

A volume of 0.1ml of plasma was diluted with 9.9ml deionized water in a test tube. The standard solution and samples were measured by the flame-photometer. The calibration curve for potassium was constructed using dilution of the standard to give 0.1, 0.3, 0.4 and 0.5 mEq/L water against photometer units.

3.7.4.4 Calcium (Ca^{++})

Calcium concentration was determined by spectrophtometric method using a commercial kit (Liner chemical, Spin). The method is based on the specific binding of cresolftalein complex (OCC), a metallochromic indicator and calcium at alkaline pH with the resolving shift in the absorption wavelength of the complex. The optical density was determined at a wavelength of 570 nm by a spectrophotometer (6305, Jenway, U.K).

$$\text{Ca concentration (mg/dl)} = \frac{\text{Test optical sample}}{\text{Standard optical sample}} \times 10$$

3.8 Statistical analysis

Data were analyzed as with a 3x2x2 factorial arrangement of treatments using analysis of variance, treatments means were compared by Duncan's multiple range tests and ANOVA table, and an interaction between three factors (season, management system and physiological status of animals) analyzed by general linear model by using SPSS version 16 computer programs.

CHAPTER IV
RESULTS

Table (1) shows the metrological data during the experimental period. The ambient temperature during the experiment range was 15.7^0C - 41.63^0C while the relative humidity fluctuated between 21% and 70%. The highest value of ambient temperature was recorded during May, while the lowest value was recorded during January. The highest value of relative humidity was recorded during August, while the lowest value was recorded during April.

4.1 The effect of the season, management system and physiological status on clinical parameters

Seasonal changes in the clinical parameters of camels are displayed in Table (2). Rectal temperature (Tr) and pulse rate varied significantly with the season. The mean value of rectal temperature and pulse rate measured during winter were the lowest values while the highest one was measured during summer. The animal registered significantly lower values for respiratory rate during winter while no variation was found between summer and autumn.

The effect of management system on the clinical parameter is shown in Table (2). Grazing camels registered significantly higher

Table (1): Metrological Data during the different seasons for Butana area (14o-16oN, 33o-36oE)

Season	Month	Mean Temperature(°C)		Relative Humidity(%)
		Minimum	Maximum	Mean
Summer	March	19.4	40.7	21
	April	21.6	41.5	19
	May	25.5	43.1	26
	June	25.5	41.2	41
Mean		23	41.63	26.75
Autumn	July	24.9	38.5	51
	August	22.7	34.1	70
	September	23.2	37	59
	October	21.9	38.4	46

Mean		23.18	37	56.5
Winter	November	18.7	37.6	30
	December	16.5	33.9	29
	January	15.7	34.4	30
	February	16.3	35.2	30
Mean		16.8	35.28	29.75

values for pulse rate compared with penned ones while the penned camels registered significantly higher values for rectal temperature and respiratory rate compared with the grazing ones.

The effect of the physiological status on the clinical parameters of camels is presented in Table (2). Rectal temperature and respiratory rate did not vary with the physiological status. Pulse rate was significantly higher in pregnant animals than that registered in non-pregnant ones.

There was an interaction between season and management type on respiratory rate, while there was interaction between season and physiological status on all the clinical parameters. There was an interaction between management system and physiological status with regard to the pulse rate and an interaction between season, management system and physiological status with regard to the respiratory rate and pulse rate.

4.2 The effect of the season, management system and physiological status on erythrocytic indices

Seasonal changes in erythrocytic indices of camels are shown in Table (3). RBCs count, PCV, MCV and MCHC varied significantly

among all seasons, while Hb concentration and MCH did not vary with the seasons. The mean value of RBCs count determined during winter was significantly higher than the values measured during summer. During autumn the animal registered significantly lower PCV and MCV values and higher MCHC value than the values obtained in summer and winter.

Table (3) shows the effect of management system on erthrothytic indices. Penned camels registered significantly lower RBCs count and PCV and higher MCV than the values obtained by grazing camel. Hb, MCH and MCHC were not affected by management system.

Table (3) shows the effect of physiological status in erythrocytic indices. Significantly higher values of RBCs and PCV were registered by pregnant camels than non-pregnant ones while mean value MCV was increased in non-pregnant. Hb, MCH and MCHC were not vary with the physiological status.

There was an interaction between season and management system on PCV while there was interaction between season and physiological status on RBCs and PCV. There was an interaction between management system and physiological status with regard to the RBCs and PCV while there was no an interaction between season, management system and physiological status with regard to the erythrocytic indices.

4.3 The effect of the season, management system and physiological status on leukocytic profile

Table (4) shows the seasonal changes in leukocytic profile. TWBCs count, neutrophils, and lymphocytes varied significantly with the season while eosinophils, basophils and monocytes were not vary with the season. TWBCs count increased during autumn and lymphocytes increased during winter while both were decreased during summer. The highest value of neutrophils was obtained during summer, while the lowest value was obtained during winter.

Table (4) shows that the effect of management system on leukocytic indices. Penned camels registered significantly lower TWBCs count and lymphocytes and higher neutrophils, eosinophils and

monocytes than the values obtained by the grazing camel. Basophils did not vary between the two groups.

Table (4) shows the effect of the physiological status in leukocytic indices. TWBCs, eosinophils, basophils and monocytes were increased in pregnant camels than non-pregnant camels. Neutrophils

were decreased in pregnant camels than non-pregnant camels while lymphocytes did not vary.

There was an interaction between season and management type on neutrophils and lymphocytes while there was no an interaction between season and physiological status on leukocytic profile. There was an interaction between management system and physiological status with regard to the neutrophils, lymphocytes and eosinophils while there was no an interaction between season, management system and physiological status with regard to the erythrocytic indices.

4.4 The effect of the season, physiological status and management system on blood metabolites

Seasonal changes in the concentration of blood metabolites of camels are presented in Table (5). Significantly higher values of total protein, albumin, globulin and cholesterol were registered during autumn than those observed during summer and winter. Significantly lower value of triglycerides was observed during summer than that

observed during autumn and winter. Glucose concentration varied significantly with the season, the highest value was obtained during summer, while the lowest value was obtained during autumn.

The effect of management system on blood metabolites of camels is displayed in Table (5). Total protein and glucose registered by penned camels were significantly lower than those registered by grazing ones while cholesterol and globulin increased in penned camels and decreased in grazing ones. There was no effect due to the management on Albumin and Triglyceride.

The effect of the physiological status on blood metabolites of camels are shown in Table (5). Total protein and triglyceride were not affected by the physiological status. Non-pregnant camels registered significantly higher values for albumin, serum cholesterol and glucose while pregnant camels registered significantly higher values for globulin.

There was an interaction between season and management type on all the blood metabolites, while there was an interaction between season and physiological status on globulin, cholesterol and glucose. There was an interaction between management system and

physiological status with regard to the albumin, total protein, cholesterol and glucose, while there was an interaction between season, management system and physiological status with regard to the albumin, total protein, globulin, cholesterol and glucose.

4.5 The effect of the season, management system and physiological status on thyroid hormones

Table (6) shows the seasonal changes in thyroid hormones. Animals registered significantly lower values for T_3 and T_4 during summer while no variation was found between autumn and winter.

Table (6) shows the effect of management system on thyroid hormones. T_3 and T_4 values were higher in the grazing camels than that measured in the penned ones.

Table (6) shows the effect of the physiological status on thyroid hormones. T_3 was higher in the pregnant camels than that obtained in the non-pregnant ones. T_4 did not vary with the physiological status.

There was an interaction between season and management type on T_3 while there was an interaction between season and physiological status on T_3 and T_4. There was an interaction between management system and physiological status with regard to the T_4 while there was an

interaction of season, management system and physiological status with regard to the T_3.

4.6 The effect of the season, management system and physiological status on some serum minerals

Table (7) shows that there are seasonal changes in some serum minerals. Mean value of Mg and Na were not vary with the season. K^+ level was significantly higher during winter than those observed during summer and autumn. Mean value of Ca^{++} was varied with the season; the highest value of Ca^{++} was obtained during winter while the lowest value obtained during summer.

Table (7) shows that the effect of management system on serum minerals. Mg^+ did not vary with the management type. Na^+ and K^+ increased significantly in grazing camels compared with the penned Ones, while Ca^{++} decreased significantly in grazing camels compared with the penned ones.

Table (7) shows the effect of the physiological status on serum minerals. Mg^+, Na^+ and K^+ were not vary with the physiological status,

Ca^{++} was significantly increased in the non-pregnant camels.

There was an interaction between season and management type on Na^{+}, K^{+} and Ca^{++} while there was no an interaction between season and physiological status on these serum minerals. There was an interaction between management system and physiological status with regard to the Na^{+}, K^{+} and Ca^{++} while there was no an interaction between season, management system and physiological status on these serum minerals.

CHAPTER V
DISCUSSION

The mean value of rectal temperature (Tr) increased during summer while it decreased during winter. This comparable to the results of Al-Haidary (2006), Mohammed *et al*. (2007b), El-Harairy *et al*. (2010) and Abdoun *et al*. (2012) who concluded that the season had a significant effect on rectal temperature of camels being low in winter and high in summer. The increase in rectal temperature during the hot season is most probably minimizes temperature gradient between the body and the environment, thus resulting in a reduction of the body heat gain (Abdel-Samee and Marai, 1997). Reduction of the body heat gain will minimize the heat stress on the animals (El-Harairy, 2010).

The reduction on respiratory rate during winter conforms to the results of Mohammed *et al*. (2007b) and El-Harairy *et al.* (2010) who reported that respiratory rate increases during summer. Fluctuation on respiratory rate is the secondary mechanism for heat dissipation.

Respiratory rate increases very little with an increase in ambient temperature in camels unlike in other domestic animals that respond to hot condition by resorting to an increased respiratory rate and, in some cases, by panting (Kelly, 1974). However, the camels get back about 75% of respired water. The decrease on respiratory rate during cold season may be to conserve heat as a secondary mechanism.

The mean value of pulse rate increased during summer while it's decreased during winter. This result on line with the finding of Mohammed *et al*. (2007b) and El-Harairy *et al*. (2010) who reported that pulse rate was significantly, lower during winter than summer. The reduction on pulse rate during cold season may be to conserve heat as a secondary mechanism.

Grazing camels registered higher values for pulse rate compared with penned ones. This most probably due to stress caused the ongoing movement of the animals.

Rectal temperature and respiratory rate did not vary with the physiological status, while pulse rate was increased significantly in pregnant camels than that registered in non-pregnant ones. This result agrees with Sarwar *et al*. (1998) with regard to the rectal temperature and respiration rate, and disagrees with regard to the effect of pregnancy

on pulse rate. Pulse rate increase in pregnant camels due to pregnancy stress.

The results showed a reduction on RBCs during summer. Contradicting results were found among different researchers with regard to the effect of the season on RBCs. Al Sultan (2003), Ayoub *et al*. (2003) and Badaway *et al*. (2008) registered a significant reduction on RBCs count during summer conform to our result, while Amin *et al*.(2007), El-Harairy *et al*. (2010) and Babeker. *et al* (2013) reported significantly higher erythrocytes count during summer than the values of winter. Salman and Afzal (2004) reported that season did not influence the red blood cells count.

The reduction on RBCs during summer may be due to nutritional deprivation that occurs in the summer as a result of poor pasture. Al Sultan (2003), Ayoub *et al*. (2003) and Badaway *et al*. (2008) attributed such changes to the haemodilution phase resulting from increasing water intake during hot season, where a considerable part is retained particularly in the extracellular compartment. El-Harairy *et al*. (2010) found that the increases of blood hematological parameters during summer may be due to reduced oxygen intake was caused by increasing ambient temperature, thus reducing metabolic heat production. Amin *et*

al. (2007) attributed the rise on the erythrocytes count during dry season to dehydration increasing the half life of the RBCs.

The overall mean of RBCs count observed in this work is comparable to the value found by AL-Busadah (2007), Barakat *et al*. (2007) and Badaway *et al*. (2008), lower than that obtained by El-Harairy *et al*. (2010) and Faroog *et al*. (2011) and higher than that found by Amin *et al*. (2007).

PCV decreased during autumn compared to summer and winter. This result agrees with Salman and Afzal (2004), Al-Haidary (2006) and El-Harairy *et al*. (2010) who reported that PCV increases during summer and disagree with Badaway *et al*. (2008) who reported that PCV decreases during summer and increases during autumn and winter, and Amin *et al*. (2007) who reported that season had no significant effect on PCV. The reduction on PCV during autumn most probably is due to virtual decreases of PCV associated with the increase in extracellular fluids. Which occur by increasing the water content of the forages during autumn. Waleed, (1987) reported that PCV was influenced by haemdilution or haemconcentration. Badaway *et al*. (2008) attributed the relative reduction in PCV values during hot season

to the reduction in circulating erythrocyte and increased rate of destruction in red blood cells.

The overall mean of PCV is comparable to the results found by Al-Haidary (2006) and El-Harairy *et al*. (2010), lower than that reported by Faroog *et al*. (2011) and higher than that found by Amin *et al*. (2007) and Babeker *et al*. (2013).

The results showed that Haemoglobin concentration did not vary with the seasons. This agrees with the finding of Salman and Afzal (2004) and Amin *et al*. (2007) who reported that season did not affect the haemoglobin concentration, but disagree with the results found by Al-Haidary (2006) and El-Harairy *et al*. (2010) who reported that the Hb concentration decreases during winter season and Badaway *et al*. (2008) who found that Hb concentration decreases during summer season.

The overall mean of Hb in this study is comparable with that found by Amin *et al*. (2007), Barakat *et al*. (2007), El-Harairy *et al*. (2010) and Faroog *et al*. (2011), and higher than that obtained by Babeker *et al*. (2013).

MCV decreased during autumn compared to summer and winter. This reduction on MCV during autumn is on line with Badaway *et al*. (2008) who obtained a significant lower value of MCV during autumn compared to values obtained for winter and summer. Amin *et al*. (2007) and Babeker *et al*. (2013) reported that MCV increased during autumn compared with summer, while Salman and Afzal (2004) found that MCV was significantly higher in summer than winter.

Due to a positive relationship between MCV and PCV, the reduction of PCV during autumn led to a decrease on MCV during autumn. Amin *et al*. (2007) referred the increases of MCV during autumn to the negative correlation between the size and count of erythrocytes.

The overall mean of MCV obtained in this result is comparable with that reported by Amin *et al*. (2007) and Barakat *et al*. (2007), higher than that of AL-Busadah (2007), Badaway *et al*. (2008), and lower than that obtained by Faroog *et al*. (2011) and Babeker *et al*., 2013).

The result showed that MCH did not vary with the seasons. This agrees with Badaway *et al*. (2008) who reported that there was no significant seasonal variation in MCH, while it disagree with Al-

Haidary (2006) who obtained raised values during summer and Amin *et al*. (2007) and Babeker *et al*. (2013) who reported that the MCH increases during autumn.

The overall mean of MCH in this work is comparable with that calculated by Al-Haidary (2006), Amin *et al*. (2007), AL-Busadah (2007), Faroog *et al*. (2011), higher than that found by Badaway *et al*. (2008), and lower than that found by Babeker *et al*. (2013).

During autumn the animal registered higher MCHC value than that values obtained in summer and winter. This result on MCHC agrees with Badaway *et al*. (2008) who reported that MCHC increases during autumn and disagree with Amin *et al*. (2007) who did not found any seasonal variation on MCHC and Babeker *et al*. (2013) who found it was increase during summer.

Due to an inverse relationship between MCHC and PCV, the reduction of PCV during autumn leading to this increase on MCHC during autumn.

The overall mean of MCHC in this study on line with that reported by Badaway *et al*. (2008) Faroog *et al*., 2011) and Babeker *et*

al. (2013), lower than that found by Amin *et al*. (2007) and AL-Busadah (2007)

Grazing camels registered significantly higher RBCs values than the penned ones, Barakat *et al*. (2007) recorded that red blood cells count did not vary between grazing and penned camels.

The hyperthermia during movement under heat may induce a water loss caused by thermo regulation. This increase may be attributed to a splenic contraction rather than to dehydration (Carlson, 1990). Acute exposure to stressful stimulation is manifested by a significant activation of the sympathetic-adrenal medullary system, including increased synthesis, circulating levels and release of catecholamines into the circulation (McCarty *et al*., 1988), resulting in splenic contraction and the release of red blood cells into the circulation. This mechanism is induced by the action of catecholamines on α-adrenergic receptors which are located in the splenic capsule (Tauler *et al*., 2003).

Grazing camels registered significantly higher PCV than the penned ones. This result on PCV disagree with Barakat *et al*. (2007) who recorded that PCV in penned camels is higher than grazing ones. The increase in PCV on free grazing camels is attributed to an increase in RBCs.

The results showed that Hb did not vary during seasons. Barakat *et al*. (2007) obtained that penned camels registered high value compared with grazing ones.

MCV raised in penned camels compared with grazing ones. This result on MCV agrees with Barakat *et al*. (2007) who found that penned camels registered significantly higher value compared with grazing ones.

MCH and MCHC did not affect by management system. This agrees with Barakat *et al*. (2007) who found that MCHC registered by penned camels and grazing ones did not vary.

The results showed that RBCs increased on pregnant camels compared with non-pregnant ones. This disagrees with Ayoub *et al*. (2003) who reported that pregnancy did not influence RBCs. The slight increase on RBC obtained on pregnant camels compared with non-pregnant ones could be attributed to physiological status due to fetal development (Muhammad *et al*., 2011).

PCV increased on pregnant camels compared with non-pregnant ones. This result on PCV disagrees with Ayoub *et al*. (2003) and Muhammad *et al*. (2011) who reported that pregnancy did not influence

PCV. The increases on RBCs justified the higher PCV value on pregnant camels due to the positive relationship between RBCs and PCV.

The results showed that MCV decreased on pregnant camels compared with non-pregnant ones. This disagrees with Ayoub *et al*. (2003) and Muhammad *et al*. (2011) who reported that pregnancy did not influence MCV. The increases on RBCs caused a reduction in MCV on pregnant camels due to the inverse relationship between RBCs and MCV.

TWBCs were varied significantly during all the seasons, being higher during autumn lower during summer. Contradicting results were found among different researchers with regard to the effect of the season on total leukocyte count. Salman and Afzal (2004) did not find seasonal variation. Badaway *et al*. (2008) obtained increases during winter, El-Harairy *et al*. (2010) reported decreased during autumn, while Babeker *et al*. (2013) found that TWBCs was increased during summer. Decreases on TWBCs during summer compared with winter attributed to a reduction in corticosteroids secretion due to prolonged exposure to high environmental temperature during the summer (Badaway *et al*., 2008).

The overall mean of TWBCs is on line with that found by Badaway *et al*. (2008) and Faroog *et al*. (2011), lower than that reported by Sarwar *et al*. (1993) and AL-Busadah (2007), and higher than that found by El-Harairy *et al*. (2010) and Barakat *et al*. (2007).

The results showed that neutrophils increased during summer. This agrees with Badaway *et al*. (2008) and Babeker *et al*. (2013) who reported that neutrophils decrease during winter and increase during hot season, while its disagrees with Amin *et al*. (2007) who reported that the neutrophils increase during autumn compared with summer.

El-Banna *et al*. (1981) and Al-Arfaj *et al*. (1992) explained elevated level of neutrophils during summer in camels due to exposure to the dusty polluted warm environmental conditions.

The overall mean of neutrophils in this study comparable to that reported by Rezakhani *et al*. (1997) and Badaway *et al*. (2008), and higher than that found by Amin *et al*. (2007) and Babeker *et al*. (2013).

Lymphocytes increased during winter and decreased during summer. This result on lymphocytes agrees with Badaway *et al*. (2008) who found that lymphocytes increase during winter and disagrees with

Amin *et al*. (2007) who reported that the lymphocytes lower during autumn compared with summer.

Camels' erythrocytes do not synthesize heat shock protein (hsp73) after temperature elevation and camel's lymphocytes exhibited strong production of constitutively expressed heat shock protein (hsp73), providing thermotolerance to camel's blood cells, because lymphocytes have a higher resistance of general protein synthesis to elevated temperature (Guerriero and Raynes 1990 and Ulmasov *et al*., 1993).

The overall mean of Lymphocytes reported in this result is comparable to that obtained by Rezakhani *et al*. (1997), AL-Busadah (2007), Badaway *et al*. (2008), Faroog *et al*. (2011) and Babeker *et al*. (2013).

The results showed that eosinophils did not vary during seasons. This agrees with Amin *et al*. (2007) who did not find seasonal variation in eosinophils, while disagree with Badaway *et al*. (2008) who found that eosinophils increased during winter and decreased during summer.

The overall mean of eosinophils on line with that found by Sarwar *et al*. (1993) and Rezakhani *et al*. (1997), AL-Busadah (2007), lower than reported by Faroog *et al*. (2011) and Babeker *et al*. (2013).

Basophils did not vary during seasons. This result in basophils agrees with Badaway *et al*. (2008) who did not find seasonal variation in basophils, while disagree with Amin *et al*. (2007) who found that basophils increased during summer.

The overall mean of basophils reported in this study comparable to that found by Sarwar *et al*. (1993), Rezakhani *et al*. (1997), AL-Busadah (2007), Amin *et al*. (2007) and Faroog *et al*. (2011), and lower than reported by Babeker *et al*. (2013).

The results showed that monocytes did not vary during seasons. This agrees with Amin *et al*. (2007) and Badaway *et al*. (2008) who were not find seasonal variation in monocytes.

The overall mean of Monocytes is comparable to that reported by Rezakhani *et al*. (1997) and Faroog *et al*. (2011), and lower than that found by Amin *et al*. (2007) and Babeker *et al*. (2013).

Pregnant camels registered increases on TWBCs compared with non-pregnant ones. Muhammad *et al*. (2011) found slight increase in

TWBCs on pregnant compared to non-pregnant she-camels, while Ayoub *et al*. (2003) found slight decrease in pregnant ones. Sarwar et al. (1993) reported that TWBCs do not affect by physiological status. Muhammad *et al*. (2011) attributed that to physiological changes associated with fetal growth and development.

The results showed that neutrophils increased on non-pregnant camels, while eosinophils increased on pregnant ones. This result agrees with Ayoub *et al*. (2003) who found that eosinophils higher in pregnant camels compared with non-pregnant ones, and disagree with their result that neutrophils higher in pregnant camels compared with non-pregnant ones.

Total protein increased during autumn. These results on total protein concentration not on line to the controversial results were found by different researchers with regard to the effect of the season in camel plasma total protein concentration. Salman and Afzal (2004), El-Harairy *et al*. (2010) and Javad *et al*. (2013) were not report any significant changes in total proteins between the seasons. Al-Haidary (2006) and Abdoun *et al*. (2012) reported that total protein increases during summer compared with winter. Abokouider *et al*. (2001) and Amin *et al*. (2007) recorded that total protein increases during summer season.

Badawy *et al*. (2008) found that the total protein decreases during winter compared to summer and autumn.

Serum total protein increase during autumn was attributed to improve the quality and quantity of feed in this season. Lynch and Jackson (1983) reported that serum total protein level is usually considered as useful indices of the nutritional status of animals.

Amin *et al*. (2007) suggested that the increase in the concentration of serum total protein during the dry season could be attributed to the stresses to which the camels were subjected under dry condition.

The overall mean of total protein concentration comparable to that found by Badawy *et al*. (2008), AL-Shami (2009), El-Bahrawy and El Hassanein (2011) and Babeker *et al*., 2013), lower than reported by Osman and Al-Busadah (2003), and higher than Omidi *et al*. (2014).

The results showed that albumin varied during all the seasons. Autumn registered higher value, while summer registered lower one. Controversial results were found by different researchers with regard to the effect of the season in camel plasma albumin concentration. This result on serum albumin concentration comparable to that found by

Mohammed *et al*. (2007a) that is the albumin increases during autumn, and Salman and Afzal (2004) who reported that albumin level was lower in summer than winter, and Badawy *et al*. (2008) who found a decrease during winter compared with autumn. While it not on line with Al-Haidary (2006) and Abdoun *et al*. (2012) who reported that the albumin was increased in the summer compare to winter. Amin *et al*. (2007) and El-Harairy *et al*. (2010) were not finding a variation in albumin values with the season.

Salman and Afzal (2004) attribute lower albumin levels during summer to temperature stress. Heat stress during hot season induces reduction of plasma albumin concentration and this may be due to the incapability of protein synthesis to counteract the protein catabolism which leads to a negative nitrogen balance under such conditions (Marai and Habeeb, 2010).

The overall mean of albumin concentration is on line with that found by Amin *et al*., 2007 Babeker *et al*., 2013 and Omidi *et al*. (2014) lower than Osman and Al-Busadah (2003), AL-Shami (2009), and Dierenfeld *et al*. (2014).

Cholesterol increased during autumn. This result in serum cholesterol concentration comparable with that result obtained by

Badawy *et al*. (2008) who found that serum cholesterol increases significantly during autumn, not comparable to El-Harairy *et al*. (2010) who obtained that the concentration of cholesterol increases during winter season compared to summer and autumn, and Javad *et al*. (2013) who reported that there was no significant difference on cholesterol and Ahmed *et al*. (2013b) who recorded that the cholesterol concentration determined during summer increased significantly compared with winter.

Serum cholesterol increasing during autumn can be attributed to the improved quality and quantity of feed in this season, Nazify *et al*. (1999) reported that cholesterol concentration was higher during winter than summer in dromedary camels, and they suggested that the seasonal changes in blood lipids and proteins might result from changes in the nutritional and energy balances or changes in environmental temperature, humidity and day length.

Ahmed *et al*. (2013b) attributed the increase in cholesterol of serum during the dry season to low dietary requirements. El-Masry *et al*. (1989) reported that the increases in cholesterol under hot months might be attributed to the increased non-esterified fatty acids and fat catabolism occurring in heat-stressed goats.

The overall mean of cholesterol is comparable to that found by Omidi *et al*. (2014), lower than the finding of Al-Sultan (2003), Badaway *et al*., 2008, and higher than that reported by El-Bahrawy and El Hassanein (2011).

The results showed that triglycerides decreased during summer. Javad *et al*. (2013) reported that triglycerides increased during summer season. Ahmed *et al*. (2013b) found that the triglyceride increased significantly during summer compared with winter. The reduction of triglycerides during summer may be attributed to the load of ambient temperature caused a decreases in basal metabolism. The decrease in basal metabolism inhibits lipolysis in the animal body (Yagil, 1985). In camels, serum triglycerides level has been reported to be affected by the diet (Wasfi *et al*., 1987).

The overall mean of triglycerides on line with that found by Al-Sultan (2003), Osman and Al-Busadah (2003), Amin *et al*. (2007) and Omidi *et al*. (2014), and lower than AL-Shami (2009).

Glucose increased during summer compared to autumn and winter, and increased during winter compared with autumn. The increases on plasma glucose concentration during summer comparable with Nazifi *et al*. (1999) who found that the concentration of serum

glucose significantly higher in summer compared with winter. The increases on glucose during winter comparable with Badawy *et al*. (2008) who found it was increased during winter compare to autumn, This result not on line with (Al-Haidary, 2006; Abdoun *et al*., 2012 and Ahmed *et al*., 2013b) who obtained that glucose concentration was increased during winter compared to summer and Amin *et al*. (2007) and Mohammed *et al*. (2007a) who reported that the glucose concentration increased significantly during autumn compared with summer. The increased blood glucose level during summer may be due to a decreased basal metabolic rate reducing the use of glucose for energy production under hot climatic conditions. Badawy *et al*. (2008) attributed this discrepancy in effect of the season on blood glucose in camels to breed differences and to the environmental conditions particularly feeding and watering systems.

From another point of view, the increases on plasma glucose concentration during summer may be due to lack of available water for the animals that occur in summer. Charnot, (1967) reported that the Islet camels have more cells secreting glucagon than insulin secreting cells. The proportion of these cells decreased in the dehydrated camel as in diabetes. However, after water deprivation for 10 days, blood glucose

increased from 20 to 80% according to Banerjee and Bhattacharjee (1963) Macfarlane *et al*. (1968), whereas glucosuria is zero. This hyperglycemia is due to the absence of renal excretion of glucose and a decrease in its use. During dehydration, insulin decreased more than 30%. The dehydrated dromedary reduces water loss by maintaining its high glucose and glucosuria practically zero. The hypo-insulinemia would maintain a low basal metabolism by decreasing glucose utilization (Bengoumi, 1992).

Amin *et al*. (2007) and Ahmed *et al*. (2013b) suggested that the decrease in plasma glucose concentration during the dry season can be attributed to the decrease in available forage.

The overall mean of glucose concentration is comparable to that found by Badawy *et al*. (2008), AL-Shami (2009), El-Bahrawy and El Hassanein (2011) and Omidi *et al*. (2014), lower than that reported by Osman and Al-Busadah (2003), and higher than that found by Al-Sultan (2003) and Babeker *et al*. (2013).

Total protein registered by penned camels significantly lower than the value registered by grazing ones. The findings of the current study about total protein concentration in camels do not support AL-

Shami (2009) who found that serum total protein concentration did not vary with the management system.

The results showed that management system did not influence albumin. This result about albumin agrees with AL-Shami (2009) who found that serum albumin concentration did not vary with management system.

Penned camels registered higher cholesterol than grazing ones. This increase on cholesterol in penned camels agrees with AL-Shami (2009) who found that cholesterol was significantly higher in indoor camels compared to free grazing ones. Higher level of cholesterol in indoor over that of grazing camels indicate that nutritional factor can influence normal values of blood metabolites (Mokhtar and El-Hisanonein, 1998). As a result of greater amount of concentration diet supplementation in indoor camel's cholesterol concentration was expected to increase (Sako *et al*., 2007).

Triglyceride did not vary with the management system. This disagrees with AL-Shami (2009) who obtained that triglyceride level was significantly higher in indoor camels compared to free grazing camels.

Grazing camels registered higher glucose than penned ones. This result on plasma glucose concentration disagrees with AL-Shami (2009) who reported increases in indoor camels compared with grazing one. The increases of plasma glucose in free grazing camels attribute to permanent transportation in the pastures. El Khasmi *et al*. (2013) reported that transportation increase plasma glucose levels in camels. This hyperglycaemia may be primarily might be due to an activation of the sympathetic nervous system, catecholamines secretion (Sanders and Straub, 2002) which is able to decrease the glycogen reserves by stimulating glycogenolysis in rat (Dronjak *et al*., 2004).

Total protein and triglyceride were not affected by the physiological status. These results were agreement with the findings of Muhammad *et al*. (2011) and Omidi *et al*. (2014) who did not find significant variation between pregnant camels and non-pregnant ones and disagree with AL-Zamely (2011) who reported an increase of total protein in non-pregnant camels.

Non-pregnant camels registered higher value of albumin compared with pregnant ones. The findings of the current study about albumin is in agreement with the findings of Saeed *et al*. (2009) AL-Zamely (2011) who found that albumin concentration increased in non-

pregnant camels compared to pregnant ones, while it does not support Muhammad *et al*. (2011) and Omidi *et al*. (2014) who were not find significant variation between non-pregnant camels and pregnant ones with regard to albumin.

AL-Zamely (2011) attributed this decrease in albumin of pregnant camels to a reduction of albumin biosynthesis due to increase pregnancy hormones especially progesterone which rises in pregnant camels, this increased may have effect in the liver and caused a decrease of albumin production (Pineda and Doole, 2003). Also there is an increase of albumin elimination by the kidneys during pregnancy which may play a role in the reduction of albumin level (Halliwell, 1988).

The results showed that non-pregnant camels registered higher cholesterol compared with pregnant ones. The higher cholesterol in non-pregnant camels agrees with Omidi *et al*. (2014) who obtained that cholesterol higher in non-pregnant camels compared with pregnant ones. During pregnancy, the synthesis of cholesterol fell markedly in rat (Leoni, 1984).

Non-pregnant camels registered higher glucose compared with pregnant ones. The findings of the current study about plasma glucose

concentration support Omidi *et al*. (2014) who found its higher in non-pregnant camels. Omidi *et al*. (2014) attribute the low level of glucose in pregnant camels due to developing fetus and mobilization of glucose from mother for providing the adequate energy of the fetus.

Animals registered significantly lower values for T_3 and T_4 during summer. The findings of the current study about T_3 and T_4 level were comparable to Nazifi *et al*. (1999) and Javad *et al*. (2013) who reported that T_3 and T_4 increased during winter compared to summer. Cold environment increases the secretion of thyrotrophic hormone, which results in a higher serum concentration of these hormones (Prakash and Rathore, 1991). Yagil and Gannani (1978) reported that camel thyroid was inhibited in hot season due to dehydration; this inhibition assists in the preservation of body water by decreasing pulmonary water loss and reducing the basal metabolism. Similarly, Khanna *et al*. (1996) reported that during summer, T_4 levels fell gradually in dehydrated dromedary camels and increased after rehydration, whereas in winter, T_4 levels increased in dehydrated camels.

T_3 and T_4 increased in grazing camels than that measured in Penned camels. This may be attributed to movement stress caused

more stimulation to thyroid gland for release these hormone and increases basal metabolism.

T_4 did not vary between non-pregnant camels and pregnant ones. This similar to the finding of Rahman *et al*. (2007) and Omidi *et al*. (2014) who found that T_4, did not change between pregnant and non pregnant she camels.

Mg^+ did not vary with the seasons. This result on Mg^+ agrees to Ahmed *et al*. (2013a) who found that there was no effect of season on Mg^+ level.

The overall mean of Mg^+ is on line with that found by Osman and Al-Busadah (2003), Al-Sultan (2003), Barakat *et al*. (2007), AL-Shami (2009) and Ahmed *et al*. (2013a).

The results showed that Na^+ did not vary with the seasons. The result of Na^+ was comparable with Mohammed *et al*. (2007a) who reported that Na^+ did not vary with seasons but not on line with (Ahmed *et al*., 2013a) and El-Harairy *et al*. (2010)who reported that Na^+ level increased during summer. El-Harairy *et al*. (2010) attributed their result to the combined effect of both absorption and reabsorption of sodium and chloride from the alimentary tract and kidney, under the effect of

aldosterone which show high level in summer and this was accompanied by an increase of plasma sodium level.

The overall mean of Na^+ is comparable to that found by Osman and Al-Busadah (2003), Al-Sagair *et al*. (2005), Barakat *et al*. (2007), Mohammed *et al*. (2007a), AL-Shami (2009) and Ahmed *et al*. (2013a).

K^+ level increased during winter than those observed during summer and autumn. The finding of K^+ in this results comparable with that fund by Babeker *et al*. (2013) who found marked increases of K^+ during winter, not on line with Ahmed *et al*. (2013a) who found K^+ level was increased during summer compared to winter and El-Harairy *et al*. (2010) who found K^+ level was increased during summer and spring. The decrease of potassium concentration during summer may be attributed to an increase of aldosterone secretion in hot and dry climate which was enhanced by renin-angiotensin system in response to changes in effective circulating fluid volume where aldosterone balance largely plasma potassium, through its effect on renal reabsorption of sodium in exchange for potassium and hydrogen ion (Kaneko,1980).

The overall mean of K^+ is comparable to that obtained by Osman and Al-Busadah (2003) Al-Sagair *et al*. (2005), Barakat *et al*. (2007), Mohammed *et al*. (2007a) AL-Shami (2009), and Ahmed *et al*. (2013a).

Mean value of Ca^{++} varied significantly with season; the highest value of Ca^{++} obtained during winter while the lowest value obtained during summer. This result in Ca^{++} agrees to Ahmed *et al*. (2013a) who reported that Ca^{++} level was increased during winter compared to summer, and Amin *et al*. (2007) who observed marked increase in the concentration of serum Ca^{++} during autumn compared to summer, and not on line with El-Harairy *et al*. (2010) who found that the highest value of calcium concentration of the dromedary she camels during summer. The rise in serum concentrations of calcium during the wet season can be attributed to the availability of plants rich in minerals during the rainy season (Amin *et al*. (2007 and Ahmed *et al*. 2013a). Rainfall can affect the mineral composition of pasture herbage (McDonald *et al*., 1995).

The overall mean of Ca^{++} is on line with that found by Osman and Al-Busadah (2003), Barakat *et al*. (2007), AL-Shami (2009) and Babeker *et al*. (2013), and higher than that reported by Mohammed *et al*. (2007a) and Ahmed *et al*. (2013a).

Na^{+} and K^{+} significantly higher in grazing camels compared with the penned camels while Ca^{+} significantly lower in grazing camels compared with the penned ones. This result on Na^{+} and K^{+} agrees

with Barakat *et al*. (2007) and AL-Shami (2009) who found that K^+ in grazing camels was higher than that found in penned camels and disagrees with their result that Na^+ level was not different between grazing and penned camels.

The higher values for serum Na^+ and K^+ in free grazing camels compared with penned ones could be due to the free grazing camels graze on plants rich in this mineral (Barakat *et al*., 2007 and AL-Shami, 2009) or/ and may be contaminated with the soil (Barakat *et al*., 2007).

The results showed that Mg^+, Na^+ and K^+ did not vary with the physiological status, while Ca^{++} significantly higher in non-pregnant camels compared with pregnant ones. This result on Ca^{++} agrees with that found by Saeed *et al*. (2009) and Muhammad *et al*. (2011) and disagrees with Sarwar *et al*. (2004) who found there was no significant difference in Ca^{++} level due to pregnancy. The reduction of Ca^{++} in pregnant camels is attributing to the formation of the fetus bones.

The lack of published haematological and biochemical reference values for camel in Sudan makes it inevitable for both the researchers to establish their local reference values. At present, most of the comparisons are being made either with the that values obtained in other countries of the world which are internationally famous for having

camel as a major part of their livestock; or with values given in certain text books (Higgins and Cock, 1986 and Jain, 1998) which provide a ready reference. However the observed values obtained in this study were within the normal values range reported previously by other researchers and compiled by (Higgins and Cock, 1986 and Jain, 1998).

The slight variation observed between the present study and earlier researchers may be attributed to many factors such as interlabrotory variation, size of samples, geographical location, quality and quantity of pasture and availability of water. Some of the differences can be explained by seasonal, nutritional and managemental factors and by the effects of age, sex, rut and stage of pregnancy.

CONCLUSIONS

1- The season and management system have a significant effect on the clinical parameters; rectal temperature, respiratory rate and pulse rate. The physiological status had a significant effect on pulse rate**.**

2- The seasonality had a significant difference on RBCs count, PCV, MCV and MCHC. The management system and physiological status had no effect on Hb, MCH or MCHC. While penned camels and non-pregnant ones registered the lowest RBCs count and PCV and the highest MCV.

3- TWBCs count, neutrophils, and lymphocytes varied among the season. Penned camels registered significantly lower TWBCs count and lymphocytes and higher neutrophils, eosinophils and monocytes compared with grazing ones. TWBCs, eosinophils, basophils and monocytes were increased in pregnant camels than non-pregnant ones.

4- The season had a significant difference on blood metabolites. During autumn, animals registered significantly higher total protein, albumin, globulin, cholesterol and triglycerides. Glucose varied among the season. The management system had no effect on albumin or triglyceride. Total protein and

glucose values registered by penned camels were lower than those registered by the grazing ones, while cholesterol and globulin were higher in penned camels than in the grazing ones. The physiological status had no effect on total protein or triglyceride. Non-pregnant camels registered higher values for albumin, cholesterol and glucose while pregnant camels registered higher values for globulin.

5- Animals registered significantly lower values for T_3 and T_4 during summer. T_3 and T_4 values obtained by the grazing camels were higher than those obtained by the penned ones. The pregnancy increased level T_3 and did not affect T_4.

6- The season had no effect on Mg^+ or Na. During winter, there were high levels of K^+ and Ca^{++}. The macro mineral (Na^+, K^+, Ca^{++}) in camel serum varied significantly with the management system. Grazing camels registered higher values for Na^+ and K^+, while penned one registered higher values for Ca^{++}. Pregnant animals registered significantly lower Ca^{++} concentration.

7- All the obtained values in this study were within the normal values range.

RECOMMENDATION

1- Animal owners should be aware, through extension, to the importance of minerals for the herd health, production and reproduction.

2- Soil and plant of the grazing area should by analyzed for minerals

3- Genetic mapping of the Sudanese camels should be done.

4- These findings and previous data could be used as a database for Sudanese camels' improvement.

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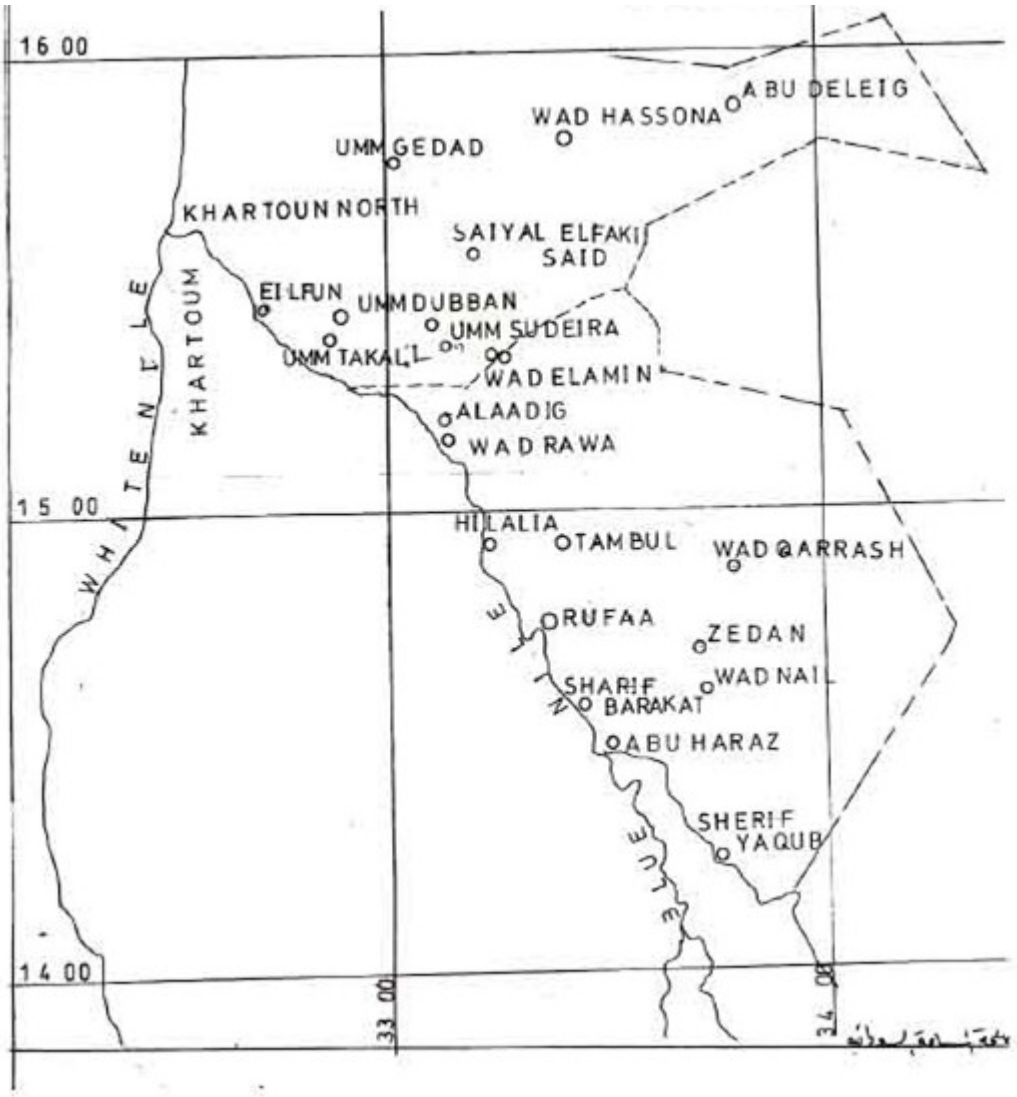
APPENDIX



Appendix (1) Location map of Butana area.

Source: Sudan National Survey Authority

Appendix (2) Tambol Camel Research Centre

Appendix (3) Open shaded yard in Tambol Camel Research Centre

Appendix (4) Non-pregnant penned camel

Appendix (5) Pregnant penned camel

Appendix (6) Butan pasture

Appendix (7) Water source in Butan pasture

Appendix (8) Non-pregnant grazing camel

Appendix (9) Pregnant grazing camel