CHAPTER ONE

INTRODUCTION

1.1 Introduction:

Camels are considered to be a good source of milk and meat and are used for other purposes such as transportation and sport racing (Salih and Hamid, 2012). Camels were first domesticated come 3,000 years ago their milk and for use as pack animals (Yagil *et al*., 1994).

Sudan is one of the largest camel populated countries in the world. Its population is about 3.2millions (Tigani *et al*., 2007).Sudan and Somalia have 70% of the total African camels and 55% of that of the world camel's population. The camels were, and still are, valued as riding, baggage, draught animals, hair hides and as well as the best food providers in the arid areas (Tigani *et al*., 2007).

The camel had been one of the most neglected species of the domestic animals, although the camel has ability to produce more milk for a longer period of time in arid zones and dry lands (an environment of extreme temperature, drought, and lack of pasture) than other domestic livestock species(Suliman, 2012).The majority of this number is kept by migratory pastoralists "*Abbala*" in arid and semi arid zones of Sudan, where camel pastoralists prevail with limited resources in subsistence production systems. The mobility is the primary means by which *Abbala* compensate for the spare resource (El Zubeir *et al*. 2008).

In the world the total camel population estimated as 20millions.In sudan camels are classified into pack and riding. They are concentrated in Butana region of North_ eastern Sudan,in Kordofan and Darfur states(in the Northern dry lands of Sudan).Camels are raised for a variety of purposes including riding, racing, ploughing, packing and loading of goods. Camel meat and milk are important staples and essential components pastoralists' life, (Turki *et al*., 2007).

Camel's milk constitutes are an important part of the diet in pastoral societies in arid and semiarid regions in western Sudan. It is of vital importance in drought areas. It's reported that camel milk contained fairly high vitamin C content. This is important as there are few alternative source of this vitamin in the diet of transhumant camel herders (Bakheit *et al*., 2008). Several studies have shown that camels are a good source of milk and they constitute the most important source of meat in arid areas. (Barakat *et al*., 2007).

The most densely populated areas are Kordofan, Eastern and Northern Darfur states, followed by other regions in the central and Northern provinces (Majid and Bakheit, 2007). However, limited information is available on camel milk composition under pastoral systems in Darfur region, Sudan. Camel milk needs to be further investigated in Western Sudan especially Middle Dar Fur state. There are only a few or scanty references on camel milk composition, or fatty acids profile.

1.2Aims of the study:

The main objective of this study was to determine the chemical composition and fatty acids profile of camel milk obtained from four different locations in Middle Darfur state, Sudan.

CHAPTER TWO

LETERTURE REVIEW

2-1Milk

Milk is the most important product obtained from camel milk being a complete food, helps to provide a nutritious and balanced diet to nomadic desert people under harsh conditions. The composition of milk varies widely and contains 2.9- 5.5% fat, 2.5-4.5% protein, 2.9-5.8% lactose, 0.35- 0.95% minerals and 8.9-14.3% solids-not-fat. It also contains the essential vitamins, which include vitamin A, vitamin D, vitamin B1, B2 and B12 and vitamin C. The content of vitamin C is of specific interest as its levels are three times that of cow milk and one-and-a-half that of human milk. The vitamin C content varies between 5.7 and 9.8 mg percent (Khan *et al*., 2004).

Farah, (1993) reported that camel's milk is generally opaque white. It has a sweet and sharp taste, but sometimes it can be salty. The taste generally depends on the type of fodder and availability of drinking water. The pH of camel's milk ranges from 6.2 to 6.5 and the density from 1.026 to 1.035. Both density and pH are lower than those of cow's milk. Compared to cow's milk, camel's milk sours very slowly and can be kept longer without refrigeration.

2.2 Camel milk production

Farah *et al*. (1989) mentioned camels *(Camelus dromedarius) are* Important as daily animals in certain regions of the world. Most of the camel milk is drunk fresh or when it has just turned sour. Camel milk has an important role in human nutrition in the hot regions and arid countries (Salih and Hamid, 2012). Camel milk is one of the most valuable food resources for pastoral people in arid and semiarid areas. In the last years milk consumption among urban population has been increased (Abd-Alall *et al*., 2012). The camel is of significant socio-economic importance in many arid and semi-arid parts of the world and its milk constitutes an important component of human diets in these regions. These areas and conditions make it difficult to estimate camel milk production, other major factors including breeds, stage of lactation, feeding and management conditions play important role in the inconsistency of data. However, the current un official data about the camel milk production are scare and are based on observations of particular research stations and rarely based on pastoral areas (FAO, 2003). Camels milk production in the world is reported to be about 5.3 million tones are consumed by humans, whereas, the remaining amount is fed to calves (FAO, 2008). Farah (1993) mentioned that it is difficult to estimate the daily milk yield of a camel under pastoralist conditions owing to the inconsistency of milking frequency. Milk yield also varies with species, breed, and stage of lactation; feeding and management conditions. The length of lactation can vary from 9 to18 months. This depends mainly on the husbandry practices, which are largely determined by the need for milk, more being required in the dry months than in the wet months when other sources of food are available. Estimates of milk yields from various countries are given in Table 1. The data are highly speculative and should be considered as guidelines for milk yields under pastoral conditions. It must also be noted that throughout lactation calves are still suckling and therefore the actual volumes of milk secreted are higher than the figures presented in the table 1.

Table 1: Milk yields of camels reported from various sources:

Country	Average daily yield in kg	Lactation length in months	Calculated yield in kg per 365 days
Algeria	4	9-16	1460
Ethiopia	5	12-18	1825
India	6.8	18	2482
Kenya	4.5	11-16	1643
Pakistan	8	16-18	2920
Somalia	5	9-18	1825

Source: Farah, (1993)

Seasonal variation effect on milk production in different species in tropical and sub tropical zones are recognized. Concerning camels, large seasonal variations in total solids and fat were reported from Jordon with maxima in mid-winter and minima in August (ElZubeir *el al*., 2008).

2.3 Camel milk properties:

Suliman (2012) mentioned that the camel milk is a complex mixture of fat, protein, lactose, minerals and vitamins. The average density of camel milk is 1.029. The pH of fresh camel milk ranges from 6.5 to 6.7. The pH of camel milk is similar to that of sheep milk. However, variations in time, pH and acidity for the same source of milk could be due to differences in hygiene of the actual milking and the total microbial count of the milk. The camel milk contains a greater content of antimicrobial components such as lysozyme, lactoferrin and immunoglobulin's than do bovine or buffalo milk.

2.4 Milk composition:

The general composition of camel milk varies in various part of the world with range of 3.07-5.50% fat, 3.5-4.5% protein, 0.7-0.95% ash and 3.4-5.6 % lactose, 12.1-15% total solid (Salih and Hamid, 2012). El Zubeir *el al*., (2008) found that the general composition of camel milk varies in various parts of the world with a range of 3.5 to 4.5% protein, 3.4 to 5.6% lactose, 3.07 to 4.5% fat, 0.7 to 0.95% ash and 12.1 to 15% total solids, These wide variations in the constituents of milk were attributed to some factors such as age, number of calving, management, stage of lactation, the sampling technique used and feed quality.

Mal and Pathak, (2010) mentioned that the percent value of moisture, total solids, fat, SNF, protein, casein, ash, acidity and pH ranged from 88.55-90.15, 9.85-11.45, 2.60-3.20, 7.25-8.25, 3.73-3.89, 2.90-3.02, 0.82-0.85, 0.12-0.14 and 6.36-6.58 respectively. Moisture and protein have been found to be higher in camel milk compared to cow milk. Comparative low percentages of total solids and fat in camel milk have definite positive benefits of drinking camel milk over cow milk. Post partum changes in gross chemical composition of camel milk showed an increase in fat from 0.10 to 3.78 while protein decreased from 17.62 to 2.66 percent after 27 days of parturition.

In Sudan Bakheit (2008) demonstrated that the chemical composition of camel milk under traditional system comprises 3.41% protein, 3.36% fat, 3.60% lactose, .081% ash, 89.26% moisture, 10.90 total solids. In late phase of lactation the ash, fat and total solids were significantly higher than in the early phase of lactation. The fat is present in fixed amount in milk and its percentage changes according to the water content. Hence a fall in water content will increase the fat percentage while an increase in water will decrease it. In the desert high water content with low fat percentage is a definite advantage. The higher ash contents during late lactation suggest that camel milk can provide a satisfactory level of minerals (Mal and Pathak, 2010). Konuspayeva *et al*. (2009). Concluded that camel milk is an important source of proteins for the people living in the arid lands of the world.

Variation in camel milk composition was also observed for camels from the same species (dromedary). Further, seasonal variations were found to play a role in camel milk composition even for camels from the same species and regions (Bakheit *et al*., 2008). An inverse relationship was found between total solids in camel milk and water intake by camel; found that all components except lactose reached their maximum in mid-winter and decrease to the lowest in the summer. For example, total solids were 13.9% in December and January and 10.2% in August which can be related to the availability of drinking water. Moreover, the fat content of camel milk decreases from 4.3 to 1.1% due to the increase in water content of milk produced by thirsty camels. The changes in camel milk composition could be due to several factors including analytical measurement procedures, camel diet, climate, water availability, livestock management and other factors (Suliman, 2012).

The composition of camel's milk quoted from various sources and the corresponding values from other animal species are presented in Table 2.There are greater variations in constituents of camel's milk than in cow's milk. Camels are known to produce diluted milk in hot weather when water is scarce. The main difference between cow's and camel's milk lies in the different physicochemical characteristics of the individual components protein, lipids, ash, etc (Farah, 1993). Evidences in ruminants has demonstrated that milk composition is strongly influenced by feeding conditions and it is suggested that when animals are breeding in environments quite different from that considered natural for them, a difference in milk composition may be found. Moreover, if camel had been kept under better management conditions milk production would be better (ElZubeir *el al*., 2008).

2.4.1 Water content:

The most important component in camel milk is the water content. The water content of camel milk fluctuates from 84 to 90 percent. The water content of camel milk is affected by amount of drinking water. Water content of fodder would also affect water content of milk. The increasing in water content could be attributed to the decrease in total solids produced by the thirsty camels (Suliman, 2012).

El Zubeir, (2008) showed that the most important factor in camel milk for people living in dry zone its water content declared that young camel and human livings in dry areas are in need of fluids to maintain homeostasis and thermoregulation.

2.4.2 Milk proteins:

Proteins represent one of the greatest contributions of milk to human nutrition (Farah, 1993). Total protein content of camel milk ranges from 2.15 to 4.90%. Camel breeds and seasonal conditions were found, in particular, to play a role in camel milk protein content. The main components of protein are casein and whey proteins were found to be similar for camel milk of the same breed. Protein content was also reported to vary according to season for the same breed and was found to be lowest (2.48%) in summer and highest (2.9%) in winter (Elobied *et al*. 2014). Mohamedy (2010) mentioned that the Milk protein content of camel milk ranges from 2 to 5.5 percent. The total protein in camel milk is similar to that of cow milk. Milk proteins perform a variety of functions in living organisms ranging from providing structure to reproduction. The main components of milk proteins are casein and whey. Casein is found in no products other than milk. Casein is precipitated when milk sours or when acid or rennin added. In cheese-making, most of the casein is recovered with the milk fat. In camel's milk, the value of casein is the lower limit of casein content of cow's milk and varies between72% and 76% of total protein.

Casein is present in milk in the form of finely divided particles similar to clay in muddy water. The particles contain, beside the protein, considerable amounts of calcium phosphate. The most observed particles in cow's milk casein have a diameter from 40 to 160 nanometer (1 nanometer = 10-7cm). In camel's milk, casein particles range in diameter from 20 to more than 300 nanometer (Farah, 1993). The casein content of dromedary and Bactrian camel milk as 2.7 and 0.89 percent respectively and that of albumin as 3.8 and 0.97 percent respectively. Milk from dehydrated camel has a severely decreased protein percentage; this demonstrates the direct effect of drinking water on the composition of milk. It must be stressed that protein content of the feed will also directly affect that of milk (Mohamedy, 2010).

The whey protein content in camel's milk varies between 22% and 28% of total protein, which is slightly more than in cow's milk. Camel milk contains more proteins and whey protein than cow milk (Salih and Hamid, 2012).

2.4.3 Milk fat:

Camel milk fat consists of up to 98% of lipids in the form of triglycerides. Lipids serve as an energy source, act as a solvent for fat-soluble vitamins and supply essential fatty acids. The triglycerides contain a variety of fatty acids and are accompanied by small amounts of di- and mono-acylglycerols, cholesterol, free fatty acids and phospholipids. The fat content of camel milk varies between 1.7 and 4.2% (Haasmann, 1998). Elobied *et al*. (2014) mentioned that fat content of camel milk is between 1.2 and 6.4 %. Compared with bovine milk, camel milk fat contains smaller amounts of short chain fatty acids and a lower content of carotene. This lower carotene content could explain the whiter colour of camel milk fat.

Milk fat serves nutritionally as an energy source, acts as a solvent for the fat soluble vitamins and supplies essential fatty acids. About 99% of milk fat is a mixture of fatty acids (triglycerides) of varying chain length from 4 to 20 carbon atoms (Farah, 1993).The camel milk fat is also different from that of other animals. When left standing, fat is distributed as small globules throughout the milk. The ratio of fat to total solids averages 31.6 percent; this is much lower than that of the buffalo, which is 40.9 percent (Mohamedy, 2010). Farah (1993) mentioned the bulk of the fat in milk exists in the form of small spherical globules of varying sizes. The surface of these fat globules is coated with a thin layer known as a fat globule membrane, which acts as an emulsifying agent for the fat suspended in milk. The membrane protects the fat and prevents the globules coalescing into butter grains and can be broken by mechanical action. The fat content of camel’s milk varies between 2.9% and 5.4% and the average size of the fat globules is about the same as cow’s milk fat globules.

According to present knowledge, the main differences between the fat in cow’s milk and camel's milk are as follows:

1. Natural creaming of camel’s milk differs markedly from that of cow’s milk. on standing, camel’s milk creams less rapidly and completely than cow’s milk and no skimmable cream can be obtained even after standing for several days.
2. Compared to cow’s milk fat, camel’s milk fat contains less short-chain fatty acids.

Long chain unsaturated fatty acids occur to about the same extents in both.

3. Butter can be obtained from camel's milk only at high churning temperature of 20°C to 25°C. These values are considerably higher than that of cow's milk, which normally vary between 8°C and 12°C.

4. The mean melting point of camel's butter is around 41.5°C and is on average 8°C higher than that of corresponding values in cow's milk butter (Farah, 1993).

The variation in the fat content is associated with the type of breed, stage of lactation and feeding condition as described by Webb *et.al*. (1980).

2.4.4 Lactose:

Lactose is the major carbohydrate fraction in milk and is a source of energy for the young calf. It is made up of two sugars, glucose and galactose, which are fermented to lactic acid when milk goes sour. The lactose content in camel's milk ranges from 4.8% to 5.8% and is slightly higher than the lactose in cow's milk. It seems that the lactose content in camel's milk is relatively constant throughout lactation (Farah, 1993).

The lactose content of camel milk varies from 2.40 to 5.80%. The wide variation of lactose content could be due to the type of plants eaten in the deserts. Camels usually prefer halophytic plants such as a triplex, Salosa and Acacia to meet their physiological requirements of salts (Elobied *et al*. 2014).

2.4.5Mineral salts and vitamins:

Farah (1993) reported that milk mineral salts are mainly chlorides, phosphates and citrates of sodium, calcium and magnesium. Although salts comprise less than 1% of the milk, they influence its rates of coagulation and other functional properties. The mineral content of camel's milk expressed in ash ranges from 0.6% to 0.8%. There is still little information about the mineral content of camel's milk. Data available however, indicate that camel's milk is rich in chloride and phosphorous, and low in calcium. Camel's milk contains less vitamin A, B1, B2, E, folic acid and pantothenic acid than cow's milk while the content of vitaminB6 and B12 is about the same level. However, various studies suggested the variation of minerals in camel milk is linked with genetic and environmental effects (Sawaya *et.al*., 1984).

Mal and Pathak, (2010) mentioned that the levels of vitamin A, E and B1 were reported to be low in camel milk compared to the cow milk. These workers reported vitamin A, E and B1 as 20.1±10.0 μg%, 32.7±12.8 μg% and 19.6±6.4 mg% in camel milk and 60.9±25.6 μg%, 171.0±114.4 μg% and 34.7±8.1 mg% in cow milk. Cow milk contains 99.6±62.0 μg% β-carotene and it is not detected in camel milk. The concentration of vitamin C in camel milk in early and late lactation has been reported 5.26±0.47 and 4.84±0.20 mg%. The levels of vitamin A, E and B1 were higher in camel colostrums than mature camel milk. Camel milk was reported to contain various vitamins, such as vitamin C, A, E, D and B group, camel milk is known to be a rich source of vitamin C; the vitamin content was reported to be three times to five times higher than that in bovine milk(Salih and Hamid, 2012).

However, the vitamin C content remains higher in mature camel milk. The higher vitamin C content may be attributed to the more synthetic activity in the mammary tissues during early phase of lactation that declined as lactation advanced. The low pH due to the vitamin C content stabilizes the milk and can be kept for relatively longer periods.

The availability of a relatively higher amount of vitamin C in raw camel milk is of significant relevance from the nutritional point as vitamin C has a powerful anti-oxidant action. Camel milk can be an alternative source of vitamin C under harsh environmental conditions in the arid and semi-arid areas (Mal and Pathak, 2010).

Table 2: Gross composition of milk from various animal species:

Species	Percentage composition				
	Moisture	Fat	Lactose	Protein	Ash
Camel	86–88	2.9–5.4	3.3–5.8	3.0–3.9	0.6–1.0
Cow	86–88	3.7–4.4	4.8–4.9	3.0–3.9	0.7–0.8
Goat	87–88	4.0–4.5	3.6–4.2	2.9–3.7	0.8–0.9
Sheep	79–82	6.9–8.6	4.3–4.7	5.6–6.7	0.9–1.0
Human	88.0–88.4	3.3–4.7	6.8–6.9	1.1–1.3	0.2–0.3

Source: Farah, (1993)

2.5 Camel milk enzymes:

Mal and Pathak (2010) mentioned that the activities of aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma glutamyl transferase (γ-GT), acid phosphatase (ACP), alkaline phosphatase (ALP) and lactate dehydrogenase (LDH) found to varies between 7.98-9.21 IU/L, 9.49-11.00 IU/L, 254.00-296.00 IU/L, 2.74-3.08 IU/L, 16.04-24.93 IU/L and 132.00-168.00 IU/L in Indian dromedary camels respectively. The activity of catalase was ranged from 0.083-0.193 moles/min/gm of protein in Indian dromedary camels. Milk enzymes play an important role in the keeping quality of camel milk. γ-GT was used as an indicator for the proper heat inactivation of camel milk because it is destroyed between 10 to 20 minutes at 72˚C.

2.6 Fatty acids profiles of camel milk:

The fatty acids are divided according to the linkage of the carbon atoms into saturated and unsaturated fatty acids. In saturated fatty acids the carbon atoms are linked in chain by single bonds, in unsaturated fatty acids by one or more double bonds (Farah, 1993).The fatty acid composition of milk is one of the aspects linked to the discussion on the health effect of milk and milk products. However, the fatty acid composition of camel milk and comparison with other species have not documented extensively especially in Bactrian camel (Faye *et al*. 2008).

Haasmann, (1998) mentioned that the fatty acid composition of milk fat has a significant influence on the technological and sensory properties of milk products, e.g. cheese and butter. In order to gain a deeper understanding of the fat composition and its technological properties, characterization of the fat is necessary. Recent advances in liquid chromatography have made it possible to separate individual triglycerides from an initial mixture of several hundred. The fatty acid composition of camel milk is characterized by a lower proportion of saturated short chain fatty acids, e.g. butyric acid, and higher concentrations of some long chain fatty acids, e.g. stearic acid and palmitoleic acid, in comparison to cow milk.

Mal and Pathak (2010) reported that the percent by weight values of butyric, caproic, caprylic, capric, lauric, myristic, myristoleic, palmitic, palmitoleic, stearic, oleic, linoleic and arachidic acids were ranged from 0.31-0.75, 0.2-0.6, 0.2-0.3, 0.2-0.4, 1-1.8, 15.9-25.2, 1.7-4.5, 25-29.5, 6.1-19.1, 1.9-11.7, 6.8-24.9, 0.9-2.0 and 0.6-3.4% respectively. Higher content of long chain fatty acids (C14-C18) and lower content of short chain fatty acids (C4-C12) are present in camel milk compared to cow milk.

Elobied (2015) reported that the percent values of saturated fatty acids caproic, caprylic, capric, lauric, tridecanoic, myristic, pentadecanoic, palmitic, heptadecanoic, stearic, arachidic, henicosanoic, tricosanoic and hetracosanoic in different seasons were ranged 2.41, 2.41, 7.90, 11.68, 12.03, 11.00, 10.65, 12.03, 4.81, 3.44, 6.87, 3.09, 1.03 and 0.69 respectively in summer season and 0.00, 1.82, 3.64, 9.55, 12.73, 10.00, 10.91, 9.55, 10.00, 5.00, 10.91, 0.91, 7.27 and 0.45 respectively in winter season. Konuspayeva *et al*. (2008) mentioned that milk fatty acid composition is one of the aspects linked to the discussion on the health effects of camel's milk and milk products. However, the fatty acid composition of camel's milk is not well documented especially in Bactrian camels.

The percent values of mono unsaturated fatty acids Myristoleic, Palmitoleic, Oleic, Eicosenoic, Erucic, and Nervonic ranged 4.4, 7.4, 48.5, 14.7, 8.8, 0.00 respectively in summer and 15.7, 16.7, 24.5, 22.5, 2.9, 1.00 respectively in winter season. The poly unsaturated fatty acids Linoliec, Eicosatrienoic, Eicosatetraenoic ranged 42.11, 27.63, 17.11 respectively in summer season and 37.50, 5.56 and 41.67 respectively in winter season (Elobied, 2015). Higher contents of long chain fatty acids were also reported for camel milk fat compared with bovine milk fat. Similarly, the unsaturated fatty acid is higher in camel milk, especially the essential fatty acids (Elobied *et al*. 2014).

2.7 Medicinal properties of camel milk:

There is a report that camel milk has medicinal properties suggesting that this milk contains protective proteins which may have possible role for enhancing immune defense mechanism. Camel milk also contains higher amount of zinc. The rapidly dividing cells of the immune system are sensitive to zinc deficiency. The role of Zn in the development and maintenance of a normally functioning immune system has been well established. Antibacterial and antiviral activities of these proteins of camel milk were studied (Mal and Pathak, 2010). Camel milk contains good amounts of lysozyme, lactoferrin, lactoperoxidase, immunoglobulin G and secretory immunoglobulin A; these antimicrobial factors were present at significantly greater concentrations in camel milk and were more heat stable compared with those in cow and buffalo milks (Salih and Hamid, 2012).

Mal and Pathak (2010) mentioned that the camel milk lysozyme showed a higher lysis value towards *Salmonella typhimurium* compared to egg white and bovine milk lysozymes. The inhibition of pathogenic bacteria by camel's milk was also observed. Camel milk is used for treating dropsy, jaundice, spleen ailments, tuberculosis, asthma, anemia and piles. The patients suffering from chronic hepatitis had improved liver functions after drinking of camel milk. Camel milk has insulin like activity, regulatory and immunemodulatory functions on β cells. Camel milk exhibits hypoglycemic effect when given as an adjunctive therapy, which might be due to presence of insulin/insulin like protein in it and possesses beneficial effect in the treatment of diabetic patients

Elsewhere, raw camel's milk and a fermented product (named *shubat*) have always been an important food for Kazakh peoples. Shubat is especially renowned and is used for some medicinal purposes (Konuspayeva *et al*., 2008). Camel milk has been used for the treatment of food allergies and autism. Camel milk can be used for the treatment of different types of tuberculosis. Camel milk possesses medicinal properties to treat different ailments such as multiple sclerosis, psoriasis, lupus and allergies-asthma. Camel milk drinking has shown good effect for treating crohn's disease (Mal and Pathak, 2010).

CHAPTER THREE

MATERIALS AND METHODS

3.1. Study area:

Middle Darfur state is in Darfur region; in western part of the Sudan, between latitudes 12°30' and 13° 30' North and longitudes 23°30' and 23°45' west. To the north of it lays North Darfur state and to the east is East Darfur state. To the west is West Darfur and to the south is South Darfur state. The Middle Darfur states its unique position because it is surrounded by many valleys for example Azum valley in the west, Aryebu and Touro on the other side. In addition to its location, it is in western part of Jebel Marra which has wet climate, fertile soil and available water resources which is used for the different types of agricultural activities (Ali, 2012).

3.2 Climate:

Climate is one of the most influential elements of the environment aspects of life; through the impact of it is a component of living organisms this is illustrated by the following:

3.2.1 Temperature:

The rates of annual temperature in the Sudan not less than 20 degrees Celsius and the temperature increases rate is from south to north, with the exception of areas bordering the northern and eastern regions and the high mountains. The average annual temperature in Zalingei is up to 25.7 degrees Celsius. In May the temperature is the highest. Averaging 41.2 degrees Celsius and the lowest in January as the average temperature is 10 degrees Celsius (JMRDPMD, 2014).

3.2.2 Relative humidity:

The study area are characterized by a high proportion of moisture and impact of the volcanic humid wind and escalation, which in turn leads to waste of humid air, in addition to the vulnerability of heavy tree cover and water surface and the large number of waterways, which are loaded with water, especially in the precipitation reaching the highest summit of the relative humidity in the month of August to more than 80% during the hours of the day of the year, (JMRDPMD, 2014). More rain and so much moisture leads to the emergence in the early morning fog, leading to reduction of the visibility to less than 400 meters and less moisture is in the month of March. This is attributed to the rule of the northern winds. The relative humidity rises in the rainy months in June-September, and relatively less in the rest of the year.

3.2.3. Rainfall:

In the study area, which is part of Darfur, the rains begins in the month of April and May and reach its maximum in August and stop at the end of October, with maximum of annual distribution of 700 mm and rapidly towards the east and north-west, while in the southern direction and west. Usually there is much rain in the mornings and evening, which stops in the middle of the day (JMRDPMD, 2014).

3.3. Soil:

Soil is classified on the basis of sources of rock, and although this type of classification is no longer acceptable as a basis for the classification in the world, it is still useful for study in specific regions which is limited, because knowledge of rock type which are derived from it and the factors that led to weathering help to understand many other properties in terms of, minerals and salts that are found out. Also concerning the degree of soil fertility, soil can be classified in the study area based on the classification of (Ali, 2012) in two types:

1 - Soil foundation and rocks found in the hills.

2 - Soil found in floodplains, valleys and streams.

3.4. Milk sampling and storage:

Forty she-camels were selected from four herds belonging to Abbala tribe from different location, ten samples were taken from each herds. Milk samples were collected from these camels and transferred to the laboratory.

At the laboratory, the samples were carried and stored in a refrigerator at 4-5 C° for later analysis.

3.5. Chemical composition determinations:

Chemical compositions were determined for the fat, protein, total solids, ash contents, titratable acidity and specific gravity of the camel milk samples.

3.5.1. Determination of fat content:

Fat content was determined using Gerber Method, Marshal (1993).Ten ml of sulfuric acid (specific gravity 1.815 at 15.5c°) was measured into clean dry Gerber butyrometer tube, and then 11 ml of sample were added carefully. Then one ml of amyl alcohol (specific gravity 0.814 at 15.5c°) was added. The content of the tube were thoroughly mixed till no white particles were seen (until the curd was completely digested). The tubes were then centrifuged at 1100 revolution per minutes (rpm) for minutes. The tubes were transferred to a water bath at 65c° for three minutes. Direct reading of fat contents was recorded from measures on the tubes.

3.5.2. Determination of protein content:

Protein content was determined using Formol titration method according to Chang (1998). Ten ml of milk sample was measured into clean dry white cup porcelain. Then 0.4 ml of saturated potassium oxalate ($C_2K_2O_4.H_2O$) was added, then 0.5 ml of phenolphthalein (0.5%) was added and titrated against 0.1 N NaOH till a faint color appeared. Then two ml of formalin (40%) was added and titrated against 0.1 N NaOH second term till no faint color seen. The protein content was then calculated as follows:

Protein% = Formol titration x 1.74

Where:

Formol titration: mls of NAOH after second term titration.

1.74: bite factor.

3.5.3. Determination of total solids content:

The total solids contents of milk sample were determined according to the method described in AOAC (1990). Five ml of sample were placed in a clean dried crucible. The weight of each sample and the crucible was recorded. The crucible contents were heated on a water bath for 10-15 minutes. The crucibles were put in an air oven at 100°C for three hours, then placed in a desicator- to cool for 30 minutes and weighed. Heating, cooling and weighing were repeated several times until the difference between two successive weightings were less than 0.5 mg. The total solids content of each of the sample were calculated as follows:

$$\text{Total solids} = \frac{W_1}{W_0} \times 100$$

Where W_1= Weight of sample after drying

W_0=Weight of sample before drying

3.5.4 .Titratable acidity of milk:

Titratable acidity was determined according to AOAC (1990).Ten ml of camel milk sample were placed into a clean porcelain dish and one ml of phenolphthalein indicator was added. The sample was titrated against 0.1 N NaOH till a faint color lasted for at least 30 seconds.

Then the titratable acidity of each sample was calculated as follows:

$$\text{Titratable acidity} = \frac{T}{W}$$

Where: T=Titration figures

W=Weight of samples

3.5.5. Determination of ash contents:

The ash content of camel milk sample was determined according to AOAC (1990). Ten ml of milk sample were weighed and placed in clean dry pre-weighed crucibles. The crucibles were put on a water bath for 30 minutes and place in a muffle furnace at 550°C for 1½-2 hours. They were then removed, placed in a desicator and left to cool, re-weighed and the ash content of sample determined as follows:

$$\text{Ash\%} = \frac{W_1}{W_2} \times 100$$

Where: W_1=Weight of ash.

W_2=Weight of sample.

3.5.6. Determination of specific gravity:

Specific gravity was determined using lactometer method according to Pakistan Society (2012). Camel milk sample was poured into a glass measuring cylinder (250ml). Then the lactometer is slowly lowered into the milk until it floats. The lactometer must not be allowed to touch the sides of cylinder or its bottom. Then reading lactometer and added 0.5 degree. Specific gravity of milk can be calculated by the following formula (for all type of lactometer):

$$\text{Specific gravity} = \frac{\text{Corrected lactometer reading}}{1000} + 1$$

3.6. Determination of Fatty acids profiles:

The milk fat was extracted from milk in liquid form by hexane. One gram of fat was dissolved in 5 ml hexane. Fatty acids were determined after methylation by gas chromatography and were confirmed by mass spectrometry for each milk sample. A Varian 3400 gas chromatograph was equipped with a non polar DB-Wax capillary column (molten silica) of 60 m length, 0.32 mm diameter and 0.25 μm film thicknesses (Christie, 1993).

3.7. Statistical analysis:

The data of the present study was statistically analyzed using SPSS software (Statistical Package for Social Sciences, version 16). In this experiment ANOVA was used. Least significant different (LSD) was used for mean separation of the chemical composition and fatty acids of camel milk. The levels of significance $p<0.05$ was used in this study.

CHAPTER FOUR

RESULTS

4.1. Chemical composition of camel milk:

Results in Table 3shown the chemical composition of camel milk obtained from four different areas in Middle Darfur state.

The average total solids content of camel milk samples collected during this study from Garsilla, Nertety, Abata and Sullo found to be 11.95±0.93%, 11.10±0.66%, 11.21±0.41%, 11.10±0.26% respectively were significantly different ($P<0.05$).

The protein contents of camel milk samples collected from Garsilla, Nertety, Abata and Sullo were no significant varied ($P>0.05$) between these areas. The values average found to be 3.56±0.24, 3.56±0.23, 3.64±0.14 and 3.64±0.18 percent respectively.

Also not significant variation ($P>0.05$) was found in the fat contents of camel milk samples among the four areas. The average values reported as follows; 3.81±0.29, 3.60±0.21, 3.72±0.21, and 3.68±0.24 percent respectively for Garsilla, Nertety, Abata and Sullo.

The average titratable acidity of camel milk samples collected from these areas found to be 0.14±0.01 in Garsilla, 0.13±0.01% in Nertety, 0.14±0.01% in Abata and 0.14±0.01% in Sullo, not significant differences ($P>0.05$) were among the different areas.

The ash contents of camel milk samples obtained from Garsilla, Nertety, Abata and Sullo, were found to be 0.95±0.17%, 0.87±0.07%, 0.94±0.13%, 0.89±0.08% respectively also no significant differences ($P>0.05$) were reported.

The specific gravity of camel milk samples collected from Garsilla, Nertety, Abata and Sullo were not significant differences ($P>0.05$). The average value was similar in these areas it was 1.029±0.01.

4.2. Fatty acids profile of camel milk:

Results in Table 4 showed the fatty acids profile of camel milk obtained from four different areas in Middle Darfur state.

The capric acid of camel milk samples from Garsilla, Nertety, Abata and Sullo were not significant differences (P>0.05). The average values found are; 0.01±0.01%, 0.003±0.01%, and 0.033±0.06 %, for Garsilla, Nertety and Sullo respectively, while were not detected in Abata.

The results demonstrated that the lauric acid of camel milk samples in the four areas were not significant different (P>0.05). The average concentrations are; Garsilla 0.02±0.03%, Nertety 0.003±0.01%, Abata 4.16±7.21% and Sullo 0.003±0.01%.

The tridecanoic acid of camel milk samples was only found in Garsilla area (0.05±0.03%).While was not detected in milk samples from Nertety, Abata and Sullo.

No significant variations (P>0.05) were found in the myristoloic acid content of camel milk samples in the four areas.

Results showed that the oleic acid of camel milk samples were not significantly different (P>0.05) in the four areas. The average values found to be 0.42±0.49%, 0.08±0.10%, 13.59±21.86%, and 0.010±0.02% for Garsilla, Nertety, Abata and Sullo respectively. The eicosenoic acids of camel milk samples collected from Garsilla, Abata and Sullo were significantly different (P<0.05). While was not detected in Nertety.

The results indicated that no significant variations (P>0.05) were reported in the caprylic acids contents in the four areas, the average values were 0.42±0.49, 0.08±0.10, 13.59±21.86, and 0.010±0.02 percent in Garsilla, Nertety, Abata and Sullo respectively.

Table 3: Chemical composition of camel milk from four different areas in Middle Darfur state:

Area	Chemical composition% of camel milk in Middle Darfur state					
	Protein %	Fat %	Titratable acidity%	Ash %	Total solids%	Specific gravity%
A	3.56±0.24	3.81±0.29	0.14±0.01	0.95±0.17	11.95±0.93a	1.029±0.01
B	3.56±0.23	3.60±0.21	0.13±0.01	0.87±0.07	11.10±0.66b	1.029±0.01
C	3.64±0.14	3.72±0.21	0.14±0.01	0.94±0.13	11.21±0.41b	1.029±0.01
D	3.64±0.18	3.68±0.24	0.14±0.01	0.89±0.08	11.10±0.26b	1.029±0.01
LS	NS	NS	NS	NS	*	NS

Mean values bearing different letters within colums are significantly different ($P<0.05$).
LS = Levels of significance

A = Garsilla

B = Nertetey

C = Abata

D = Sullo

The palmitoleic acid of camel milk samples showed no significant differences (P>0.05) in the four areas. The highest values (0.14± 0.21%) were in Garsilla, while the lowest one (0.003± 0.01%) was in Sullo.

The heptadecenoic acids of camel milk samples collected from Garsilla, Abata and Sullo were significantly different (P<0.05). However, it was not detected in Nertety. The stearic acid of camel samples obtained from Garsilla, Nertety, Abata and Sullo revealed no significant variations (P>0.05).

The arachidic acid of camel milk samples were not significant differences (P>0.05). The average values found are; in Abata 016±0.24% and Sullo 0.32±0.31%. While was not detected in Garsilla and Nertety.

The eicosadenoic acid of camel milk samples were not significant differences (P>0.05). The average values found to be 0.03±0.03% in Abata and 0.13±0.12% in Sullo. While was not detected in Garsilla and Nertety.

The average values of palmitic acid found are; in Abata 0.01±0.02% and Sullo 0.02±0.03%. While was not detected in Garsilla and Nertety. Also were no significant variations (P>0.05).

The average values of linoliec acid of camel milk samples found to be only in Abata area 1.64±2.84%, while in Garsilla, Nertety and Sullo areas not detected.The linolenic acid of camel milk samples were not significant differences (P>0.05). The average values found are; in Abata 0.19±0.26% and Sullo 0.02±0.03%, while in Garsilla and Nertety areas were not detected.

The averages values of Erucic, tricocenoic and nervonic found to be only in Abata area 0.25±0.44%, 0.08±0.13% and 0.06±0.10% respectively, while in Garsilla, Nertety and Sullo areas were not detected.

The behenic acid of camel milk samples only found in Sullo area, the average is 0.02±0.04%, while in Garsilla, Nertety and Abata areas were not detected.

Table 4: Fatty acids profile of camel milk samples fat obtained from four different areas in Middle Darfur state.

Name of acids (Mean+Sd)	Areas				LS
	A	B	C	D	
Capric	0.01±0.01	0.003±0.01	ND	0.033±0.06	NS
Lauric	0.02±0.03	0.003±0.01	4.16±7.21	0.003±0.01	NS
Tridecanoic	0.05±0.03	ND	ND	ND	NS
Myristoloic	0.03±0.03	0.01±0.01	ND	0.017±0.02	NS
Oleic	0.42±0.49	0.08±0.10	13.59±21.86	0.010±0.02	NS
Eicosenoic	0.06±0.09[b]	ND	0.15±0.26[b]	1.21±0.94[a]	*
Caprylic	0.01±0.02	0.003±0.01	0.06±0.10	0.003±0.01	NS
Palmitoleic	0.14±0.21	0.04±0.02	0.13±0.22	0.003±0.01	NS
Heptadecenoic	0.01±0.01[b]	ND	0.06±0.05[a]	0.02±0.03[b]	*
Stearic	ND	0.04±0.04	2.94±3.84	1.23±1.77	NS
Arachidic	ND	ND	016±0.24	0.32±0.31	NS
Eicosadenoic	ND	ND	0.03±0.03	0. 13±0.12	NS
Palmitic	ND	ND	0.01±0.02	0.02±0.03	NS
Linoliec	ND	ND	1.64±2.84	ND	NS
Linolenic	ND	ND	0.19±0.26	0.02±0.03	NS
Erucic	ND	ND	0.25±0.44	ND	NS
Tricocenoic	ND	ND	0.08±0.13	ND	NS
Nervonic	ND	ND	0.06±0.10	ND	NS
Behenic	ND	ND	ND	0.02±0.04	NS

Mean values bearing different letters within rows are significantly different (P<0.05).
LS = Levels of significance

ND = Not Detected

A = Garsilla

B = Nertety

C = Abata

D = Sullo

CHAPTER FIVE

DISCUSSION

5.1 Chemical composition of camel milk:

Total solids contents of the camel milk samples collected from four different areas in Middle Darfur state were significantly different (P<0.05) (Table 3). The highest total solid was found in the milk samples in Garsilla area this could be due to stage of lactation and feeding conditions. These results were in agreement with those reported by Suliman, (2012) who found that the total solids content of the camel milk ranges between 10.2-13.9%, this might be related to the availability of drinking water.

The results showed that no significant variations (P>0.05) were found in the protein contents of camel milk samples (Table 3). These results agreed with those of Salih and Hamid (2012) and Mohamedy (2010) who reported that milk protein content of camel milk ranges from 3.5-4.5 and 2 to 5.5 percent respectively.

The fat contents of camel milk samples were not significant differences (P>0.05). However, relatively highest fat contents in the camel milk were recorded in Garsilla area (Table 3). The variation in the fat content is associated with the type of breed, stage of lactation and feeding condition as described by Webb *et.al*. (1980). Similar results were reported by Farah (1993) who found that fat content of camel's milk varies between 2.9% and 5.4%.

The results showed that the titratable acidity of the camel milk samples also were not significantly differences (P>0.05) (Table 3). These results were consistent with those reported by Mal and Pathak (2010) who found that acidity of camel milk ranged from 0.12-0.14.

The results indicated that not significant differences (P>0.05) in the ash contents of camel milk samples were observed (Table 3). These results confirmed the findings of Salih and Hamid (2012) and Khan *et al*. (2004**)** who reported that ash ranged from 0.7-0.95% and 0.35- 0.95% respectively.

The specific gravity of camel milk samples was not significantly different (P>0.05), (Table 3). Similar results were obtained by Suliman (2012) and Farah (1993) who reported that specific gravity was 1.029 and 1.026-1035 respectively.

5.2 Fatty acids profile of camel milk:

Camel milk is seemed to be varied in fat content due to many factors such as age, lactation stage, season, feed…etc. Moreover fatty acids of camel milk had importance for human consumers both from nutritional and health properties. Also it differed from other mammal's milk in the ratio of unsaturated fatty acid to saturated fatty acid which made it healthy food.

The fatty acid composition of camel milk fat samples collected from four different areas in Middle Darfur state (Table 4) was comparable with results mentioned by Mal and Pathak (2010), in particular the caprylic, capric, lauric, myristic, myristoleic, palmitic, palmitoleic, oleic, linoleic and arachidic was lower.While results of the stearic was similar to those reported by Mal and Pathak (2010). However these results were in agreement with those reported by Haasmann (1998) who found the fatty acid profile of camel milk is characterized by a lower proportion of saturated short chain fatty acids, and higher concentrations of some long chain fatty acids.

The results showed that most SAT fatty acids caprylic, capric, lauric, tridecanoic, myristic, pentadecanoic, palmitic, heptadecanoic, stearic, arachidic and tricosanoic were lowest; these results were not in agreement with those reported by Elobied (2015). This might be due to the availability of different types of browsers plants which might be rich in these types of fatty acids.

Also the results showed that most of MUSAT fatty acids myristoleic, palmitoleic, oleic, eicosenoic, erucic, nervonic and PUSAT fatty acids Linoliec, were lowest than those mentioned by Elobied (2015), this might be due to high content of fat in the browser plants that dominant in the studied area and an increase of feed intake.

CHAPTER SIX

Conclusion and Recommendation

6.1 Conclusion:

It has been shown in this work that the total solids contents of camel milk samples obtained from Garsilla, Nertety, Abata and Sullo were significantly different, while no significant differences were found in the protein, fat, acidity, ash and specific gravity. However, higher total solids, fat and ash were recorded in Garsilla area. While higher protein content was reported in Abata and Sullo. Higher acidity values were secured in Garsilla, Abata and Sullo, moreover all areas were recorded the same specific gravity.

The results demonstrated that the fatty acids profile of the camel milk samples in the four areas seems to be similar except ecosenoic and heptadecenoic fatty acids.

6.2. Recommendations:

1- Further studies about the physicochemical characteristics of the camel milk such as pH, vitamins, lactose and minerals contents in Western Sudan.

2-More study about the fatty acids profile of camel milk in Western Sudan.

References

Abd-Alall, A. A, Gouda, A.S.A., Dardir, H.A. and Ibrahim, A.k (2012). Prevalence of some milk borne Bacterial pathogens threatening camel milk consumers in Egypt. Journl of global veterinaria 8 (1): 76-82.

Ali, M.M.H (2012). Taxonomic study of trees and shurbs of Zalingei. M.Sc. Thesis, faculty of foresty . University of Khartoum, Sudan.

AOAC (1990). Official Methods of Analysis, 15th edition Association of Official Analytical Chemists. Washington, D.C., U.S.A.

Bakheit, S.A.; Majid, A.M and Abu-Nikhala, A.M (2008). Camels (camelus dromedarius) under pastoral systemin North Kordofan, Sudan: seasonal and parity effects on milk composition. Journal of camelid sciences, 1: 32-36.

Bakheit, S.A (1999). Studies on milk production and composition of camels milk (camelus dromedarius) under nomadic system. M.Sc. Thesis, University of Khartoum, Sudan.

Bakheit, Sallam. A (2008). Acomparative study of production and reprodutive performance of camels (camelus dromedarius) under semi-intensive and traditional system in western Sudan. Ph.D. Thesis, Faculty of Animal production, University of Khartoum, Sudan.

Barakat, S.M, Turki, I.Y, El Bashir, S.M, Ali, S.A and Omer, S.A. (2007). Comparson of Some Blood Constituents in Stabled and Grazing Camels (camelus dromedarius) in Sudan. Journal of Science and Technology. Vol. 8 (2) June 2007: 21-26.

Chang, S.K.C. (1998). Protein analysis. *In* S.S. Nielsen, ed. *Food analysis*. 2nd edition, pp. 237–249. Gaithersburg, MD, USA, Aspen.

Christie, W.W (1993). Preparation of ester derivatives of fatty acids for chromatographic analysis. In Advances in Lipid Methodology – Two, pp. 69-111 (1993) (edited by W.W. Christie, Oily Press, Dundee).

Elobied, A.A. (2015). Effect of management systems and seasons on the physicochemical properties and fatty acids profiles of Sudanese camel milk. Ph.D Thesis, Faculty of Animal Production Science and Technology, Sudan University of Sconce and Technology.

Elobied, A.A, Osman, A.M, Abu kashwa, S.M, Ali, A.S, Ibrahim, M.T and Salih, M.M. (2014). Effect of parity and breed on some physico-chemical components of Sudanese camel milk. Journal of Research opinions in animal and veterinary sciences, 5(1) 20-24.

ElZubeir, I.E.M, Shueip, E.S, ElOwni, O.A.O and Musa, H.H (2008). Influence of season and management on composition of raw camel (camelus dromedarius) milk in Khartoum state, Sudan. Journal of Tropical and Subtropical Agroecosystems, 8: 101 - 106.

FAO. (2003). Food Agricultural Organization. Report FAO workshop on camel milk Retrieved. From. http://www.fao.org/ ag/ againfo/ resources/ en/ publications/ agapubs/ chamelle Book.

FAO. (2008). Food Agricultural Organization. Camel milk. Retrieved. From. http://www.fao.org/ ag/ againfo/ themes/ en/ dairy/ camel.

Farah, Z. (1993). Composition and characteristics of camels milk. Journal of Dairy Research (60): 25-28.

Farah, Z, Streiff, I and Bachmann, M.R (1989). Manufacture and characterization of camel milk butter. Laboratory of Dairy Science, SWISS Federal Institute of Technology, Zurich, Milchwissenchaft 44 (7) 412-414.

Faye, G, Konuspayeva.G, Narmuratova. M and loiseau. G (2008). Comprative fatty acid gross composition of milk in Bactrian camel and dromedary. Journal of camelid sciences 1: 48- 53.

Haasmann, S.O .(1998). Analytical characterization of camel meat and milk fat. Ph.D. Thesis, Department of chemistry, Brunel University.

JMRDPMD, (2014). Annual report, Jabel Marra Rural Development Project, Meteorological Division, Zalingei.

Khan, H, Athar, I.H and Aslam, M (2004). Evaluation of Cheese Prepared by Processing Camel Milk in Pakistan. J. Zool., vol. 36(4), pp. 323-326.

Konuspayeva, G, Lemarie, E, Faye, B, Loiseau, G and Montet, D (2008). Fatty acids and colestrol composition of camels (Camelus bactrianus, Camelus dromedarius and hybrids) milk in Kazakhstan. Journal of Dairy Sci. Technol. 88 (2008) 327- 340.

Konuspayeva, G, Faye, B and Loiseau, G (2009). The composition of camel milk: A meta-analysis of the literature data. Journal of Food Composition and Analysis 22 (2009) 95–101.

Majid, A.A and Bakheit, A. O (2007). Camel Research and Development in the Sudan: Analytical Review of Research. Journal of Science and Technology. Vol. 8 (2) June 2007: 78-87.

Mal, G and Pathak, K.M.L (2010). Camel milk and milk products. National Research Center on Camel, P.B. No. 07, Bikaner, Rajasthan 334001 India.

Marshal, R.T. (1993). Standard method for the examination of dairy product. American Public Health Association. Washinton. DC, USA.

Mohamedy, R H.H (2010). The effect of Heat Treament on fat, protein And lactose content of camel milk. M.Sc. Thesis, Dairy production and Technology, University of Khartoum, Sudan.

Pakistan society of animal scientists (2012). Determination of specific gravity of milk. From. http://paksas.blogspot.com/2012/08/determination-of-specific-gravity-of.html#. VOBnqLG9rrM.

Salih, M.M. and Hamid, O. I.A. (2012). Effect of Fortyfying Camels Milk with Skim Milk Powder on the Physicochemical, Microbiologocal and Sensory Caracteristics of Set Yoghurt. Advance Journal of Food Science and Technology: 1-6.

Sawaya, W. N; J. K. Khalil; A. Al shalhat and H. A. Mohammed. (1984). Chemical composition and nutritional quality of camel milk. J. of food science. 49: 744 – 747.

Suliman, E.S.K.(2012). Chemical composition and Microbial load of Gariss produced by Nomadic camel Herders in Al Gadarif state, Sudan. M.Sc. Thesis, Faculty of Animal production, University of Khartoum, Sudan.

Tigani, T.A, Hassan, A.B and Abaker, A.D. (2007). Bacteriological and Pathological Studies on Condemned Lungs of one Humped Camels (Camelus dromedarius) Slaughtered in Tamboul and Nyala Abattoirs, Sudan.Journal of Science and Technology. Vol. 8 (2) June 2007: 3-12.

Turki, I.Y, Ahmed, R.M, Agab, H and Tageddin, M. (2007). Feedlot Performance of Dromedary Camel (Camelus dromedarius) Calves Fed Different Dietary Regimes. Journal of Science and Technology. Vol. 8 (2) June 2007: 102-109.

Webb, B.H.; Johnson, R. H. and Alford, J. A. (1980). Fundamental of dairy Chemistry. West – port, Avi Publishing Company, USA.

Yagil, R., Zagorski, O., van Creveld, C. and Saran, A (1994). Science and camels milk production. Ed. Saint Marin, G. Expansion Scientifique Francais, Paris, 75-89.