Introduction

The camel is ideal domestic animal in desert with prolonged, dry and hot period of eight months or more and scarce, erratic annual rainfalls between 50 to 550 mm (Ramet, 2001). Camels live in wide pastoral areas in Africa and Asia and are divided into two different species belonging to the genus Camelus. Dromedary camels (*Camelus dromedarius*, one humped) that mainly live in the desert areas (arid), and Bactrian camel (*Camelus bactrianus*, two-humped) which prefer living in the cooler areas (Yagil, 1982 and Farah, 1996). Camels are considered to be a good source of milk and meat, and are used for other purposes such as transportation and sport racing (Kaufmann, 2005).

The total camel's population in the world is estimated to be about 26 million (Food and Agriculture Organization FAO, 2011). Ministry of Animal Resources, Fisheries and Ranges (MARFR, 2012) estimated the total camel population as 4.75 million in Sudan. Agab (1993) mentioned that camels are concentrated in two main regions; the Eastern region, where camels are found in the Butana plain and the Red Sea hills, and Western regions (Darfur and Kordofan). 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. On the other hand camels in the Sudan and elsewhere are classified as pack (heavy) and riding (light) types according to the function they perform and probably as a result of selection applied for these traits by the various camel-keeping tribes (El-Fadil, 1986).

Abbala in Sudan adopted many production systems including: traditional nomadic system, transhumant or semi-nomadic system, semi-sedentary system and recently a modified management system (intensive system) which is limited to racing and dairy camels as a kind of commercial investment in Khartoum state (Eisa and Mustafa, 2011). Camels are raised in different ecological zones ranging from desert zone, the Savanna and semiarid zones. In Sudan camel grazes on different types of browsed plants include trees, legumes, grasses, bushes and shrubs. The interaction between the browsing/grazing camel and its environment is important for the improvement of camel production (Dereje and Uden 2005).

Several researchers have published that camel milk production and composition were affected by many factors such as breed, feeding and management conditions, lactation number and stage of lactation. In addition camel milk plays a significant role in human diet in arid countries and hot regions. It is just like the bovine milk of its essential nutrients and since ancient times being used for curing a number of diseases. It is unique from other ruminant milk in terms of its composition as well as its functionality. Meanwhile, most of the camel milk in the Sudan is drunk fresh and some times sour (fermented) (*Garis*) or with tea (Sbanes). Moreover processing and manufacturing of camel milk into milk products like butter, ghee, cheese, ice cream, etc, not found except in some limited researches (Eisa and Mustafa, 2011).

Camel milk contains different proportions of fatty acids especially omega-fatty acids which play a vital role in normal growth, dermal integrity, renal function, and parturition (Lands, 1992). Camel research in the Sudan has been focused mainly on functional anatomy, diseases, husbandry, production and reproduction (Majid, 2000). Up to my knowledge no research studies on camel's milk lipid profiles were done under Sudan condition.

The objectives of this study are to:-

1- Describe some field management practices adopted by herdsmen and camel owners.
2- Evaluate the favorite browse plants for camel and its relationship with chemical analysis of milk.
3- Study the effect of management systems and seasons on camel milk composition and fatty acids profiles.

Chapter two

2. Literature review

Table 1: Dromedary camel classification

Order	*Artiodactyla (even-toed ungulates)*
Suborder	*Tylopoda (pad-footed animals)*
Family	*Camelidae*
Subfamily	*Camelinae*
Genus	*Camelus*
Species	*Camelus dromedarius*

Cited from (Wilson, 1984)

2.1 Camel classification:-

Camels are classified in the suborder *Tylopoda* (pad-footed animals) as shown in table (1) that represents with the suborders *Suiformes* (pig-like) and *Ruminantia* (ruminants) the order *Artiodactyla* (even-toed ungulates). This makes obvious that camelids (family *Camelidae)* as ruminating animals are classified in proximity to ruminants but developed in parallel and are not part of the suborder *Ruminantia*. Some differences as foot anatomy, stomach system and the absence of horns underline this fact (Schwartz and Dioli, 1992, Fowler, 1998 and Wernery, 2003). The family Camelidae has three genera, Camillus, Lama and Vicuna (the “old world genus”). The Camillus has two species, Bactrian (two humped) and dromedarius (the one humped) (the “new world genus”). The lama has three species while the Vicuna has only one species (Wilson, 1984).

2.2 Importance of camel :-

Camels are very drought tolerant; they can live in arid zones of many countries in the world and provide milk, meat, hides, wool and transport.

Therefore, there has even been an increasing interest in the dromedary in arid countries, where other domesticated animals have difficulties to survive. Camels can graze on low productive pastures in which the production of milk is possible and economically profitable. For this reason, camels may reduce the dependence on pasture than other livestock that usually is unadapted to drought than camels (Yagil, 1982, Morton, 1984; Wilson, 1984, Farah, 1993, Semereab and Molla, 2001, Sela *et al*., 2003, Farah, 2004).

Camel milk is one of the most valuable food resources for nomads in arid regions and can contribute to a better income for pastoralists; in the last years milk consumption among the urban population was increasing (Farah, 2004 and Chaibou, 2005). Camel milk is mainly consumed in its raw state (boiling of the milk is not common as it is known to remove its “goodness”) (Radwan *et al*., 1992; Semereab and Molla, 2001).

Many products can be transformed from camel milk such as fermented milk called “Al-Gariss”, cheese but the ability of coagulation is much lower in camel milk than in the milk of cows, ewes or goats (Gast *et al*., 1969, Ottogalli and Resmini, 1976) and butter but it gaves unaccepted results in consistency and taste (Gast *et al*., 1969, Farah *et al*., 1989 and Abu-Lehia, 1997).

Besides milk, meat is one of the most important products of the camel. It is good in yield and quality of the carcasses. But camels are still not bred for meat production in many regions as camels are considered less valuable. For this reason, usually males and infertile female camels are sold as slaughter animals by pastoralists. Nevertheless, the sale of these camels for meat production can present an important source of income. (Farah and Fischer, 2004). Camel meat is cited as a good source of protein, with low fat content and cholesterol level .The camel meat has greater total protein than beef (Babiker and Tibin, 1986).

Camel wool is one of the world's most expensive natural animal fibers. In some countries, camels are kept in the backyards of cities to gain wool, besides milk and meat. An adult camel usually produces 2 - 3 kg per shearing (Radwan *et al*., 1992). Camel hides are known for their strength and durability. They are used by camel breeders, but also as fashion accessories (Wernery, 2003). Other products used are: dung as fertilizer, source of fuel for pastoralists and bones for production of jewellery or bone-meal for fertilizing purposes (Köhler-Rollefson, 2000).

2.3 Camel production system:-

Sudanese camel herders, locally known as *abbala* who adopted one of three production systems (Eisa and Mustafa, 2011) including: the traditional nomadic system, transhumant or semi-nomadic system and sedentary management system. These systems are similar to those reported in Pakistan (Aujla., *et al* 1998). In Sudan recently semi- intensive system had been practiced in Khartoum state for commercial camel milk production (El Zubeir and Nour, 2006 and Eisa and Mustafa, 2011).

2.3.1 The traditional nomadic system:-

Sometimes the above system is called pastoral system, it is characterized by continuous mobility for both family and camel herds through the year. In this system nomads move from one place to another following certain migratory routes in response of availability to grazing and water. In most pastoral societies slaughter for meat is rare except for a few old and infertile animals (Wilson, 1998), and during ceremonies (Guliye *et al*., 2007). Where milk is the main production objective, males may be sold for slaughter and there is thus a dominance of females in the herd. However, where the transport role is important, more males are kept and there will be as many males as females in the herd (Wilson, 1998). This system is adopted by *Kababish* tribes in North Kordofan states (Mukasa-Mugerwa, 1981 and Ishag and Ahmed, 2011).

2.3.2 The semi- nomadic system:-

It's called transhuman system, it is practiced by semi-nomadic tribes (Ishag and Ahmed, 2011). This system is found in the eastern and southern parts of the camel belt in Sudan (Al Khouri and Majid, 2000 and Abbas *et al*., 1992). It is mainly adopted in Gadarif and Butana area by semi-nomadic tribes such as *Lahawiyin*, *Kawahla*, *Shukriya*, *Rashaida*, *Bija* and *Bawadra.*tribes Darosa (2005). This system is characterized by two phases, the first is the mobile phase in which young men travel during the dry season with their animals fetching for water and feed, while families are settled in villages, and the second phase when camel herds come home and stay around the villages especially in the rainy season (Al Khouri and Majid, 2000).

2.3.3 The sedentary system:-

This system is practiced in eastern region of Sudan (east of River Nile and west of the Red Sea hills) also it is found in the agricultural areas in the central and southern parts of the camel belt (Al Khouri and Majid, 2000). Ishag and Ahmed, (2011) mentioned that the sedentary system is adopted by majority of camel owners in Sudan.

2.3.4 The semi-intensive system:-

This system had been recently established in Sudan as a commercial investment in the pre-urban areas in Khartoum state (Eisa and Mustafa, 2011). In this system camels are kept in open fences in which continuous water supply through pipe line and good feed quality including concentrate supplement are provided. Also camel herders from natural pastures of Kordofan and Darfur select a group of lactating she-camel and kept it in west Omdurman for producing milk in commercial quantities (Mohamed, 2009).

2.4 Husbandry practices of camels in the field:-

Good husbandry and management techniques are the reasons for the success of camel pastoralists in an environment characterized by irregular rainfall and frequent droughts. Farah *et al*., (2004) observed that selection and breeding are the most important husbandry practices in camel management. The selection is traditional. It means the bull or his father should have mainly female progeny with good milk performance and it should be fully grown and strong (Farah *et al*., 2007).

2.4.1 Breeding practices:-

Breeding management consists of selection and culling of breeding female and male animals, and controlled breeding. Concerning the selection of breeding females, all females were used for breeding (Farah *et al*., 2004). Elmi, (1989) and Farah *et al*., (2004) reported that breeding management usually focused on bull selection and herders selected their breeding bulls according to specific criteria such as consideration was given to the bull's dam (milk production, fitness), bull's sire (fitness) and bull's performance ranking (body confirmation, fitness, docility, disease, drought tolerance).

Once a bull was selected, it usually served as long as possible and it kept up to 18 years. According to Wilson, (1984), camels considered to be seasonal polyoestrous animals. Usually the ovulation of the female dromedary is induced by copulation or the presence of a male. Rao *et al*., (1970) reported that camel bulls show their sexual cycle during 3-4 months in winter season, beginning in December, also they mentioned that the gestation period is between 370 -375 days. Ahmed *et al*. (2012) mentioned that the gestation period ranged between 365-398 days. Rao *et al*., (1970) and Farah, (2004) mentioned that camels are mated for the first time at the age of 3-4 years. It is possible to breed with camels up to 25-30 years leading to 8-10 calves in a lifetime.

According to Drosa (2005) the breeding system is based on successful management of mate breeding camels. Ahmed *et al*., (2006) reported that the male reaches sexual maturity at seven years and capable of serving 10 females, 10 services per day (including the night). A single male can successfully serve 60 to 67 females in breeding season.

Wardeh (2004) and Ahmed *et al*.(2006) reported that rutting bull camel well be able to identify female on heat by smelling female genital area by observing symptoms such as restlessness and urination.

On the other hand Jasara and Aujla (1998) and Farah *et al*., (2004) noted that normally camels are sexually mature at the age of 4.5 years based on breed and forage situation, but Somali camel herders rarely let them mate before they reach physical maturity at five to six years. On the other hand Wardeh, (1989) in Sudan mentioned that the female camel reaches sexual maturity at the age of 3 years, but usually ready for fertility at the age of 4 to 5 years, Accordingly a female camel has it's first calf at 6-7 years under normal conditions, thus a female camel that gives birth every each 2 year will have eight to ten calves in her breeding life of around 25 to 30 years. Skidmore (2005) found that there are many factors affecting age at puberty including nutrition, season of birth and breed of camel.

2.4.2 Pregnancy detection:-

According to Elmi, (1989) pastoralist can detect pregnancy 7–10 days after successful mating by observing many signs such as lifting and coiling upwards of the tail, curving of the neck when approached by a male camel, nervousness, lifting upwards of the head and pointing of the ears. Also more scientific methods for the determination of camel pregnancy have been developed including, determination of the pH and the specific gravity of the cervical mucus.

2.4.3 Milk Letdown and milking procedure:-

Farah (1996) mentioned that the presence of the calf is considered necessary for milk let down and hand stripping is also used to enhance this response. Moreover, Eisa and Mustafa, (2011) mentioned that milk letdown in camel is easily noticeable after a short period of suckling (1.5-2 min) when the teats suddenly swell, becoming much larger. If a calf dies, the dam dries up if milking is not stimulated. The nomad makes what look like a doll (bao) from the skin of the dead calf, to trick of the dam. It is sufficient for the dam to see and smell the doll of her calf for milk secretion to be stimulated.

Camels in Sudan are milked by men except in Rashaida tribe, women can practice milking of camel. Before milking, the calf is allowed to suckle until the milk begins to flow and the camel can be milked, the milking is done standing. The milker stands on one leg and balances the milking bowl on his curved left leg. The left hand holds the bowl, while the camel is milked with right hand. Sometimes both udder halves are milked at the same time by two herdsmen (Eisa and Mustafa, 2011).

2.4.4 Calves management:-

According to Farah *et al*., (2004) calf management is considered important by herders and it given considerable attention. It is begins from the parturition process especially in dystocia cases followed by the first suckling which taking place between one to three hours post calving. In addition to several management processes such as sufficient milk supply, provision of water during the dry season, provision of good pasture and tick control are important calf care measures. However, Schwartz and Dioli (1992) observed that the majority of the herders did not allow their calves to access initial colostrum, but instead milked it out. This arises from a common belief that colostrum will result in ill-health to newborn calves. According to Yagil (1994), the above mentioned belief is probably due to the normal powerful laxative effect of colostrum. It is highly possible that the high calf mortality usually reported could be attributed to this practice of denying the calves access to colostrum.

2.4.5 Calves weaning:-

According to Farah *et al*., (2004) weaning of calves is at age of 8-18 months, 1-1.5 years (Ahmed *et al*., 2012), depending on the browse situation, the milk production of the dam, and the growth of the calf and future use of the calf (sale or slaughter). Farah *et al*., (2004) mentioned that several different systems of weaning are practiced by Somalia herders, of which the most famous are: tying the dam’s teats with a softened bark. This practice is common in Sudan called (*sorar*) used to prevent calves from suckling at pasture during the day by tying up one or more teat with special strings using tape of goats or cows leather with narrow and small part of wood (Eisa and Mustafa, 2011). Jasara and Isani (2000) reported that the majority of pastoralists mentioned that the weaning period is one year.

After complete weaning, the selection of future sires is made, and the rejected males at this age are castrated, sold or slaughtered (Farah *et al*., 2004).

2.4.6 Feeding:-

Mouna (2006) reported that the camel is a multi-purpose domestic livestock species, well adapted to arid zones, it is capable to feed in areas where other species thrive or do not survive. Its size helps it to eat at higher levels above the ground than cattle, sheep and goat. The amounts of feed eaten by camels still little known, especially under free-ranging conditions. Many researchers have differing results in feed intake but it does show that intakes of feed per unit of body weight are low compared to other domestic species (Evans *et al*., 1995 and Wilson, 1998). Reasons for the observed differences in feed intake for camels and other livestock may relate to their lower metabolic rate and their more nutritious diet (Evans *et al*., 1995). Rutagwenda *et al*., (1989) observed that unlike cattle, camels are able to seek out herbs, fruits and succulent leaves of a great variety of plants. Wilson, (1984) stated that when camels bred extensively are economic utilization of rangelands. They usually browse on multi plants by take a few bites and move to another. Also Dereje and Uden (2005) noted that camels did not eat for a long time from one plant regarding to its density, but they move continuously, taking small bites of each plant. Especially during the dry season, they spread out during browsing, resulting in low pressure on each plant. They also mentioned that the camel spends 8 to 10 hours grazing daily, irrespective of whether the pasture is good or poor. Grenot (1992) stated that during summer camels feed mainly at night especially during moonlight nights, and then rest from morning until afternoon wherever they have to bed down. Also, he stated that the highest food consumption of 30 – 40 kg fresh forage (8-12 kg dry matter) this found on salty pastures and the lowest food intakes (5 kg/day) were noted from dried grass pastures. Also he stated that camel requires 8-10 hours of grazing daily to be satisfied depending on breed, body size and feed availability. Also, Wilson (1989) stated that, the total dry matter intake of camel needs to be about 4% of body weight and that feeding times required satisfying this requirement may be as much as 15 or more hours per day. Consequently, a mature camel weighing 650 Kg would require about 26 Kg of dry matter, which might represent between 80 and 100 Kg of total feed intake of plants with high moisture contents.

2.4.7 Watering:-

Camel has remarkable ability to go without water for long periods in extremely harsh conditions and can flourish where no other domestic animal can survive, as in the desert going without water in all winter while can grasp green plants having high water content. This exceptional ability is the result of several anatomical and physiological characteristics. During the six or seven cold months in Sahara region camels do not drink even if water is offered to them. Where green forage is available in mid climates, the camel may go several months without drinking (Ramet, 2001). Camels under very hot conditions may drink only once every eight to ten days and lost up to 30 percent of its body weight through dehydration (Yagil and Etzoin, 1980,Yagil, 1982, Wilson 1984 and Yagil, 1985). According to Cossins and Upton (1987), Evans *et al*., (1995) and Farah *et al.,* (2004) watering interval for the camels almost ranged between 7-14 days. Moreover, Elmi, (1989) reported it is ranged between 14 to 21 days, decreasing to 6-7 days during severe dry seasons. Farah *et al.,* (2004) stated that the home-based herds were more frequently watered than the nomadic herds (after 6 and 10 days respectively) accordingly to availability of forage, the water content in the forage and distance to water sources. So that, they found that the nomadic herds are less frequently watered because they feed in areas with good and relatively plentiful forage, usually far from watering points. Ahmed *et al*. (2006) explained that water requirement is very much dependent on the type of grazing available and on the environment temperature. Camels are moved constantly to where better feed exits. The animals are kept where the distance to water is not usually more than two days camel walk, and pastoralists prefer to water camels between 9:00 am and 3:00 pm. In Sudan Köhler *et al*., (1991) found that Rashaidi camel needs watering approximately once every six days. Watering interval varies in different season and climatic regions due to air temperature, type of nutrition and availability of water. According to Gauthier-Pilters and Dagg (1981) stock water is a limitation during the dry season, particularly in areas underlain by basement complex rocks (non-water bearing rocks) as in case of Butana, Hamar district, Beja and eastern Darfur. All these areas are important grazing land where pastoralist is major economic activity. Most pastoralists utilize these areas as wet season grazing land and move out before the surface water in natural ponds and drought is exhausted. Upton (1986) reported that inappropriate distribution of water points for live stock could limit range land use, leading to partial over grazing and partial under – utilization of range land. Watering intervals are particularly important in lactating camels. Thus, Grenot (1992) stated that dehydrated camel was found to produce milk of higher water content with lower fat content when compared with the milk of fully watered camels.

2.5 Favorable browse plants:-

Information of the quality of feeds selected by the camel, its behavioural activities and feed preferences are important to the understanding of the forage-camel relationship. An interaction between the browsing/grazing camel and its environment is important to the development of proper husbandry decisions and for the improvement of camel production (Dereje and Uden 2005).

The camel is a favored browser of a broad spectrum of fodder plants, including trees, shrubs, and sometimes hard-thorny, bitter and halophytic (salty) plants that grow naturally in the desert and other semi-arid areas (Coppock *et al*., 1986 and Wilson, 1989). Camels generally browse leaves, young branches, fruits, flowers and pods. Leaves from trees are generally richer in minerals than grasses (Kuria *et al*., 2004). An important feature of camels browsing habits is that they are not in direct competition with other domestic animals either in terms of the type of feed eaten or in the height at which they eat above the ground (Wilson, 1989).

Yagil, (1994) stated that the quantity of feed eaten by a camel depends on the water content of the forage. If a camel eats 30 – 40 Kg of fresh fodder which has water content of 80%, then the intake is only 6-8 Kg dry matter. Also the Camels feed intake depends on its selective feeding of a wide variety of vegetation and different parts of browse which differ in quality. For example, intake rates can be rapid where favored or selected browse is abundant but can be slower on thorny species that have little leaf (Wilson, 1989 and Hashi *et al*., 1995).

Darosa and Agab(2008) reported that camel grazes in Butana (Sudan) on different types of browsed plants includes trees (Sunut, Samar, Kitir, Sayyal, Salam, Lao'at and Sidir), legumes (Tabar, Hantout,Diraisa, Shara and Siha), grasses (Dobalab, Tumam and Ghabash), bushes and shrubs (Tondub and Kormut). But the most preferred plants such as Siha (*Blepharis edulus* and *Chorchorus olitorius*), are now restricted only to remote unreachable areas, natural depressions and courses of seasonal valleys and water run-ways.

2.6 Camel milk production:-

Camels are known to thrive in arid and desert countries. These pastoralist areas and conditions make it difficult to estimate camel milk production. Al haj and Al Kanhal, (2010) reported that other major factors including breed, feeding and management conditions, lactation number and stage of lactation affected the production of camel milk. The average of daily camel milk yield, lactation length and lactation yield have been reviewed by number of researchers and reported by Yagil (1982), Farah (1996), Cardellino *et al*., (2004) and Yaqoob and Nawaz (2007). Field (1979) estimated daily milk yield of camels at 21 liters in second week of lactation, decreases daily milk yield to 4.80 to 2.21 liters by the sixteenth week of lactation. Depending on management and environmental conditions, the average lactation length in camel is 12 months with a range from 9 to 18 months. According to Khanna (1986) an average daily milk yield varying from 3.5 to 10 litres and can reach 40 liters in exceptionally good camels, while the lactation yield ranged between 2000 and 6000 liters. Farah *et al*., (2007) mentioned that camels have the capability to produce more milk than any other species and for longer periods of time under harsh conditions and they found the one she-camel produced between 3 to 10 kg during a lactation period of 12 to18 months. Even higher milk yields of up to 35 kg per day have been recorded (Jasra and Aujla, 1998). Most of the authors did not specify the number of milkings per day (Cardellino *et al.*, 2004). According to Eisa and Mustafa, (2011) Sudanese camel can reach 10kg of milk/day in the early lactation and good conditions and decline to 2 kg milk/day in the late lactation and bad conditions otherwise it ranges between 5-10 kg/day. Al haj and Al Kanhal, (2010) found that most camel milk production is consumed locally by families and their animals, and does not reach the urban markets because most of the camel herds are located in the arid and desert areas which are far from the commercial markets. Furthermore, Haddadin *et al.*, (2008) revealed that fresh camel milk and their products have unique flavor and good nutritional values; therefore it can compete in the market if it is packed in an attractive packaging to maintain acceptable sensory properties such as taste, aroma, color and texture during their shelf life.

2.7 Physical properties of Camel milk:-

Camel milk is usually opaque-white in color and has an acceptable taste (Yagil and Etzoin, 1980, Alwan and Igwegbe, 2013). The milk normally has a sweet and sharp taste, but sometimes can also have a salty taste due to the type of plants eaten in the desert by the camels (Rao *et al.*, 1970, Khaskheli *et al*, 2005 and Alwan and Igwegbe, 2013). The changes in taste are mainly caused by the type of fodder and availability of drinking water (Farah, 1996). Camel milk is frothy when shaken slightly (Shalash, 1979).

The average density of camel milk is 1.029 g cm-3 (Farah, 1996), and has been reported to be less viscous than bovine milk (Laleye *et al.*, 2008). The viscosity of camel milk at 20º C is 1.72 mPa/s, whereas the viscosity of bovine milk at the same conditions is 2.04 mPa/s (Kherouatou *et al*., 2003). The specific gravity of camel milk was significantly lower than that of cow milk. This is due to the increased content of longer chain fatty acids (Abu-Lehia, 1989), also Igbal *et al*., (2001) found that specific gravity of camel milk ranged between 1.028 t0 1.033 which is lower than that of cow, buffalo and sheep milk. The density of camel milk was found to be highly associated with protein, lactose, and ash. Elsewhere, conductivity had a negative correlation with fat, lactose, ash, protein and density. (Abdelgadir *et al*., 2013).

2.8 Camel milk composition:-

Camel milk composition was found to be less stable than other species such as bovine milk. These variations in camel milk composition could be affected by several factors such as analytical measurement procedures, geographical locations, feeding conditions and samples being taken from different breeds, in addition to other factors including stage of lactation, age, and calving number (Khaskheli *et al*., 2005 and Al haj and Al Kanhal, 2010). According to Konuspayeva *et al*., (2009) geographical origin and seasonal variations were found to be the most effective factors in camel milk composition. When they studied the effect of geographical origin on camel milk composition they found that the milk composition from camels living in East Africa has higher fat content than the milk from camels living in Africa and Western Asia. Alwan *et al*., (2014) reported that the important factors that affect the composition of camel milk is the amount of water available to the she-camels; hence they found the moisture contents of milk from she-camel reared in desert was higher than those reared on farm. Mehaia *et al*., (1995) demonstrated that many variations in camel milk composition were observed for camels from the same species (Dromedary) but bred in different parts of the world. Haddadin *et al*., (2008) and Shuiep *et al*., (2008) showed that camel milk composition was also affected by seasonal variations even for camels from the same species (Dromedary) and regions. Also Haddadin *et al*., (2008) found a contrary relationship between total solids in camel milk and water intake by camels; they studied all components except lactose reached their maxima in winter and were lowest in summer. For example, total solids were 13.9% in December and January, and 10.2% in August due to availability of drinking water. In another study, the fat content of camel milk was reported to decrease from 4.3 to 1.1 percent due to the increase in water content of milk produced by thirsty camels (Yagil and Etzion, 1980). 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 (Konuspayeva *et al*., 2009).

2.8.1 Protein:-

Konuspayeva *et al*., (2009) reported that dromedary camel milk protein contents in range of 2.15 to 4.90 percent. Camel milk from same breed has similar protein content (whey proteins and caseins) and different for other breeds (Sawaya *et al*., 1984; Elamin and Wilcox, 1992, and Mehaia *et al*., 1995). With the change in season, protein content of same strain varied. It is found to be low in summer (2.48 percent) and high in winter (2.9 percent) (Mehaia *et al*., 1995).

Camel milk protein is categorized into two main components:

2.8.1.1 Caseins:-

Casein (CN) is the major protein in camel milk. Dromedary camel milk has about 1.63 – 2.73 % casein represented about 52 – 87 % of the total proteins (Mehaia *et al*., 1995 and Khaskheli *et al*., 2005). The β-CN is the main camel milk casein followed by α_{s1}-CN, and constitutes about 65% and 21% of total casein, respectively (Kappeler *et al*., 2003). Camel milk has high digestibility and less allergic reactions in infants as α_{s1}-CN slowly hydrolyze than β-CN (El-Agamy *et al*., 2009). 3.47 % k-casein is present in camel milk casein (Kappeler *et al*., 2003) compare to 13 % in bovine milk (Davies and Law, 1980).

2.8.1.2 Whey proteins:-

Whey proteins are the second main component of camel milk proteins and constitute 20-25 % of the total proteins. The dromedary camel milk whey protein content ranges between 0.63 and 0.80 % of the milk (Mehaia *et al*., 1995 and Khaskheli *et al*., 2005). The composition of camel milk whey proteins is different to that of bovine milk whey, where camel milk is deficient in β-lactoglobulin, as also observed for human milk (El-Agamy *et al*., 2009). In bovine milk whey proteins, β-lactoglobulin is the main component (50%) and α-lactalbumin is the second (25%), whereas in camel milk whey, β-lactoglobulin is deficient (Farah, 1986, Farah and Atkins, 1992, El-Agamy, 2000, Merin *et al*., 2001, Kappeler *et al*., 2003 and Laleye *et al*., 2008) and α-lactalbumin is the main component.

2.8.2 Lactose:-

Konuspayeva *et al*., (2009) stated that the lactose content of dromedary camel milk ranged from 2.40 to5.80%. Khaskheli *et al*., (2005) assumed that the wide variation of lactose content could be referred to the type of plants eaten in the deserts. Camels usually prefer halophilic plants such as Atriplex, Salosa and Acacia to fulfill their physiological requirements of salts (Yagil, 1982). Therefore, camel milk is sometimes described as sweet, salty and at other times as bitter. Several researches reported that the lactose content was the only component that almost remains stable over a season (Haddadin *et al*., 2008) also under hydrated or dehydrated conditions (Yagil and Etzion, 1980). On the other hand, lactose content was found to change slightly for camel milk of some dromedary breeds in different part of the world (Sawaya *et al*., 1984, Elamin and Wilcox, 1992, Mehaia *et al*., 1995 and Haddadin *et al*., 2008). A strong positive correlation between lactose and protein in dromedary camel milk found by Abdelgadir *et al*. (2013).

2.8.3 Fat:-

It is reported that dromedary camel milk fat level varies from 1.2 to 6.4 percent (Konuspayeva *et al*., 2009) and a strong positive correlation between fat and protein contents is observed (Haddadin *et al*., 2008). It was also revealed that fat contents could be reduced from 4.3 to 1.1 percent in the milk of thirsty camels (Yagil and Etzion, 1980). The lipid fraction in camel milk is characterized by a high proportion of long chain fatty acids, which accounts for 96.4 percent compared to 85.3 percent in bovine milk (Schlimme, 1990). Camel milk fat differed from mammalian fats by its high content of the long-chain fatty acids C14:0, C16:0, C18:0 and C18:1(Konuspayeva *et al*., 2008). Milk fat of dromedary camels carries a lower level of carotene and lesser concentrations of short chain fatty acids as compared to milk of bovine (Stahl *et al*., 2006).

2.8.3.1 Lipid profiles:-

Zhang *et al*. (2005) found the even-numbered saturated fatty acids (C12:0-C18:0) in camel milk at 90 day postpartum accounted for 57.54% of total fatty acids with C16:0, C18:0, and C14:0 as the major components (30.12, 15.15, and 11.49%) respectively also he mentioned that polyunsaturated fatty acids (PUSAT) (C18:1-C18:3) in camel milk accounted for 30.25% of total fatty acids, mainly C18:1 (26.05%). Short-chain fatty acids (C4:0-C8:0) of camel milk have been reported to be in the range of 0.1 to 1.2%, which were considerably lower than those of bovine milk (Abu-Lehia, 1989, Farah, 1993, Gorban and Izzeldin, 2001, Cardak *et al*., 2003 and Sheraz *et al*., 2013) and a higher amount of long chain fatty acids (C14-C22) compared with bovine milk fat (Abu-Lehia, 1989, Haddadin *et al*., 2008 and Rüegg and Farah, 1991). On the other hand Faye *et al* .(2008) reported that saturated (SAT), mono-unsaturated (MUSAT) and Poly-unsaturated (PUSAT) fatty acids were 67.7 %, 26.8 % and 2.5 % subsequently, also they reported that winter showed high percent of (SAT) fatty acids than summer also it was applicable for (PUSAT) and the opposite was true for (MUSAT). Factors that affect the fatty acid composition of camel milk include breed, feeding, composition of dietary fat, dietary protein, seasonality and region, and stage of lactation (Palmquist *et al*., 1993; Gorban and Izzeldin, 2001).

2.8.3.2 Cholesterol:-

It is reported that the average of cholesterol content of camel milk fat (34.5 mg 100 g^{-1}) was found to be higher than that recorded for bovine milk fat (25.63 mg 100 g^{-1}) (Gorban and Izzeldin, 1999). Moreover, Konuspayeva *et al*., (2008) revealed that the ratio of unsaturated/saturated acid was more favorable in camel's milk compared with that of cows or other mammalians, so it gave nutritional advantage to camel's milk, although it had a higher content of cholesterol (37.1 mg100 g^{-}1). Nevertheless, it was also found to be lower than that reported for some bovine milk (Haddadin *et al*., 2008).

Table 2: Composition of camel milk lipid and colostrum

Lipid class	% composition camel colostrum	% composition camel milk
Free cholesterol	1.22	0.84
Cholesteryl esters	0.07	0.10
Free fatty acids	0.42	0.65
Triacyglycerols	97.21	96.24
Diacylglycerols	0.24	0.70
Monoacyglycerosl	0.13	Trace
Phospholipids	0.67	1.21
Others	0.06	0.26

Cited from Gorban and Izzeldin (2001)

2.8.4 Vitamins:-

Many researchers (Sawaya *et al*., 1984, Farah *et al*., 1992, Stahl *et al*., 2006 and Haddadin *et al*., 2008) published that dromedary camel milk contains 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 (Farah *et al*., 1992, Stahl *et al*., 2006 and Hessain *et al*., 2013). So that, camel milk could be a good source of vitamin C for nomadic people living in the desert area where vegetables and fruits are not available (Sawaya *et al*., 1984). The mean of vitamin C content in dromedary camel milk is 34.16 mg $L^{-}1$ (Sawaya *et al*., 1984 and Farah *et al*., 1992), 44 mg $L^{-}1$(Mohamed *et al*., 2005) and 33 mg $L^{-}1$(Haddadin *et al*., 2008). Compared with bovine milk, the niacin (B3) content was reported to be higher in camel milk (Sawaya *et al*., 1984 and Haddadin *et al*., 2008). The content of vitamin A and riboflavin (B2) in dromedary camel milk was found to be lower than that of bovine milk (Sawaya *et al*., 1984, Farah *et al*., 1992 and Stahl *et al*., 2006). The mean concentrations of pantothenic acid, folic acid and B12 in camel milk from Jordan were reported to be much higher than that indicated for bovine milk (Haddadin *et al*., 2008). While, the concentration of vitamin E was very close to that of bovine milk (Farah *et al*., 1992).

2.8.5 Ash:-

The total content of minerals is usually expressed as total ash. This amount was found to range from 0.60 to 0.90% in dromedary camel milk (Konuspayeva *et al*., 2009). The differences in mineral content were affected by several factors such as feeding, breed, analytical procedures (Mehaia *et al*., 1995) and water intake (Haddadin *et al*., 2008). Al haj and Al Kanhal, (2010) reviewed that the mean values of dromedary milk minerals are as follows: calcium, 114 mg/100g, potassium, 156 /100g, sodium, 59/100g, iron, 0.29/100g, magnesium, 10.5/100g, manganese, 0.05/100g and zinc, 0.53/100g. Camel milk is a rich source of chloride (Khaskheli *et al*., 2005). Camels usually prefer halophilic plants such as Atriplex, Salosa and Acacia to meet their physiological requirements of salts (Yagil, 1982). Moreover, the decrease in major milk components and increase in chloride content of milk from dehydrated camels might be another cause for the salty taste in camel milk (Yagil and Etzion, 1980). The minerals Na, K, Fe, Cu and Mn in dromedary camel milk were considerably higher than those reported for bovine milk (Sawaya et al., 1984 and Mehaia *et al*., 1995). Several minerals play important roles in different biological activities such as: Fe is found to play an essential role in a number of biological systems, including oxygen transport and storage as well as DNA synthesis (Al-Attas, 2008), also he stated that Mn plays a key role in cellular metabolism, where the presence of this element is important for the function of a number of enzymes. Furthermore, the content of Ca, P and Mg of dromedary camel milk are close to bovine milk (Sawaya *et al*., 1984).

2.8.6 Camel milk pH:-

pH is the negative log of the hydrogen ion concentration and thus is a very crucial factor to determine the activity of enzymes, dissociation of acid and also the structural conformation of protein. The acidic and bitter taste is also caused due to the pH that is the non-dissociation of the acids. In the manufacturing of dairy products pH plays a significant role to determine the final product quality.

The Natural pH of fresh camel milk ranges from 6.5 to 6.7 (Shalash, 1979, Mehaia *et al*., 1995 and Khaskheli *et al*., 2005), but a slightly lower pH of 6.4 can be recorded (Abu-Taraboush *et al*.,1998 and Yagil *et al*., 1984). Furthermore, Mal *et al*., (2006a and 2006b) mentioned that the pH and acidity of the camel milk have been widely reported to range from

6.36-6.58 and 0.12-0.14, respectively. Moreover, Alwan *et al*., (2014) found that the pH of camel milk was ranged from 6.3 for she-camel reared under normal desert conditions and 6.57 for she-camel reared under good farm conditions. The pH of camel milk is similar to that of sheep milk (Yagil *et al*., 1984), but slightly lower than bovine milk (Sawaya *et al.*, 1984).

2.9 Factors affecting yield and composition of camel milk:-

As mentioned previously, several factors affected camel milk composition including management systems (Bakheit *et al*., 2008, Shuiep *et al*., 2008 and Riyadh *et al*., 2012), geographical locations, feeding conditions (Khaskheli *et al*., 2005 and Bakheit *et al*., 2008), seasons (Shuiep *et al*., 2008; Riyadh *et al*., 2012), stage of lactation and calving number (El-Amin *et al*., 2006, Zeleke, 2007 and Riyadh *et al*., 2012).

2.9.1 Management systems:-

Riyadh *et al*., (2012) found that camel milk composition influenced by management system, they mentioned that the highest level of protein, lactose and SNF were recorded for semi-nomadic system while the lowest values were for nomadic system. Riyadh *et al*., (2012) and Wafa and El Zubeir (2014) mentioned that fat was higher in settled system compared to nomadic and semi-nomadic systems. In contrast they found that pH level was high in semi-nomadic than settled system. Moreover, they reported that minerals contents were lower in nomadic system. Alwan *et al*., (2014) showed that water content, protein, lactose, total solids and acidity were significantly differ for she-camels reared under normal desert conditions than those reared under good farm conditions (both group were in the same age and parity).

According to Qureshi (1986), camel may produce an average of 8 to 20 littres of milk daily, but under intensive management conditions it may produce from 15 to 40 litres daily. Also Khan and Iqbal (2001) reported daily milk yield of camel varies from 3.5 litres (under desert conditions) to 40 litres (under intensive management). Farah (1993) demonstrated that daily milk yield varies from 3.5 litres for camels under desert conditions to 18 litres for those on irrigated land. Also Wafa and El Zubeir (2014) found that the mean daily milk yield of the camels reared under semi intensive farming system is higher than that reared under grazing system.

2.9.2 Season:-

According to Wilson (1998) that the high content of water in the camel milk is an important factor for herders living in the arid zone. Also, Alwan *et al*., (2014) reported that the lactating camel loses water to the milk in times of drought. Salman, (2002) mentioned that camel milk yield in Butana area can reach 8 liters per day in the rainy season and good conditions, but at the end of summer the amount of milk decreases to 1.38 liters/day. On the other hand, Ahmad *et al*., (2012) found that the season of the year had effect on daily milk yield, they revealed daily milk yield higher in winter (8.34 L) than summer (7.89 L). Musaad *et al*., (2013) explained that the highest camel milk yield was recorded in summer with 48.2 L/week, compared with 34.1 L/week in winter.

Shuiep *et al*., (2008) and Haddadin *et al*., (2008) reported a minimum fat content in camel milk at the hot season while it was high in autumn for protein and lactose. Furthermore, Ahmad *et al*., (2012) found that acidity, SNF, fat, protein, lactose and ash of camel milk were affected by season, where fat and protein contents were higher in summer than in winter, wheras, lactose showed the opposite results. Also, Abdelgadir *et al*., (2013) showed that fat and lactose content in camel milk tend to increase in winter and decrease in summer.

2.9.3 Stage of lactation:-

Several studies indicated that camel milk can reach it's peak in different stage of lactation. According to Basmaeil and Bakkar, (1987) who found that the peak yield of camel milk was attained at 14 weeks which persisted for 12 weeks thereafter. Khan and Iqbal (2001) observed that milk yield reached the peak yield during the second to the third month of lactation. Ahmad *et al*., (2012) found that the highest camel milk yield at early stage of lactation was at (1-6) months while Wafa and El Zubeir (2014) stated that it was at (1-3) months.

Abdul Raziq *et al*., (2011) demonstrated that fat and ash content of camel milk was higher in (7^{th} month) of lactation than in the initial stage of lactation (2^{nd} month), while protein and lactose content of camel milk was higher in (2^{nd} month) of lactation than in the late stage of lactation (7^{th} month). Acidity, SNF, Protein and lactose were gradually decreased by subsequent stage of lactation (Ahmad *et al*., 2012). Also pH was affected by lactation stage and declined in 2^{nd} lactation stage than in 1^{st} (Riyadh *et al*., 2012). Also Wafa and El Zubeir (2014) found that the highest content of SNF, fat, protein and lactose were recorded in camel milk during the early stage of lactation (1-3) months.

2.9.4 Parity:-

Various findings were reported by many researchers in the effect of parity in camel milk yield and composition. Bekele *et al*., (2002) revealed that the highest daily milk yield between the third and fifth parities (the highest lactation), and the lowest at the first and after the seventh parity. Furthermore, Musa *et al*. (2006) mentioned that peak milk yield was reached at nine years of age, i.e., at the third or fourth parities. Also Zeleke (2007) stated that the lowest milk yield in camels was at the sixth parity and the highest at the third. Moreover, Raziq *et al*. (2008) found the highest milk production was at the fifth and also mentioned a significant difference between the first parity and all the other ones. Al-Saiady *et al*., (2012) reported that the highest milk productivity at the third and sixth parities. On the other hand Musaad *et al*., (2013) observed that the highest milk yield was at sixth and eighth parities and the lowest was at the first and last (ninth parity).

Riyadh *et al*., (2012) mentioned that the SNF was higher in first (9.73 %) and second parity (9.34 %). Zeleke (2007) and Musaad *et al*., (2013) showed that parity had significant effect on fat, protein and dry matter of camel milk in Eastern Ethiopia, they found that milk fat was higher in the 3rd parity as compared to other parities. Moreover, Abdul Raziq *et al*., (2011) stated that the fat content was highest in the 4th parity camel milk. Also they found the camel milk protein content from the camels in parity 1-3 was lower than that from in parity 4-6.

2.9.5 Breed:-

Several studies indicated that camel milk composition was affected by the breed of lactating camels (Alshaikh and Salah, 1994, Gaili *et al*., 2000, Khaskheli *et al*., 2005, Konuspayeva *et al*., 2009, Ereifej *et al*., 2011 and Riyadh *et al*., 2012). In study of some dromedary camel breed in Saudi Arabia Riyadh *et al*.(2012) found that the Soffer camels breed had highest content of SNF, protein and lactose compared with other studied breeds (Shoal, Majahiem and Maghatier). Hamara and Wadha milk has less protein content as compared to Majaheim milk (Mehaia *et al*., 1995). Moreover, Riyadh *et al*. **:** (2012) reported that pH and minerals content were affected by several factors including breed of the lactating camels. On the other hand, lactose content was found to change slightly for camel milk of some dromedary breeds in different parts of the world (Sawaya *et al*., 1984; Elamin and Wilcox, 1992; Mehaia *et al*., 1995 and Haddadin *et al*., 2008).

2.10 The relationship between yield and composition of camel milk:-

The correlation between milk yield and concentration of the different milk components was significantly negative (Abdelgadir *et al*., 2013). In Bactrian camels fat and protein of milk were the lowest when yield was highest (Cherepanova and Belokobylenko, 1986). In the same issue Ahmad *et al*., (2012) found that a negative relationship between daily milk yield with fat and protein contents in dromedaries camels. Furthermore, Bachmann and Schulthess(1987) mentioned that two-thirds of each Randille and Somali camels had a negative correlation between milk yield and total solids while the third had positive correlation. On the other hand, Alshaikh and Salah, (1994) studied the effect of milking interval on secretion rate of milk and milk composition and concluded that milking frequency has been observed to change the milk composition in camels.

2.11 The medical significance of camel's milk:-

Unique composition and nutritional values of camel milk are well known from ancient times for its beneficial health effects. The medical significance of camel's milk was documented in the Sunnah before 1400 years by Prophet Mohamed Peace Be Upon Him. Camel milk is remedy for viruses causing diarrhea as Rota Virus considering it could be important from public health point of view to anticipate the vital hazard in camel raw milk and its products. Furthermore, the fermented camel milk can be considered as a good food of high nutritive and therapeutic applications. Meanwhile, the high content of antimicrobial agents in camel milk may explain its potential as an antiviral activity especially against diarrhea-causing viruses (Mona *et al*., 2010). Also Al haj and Al Kanhal (2010) mentioned that camel milk has Hypocholesterolaemic, hypoglycaemic, antimicrobial and hypoallergenicity effects.

Camel milk plays a significant role in human diet in arid countries and hot regions. It is just like the bovine milk in its essential nutrients and since ancient times being used for curing a number of diseases. It is unique from other ruminant milk in terms of its composition as well as its functionality, as it contains high concentration of immuneglobulins and insulin. Furthermore, it is high in vitamins (A, B_2, C and E) and minerals (sodium, potassium, iron, copper, zinc and magnesium) and low in protein, sugar and cholesterol. Vitamins present in camel milk have antioxidant activity and helpful in controlling tissue damage caused by harmful substances. Raw camel milk as well as its fermented products is used as curative agents to manage constipation, diarrhea, stomach ulcers, wounds, liver disorders and to improve ovulation of female ovaries. Moreover, camel milk is full of evenly balanced nutritional constituents and also displays a wide variety of biological actions that influence growth and development of particular body organs, metabolic responses towards nutrients absorption, digestion and fight against diseases. It allows maintaining a positive microflora, encourages development of bifido-bacteria and therefore, can be recommended for use in variety of products as a functional food. Overall camel milk is beneficial with enriched nutrients that are good for health (Seher *et al*., 2013).

Many researches try to clarify the health benefits of omega 3 fatty acids. The U.S. Food and Drug Administration gave "qualified health claim" status to Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) *n*−3 fatty acids, stating that "supportive but not conclusive research shows that consumption of EPA and DHA [*n*−3] fatty acids may reduce the risk of coronary heart disease.". Likewise, researchers find that *n*−6 fatty acids (such as γ-linolenic acid and arachidonic acid) play a similar role in normal growth. However, they also find that *n*−6 was "better" at supporting dermal integrity, renal function, and parturition. These preliminary findings led researchers to concentrate their studies on *n*−6, and it is only in recent decades that *n*−3 has become of interest (Lands, 1992).

Chapter three

3. Materials and Methods

This study was conducted in Butana area and Khartoum state during 2012 to 2014 starting with general survey to collect the information about the camel owners and their adopted practices in camel production in the different seasons, collection of favored browser plant grasped by camels and camel milk samples.

3.1 Questionnaire:-

A set of detailed structured questionnaires were used to collect information from total of 200 (summer n=100, winter n=100) camel owners in outdoor system as interview conducted over single visit (Appendix.1). The questionnaire was designed to obtain information on general household information, herd structure purpose and size, management systems/field practices and feeding/watering practices.

3.2 Source of samples:-

3.2.1 Browser plant samples:-

A total of 23 Samples (9 plants in summer and 14 in winter as showed on table 3) of edible parts of favorable plants for camel available in outdoor system were collected in paper bags and kept the bag open for several weeks under shade in room temperature until dried then grinded, mixed and 10 gm from each plants samples were taken in plastic self tied sachets and sent to the lab for analysis.

Table 3 favorable plants for camel found in outdoor system

Type of plant	**Scientific name**	**Local name**
Trees	*Acacia senegal*	Hashab

	Balanites aegyptiaca	Hegleig
	Acacia mellifera	Kitir
	Acacia nubica	Laoat
	Acacia chrenbergiana	Salam
	Acacia tortilis	Sayyal
	Ziziphus spirachristi	Sidir
	Acacia nilotica	Sunut
	Acacia seyal	Talih
Weed and grasses	*Tragus beteroianus*	Abuareda
	Launaea cornuta	Molaita
	Cassia angustifolia	Senna makka
	Blepharis edulisi	Siha

3.2.2 Milk samples:-

The study was conducted in two management systems outdoor system (traditional nomadic system) and indoor system (intensive system) and two seasons (summer and winter). Outdoor system milk samples were taken from Butana area (Showak, Sharif Hassab Allah , um-gargoor, Alsobagh and Tambool) and indoor milk system samples were taken from Khartoum state. A total of 111 camel (*Camelus dromedaries*) milk samples in different management systems and season [56 indoor (31 in summer, 25 in winter) and 55 out door (30 in summer, 25 in winter)] were randomly collected (40 ml) in clean plastic containers were taken separately from milk pot after individual milking of she-camel in June 2013 for summer samples and

February 2014 for winter samples. Samples were kept in ice thermo flask until analysis.

3.2.3 Camel milk samples for fatty acids:-

A total of 76 camel (*Camelus dromedaries*) milk samples out of the 111 samples in different management systems and season [38 indoor (18 in summer, 20 in winter) and 38 outdoor (18 in summer, 20 in winter)] were randomly selected (10 ml) in clean plastic containers. Samples were kept in ice thermo flask until analysis of fatty acids.

3.3 Analysis of samples:-

3.3.1 Browser plants analysis:-

To determine moisture, protein, Fat, fiber, ADF, NDF, starch, sugar and ash using Bruker Optik GmbH, Rudolf-Plank-Straße 27, D-76275 Ettlingen device based on specific Infra Red spectra for the trees in studied area.

3.3.2 Physicochemical analysis of camel milk:-

Some physicochemical analysis including density, conductivity, freezing point, pH, fat, solids non fat, lactose, protein and ash, were done using automatic milk analyzer device Lactoscan™, model name: LA, Bulgaria.

3.3.3 Preparation of samples for fatty acids analysis:-

Transesterification method as described by Lewis *et al*., (2000) was used to determine the fatty acid profiles and method steps as following:

1. 5 ml of milk was taken in screw capped tube.
2. Add 3 ml of methanolic HCl 1% to the milk.
3. 2 ml of methanol and 2 ml of hexane was added.
4. The tube was closed tightly and heated at 100°C for one hour in water bath and it was shaked many times during heating process.
5. Then it was cooled at room temperature.

6. 2 ml hexane and 2 ml distill water was added and mixed it not vigorously.
7. The mixed was taken to centrifuge in 2000 run per minute for one minute.
8. Finally the upper layer of hexane was taken to small tube and small amount of sodium sulphate (anhydrous) was added then injected in Gas chromatography (GC) device.

3.3.3.1 Fatty acids analysis:-

Fatty acids analysis including area, height, area% and height% were done using Gas chromatography, GC-2010, Shimadzu, Japan. With DB-1 oven column of 0.30μ length, diameter 0.25 μm and 0.25 μm film thickness.

3.4 Feeding of camels:-

In indoor system the camels are kept in dairy farms under semi-intensive system management with relatively good and clean water supply and feed on fresh bersim, fresh abu 70 and abu 70 hay in addition to complementary diet contains: ground nut cake, sorghum grain, wheat bran that provided to dairy cow. The construction of house builds to prevent camels from the direct sunlight. While in outdoor system, natural grazing is used among *Abbala* who practice traditional movement searching for natural pastures.

3.5 Statistical analysis:-

Questionnaire results were analyzed mainly in the form of descriptive tabular summaries and Chi-square test was used. Independent samples T. test was used to analyze the chemical composition of the browser plants in the two seasons.

Independent samples T. test was used to analyze the obtained data of the effect of management systems and season on some physicochemical components of Sudanese camel’s milk data.

Complete randomized design was used to analyze the obtained data of the effect of parity and breed on milk yield and physicochemical components using one way ANOVA followed by Least significant difference test (LSD). The correlation between different physicochemical components of camel milk was calculated using simple correlation (Pearson).

Fatty acid profiles analyses were done using descriptive tabular summaries, general linear model followed by LSD test as 2 X 2 factorial arrangements was used to analyze the effect of management systems and season on fatty acid profiles.

Chapter four

4. Results

4.1 General household information:-

The results from questionnaire showed that most of camel owners (71%) were above 40 years old, table (4). Most of owners were illiterate, figure (1). The results also showed that 7% of camel owners had experience less than 10 years while the majority 78% had more than 20 years table (5).

Table 4: Age group of camel owners

Age group (years)	n	%
20-40	58	29
40-60	70	35
over 60	72	36
Total	200	100.0

Figure 1. Education level of camel owners

Table 5: Experience of camel owners

Experience (years)	n	%
less than 10	14	7
10-20	30	15
more than 20	156	78
Total	200	100

4.2 Herd structure, purpose and size:-

The questionnaire survey showed that about 61% of camel owners owned camel, sheep, goat and cattle followed by those owned camel only (38%) and few of them owned camel and cattle (table 6). More than 40% of interviewed owners keep camels for milk only while 55% keep camel for milk and other purposes (table 7). The obtained results from interviewed owners showed that around 50% have mature camels with age ranged between 5 to 15 years followed by growers camels (1-4 years) (table 8).

Table 6: Livestock species in the studied area

Livestock species	n	%
Camel	76	38
Camel, cattle	2	1
Camel, sheep, goat	98	49
Camel, sheep, goat, cattle	24	12
Total	200	100

Table 7: Purpose of keeping camels in the studied area

Purpose	n	%
Milk	86	43
Milk, Holding	54	27
Milk, racing	40	20
Racing, holding, milk	16	8
Holding	2	1
Racing	2	1
Total	200	100

Table 8: Camel herd composition in the studied area

Camel age categories (year)	n	%	Range	Mean
Less than one	2720	14.85	1 – 46	13.60
Between 1-4	4406	24.04	0 – 77	22.03
Between 5-15	8712	47.54	4 – 168	43.56
More than15	2486	13.57	0 – 70	12.43
Total	18324	100		

4.3 Management systems and milking practices:-

The majority of camel owners adopted the semi-sedentary system, followed by those owners adopted the nomadic management system, while the lowest of them adopted the semi-nomadic system (Figure 2).

Figure 2. Management systems in the studied area

Milk production can be categorized into three groups, less than 2.25 kg, from 2.25 to 4.5 kg and more than 4.5kg, more than 50% of camel owners milked their camels twice a day followed by those who milked their camels ones a day (figures 3). On the other hand the most of camels (83%) produce more than 2.25 kg in winter compare to 47% in summer, in contrast to those produce less than 2.25 kg as 17% in winter and 53% in summer, The chi-square test was found to be significant ($\chi^2 = 130.1$, $P < 0.01$), figure (4).

The results showed that 56% of the camel owners allow the calves to suck one quarters of udder in summer, while 71% of them allow the calves to suck more than two quarters in winter, The chi-square test was found to be significant ($\chi^2 = 36.61$, $P < 0.01$) between average of milk production in different season. (table 9)

Figure 3. Milking numbers practiced by camel owners

Figure 4. Effect of season on average milk production (kg)

Table 9: Effect of season on amount of milk providing to young camel

	Season				Overall	
	Summer		Winter			
	N	%	n	%	n	%
One quarter	56	56	0	0	56	28
Two quarters	44	44	29	29	73	36.5
More than two quarters	0	0	71	71	71	35.5
Total	100	100	100	100	200	100

4.4 Feeding and watering practices:-

About 50% of camel owners didn't provide any additional feed to their camels followed by 32.5% provide both sorghum grain and stalks, while about 15% offer only grains to their camels and the lowest percentage of camel owners supply their camels with sorghum stalks only (table 10), The chi-square test revealed insignificant ($\chi^2 = 0.957$, $P > 0.05$) between type of additional feed in different season. Elsewhere the majority of camel owners (56%) watering their camels in less than 3 days interval, whereas 71% watering their camels in more than 5 days interval in winter (table 11), The chi-square test for independence was found to be significant ($\chi^2 = 130.1$, $P < 0.01$).

Table 10: Effect of season on feeding camels

Type of additional Feeds	Season				Overall	
	Summer		Winter			
	n	%	n	%	n	%
No additional feed	48	48	47	47	95	47.5
Feeding sorghum grain + stalks	32	32	33	33	65	32.5
Feeding sorghum grain	16	16	15	15	31	15.5
Feeding sorghum stalks	4	4	5	5	9	4.5
Total	100	100	100	100	200	100

Table 11: Effect of season on drinking interval

Drinking interval (day)	Season				Overall	
	Summer		Winter			
	n	%	n	%	n	%
Less than 3	56	56	0	0	56	28
Between 3-5	44	44	29	29	73	36.5
More than 5	0	0	71	71	71	35.5
Total	100	100	100	100	200	100

Table 12: Type of extension services provided in the study area

Type of extension service	n	%
No extension service	134	67.0
Diseases awareness	30	15.0
Increase the productivity	28	14.0
Range management	8	4.0
Total	200	100.0

Most of camel owners mentioned that they did not receives any extension services, while 33% of them mentioned that they received awareness about diseases of camels, increases of camel productivity and range management (table 12).

4.5 Effect of season on proximate analysis of browser plants:-

The results revealed significant effects of season on all proximate analysis parameters of the studied browser plants except for starch and ADF as showed in table (13 and 14). Moreover the overall proximate analysis parameters of winter samples record higher values compare to summer samples except starch, CF, ADF and NDF. The results showed that Hashab, Higlieg, Kitir, Laoat and Talih records higher values of starch in summer compare to winter’s values, with exception of Laoat and Talih the results showed that winter values was higher in sugar. The results of proximate analysis parameters of the different browser plants species affected by season showed significant differences in all proximate analysis parameters of the studied browser plants except moisture in Salam, fat in Sidir and ADF in Hashab. Regarding protein results Sayyal in winter had the highest value, while Hashab had the lowest value. Concerning moisture, fat and sugar in winter samples, Higlieg showed the highest values in moisture and sugar whereas, Sayyal records the highest value in fat. Elsewhere, Salam showed the lowest value in moisture, Hashab had the lowest value in fat and Sidir had the lowest value in sugar. Salam showed the highest value in ash while, Sidir had the lowest value.

The results of weeds and grasses showed that Molaita had the highest values in protein, fat, starch, sugar and ADF, also Siha records the highest value in moisture. While, Senna maka had the lowest values in moisture, protein, starch and ash (table 15).

Table 13: Effect of season on moisture, protein, fat and ash of different browser plant

Hashab	Higlieg	Kitir	Laoat	Salam	Sayyal	Sidir	Sunu

	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S
Moisture	4.81± 0.03	9.06± 0.03	9.11± 0.03	12.0± 0.07	6.10± 0.03	11.24± 0.04	8.87± 0.06	7.60± 0.04	4.96± 0.08	5.04± 0.04	7.38± 0.62	9.05± 0.04	8.74± 0.04	9.21± 0.03	6.68± 0.07
P. value	0.000		0.000		0.000		0.000		0.209		0.042		0.000		0.005
Protein	6.52± 0.06	18.0± 0.04	13.7± 0.03	24.3± 0.09	26.10± 0.13	27.93± 0.12	25.27± 0.14	27.58± 0.02	9.74± 0.17	16.58± 0.44	22.37± 0.01	33.42± 0.03	24.54± 0.03	26.83± 0.07	18.66± 0.10
P. value	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000
Fat	0.13± 0.02	0.83± 0.07	7.49± 0.26	8.91± 0.06	3.60± 0.07	9.27± 0.04	1.73± 0.04	7.06± 0.01	1.44± 0.05	2.66± 0.37	4.11± 0.07	9.06± 0.04	6.92± 0.02	6.97± 0.03	4.54± 0.03
P. value	0.000		0.008		0.000		0.000		0.027		0.000		0.071		0.000
Ash	5.29± 0.03	13.7± 0.13	7.79± 0.05	13.2± 0.08	9.87± 0.05	11.47± 0.06	10.23± 0.04	10.36± 0.04	10.10± 0.05	21.52± 0.41	13.97± 0.07	10.70± 0.08	3.57± 0.03	4.21± 0.04	11.12± 0.03
P. value	0.000		0.000		0.000		0.012		0.000		0.000		0.000		0.000

S: Summer, W: winter

Table 14: Effect of season on carbohydrates of different browser plants in the

	Hashab		Higlieg		Kitir		Laoat		Salam		Sayyal		Sidir		Sunu
	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S
Starch	10.3± 0.64	3.66± 0.60	15.4± 0.21	13.9± 0.36	11.26± 0.20	5.15± 0.32	16.22± 0.49	10.23± 0.39	3.07± 0.22	9.59± 0.25	3.04± 0.25	6.76± 0.53	6.80± 0.09	7.36± 0.33	12.10± 0.22
P. value	0.000		0.003		0.000		0.000		0.000		0.000		0.048		0.000
Sugar	1.02± 0.08	8.28± 0.08	7.02± 0.01	18.8± 0.10	5.84± 0.04	10.27± 0.04	9.71± 0.05	5.43± 0.06	1.93± 0.03	7.70± 0.18	3.74± 0.07	12.44± 0.03	0.49± 0.02	0.65± 0.04	1.84± 0.08
P. value	0.000		0.000		0.000		0.000		0.000		0.000		0.005		0.000
CF	32.3± 0.39	22.2± 0.24	21.7± 0.50	6.57± 0.06	18.63± 0.06	4.99± 0.03	16.53± 0.07	10.05± 0.11	29.24± 0.11	21.43± 0.50	15.62± 0.03	5.59± 0.07	1.33± 0.03	1.57± 0.11	21.37± 0.05
P. value	0.000		0.000		0.000		0.000		0.000		0.000		0.019		0.000
ADF	40.4± 0.04	43.3± 2.87	25.6± 0.12	12.4± 0.04	36.55± 0.20	15.82± 0.14	32.43± 0.10	33.11± 0.18	53.53± 0.14	54.95± 0.23	45.37± 0.02	18.12± 0.14	14.23± 0.03	15.53± 0.45	52.66± 0.02
P. value	0.224		0.000		0.000		0.004		0.001		0.000		0.008		0.000

NDF	78.1± 0.40	33.3± 0.70	48.9± 0.22	1.77± 0.27	38.71± 0.39	11.71± 0.43	31.82± 0.21	24.41± 0.25	71.47± 0.41	82.04± 0.09	34.89± 0.56	11.38± 0.31	15.43± 0.03	16.59± 0.27	51.83± 0.33	[illegible]
P. value	0.000		0.000		0.000		0.000		0.000		0.000		0.017		0.000	

S: Summer, W: winter, CF: crude fiber, ADF: acid detergent fiber, NDF: neutral detergent fiber

Table 15: proximate analysis of different weeds and grasses in winter in the study are

	Moisture	Protein	Fat	Starch	Sugar	CF	ADF	NDF
Siha	9.37±0.04	22.88±0.08	0.89±0.05	9.20±0.08	11.02±.05	18.16±0.08	41.69±0.12	33.50±1.09
Molaita	9.20±0.10	30.45±0.12	3.61±0.09	10.54±0.36	13.93±0.07	12.13±0.15	45.04±0.18	8.96±0.35
Senna maka	6.98±0.03	13.99±0.01	3.23±0.04	7.04±0.08	12.49±0.01	12.97±0.09	23.92±0.07	26.54±0.32
Abuareda	7.62±0.03	28.57±0.18	0.61±0.10	7.61±0.20	6.70±0.10	16.75±0.15	44.72±0.34	29.82±0.66

4.6 Effect of management systems and season on some physicochemical components of camel milk:-

The mean values of camel milk yield and physicochemical components that influenced by management systems and season were showed in table 16 and 17.

The results revealed that management systems and season had significant effect on most physicochemical parameters. The milk yield, Density and freezing point were higher in indoor system and in winter. But conductivity showed contrary results. While pH was higher in outdoor and winter. SNF and protein showed higher values in indoor system and summer. Fat and ash content were higher in indoor and winter in contrast to lactose content.

The management system had high significant effect (P<0.01) on camel milk yield, density, conductivity and ash, significant effect (P<0.05) on pH, fat and protein. Whereas, freezing point, solid non fat, lactose showed no significant differences (P>0.05). Outdoor system ranked higher values in conductivity, pH, SNF, protein and lactose.

Season was significantly affected the conductivity, fat, protein and ash while, it had no significant effect on other parameters. Conductivity was higher in summer than winter, but fat and ash content 3.88% and 0.65% was found to be higher in winter than summer. In contrast, protein content showed higher mean value in summer 3.50% compare to those samples collected in winter 3.17%.

Table 16 Effect of management system on some physicochemical components of Sudan

Parameters / Management system	Milk yield (kg)	Density (Kg/m3)	Freezing Points (˚C)	Conductivity (mS/cm)	pH	SNF (%)	Fat (%)	Prote (%)
Indoor	5.85	28.74	0.51	6.37	5.98	8.46	3.58	3.29

Outdoor	3.95	27.30	0.49	6.46	6.58	8.63	3.36	3.45
P. value	0.000	0.008	0.069	0.000	0.017	0.289	0.023	0.02

Indoor (n=56), outdoor (n=55)

Table 17 Effect of season on some physicochemical components of Sudanese ca

Parameters / Season	Milk yield (kg)	Density (Kg/m3)	Freezing Points (˚C)	Conductivity (mS/cm)	pH	SNF (%)	Fat (%)	Prote (%)
Summer	4.92	27.91	0.49	7.64	6.09	8.64	3.14	3.50
Winter	5.11	28.34	0.51	4.71	6.47	8.40	3.88	3.17
P. value	0.822	0.830	0.479	0.000	0.075	0.206	0.000	0.00

Summer (n=61), winter (n=50)

4.7 Effect of parity on some physicochemical components of camel milk:-

The mean values of camel milk yield and component affected by parity number showed significant differences in milk yield, SNF, fat and protein ($P<0.05$) contents in different parities Table 18. The results revealed that density, freezing point, conductivity, pH, lactose and ash showed no significant differences ($P>0.05$). Fourth and third parities shows higher milk yield (5.68 and 5.16 kg respectively) while first lactation showed the lowest (4.05 kg). Moreover, SNF, Fat and protein contents showed gradual reduction by subsequent parity except in second lactation. Starting from the third lactation SNF, fat and protein contents gradually decreased. Also the first and second lactation showed highest SNF (7.86 and 8.1%) respectively while the other lactation showed no significant difference ($P>0.05$). Elsewhere, the results showed that the milk in the first parity had the highest fat content (4.06%) with no significant difference (from second to fifth lactation). In addition, there was slight decrease in fat content from 3.61 to 3.49%.

Table 18: Effect of parity number on milk yield and component of Sudanese Camel

Parity	Milk yield (kg)	Density (kg/m^3)	Freezing point (˚C)	Conductivity (mS/cm)	pH	SNF (%)	Fat (%)	Protein (%)	Lactose (%)	Ash (%)
1st (N=16)	4.05± 1.26^{b}	27.5± 1.21	0.51± 0.02	7.78± 1.25	6.66± 0.15	7.86± 0.36^{ab}	4.06± 2.75^{a}	2.87± 0.13^{a}	4.32± 0.27	0.58± 0.08
2nd (N=8)	4.48± 1.25^{ab}	28.6± 1.44	0.51± 0.03	6.74± 0.93	6.65± 0.05	8.1± 0.39^{a}	3.61± 0.44^{ab}	2.96± 0.14^{a}	4.61± 0.24	0.6± 0.1
3rd (N=16)	5.16± 1.41^{a}	27.13± 1.99	0.47± 0.05	8.23± 1.75	6.62± 0.13	7.62± 0.61a^{bc}	3.37± 0.92^{b}	2.78± 0.22^{ab}	4.34± 0.5	0.58± 0.06
4th (N=15)	5.68± 1.95^{a}	26.92± 2.29	0.48± 0.04	7.8± 1.39	6.59± 0.08	7.54± 0.68^{b}	3.25± 0.98^{b}	2.75± 0.25^{b}	4.45± 0.54	0.6± 0.05
5th (N=5)	4.81± 0.88^{ab}	25.94± 3.38	0.47± 0.07	8.41± 2.59	6.66± 0.13	7.18± 0.97^{bc}	2.67± 0.86^{b}	2.62± 0.35^{b}	4.4± 1.09	0.56± 0.06
Over all	4.88± 1.56	27.26± 2.02	0.49± 0.04	7.82± 1.56	6.63± 0.12	6.69± 0.62	3.49± 0.91	2.81± 0.22	4.4± 0.5	0.59± 0.07
P. value	0.043	0.187	0.085	0.228	0.404	0.045	0.013	0.045	0.704	0.671

Different superscript letters in the same column means significant at P<0.05

4.8 Effect of breed on some physicochemical components of camel milk:-

Effect of breed on physicochemical milk components is shown in Table 19. Milk yield, freezing point, conductivity, SNF, fat, protein, lactose, and ash differed significantly (P<0.05). Kenana type showed the highest milk yield (5.95 kg) compared to Arabi (3.93 kg) which is the lowest. While, freezing point, SNF, fat, protein, lactose and ash in Anafi type showed the lowest level compared to other breeds. Also the results showed that milk obtained from Anafi breed showed significantly high in conductivity while Daili was the lowest (6.95) with no significant difference (P>0.05) between Kenana and Arabi. Most of the parameters showed positively correlation (P<0.01) with each other as shown in Table 20.

Table 19: Effect of breed type on milk yield and components of Sudanese camel

Type	Milk yield (kg)	Density (Kg/m^3)	Freezing point (˚C)	Conductivity (mS/cm)	pH	SNF %	Fat %	Protein %	Lactose %	Ash %
Anafi (N=10)	5.22± 1.14^{ab}	25.38± 1.84	0.43± 0.04^{b}	9.25± 1.3^{a}	6.62± 0.1	7± 0.59^{b}	2.53± 0.76^{b}	2.57± 0.21^{b}	3.91± 0.43^{b}	0.57± 0.08^{b}
Kenana (N=21)	5.92± 1.55^{a}	28.44± 4.88	0.50± 0.04^{a}	7.98± 1.36^{b}	6.62± 0.12	8.1± 1.31^{a}	4.04± 0.64^{a}	2.96± 0.48^{a}	4.45± 0.72^{a}	0.66± 0.11^{a}
Daili (N=12)	4.34± 1.35^{c}	28.21± 1.69	0.50± 0.03^{a}	6.95± 1.2^{c}	6.63± 0.1	7.97± 0.55^{a}	3.49± 0.69^{a}	2.91± 0.2^{a}	4.57± 0.39^{a}	0.56± 0.05^{b}
Arabi (N=18)	3.93± 1.19^{c}	27.45± 1.5	0.50± 0.03^{a}	7.45± 1.6^{bc}	6.65± 0.13	7.73± 0.49^{a}	3.53± 1.05^{a}	2.83± 0.18^{a}	4.69± 0.54^{a}	0.55± 0.06^{b}
Over all	4.91± 1.56	27.6± 3.28	0.49± 0.04	7.83± 1.55	6.63± 0.12	7.79± 0.94	3.53± 0.94	2.85± 0.34	4.46± 0.62	0.59± 0.09
P. value	0.000	0.091	0.000	0.002	0.550	0.035	0.000	0.016	0.009	0.000

Different superscript letters in the same column means significant at P<0.05

Table 20: Milk components correlation matrix of some Sudanese camel breed types (n=60)

	Milk yield	Density	Freezing point	Cond.	pH	SNF	Fat	Protein	Lactose	Ash
Milk yield	1	0.116	-0.111	0.180	0.148	0.096	-0.038	0.099	-0.127	0.386**
Density	-	1	0.504**	-0.343**	0.083	0.980**	0.419**	0.982**	0.698**	0.676**
Freezing point	-	-	1	-0.479**	0.236	0.541**	0.455**	0.537**	0.593**	0.219
Conductiviy	-	-	-	1	-0.152	-0.376**	-0.316*	-0.375**	-0.195	0.099
pH	-	-	-	-	1	0.067	-0.004	0.063	0.043	-0.092
SNF	-	-	-	-	-	1	0.578**	1**	0.684**	0.667**
Fat	-	-	-	-	-	-	1	0.567**	0.306*	0.317*
Protein	-	-	-	-	-	-	-	1	0.684**	-0.67**
Lactose	-	-	-	-	-	-	-	-	1	0.546**
Ash	-	-	-	-	-	-	-	-	-	1

**: correlation is significant at $P<0.01$ *: correlation is significant at $P<0.05$

4.9 Fatty acids composition of camel milk in different management systems and seasons:-

Regarding whole fatty acids composition the camel milk pattern of FA showed in table 21 revealed that the fatty acids ranged from C6 to C24, the most frequent fatty acids were C13:0, C18:2 ω-6, C18:1 ω-9, C16:0, C15:0 and C12:0 while the less frequent were C24:1, C24:0, C22:6 and C6. The results revealed that C24:1 ω-9 and C22:6 ω-3 exist just in outdoor-winter system, in contrast to C14:1 and C20:5 which absent in outdoor-winter. C6:0 showed the highest concentration 53.92% in outdoor-summer while it was not found in winter in both management systems, also C8:0 is not found in indoor winter. C24:0 records the second rank of concentration 42.67% followed by C17:1 40.77%. On the other hand the less concentration was recorded by C22:2 ω-6 in summer in both management systems, also C22:1 ω-9 record low concentration 0.96% (table 22).

Table 21: Fatty acid composition of camel milk fat in study area

Fatty acids	Chemical name	frequency	%
C6:0	Caproic	7	8.97
C8:0	Caprylic	11	14.10
C10:0	Capric	31	39.74
C11:0	Undecanoic	45	57.69
C12:0	Lauric	55	70.51
C13:0	Tridecanoic	63	80.77
C14:0	Myristic	54	69.23
C14:1	Myristoleic	19	24.36
C15:0	Pentadecanoic	55	70.51
C15:1	Cis-10-Pentadecanoic	17	21.79
C16:0	Palmitic	56	71.79
C16:1	Palmitoleic (Omega 7)	22	28.21
C17:0	Heptadecanoic	36	46.15
C17:1	Cis-10-Heptadecanoic	11	14.10
C18:0	Stearic	22	28.21
C18:1	Oleic (Omega 9)	58	74.36
C18:2	Linoleic (Omega 6)	59	75.64
C20:0	Arachidic	44	56.41
C20:1	Eicosenoic (Omega 9)	33	42.31
C20:3	Eicosatrienoic (Omega 6)	25	32.05
C20:4	Eicosatetraenoic (Omega 6)	44	56.41
C20:5	Eicosapentaenoic (Omega 3)	9	11.54
C21:0	Henicosanoic	11	14.10
C22:1	Erucic (Omega 9)	9	11.54
C22:2	Docosadienoic (Omega 6)	9	11.54
C22:6	Docosahexaenoic (Omega 3)	3	3.85
C23:0	Tricosanoic	18	23.08
C24:0	Tetracosanoic	3	3.85
C24:1	Nervonic acid (Omega 9)	1	1.28

Table 22: Fatty acid concentration (area %) in different management

systems and season

Management system / Season	Indoor		Outdoor	
	Summer	Winter	Summer	Winter
C6:0 Caproic	9.03	0.00	53.92	0.00
C8:0 Caprylic	9.13	0.00	11.03	1.95
C10:0 Capric	16.56	28.03	8.51	7.99
C11:0 Undecanoic	4.48	12.00	3.40	1.63
C12:0 Lauric	4.55	10.57	4.30	3.02
C13:0 Tridecanoic	4.52	8.52	4.81	4.34
C14:0 Myristic	9.44	5.03	8.22	7.68
C14:1 Myristoleic	9.22	7.56	9.00	0.00
C15:0 Pentadecanoic	2.40	22.78	2.60	5.66
C15:1 Cis-10-Pentadecanoic	2.79	4.10	2.43	5.76
C16:0 Palmitic	11.64	4.86	18.82	23.13
C16:1 Palmitoleic (Omega 7)	16.91	16.09	5.22	6.67
C17:0 Heptadecanoic	2.38	25.03	2.48	6.54
C17:1 Cis-10-Heptadecanoic	40.77	3.87	6.55	5.65
C18:2 Linoleic (Omega 6)	7.65	20.56	7.29	2.74
C18:1 Oleic (Omega 9)	27.83	14.55	20.52	25.70
C18:0 Stearic	2.13	12.55	6.04	9.92
C20:0 Arachidic	3.19	15.33	4.15	4.78
C20:1 Eicosenoic (Omega 9)	2.08	23.65	3.50	5.82
C20:3 Eicosatrienoic (Omega 6)	1.34	7.71	6.82	4.97
C20:4 Eicosatetraenoic (Omega 6)	3.51	8.34	5.53	6.74
C20:5 Eicosapentaenoic (Omega 3)	1.80	6.57	2.24	0.00
C21:0 Henicosanoic	6.98	12.98	8.23	13.74
C22:1 Erucic (Omega 9)	0.96	9.64	1.31	4.47
C22:2 Docosadienoic (Omega 6)	0.59	7.04	1.05	5.50
C22:6 Docosahexaenoic (Omega 3)	0.00	0.00	0.00	6.24
C23:0 Tricosanoic	0.38	8.49	6.55	4.31
C24:0 Tetracosanoic	42.67	7.95	0.00	0.00
C24:1 Nervonic (Omega 9)	0.00	0.00	0.00	2.85

4.10 Fatty acids profiles frequency and concentration in different management systems and seasons:-

Table 23: Frequency of fatty acid profiles in different management systems

Fatty acid (FA) profiles	Management system				Overall	
	Indoor		Outdoor			
	n	%	n	%	N	%
SAT	203	55.7	309	66.2	512	61.6
MUSAT	88	24.2	82	17.6	170	20.4
PUSAT	73	20.1	76	16.2	149	18
Total	364	100	476	100	831	100

For this table and subsequent tables: n: frequency, N: total number, SAT: Saturated Fatty acids, MUSAT: Mono Unsaturated Fatty acids, PUSAT: Poly Unsaturated Fatty acids

The most frequent profile of fatty acids was saturated fatty acids (SAT) 61.6% which was high in outdoor system 66.2% and summer 66.7%, while it was in contrast to poly unsaturated fatty acids (PUSAT) which showed the lowest frequent in the same management system and season table 23 and 24.The concentration results of fatty acids profile (table 25) revealed that the mono unsaturated fatty acids (MUSAT) concentration was the highest in summer season in both management systems and outdoor-winter, while PUSAT was the lowest concentration in the same management systems and season.

Table 24: Frequency of fatty acid profiles in different seasons

Fatty acid (FA) profiles	Season				Overall	
	Summer		Winter			
	n	%	n	%	N	%
SAT	292	66.7	220	55.8	512	61.6
MUSAT	68	15.6	102	25.9	170	20.4
PUSAT	77	17.7	72	18.3	149	18.0
T[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 25: Fatty acid profiles concentration (area %) in different management systems and season

Management system		Indoor		Outdoor	
	Season	Summer	Winter	Summer	Winter
SAT		7.15	14.47	7.65	7.30
MUSAT		20.10	11.30	11.20	14.32
PUSAT		4.47	13.66	6.22	5.37

Fatty acids (FA)	Management system					
	Indoor		Outdoor		Overall	
	n	%	n	%	N	%
Omega 3 FA	6	4.7	6	4.2	12	4.4
Omega 6 FA	66	52.0	70	48.6	136	50.2
Omega 7 FA	19	15.0	3	2.1	22	8.1
Omega 9 FA	36	28.3	65	45.1	101	37.3
Total	127	100	144	100	271	100

4.11 Omega fatty acids profiles frequency and concentration in different management systems and seasons:-

The results showed that omega 6 FA records the highest in both management systems and seasons followed by omega 9 FA while omega 3 was somewhat records the lowest values, table 26 and 27. On the other hand omega 9 revealed the highest concentration in both management systems and seasons followed by omega 7 except in outdoor-summer 5.22 %, while omega 3 is somewhat the lowest concentration, table 28.

Table 28: Omega fatty acids concentration (area %) in different management systems and season

Management system	Indoor		Outdoor	
Season	Summer	Winter	Summer	Winter
Omega 3	1.80	6.57	2.24	6.24
Omega 6	4.92	14.0	6.53	5.28
Omega 7	16.91	16.09	5.22	6.67
Omega 9	19.94	17.29	14.21	15.39

	Summer		Winter			
	n	%	n	%	N	%
Omega 3 FA	7	5.4	5	3.5	12	4.4
Omega 6 FA	69	53.1	67	47.5	136	50.2
Omega 7 FA	5	3.8	17	12.1	22	8.1
Omega 9 FA	49	37.7	52	36.9	101	37.3
Total	130	100	141	100	271	100

4.12 Saturated fatty acids profiles frequency in different management systems and seasons:-

Regarding saturated fatty acids frequency of the camel milk in different management systems table 29 and seasons table 30 revealed that the saturated fatty acids ranged from C6:0 to C24:0, the most frequent fatty acids were C13:0, C16:0, C15:0 and C12:0 while the less frequent was C24:0 in both management systems and seasons. In indoor system C13:0 showed the highest frequent followed by C12:0, while C8:0 and C24:0 showed the lowest with the same value 1.48%. Moreover, in outdoor C16:0 records the highest value followed by C13:0, while C6:0 showed the lowest value and C24:0 is absent. In summer C13:0 and C16:0 records the highest with the same value 12.03% followed by C14:0 whereas C24:0 was the lowest value. Elsewhere in winter C13:0 revealed the highest value followed by C15:0 and C20:0 with 10.91% for both also C14:0 and C17:0 revealed the same values 10%, whereas C24:0 showed the lowest and C6:0 was absent.

Table 29: Frequency of saturated fatty acid in different management systems

Fatty acid	Chemical name	Management				Overall	
		Indoor		Outdoor			
		n	%	n	%	N	%
C6:0	Caproic	5	2.46	2	0.65	7	1.37
C8:0	Caprylic	3	1.48	8	2.60	11	2.15
C10:0	Capric	15	7.39	16	5.19	31	6.07
C11:0	Undecanoic	21	10.34	24	7.79	45	8.81
C12:0	Lauric	25	12.32	30	9.74	55	10.76
C13:0	Tridecanoic	26	12.81	37	12.01	63	12.33
C14:0	Myristic	19	9.36	35	11.36	54	10.57
C15:0	Pentadecanoic	23	11.33	32	10.39	55	10.76
C16:0	Palmitic	18	8.87	38	12.34	56	10.96
C17:0	Heptadecanoic	11	5.42	25	8.12	36	7.05
C18:0	Stearic	13	6.40	8	2.60	21	4.11
C20:0	Arachidic	11	5.42	33	10.71	44	8.61
C21:0	Henicosanoic	6	2.96	5	1.62	11	2.15
C23:0	Tricosanoic	4	1.97	15	4.87	19	3.72
C24:0	Tetracosanoic	3	1.48	0	0.00	3	0.59
Total		203	100	308	100	511	100

Table: 30 Frequency of saturated fatty acid in different seasons

Fatty acid	Chemical name	Season				Overall	
		Summer		Winter			
		n	%	n	%	N	%
C6:0	Caproic	7	2.41	0	0.00	7	1.37
C8:0	Caprylic	7	2.41	4	1.82	11	2.15
C10:0	Capric	23	7.90	8	3.64	31	6.07
C11:0	Undecanoic	29	9.97	16	7.27	45	8.81
C12:0	Lauric	34	11.68	21	9.55	55	10.76
C13:0	Tridecanoic	35	12.03	28	12.73	63	12.33
C14:0	Myristic	32	11.00	22	10.00	54	10.57
C15:0	Pentadecanoic	31	10.65	24	10.91	55	10.76
C16:0	Palmitic	35	12.03	21	9.55	56	10.96
C17:0	Heptadecanoic	14	4.81	22	10.00	36	7.05
C18:0	Stearic	10	3.44	11	5.00	21	4.11
C20:0	Arachidic	20	6.87	24	10.91	44	8.61
C21:0	Henicosanoic	9	3.09	2	0.91	11	2.15
C23:0	Tricosanoic	3	1.03	16	7.27	19	3.72
C24:0	Tetracosanoic	2	0.69	1	0.45	3	0.59
Total		291	100	220	100	511	100

4.13 Mono unsaturated fatty acids frequency in different management systems and seasons:-

Frequency of MUSAT acids in different management systems table 31 and season table 32 revealed that the shortest MUSAT acid was C14:1 and the longest C24:1. The most frequent was C18:1 ω-9 followed by C20:1 ω-9 while the lowest was C24:1 ω-9 in both management systems and seasons. C18:1 ω-9was the highest value in both management systems followed by C16:1 ω-7 whereas C22:1was the lowest and C24:1 was absent in indoor system. In addition outdoor C20:1 was the second rank value while C24:1 was the lowest. Elsewhere C18:1 was the highest value in both seasons followed by C20:1, but C24:1 was the lowest value in winter and absent in summer.

Table 31: Frequency of mono saturated fatty acid in different management systems

Fatty acid	Chemical name	Management				Overall	
		Indoor		Outdoor			
		n	%	n	%	N	%
C14:1	Myristoleic	17	19.32	2	2.44	19	11.18
C15:1	Cis-10-Pentadecanoic	9	10.23	8	9.75	17	10.00
C16:1	Palmitoleic (Omega 7)	19	21.59	3	3.66	22	12.94
C17:1	Cis-10-Heptadecanoic	7	7.95	4	4.88	11	6.47
C18:1	Oleic (Omega 9)	22	25.00	36	43.90	58	34.12
C20:1	Eicosenoic (Omega 9)	11	12.50	22	26.83	33	19.41
C22:1	Erucic (Omega 9)	3	3.41	6	7.32	9	5.29
C24:1	Nervonic acid (Omega 9)	0	0	1	1.22	1	0.59
Total		88	100	82	100	170	100

Table 32: Frequency of mono saturated fatty acid in different seasons

Fatty acid	Chemical name	Season				Total	
		Summer		Winter			
		n	%	n	%	N	%
C14:1	Myristoleic	3	4.4	16	15.7	19	11.18
C15:1	Cis-10-Pentadecanoic	7	10.3	10	9.8	17	10.00
C16:1	Palmitoleic (Omega 7)	5	7.4	17	16.7	22	12.94
C17:1	Cis-10-Heptadecanoic	4	5.9	7	6.9	11	6.47
C18:1	Oleic (Omega 9)	33	48.5	25	24.5	58	34.12
C20:1	Eicosenoic (Omega 9)	10	14.7	23	22.5	33	19.41
C22:1	Erucic (Omega 9)	6	8.8	3	2.9	9	5.29
C24:1	Nervonic acid (Omega 9)	0	0	1	1.0	1	0.59
Total		68	100	102	100	170	100

4.14 Poly unsaturated fatty acids frequency in different management systems and seasons:-

Frequency of PUSAT acids in different management systems table 33 and season table 34 revealed that the shortest PUSAT acid was C18:2 and the longest C22:6. C18:2 ω-6 the was most frequent followed by C20:4 ω-6 which were the highest in both management systems while C22:6 was absent in indoor system and it was the lowest value as 3.95% which was the same value for C22:2 and C20:5 in outdoor system. Moreover, C18:2 was most frequent in summer followed by C20:3 whereas C22:2 was the lowest and C22:6 was absent. Winter values showed that C20:4 was the highest frequency followed by C18:2 and C22:0 record the lowest value.

Table 33: Frequency of poly unsaturated fatty acid in different management systems

Fatty acid	Chemical name	Management				Overall	
		Indoor		Outdoor			
		n	%	n	%	N	%
C18:2	Linoleic (Omega 6)	33	45.83	26	34.21	59	39.86
C20:3	Eicosatrienoic (Omega 6)	10	13.89	15	19.74	25	16.89
C20:4	Eicosatetraenoic (Omega 6)	17	23.61	26	34.21	43	29.05
C20:5	Eicosapentaenoic acid (Omega 3)	6	8.33	3	3.95	9	6.08
C22:2	Docosadienoic (Omega 6)	6	8.33	3	3.95	9	6.08
C22:6	Docosahexaenoic (Omega 3)	0	0.00	3	3.95	3	2.03
Total		72	100	76	100	148	100

Table 34: Frequency of poly unsaturated fatty acid in different seasons

Fatty acid	Chemical name	Season				Overall	
		Summer		Winter			
		n	%	n	%	N	%
C18:2	Linoleic (Omega 6)	32	42.11	27	37.50	59	39.86
C20:3	Eicosatrienoic (Omega 6)	21	27.63	4	5.56	25	16.89
C20:4	Eicosatetraenoic (Omega 6)	13	17.11	30	41.67	43	29.05
C20:5	Eicosapentaenoic acid (Omega 3)	7	9.21	2	2.78	9	6.08
C22:2	Docosadienoic (Omega 6)	3	3.95	6	8.33	9	6.08
C22:6	Docosahexaenoic (Omega 3)	0	0.00	3	4.17	3	2.03
Total		76	100	72	100	148	100

4.15 Effect of management system and season on fatty acids profile:-

Management systems was significantly affected both SAT (P<0.01) and PUSAT (P<0.05) fatty acid profiles where indoor system records the highest values in both, but it had insignificant effect (P>0.05) on MUSAT fatty acids. On the other hand season was highly significant (P<0.01) affected the SAT and PUSAT where winter showed the highest values. Elsewhere all fatty acids profile was highly affected (P<0.01) by the interaction between management system and season, table 35.

Table 35: Effect of management system and season on fatty acids profile

Factors	**Parameters**

Management system	**Season**	SAT	MUSAT	PUSAT
Indoor	Summer	7.15	20.10	4.47
	Winter	14.47	11.30	13.66
Outdoor	Summer	7.65	11.20	6.22
	Winter	7.30	14.3	5.37
Standard error		0.536	0.878	0.913
Main effects				
Management system	Indoor	9.24	14.3	9.13
	Outdoor	7.46	12.87	5.53
P. value		0.001	0.185	0.020
Season	Summer	7.40	15.12	5.40
	Winter	9.19	12.66	9.63
P. value		0.001	0.200	0.003
Management systems XSeason				
P. value		0.000	0.008	0.000

4.16 Effect of management systems and season on omega acids:-

The effect of management systems and season on omega acids table 36, revealed significant difference (P<0.05) on omega 6 where indoor system revealed the highest value, although management systems was insignificantly affected omega 7 and omega 9 but indoor system showed the highest values in both while it records the lowest value in omega 3. Elsewhere, season was highly affected (P<0.01) omega 3 and omega 6 where winter records the highest value in both. Omega 6 was highly (P<0.01) affected by the interaction between management system and season.

Table 36: Effect of management system and season on omega fatty acids

Factors		Parameters			
Management system	**Season**	Omega 3	Omega 6	Omega 7	Omega 9

Indoor	Summer	1.8	4.92	16.91	19.94
	Winter	6.57	14.07	16.10	17.29
Outdoor	Summer	2.24	6.53	5.22	14.21
	Winter	6.24	5.28	6.67	15.39
Standard error		3.48	1.01	4.02	1.25
Main effects					
Management system	Indoor	3.39	9.77	16.22	18.99
	Outdoor	4.24	5.96	15.70	14.92
P. value		0.965	0.019	0.312	0.226
Season	Summer	1.99	5.81	12.23	16.90
	Winter	6.37	9.87	15.54	15.87
P. value		0.010	0.010	0.975	0.816
Management systems X Season					
P. value		0.774	0.001	0.912	0.541

Chapter five

5. Discussion

Camels play a vital role in some arid and semi arid zones in Sudan beside other species such as sheep, goat and cattle. This study revealed that the illiterate camel owners were 73 % which agreed with the results found by Darosa and Agab, (2008). Also the study revealed that the interviewers bred mixed species of animals. The highest percentage of them bred camel with sheep and goat and the lowest bred camel with cattle this might be due to small animals had capability of living in harsh condition more than cattle, moreover camel owners tend to slaughter small animals neither than camel and cattle, this finding agreed with Ishag and Ahmed (2011). The study showed that the main purpose for keeping camel was milk production because it was the main food for *abbala* in the studied area, this agreed with the finding of Eyassu, (2009). The study showed that the highest percentage of the age group was 5-15 years, it might be the ideal interval age for highly production of milk and other purposes. This study found that there were mainly three management systems adopted in the studied area: semi-sedentary system, nomadic management system and semi-nomadic system, most of interviewed owners adopted semi-sedentary system because there was increment in land use for agricultural crops particularly in the studied area, this finding agreed with Ishag and Ahmed (2011), Al-Khouri and Majid (2000) and Abbas *et al* (1992). More than 50% of interviewed owners milked their animals twice a day this might be due to milk yield and availability of feed, this finding was similar to that reported by Eyassu, (2009). Moreover, the results showed that the milk production was somewhat higher in winter than summer, this might be due to the availability of rich pasture and residual of agricultural schemes, these results agree with those reported by Salman, (2002) and Ahmad *et al*., (2012) and disagreed with the finding reported by Musaad *et al*., (2013). Elsewhere, the majority of respondents provided more than two quarters of udder to their calves in winter, this might be due to the abundance of milk production, coupled with water consumption of the camel owners (*they didn’t need more water in winter in contrast in summer*), also they take most of milk production for their food and compensate shortage of milk to the calves by increase watering frequency in summer. The results revealed that about 50% didn’t provide any additional feed to their camels because they depended on pasture and residual of agricultural schemes. This finding was inline with those reported by Eyassu, (2009). More than 50% of respondents watered their camels in less than 3 days in summer and more of 70% watered their camels in more than 5 days in winter, this might be due to the known anatomic and physiological proprieties of camel, range condition such as water content in the forage, air temperature. This finding is similar to those reported by Köhler *et al*., (1991). Generally, most of respondents showed that they didn’t receive any extension service, it might be due to far distance and the harsh and bad roads, moreover, they depend on their own opinions especially in the way of rearing their camels and solving their problems the second rank of them received an extension services about diseases.

Camel preferred many species of trees, shrubs and bushes, the preference is managed by many factors such as season, soil, eaten part, plant age …etc. Many anatomical characteristic of camel mouth parts help it to be a selective browser animal rather than grazer such as the mobile and prehensile split upper lip, the long tongue, horny nature of the oral cavity, the stretched neck and extended head to grasp the thorny twigs. The overall results of this study revealed that winter proximate analysis values were higher than summer, this might refer to the availability of nutrient and water in this season, because winter is subsequent to autumn season. This finding agreed with that of Teka *et al*, (2012). CP and Ash contents were significantly higher in winter than in summer in most studied plants, this might be attribute to the availability of new buds, soft leaves and salty plants during wet and winter seasons. These findings were almost agreed with those of Alia *et al*., (2007) and Mokoboki, (2011). In contrast, CF and NDF were higher in summer season than in winter season, this might be due to high content of structured fiber and lack of other soluble nutrient. These findings were inline with those reported by Mokoboki, (2011). Generally the results revealed that some proximate analysis parameters were fluctuated some times in winter and the other in summer, this might be due to stage of the plants growth Al-Soqeer, (2008), site collection of plants Kuria *et al*., (2012) and genotypic factors which control accumulation of forage nutrients that varies among species Rubanza *et al*., (2005).

Many factors were affecting camel milk yield and composition including management system, season, parity number and breed. Generally these factors showed a wide variation in milk yield and composition. The results revealed that most physicochemical parameters were significantly influenced by management system and season. Moreover the milk yield was higher in winter. This contributed to more quantity and quality of feed consumed by camels in cold season, also the milk yield was higher in indoor system than outdoor system. It might be due to the availability of balanced feed. These results agreed with those found by (Qureshi, 1986, Farah ,1993 , Khan and Iqbal, 2001 and Wafa and El Zubeir 2014) who found that camel milk yield is higher in intensive conditions than desert conditions. On the other hand density, freezing point and fat were higher in indoor and winter, this could be due to the previous reasons in addition to the physical prosperities of milk fat and it's relationship with density, also it could lead to increase in freezing point, morever, feeding system that based on addition of concentrates that raised the milk fat, beside the construction of house that prevented camels from the direct sunlight in the indoor system, this finding was in agreement with findings of Riyadh *et al*., (2012) but disagreed with Parraguez *et al*., (2003) and Shuiep *et al* (2008). The results showed that protein content was higher in outdoor system than indoor system, it could be due to the availability and sufficient nutrient source of protein from different browsers plants in the outdoor system of our study. These results were inline with those of Alia *et al*., (2007) who found that camel had selected the mostly green material from deep rooted bushes and trees which rich in crude protein, but in contrast to those of Riyadh *et al*., (2012) who found that protein content was higher in settled system than nomadic systems. In general, Konuspayeva *et al* (2009) and Al haj, and Al Kanhal (2010) mentioned that camel milk composition was affected by regional differences including feeding conditions. During winter fat content was higher than that' samples collected in summer, this might explain that seasonal changes had an effect on the quality of feed in the range. Moreover, the hydration status of the camels during summer could be another reason as stated by Yagil (1982).This finding agreed with (Bakheit *et al*., 2008, Haddadin *et al.,* 2008, Shuiep *et al*., 2008 and Abdelgadir *et al*., 2013) and In contrast, protein content showed higher mean value in summer compare to those samples collected in winter, this finding agreed with Shuiep *et al*., (2008) but disagreed with Abdelgadir *et al*., (2013). This could be due to individual variations as mentioned by Yagil and Etzion (1980) and stage of lactation and/or parity number as reported by El-Amin *et al*., (2006). Ash content showed higher mean value in winter milk samples than in summer milk samples. This might be due to the availability of salty plants during wet and winter seasons. These findings were almost agreed with those of Alia *et al*., (2007) and similar to those of Abdelgadir *et al*., (2013).

Parity number had significantly affected mean values of camel milk yield and components. The results revealed significant differences in milk yield, SNF, fat and protein contents in different parities. This could be explain by natural lactation curve and udder tissues conformation which showed increase and develop in milk yield by subsequent parity number. Fourth and third parities shows higher milk yield while first lactation showed the lowest. This was in line with Al haj and Al Kanhal (2010) who stated that production of camel milk was affected by many factors such as breed, feeding and management conditions, parity number and stage of lactation. The first and the second lactation showed highest SNF while the other lactation showed no significant differences. These results were similar to those found by Riyadh *et al*., (2012). Fat content was the highest in the first parity and tend to decrease by subsequent parity until the fifth parity number with insignificant difference. This finding disagreed with Zeleke (2007) who mentioned that the effect of parity on fat content of camel milk was significant. Effect of breed on physic-chemical milk components showed significant difference in milk yield, freezing point, conductivity, SNF, fat, lactose, protein and ash. These results agreed with those of other researchers (Alshaikh and Salah, 1994, Gaili *et al*., 2000, Khaskheli *et al*., 2005, Konuspayeva *et al*., 2009 and Ereifej *et al*., 2011) who reported that camel milk components were significantly affected by breeds of lactating camels. Most of the parameters showed positively correlation ($P<0.01$) with each other, this finding agreed with results of Abdelgadir *et al*., (2013), but the positive correlation between fat and lactose, fat and ash disagreed with

Abdelgadir *et al*., (2013), also strong positive correlation between fat and protein contents was found by Haddadin *et al.,* (2008). The results showed a negative correlation between conductivity with density, freezing point, SNF, fat, protein and lactose. These results were in line with those of Abdelgadir *et al.* (2013) who found a negative correlation in conductivity with density, fat, protein, lactose and ash.

Camel milk is seemed to be varied in fat content due to many factors such as age, lactation stage, parity number, season, feed …etc. Moreover camel milk fatty acids had an importance for human consumers both from nutritional and health properties. Also it differed from other mammals milk in the ratio of unsaturated fatty acid to saturated fatty acid which made it healthy food. The FAs presented in the ruminants diet, were metabolized and biohydrogenated in the rumen, producing not only C18:0, but also in a wide range of isomers of poly-unsaturated and mono-unsaturated FA (Chilliard *et al*., 2007).The results showed that the proportion of polyunsaturated FA was 18%, monounsaturated 20.4% and of saturated was 61.6% with a ratio saturated/unsaturated FA of 1.60:1. These results were almost similar to those found by Konuspayeva *et al*., (2014). Also the results revealed that the fatty acids range from C6 to C24 where C6:0, C22:6, C24:0 and C24:1were less abundant, the most frequent fatty acids were , C12:0, C13:0, C15:0, C16:0, C18:1 ω-9 and C18:2 ω-6. This could be due to different favored plants available in the study area which gave the camels many choices particularly in outdoor system and balanced rations fed to camels in indoor system. These finding were meanwhile inline with those of Konuspayeva et al., (2008). Also the results showed that C22:6 and C24:1 just existed in outdoor system. This might be due to the availability of different types of browsers plants which might be rich in these types of fatty acids. These results agreed with Faye *et al*., (2013) who found C22:6 in camel milk kept in indoor barns and fed balance rations containing olive cake. Also C20:5 were found in indoor system. This result also agreed with Faye *et al*., (2013). The results showed that most of MUSAT fatty acids were ω-7 and ω-9 fatty acid types and all existed PUSAT fatty acids were either ω-3 or ω-9 fatty acid types. Hence, the study revealed that C18:1 ω-9 was found to be 14.55% in indoor winter, this might be due to type of concentrate that provided to the camels and its interaction with season which might effect micro flora activities. These findings were inline with those of Konuspayeva *et al*., (2014) who kept camels in barns in winter season. Moreover the results revealed that the proportion of PUSAT fatty acids were the lowest while the SAT fatty acids were the highest in both management systems and seasons. This could be due to the same reasons mentioned previously. These results were similar to those of Narmuratova *et al*., (2006), Konuspayeva *et al*., (2008), Jirimutu *et al*., (2010), Dreiucker and Vetter, (2011), Shibani *et al*., (2011), Faye *et al*., (2013) and Konuspayeva *et al*., (2014). The results showed that the most frequent SAT fatty acids were C12:0, C13:0, C14:0, C15:0 and C16:0. These findings were inline with Jirimutu *et al*., (2010). Because of few researches had been done on effect of management systems and season on fatty acids profiles, the obtained results showed that (SAT, MUSAT and PUSAT) fatty acids profiles were higher in indoor system, this might be due to balanced rations, clear and maintained water supply, shaded barns, …etc. These results were some what similar to Shibani *et al*., (2011), Faye *et al*., (2013) and Konuspayeva *et al*., (2014). The results showed that SAT and PUSAT were higher content in winter than summer, this might be due to high content of fat in the browser plants that dominant in the studied area and increment of feed intake in winter. These findings were mean while similar to those of Bakheit *et al*., 2008, Haddadin *et al.*, 2008, Shuiep *et al*., 2008 and Abdelgadir *et al*., 2013. Moreover the results were almost applicable for omega fatty acids types in both management systems and seasons.

Conclusion and recommendation

The study concludes that:-

- Majority of camel owners adopted the semi-sedentary system and tend to reared camels with small animals, they didn't provide additional feed to their camels except in especial conditions.
- Seasons significantly affected most of proximate analysis parameters of the studied browser plants and winter records higher values than summer.
- Both management system and season had no significant effect on freezing point, SNF, and lactose. Whereas it were affected the other physicochemical components.
- Both parity and breed had significant effect on milk yield and some physicochemical components of camel milk. Highest milk yield was found during 3rd and 4th parity. Moreover, Kenana breed showed high values in milk yield, SNF, fat, protein and ash.
- Most of MUSAT fatty acids were ω-7 and ω-9 fatty acid types and all existed PUSAT fatty acids were either ω-3 or ω-9 fatty acid types, PUSAT fatty acids were the lowest while the SAT fatty acids were highest in both management systems and seasons.

The study recommended to:-

- More attention and care should be given to camels owners and their animals to solve unfavorable production conditions (range management, diseases awareness and increase the productivity).
- Further studies and research in lipids profile should be done in different locations and management systems under Sudan conditions.

References:

Abbas B., Chabeuf N., Saint-Martin G., Bonnet P., Maillaird A., Beshir H. and Musa B. E., (1992). Camel pastoralism in the Butana and north eastern Sudan: an interdisciplinary study. Nomadic Peoples. 31: 64-84.

Abdelgadir, M. M., Faye, B. and Sallal, E. A. (2013). Seasonal and physiological variation of gross composition of camel milk in Saudi Arabia. *Emirates Journal of Food and Agriculture*. 25 (8): 618-624.

Abdul Raziq, K. Verdier, K., Younas, M., Khan S., Iqbal, A. and Khan, M. S. (2011). Milk composition in the Kohi camel of mountainous Balochistan, Pakistan. *Journal of Camelid Science* 4: 49-62.

Abu-Lehia, I. H. (1989). Physical and chemical characteristics of camel milk fat and its fractions. *Food Chemistry*. 34: 261-271.

Abu-Lehia, I. H. (1997). Studies on manufacturing camel butter from cream. *Journal of Camel Practices Research*. 4: 241-245.

Abu-Taraboush, H. M., Al-Dagal, M. M. and Al-Royli, M. A. (1998). Growth, viability, and proteolytic activity of Bifidobacteria in whole camel milk. *Journal of Dairy Science*. 81, 354 – 361.

Agab, H., (1993). Epidemology of Camel Diseases in Eastern Sudan with Emphasis on Brucellosis. M.V.Sc. Thesis, University of Khartoum, Sudan.

Ahmed, Shek M, Hegde B. P. and Taless B. (2006). Traditional and marketing of meat, milk and hides in Afder Zone, Somali State, Ethiopia. *International Conference on Camels*. Al Qassim, KSA, 9-12, May, 2006.

Ahmad, S., Yaqoob, M., Bilal, M. Q., Khan, M. K., Muhammad, G. Yang, L.-G. and Tariq, M. (2012). Factors affecting yield and composition of camel milk kept under desert conditions of central Punjab, Pakistan. *Tropical Animal Health and Production*. 44:1403-1410.

Al-Attas, A. S. (2008). Determination of essential elements in milk and urine of camel and in *Nigella sativa* seeds. *Arabian Journal of Chemistry*. 1: 123 – 129.

Al haj, O. A. Al Kanhal, H. A. (2010). Compositional, technological and nutritional aspects of dromedary camel milk. *International Dairy Journal*. 20: 811 – 821.

Alia, S. A., Khalid, A. A. and Abdalla, M. A. (2007). Seasonal variation in botanical and chemical composition of plants selected by one-humped camel (*camelus dromedarius*), Pakistan Journal of Biological Science. 10 (6): 932-935.

Al Khouri, F. and Majid,A. M. (2000). Camel in Sudan: Ecology, production systems, characterization and herd dynamics. The Camel Applied Research and Development Network (CARDN). *The Arab Center for Studies of Arid Zones and Dry Land (ACSAD)*. CARDN/ACSAD/ Camel/ P 96/ 2000. 137 pp.

Al-Saiady, M. Y., Mogawer, H. H., Faye, B., Al-Mutairi, S. E., Bengoumi, M., Musaad, A. and Gar-Elnaby, A., (2012). Some factors affecting dairy she-camel performance, *Emirates Journal of Food and Agriculture*. 24 (1): 85-91.

Alshaikh, M. A. and Salah, M. S. (1994). Effect of milking interval on secretion rate and composition of camel milk in late lactation. *Journal of Dairy Research*. 61: 451-456.

Al-Soqeer, A.A. (2008). Nutritive value assessment of Acacia species using their chemical analyses and in vitro gas production technique, *Research Journal of Agriculture and Biological Sciences*, 4(6): 688-694.

Alwan, A.O and Igwgebe, A.O. (2013). Physico-Chemical Properties of Stirred-Curd Cheddar Cheese Manufactured from Farm-reared Camel and Cow's Milk: A Comparative Study. Accepted for Publication in *Scottish Journal of Art and Science Studies*, 2014.

Alwan, A.O., Igwgebe, A.O. and Ahmad A. A., (2014). Effects of rearing conditions on the proximate composition of Libyan Maghrebi camels' (*camelus dromedarius*) milk. *International Journal of Engineering and Applied Sciences*. 4: (8): 1-6.

Aujla K. M., Jasara A. W. and Munir M. (1998). The socio-economics rofile of camel herders in South-western Mountains Areas of Pakistan. Proceedings of the third annual meeting for animal production *under arid condition*. 2:154-174.

Babiker S. A, and Tibin I. M. (1986) . Comparative study of camel meat and beef. *Small ruminant and camel group, ILCA*, Document no.SRC12: 73-77.

Bachmann, M. R. and Schulthess, W. (1987). Lactation of camels and composition of camel milk in Kenya. *Milchwissenschaft (Milk Science)*. 42: 766-768.

Bakheit, S. A., Majid, A. M. and Abu- Nikhila, A. M. (2008). Camels (*Camelus dromedarius*) under pastoral systems in North Kordofan, Sudan: Seasonal and parity effects on milk composition. Journal of Camelid Science 1:32-36.

Basmaeil, S.M. and Bakkar, M.N. (1987). Milk production of Majaheem camels in Saudi Arabia during the first lactation season. *In Proc. Saudi Biology Soc. Jeddah*. 10: 75-79.

Bekele, T., Zeleke, M. and Baars, R.M.T. (2002). Milk production of the one humped camel under pastoral management in semi-arid eastern Ethiopia. *Livestock Production Science.* 76: 37-44.

Cardak, A.D., Yetismeyen, A. and Brückner, H., (2003). Quantitative comparison of free fatty acids in camel, goat and cow milk. *Milchwissenschaft (Milk Science)*. 58: 127-130.

Cardellino, R., Rosati, A., and Moscom, C. (2004). Current status of genetic resources, recording and production systems in Africa, Asia and America camelids FAO, ICAR seminar on camelids. Sousse, Tunisia: *Food and Agriculture Organization of the United Nations and International Committee for Animal Recording.*

Chaibou, M. (2005). Productivité zootechnique du désert: le cas du basin laitier d'Agadez au Niger. Diss. med. vet., Montpellier, France.

Cherepanova, V.P. and Belokobylenko, V. (1986). The correlation between fat and protein in the milk of camels. *Zhivotnovodstvo*. 10: 33-34.

Chilliard, Y., Glasser, F., Ferlay, A., Bernard, L., Rouel, J. and Doreau, M. (2007). Diet, rumen biohydrogenation and nutritional quality of cow and goat milk fat. *European Journal of Lipid Science and Technology,* 109:828–855.

Coppock, D. L., Swift, D. M. and Ellis, J. E. (1986). Livestock feeding ecology and resource utilization in a nomadic pastoral ecosystem. *Journal of Applied Ecology.* 23 (2): 573-584.

Cossins, N.J. and Upton, M. (1987). The Borana pastoral system of southern Ethiopia. *Agricultural Systems.* 25:199- 218.

Darosa, A. E. M. and Agab, H. (2008). A field survey of some camel (*Camelus dromedarius*) production traits and constraints in Butana area, Sudan. *Assiut Veterinary Medicine Journal*. 54 (116): 27-37.

Darosa, A. E. M. (2005). Studies on some camel production traits and health in Butana Area, Sudan. *Ph.D. Thesis. University of Khartoum, Sudan.*

Davies, D. T., and Law, A. J. R. (1980). Content and composition of protein in creamy milk in South-West Scotland. *Journal of Dairy Research*. 47: 83-90.

Dereje, M. and Uden P. (2005). The browsing dromedary Camel I. Behavior, plant preference and quality of forage selected. Animal Feed Science and Technology 121: 297-308.

Dreiucker, J. and Vetter, W. (2011). Fatty acids patterns in camel, moose, cow and human milk as determined with GC/MS after silver ion solid phase extraction. *Food chemistry*, 126:762-771.

Eisa, M.O., and Mustafa A.B. (2011). Production Systems and Dairy Production of Sudan Camel (*Camelus dromedarius*): A Review *Middle-East Journal of Scientific Research*. 7 (2): 132-135.

El-Agamy, E. I. (2000). Effect of heat treatment on camel milk proteins with respect to antimicrobial factors: a comparison with cows' and buffalo milk proteins. *Food Chemistry*. 68, 227 – 232.

El-Agamy E. I., Nawar M., Shamsia S. M., Awad S. and Haenlein G. F. W. (2009). Are camel milk proteins convenient to the nutrition of cow milk allergic children. *Small Ruminant Research*. 82: 1-6.

El-Amin, E. B., El Owni, O. A. O. and I El Zubier, E. M. (2006). Effect of parity number, lactation stage and season on camel milk composition in Khartoum State, Sudan. Proceedings of the *International Scientific Conference on Camel. Part IV*: *2173-2183. Qassim University, Saudia Arabia, pp. 9-11*.

Elamin, F. M., and Wilcox, C. J. (1992). Milk composition of Majaheim camels. *Journal of Dairy Science*. 75, 3155-3157.

El-Fadil, S.A., (1986). Study on the mechanism of resistance to camel diseases. *Dissertation submitted in partial fulfilment of the requirements for the degree of Doctor of Agricultural Science*. George August university, Gottingen, Germany.

Elmi, A.A. (1989). Camel husbandry and management by Ceeldheer pastoralists in central Somalia. *Pastoral Development Network, Paper 27d, ODI*, London

El Zubeir, I. E. M. and Nour E. M. (2006). Studies on some camel management practice and constraints in pre-urban area of Khartoum state, Sudan. *International Journal of Dairy Science*. 1: 104-112.

Ereifej, K. I., Aludatt, M. H., Alkhalidy, H. A., Ali, I. and Rababah, T. (2011). Comparison and characterization of fat and protein composition for camel milk from eight Jordanian locations. *Food Chemistry*. 127: 282-289.

Evans, J.O., Simpkin S.P. and Atkins D.J. (1995). *Camel Keeping in Kenya*. *Range Management Handbook of Kenya*, Volume III, 8, Range Management Division, Ministry of Agriculture, Livestock Development and Marketing, Republic of Kenya.

Eyassu, S. (2009). Analysis on the contributions of and constraints to camel production in Shinile and Jijiga zones, eastern Ethiopia. *Journal of Agriculture and Environment for International Development*, 103 (3): 213-224

FAO (2011). Food and Agriculture Organisation. Statistics, data base, Italy, Rome.

Farah, Z. (1986). Effect of heat treatment on whey proteins of camel milk. *Milchwissenschaft (Milk Science)*. 41, 763-765.

Farah, Z., Streiff, T. and Bachmann, M. R. (1989). Manufacture and characterization of camel milk butter. *Milchwissenschaft (Milk Science)*. 44: 412-414.

Farah, Z., and Atkins, D. (1992). Heat coagulation of camel milk. *Journal of Dairy Research*. 59, 229 – 231.

Farah, Z., Rettenmaier, R. and Atkins, D. (1992). Vitamin content in camel milk. *Internet Journal of Vitamin and Nutrition Research*. 62: 30-33.

Farah, Z. (1993). Composition and characteristics of camel milk. *Journal of Dairy Research*. 60: 603-626.

Farah, Z. (1996). Camel milk properties and products. St. Gallen, Switzerland: SKAT, Swiss Centre for Developments Cooperation in Technology and Management.

Farah, Z. and Fischer, A., (2004). *The camel (C. dromedarius) as a meat and milk animal*: handbook and product development. University publishing company. www.camelgate.com.

Farah, Z. (2004). An introduction to the camel. In: Farah, Z. and A. Fischer (eds): Milk and meat from the camel - Handbook on products and processing. vdf Hochschulverlag, Zürich, Switzerland, pp. 15-28.

Farah, K.O., Nyariki, D.M., Ngugi, R.K., Noor, I.M. and Guliye, A.Y. (2004). The Somali and the camel: Ecology, Management and Economics. *Anthropologist*. 6 (1): 45-55.

Farah, Z., Mollet, M., Younan, M., and Dahir, R. (2007). Camel dairy in Somalia: limiting factors and development potential. *Livestock Science*. 110: 187-191.

Faye, B., Konuspayeva G., Narmuratova and M., Loiseau, G. (2008). Comparative fatty acid gross composition of milk in Bactrian camel, and dromedary. *Journal of Camelid Science* 1:48-53.

Faye, B., Konuspayeva, G. Narmuratova, M. Serikbaeva, A. Abdelgadir, M. and Mehri, H. (2013). Effect of crude olive cake supplementation on camel milk production and fatty acid composition, *Dairy Science and Technology,* 93 (3): 225-239.

Field, C. R. (1979). Camel growth and milk production in Marsabit district. Northern Kenya. In Proc. *Workshop on Camels, 18-20 December* 1979, Khartoum, Sudan.

Fowler, M. E. (1998). *Medicine and surgery of South American camelids*. Iowa State University Press, Ames, Iowa, USA.

Gaili, E. S. E., Al-Fknah, M. M. and Sadek, M. H. (2000). Comparative milking performance of three types of Saudi camels (Camelus *dromedaries*). Journal of Camel Practices and Research, 7: 73-76.

Gast, M., Maubois, J, -L., Adda, Blanc-Patin, J. E. and Jeunet, R. (1969). Milk and dairy products in Ahaggar. Centr. Rech. Anthr. Prehist. Ethn. 4: 39-49.

Gauthier-Pilters, H. and Dagg, A. I. (1981). The Camel: Its Evolution, Ecology, Behavior, and Relationship to Man. Photographs by Hilde Gauthier-Pilters. Chicago: University of Chicago Press.

Gorban, A. M. S. and Izzeldin, O. M. (1999). Study on cholesteryl ester fatty acids in camel and cow milk lipid. *International Journal of Food Science and Technology,* 34, 229-234.

Gorban, A. M. S. and Izzeldin, O. M. (2001). Fatty acids and lipids of camel milk and colostrum. *International Journal of Food Science and Nutrition*, 52: 283-287.

Grenot, C. J. (1992). Ecophysiological characteristics of large herbivorous mammals in arid Africa and the Middle East. Journal of Arid Environments, 23: 125-155.

Guliye, A.Y., Noor, I.M., Bebe, B.O. and Koskey, I.S. (2007). Role of camels (*Camelus dromedarius*) in the traditional lifestyle of Somali pastoralists in northern Kenya. *Outlook on Agriculture*, 36 (1): 29-34.

Haddadin, M. S. Y., Gammoh, S. I., and Robinson, R. K. (2008). Seasonal variations in the chemical composition of camel milk in Jordan. *Journal of Dairy Research*. 75, 8-12.

Hashi, M.A., Kamoun, M. and Cianci, D. (1995). Feed requirements of the camel. *CIHEAM – Options Mediterraneennes.* 13: 71-80.

Hessain, M. E. M., Mohamed, I. M. A. and Elzubeir, I. E. M. (2013). Effect of heat treatment on chemical composition and vitamin C of camel milk. International Conference on Sustainability of Camel Population and Production, 17^{th} – 20^{th} Feb. 2013. Faculty of Agricultural and Food Science, King Fiasal University, Hafuf Al-Ahssa, Saudi Arabia. P: 149-150.

Igbal, A., Gill R. A. and Younas, M. (2001). Milk composition of Pakistani camel (*Camelus dromedarius*) kept under station/farmer's conditions. Emirates Journal of Agricultural Science,13:7-10.

Ishag, I. A. and Ahmed, M. K. A. (2011). Characterization of production system of Sudanese camel breeds. *Livestock Research for Rural Development.* 23:3. Available at www.irrd.org/irrd23/3/ishag23056.htm

Jasra, A. W. and Aujla, K. M. (1998). Socioeconomic profile of camel herders in southwestern mountainous areas of Pakistan. *Camel Newsletter*. 15: 14-17.

Jasra, A. W. and Isani, G. B. (2000). Socio-economics of camel herders in Pakistan. *The Camel Applied Research and Development Network* (CARDN).Pakistan/ACSAD/P94/2000.

Jirimutu, B., Li, J., Alam, M. S., Li, H., Guo, M. and Zhang, H. (2010). Fatty acid and protein profiles, and mineral content of milk from the wild Bactrian camel (*Camelus bactrianus ferus*) in Mongolia. Milchwissenschaft, 65 (1): 21-25.

Kappeler, S., Farah, Z. and Puhan, Z. (2003). 50-Flanking regions of camel milk genes are highly similar to homologue regions of other species and can be divided into two distinct groups. *Journal of Dairy Sci*ence; 86: 498-508.

Kaufmann, B.A. (2005). Reproductive performance of camels *(Camelus dromedarius)* under pastoral management and its influence on herd development. *Livestock Production Science*; 92: 17-29.

Khanna, N.D. (1986). Camel as a milch animal. *Indian Farming*, 36 (5): 39-40.

Khan, B. B. and Iqbal A. (2001). Production and composition of camel milk-Review. Pakistan Agricultural Science;38 (3-4): 64-68.

Khaskheli, M., Arain, M. A., Chaudhry, S., Soomro, A. H., and Qureshi, T. A. (2005). Physico-chemical quality of camel milk. *Journal of Agriculture and Social Sciences*; 2:164-166.

Kherouatou, N., Nasri, M. and Attia, H. (2003). A study of the dromedary milk casein micollo and its changes during acidification. *Brazilian Journal of Food Technology*,6: 237-244.

Köhler-Rollefson, I. (2000). The camel and human society. In: Gahlot, T. K (ed.): Selected topics on camelids. The Camelid Publishers, Bikaner, India, pp. 1-17.

Köhler-Rollefson, , Musa, B. E. and Achmed, M. F. (1991). The camel pastoral system of southern Rashaida in eastern Sudan. *Nomadic people*. 29: 68-76.

Konuspayeva, G., Lemarie, E., Faye, B., Loiseau, G., and Montet, D. (2008). Fatty acid and cholesterol composition of camel's (*Camelus bactrianus, Camelus dromedarius* and hybrids) milk in Kazakhstan. *Dairy Science and Technology*,88: 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: 95-101.

Konuspayeva, G., Faye, B. and Abdelgadir M. M. (2014). Some lipid components of the camel milk and blood in intensive farm in Saudi Arabia, *Emirates Journal of Food and Agriculture*, 26 (4): 349-353.

Kuria, S.G., Wahome, R.G., Gachuiri, C.K. and Wanyoike, M.M. (2004). Evaluation of forages as mineral sources for camels in western Marsabit, Kenya. *South African Journal of Animal Science*, 34(3): 180-188.

Kuria, S.G., Tura, I. A., Amboga, S. and Walaga, H. K. (2012). Forage species preferred by camels (Camelus dromedarius) and their nutritional composition in North Eastern Kenya, Livestock Research for Rural *Development*, 24 (8).

Lands, William. (1992). "Biochemistry and physiology of *n*–3 fatty acids". *FASEB Journal* (*Federation of American Societies for Experimental Biology*) 6 (8): 2530-2536. PMID 1592205.

Laleye, L. C., Jobe, B. and Wasesa, A. A. H. (2008). Comparative study on heat stability and functionality of camel and bovine whey proteins. *Journal of Dairy Science*. 91, 4527-4534.

Lewis, T., Peter, D. N. and Tom, A. M. (2000). Evaluation of extraction methods for recovery of fatty acids from lipid-producing microheterotrophs, *Journal of Microbiological Methods*, 43: 107-116.

Majid, A. A. (2000). The one-humped camel (*Camelus dromedarius*) in the Sudan. Annotated Bibliography (1905 -2000). *National Centre for Research*, Sudan. Pp: 123.

Mal, G., Suchitra, S.D., Jain,V. K. and Sahani, M.S. (2006a). Therapeutic value of camel milk as a nutritional supplement for multiple drug resistant (MDR) tuberculosis patients. *Israel Journal of Veterinary Medecine*. 61(3-4): 88-94.

Mal, G., Suchitra, S.D. and Sahani, M.S. (2006b). Milk production potential and keeping quality of camel milk. *Journal of Camel Practice and Research*. 13(2): 175-178.

Mehaia, M. A., Hablas, M. A., Abdel-Rahman, K. M., and El-Mougy, S. A. (1995). Milk composition of Majaheim, Wadah and Hamra camels in Saudi Arabia. *Food Chemistry*. 52: 115-122.

Merin, U., Bernstein, S., Bloch-Damti, A., Yagil, R., van Creveld, C. and Lindner, P.(2001). A comparative study of milk serum proteins in camel (*Camelus dromedarius*) and bovine colostrums. *Livestock Production Science*. 67: 297 – 301.

Ministry of Animal Resources, Fisheries and Ranges. (MARFR). (2012). Information center, Khartoum, Sudan.

Mohamed, H. E., Mousa, H. M. and Beynen, A. C. (2005). Ascorbic acid concentrations in milk from Sudanese camels. *Journal of Animal Physiology and Animal Nutrition*. 89: 35 – 37.

Mohamed I. A. (2009). Production system, phenotypic and molecular characterization of Sudanese camels (*Camelus dromedarius*). *Ph.D thesis, University of Khartoum*, Sudan.

Mokoboki, H. K. (2011). Effect of species within season on techniques used to measure nutritive value and anti-nutritional factors in browse tree leaves, *Life Science Journal*, 8(S2) 111-119.

Mona, E. Y., Ragia, O. M., Abeer, A. KH. and Mosa T. E. (2010). Biochemical effects of fermented camel milk on diarrhea in rats. *New York Science Journal* 3: (5)106-111.

Morton, R. H. (1984). Camels for meat and milk production in sub-Sahara. *African Journal of Dairy Science*. 67: 1548-1553.

Mouna M. E. (2006). Causes and impact of desertification in the Butana area of Sudan. *Ph.D. Thesis University of Bloemfontein*, South Africa.

Mukasa-Mugerwa, E. (1981). The camel (*Camelus dromedarius*): A bibliographical review. Addis Ababa, Ethiopia: *International Livestock Centre for Africa*. ILCA Monograph.

Musa, H.H., Shuiep, E.S., Ibtissam, El Zubier, E.M. and Chen, G.H., (2006). Some reproductive and productive traits of camel (*Camelus dromedarius*) in Western Sudan, *Journal of Animal and Veterinary Advances*,5: 590-592.

Musaad, A., Faye, B. and Abu Nikhela, A. (2013). Lactation curves of dairy camels in an intensive system. *Tropical Animal Health and Production.* 45:1039-1046.

Narmuratova, M., Konuspayeva, G., Loiseau, G., Serikbaeva, A., Barouh, N., Montet, D.and Faye, B. (2006). Fatty acids composition of dromedary Bactrian camel milk in Kazakhstan. *Journal of Camel Practices Research*, 13:45–50.

Ottogalli, G. and Resmini, P. (1976). News on the problems of milk of Somalia. Some data on the physico-chemical characteristics of the milk of zebu and dromedary. *The milk industry.* 12: 3-10.

Palmquist, D.L., Beaulieu, A. D. and Barbano, D. M. (1993). Feed and animal factors influencing milk fat composition. *Journal of Dairy Science*,76: 1753-1771.

Qureshi, M. H. (1986). The camel. Seminar on camel production and health, 20-23 October 1986. FAO, Rome, Italy.

Radwan, A. I.,. BEKAIRI, S. I and Prasad, P. V. S. (1992). Serological and bacteriological study of brucellosis in camels in central Saudi Arabia. Rev. Sci. Tech. Off. Int. Epiz. 11, 837 – 844.

Ramet, J. P. (2001). Technology of making cheese from camel milk. FAO, Italy, Rome.

Rao, M.B., Gupta, R.C. and Dastur, N.N. (1970). Camel milk and milk products. Indian Journal of Dairy Science. 23 (2): 71-78.

Raziq, A., Younas, M. and Kakar, M.A. (2008). Camel a potential dairy animal in difficult environments. *Pakistan Journal of Agricultural*

Science,45(2): 263-267.

Riyadh, S. A., Faris, F. A., Elsayed, I., Mohammad, A. A. ,Ahmad, S. and Moez, A. (2012). Effect of production system, breed, parity and stage of lactation on milk composition of dromedary camels in Saudi Arabia. Journal of Animal Veterinary Advanced,11 (1): 141-147.\

Rubanza, C. D. K., Shem, M. N., Otsyina, R., Bakengesa, S. Ichinohe, S. Fujihara, T. (2005). Polyphenolics and tannins effect on in vitro digestibility of selected Acacia species leaves. *Animal Feed Science and Technology,* 119: 129-142.

Rüegg, M.W., and Farah, Z. (1991). Melting curves of camel milk fat. *Milchwissenschaft (Milk Science)*,46, 361 -362.

Rutagwenda, T., Lechner-Doll, M., Engelhardt V. W., Schultka, M. and Schwartz, H. J. (1989). Adoption strategies of camels on a thorn bush savannna pasture. Comparision with other domestic animals. In: Options Mediterranean - series Seminaries No 2: 69-73.

Salman, M. (2002). Some husbandry aspects in the. Butana area in Eastern Sudan. M.Sc. Thesis. University of Khartoum, Sudan.

Sawaya, W. N., Khalil, J. K., Al-Shalhat, A., and Al-Mohammad, H. (1984). Chemical composition and nutritional quality of camel milk. *Journal of Food Science*,49: 744 – 747.

Schlimme, E. (1990). Compendium to the milk-economic chemistry. VV W GmbH economical publishing company, Miinchen, Germany.

Schwartz, H. J. and Dioli M. (1992). The one-humped camel (*Camelus dromedarius*) in eastern Africa: a pictorial guide to diseases, health care and management. Scientific Books D- 6992 Weikersheim Federal Republic of Germany. pp. 1-7.

Seher, A. Hifsa, A. Aalia, N. and Lubna S. (2013). Physico-chemical analysis and composition of camel milk. *International researchers.* 2 (2): 83-98. ISSN 227-7471 www.iresearcher.org

Sela, S., Pinto, R. Merin U. and Rosen B. (2003). Thermal inactivation of Escherichia coli in camel milk. *Journal of Food Prot*. 66, 1708-1711.

Semereab, T. and Molla B. (2001). Bacteriological quality of raw milk of camel (Camelus dromedarius) in Afar region (Ethiopia). *Journal of Camel Practice and Research*,8: 51- 54.

Shalash, M. R. (1979). Utilization of camel meat and milk in human nourishment. Provisional Report No. 6 Workshop on camels, Khartoum, Sudan. Stockholm, Sweden: *International Foundation of Science*,285-306.

Sheraz, A., Tahir, Z., Nuhat, H., Muhammad, W. S., Fiaz, A. and Muhammad, S. J. (2013). Fatty acids profile of milk cow, buffalo, sheep, goat and camel by gas chromatography. *Middle-East Journal of Scientific Research,*13: 1033 – 1042.

Shibani, M., Ringseis, R., Alkazali, M., Kerfakh, M. and Eder, K. (2011). Concentrations of conjugated linoleic acids in milk and tissues from single-humped camel (*Camelus dromedarius*) kept under intensive standardized management. *African Journal for Agricultural Research*, 6:3470-3474.

Shuiep, E. S., El Zubeir, I. E. M., El Owni, 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. *Tropical and Subtropical Agroecosystems,*8: 101-106.

Stahl, T., Sallmann, H. P., Duehlmeier, R. and Wernery, U. (2006). Selected vitamins and fatty acid patterns in dromedary milk and colostrums. *Journal of Camel Practice and Research,*13: 53-57.

Skidmore, J.A. (2005). Reproduction in dromedary camels: an update. *Animal Reproduction*,2: (3) 161-171.

Teka, H., Casper, I. M., Angassa, A. and Hassen, A. (2012). Effect of Seasonal Variation on the Nutritional Quality of Key Herbaceous Species in Semi-arid Areas of Borana, Ethiopia, Indian Journal of Animal Nutrition, 29(4): 324-332

Upton, M. (1986). Production policies for pastoralists: The Borana case. *Agriculture Systems*,20: 17-35.

Wafa, I. A. B. and El Zubeir,.I. E. M. (2014). Impact of husbandry, stages of lactation and parity number on milk yield and chemical composition of dromedary camel milk. *Emirates Journal of Food and Agriculture*,26 (4): 333-341.

Wardeh, M. F. (1989). Arabian Camels, Origin, Breeds and Husbandary. *Al-Mallah Publishing*. Damascus, Syria 500 pp.

Wardeh, M. F. (2004). Classification of the dromedary camel. *Journal of camel Science,*1: 1-8.

Wernery, U. (2003). Novel observations on camel milk. Proceeding: *The 9th*

Kenya camel forum. 17th-22th Feb. 2003Wajir District, Kenya.
Wilson, T. R. (1984). The camel. Longman Group Ltd., London, United Kingdom. pp. 7-21, pp. 83-101.
Wilson, R. T. (1989). The nutritional requirements of camel. *CIHEAM – Options Méditerranéennes - Série Séminaires, 2: 171-179.*
Wilson, R.T. (1998). Camels. CTA Series, Mac Millan Educational Press Ltd., London, UK. Pp: 120-124.
Yagil, R. and Etzion, Z. (1980). Effect of drought condition on the quality of camel milk. *Journal of Dairy Research*,47 (2): 159-166.
Yagil, R. (1982). Camels and camel milk. *Animal Production and Health.* paper No;26:1-69, FAO, Rome.
Yagil, R. (1994). The camel in today's world: *A Handbook of Camel Management*. GIFRID/Deutsche Welthungerhilfe, pp: 74.
Yagil, R. (1985). The desert camel: comparative physiological adaptation. *Comparative Animal Nutrition*. Vol. 5. Karger, Basel.
Yagil R. Saran A., and Etzion Z. (1984). Camels milk: for drinking only. *Comparative Biochemistry and Physiology*,78A: 263-266.
Yaqoob, M., and Nawaz, H. (2007). Potential of Pakistani camel for dairy and other uses - review article. *Animal Science Journal*. 78: 467-475.
Zeleke, Z. M. (2007). Non-genetic factors affecting milk yield and milk composition of traditionally managed camels (*Camelus dromedarius*) in Eastern Ethiopia. *Livestock Research for Rural Development* 19: (6). Available at www.irrd.org/irrd19/6/zeleke19085.htm
Zhang, H., Yao J., Zhao D., Liu H.,Li J., and Guo M., (2005). Changes in Chemical Composition of Alxa Bactrian Camel Milk During Lactation. *Journal of Dairy Science*, 88:3402–3410.

Appendices

Sudan University of Science and Technology

College of Graduate Studies and Scientific research

Questionnaire about field and management practices of camel rearing in Butana area

---

Date: /   /

interviewed No.: ……

1- **General household information:-**

1. Owner name: ……………………………………………………………..

2. Location: …………………………………………………………………

3. Age: ……………………………………………………………………

4. Education level?

(1) Illiterate ( ). (2) Khalwa or basic education ( ).

(3) Secondary school ( ) (4) University ( ).

5. Experience (1) less than 10 years ( ). (2) 10-20 years ( ). (3) more than 20 years ( ).

2- **<u>Herd structure:-</u>**

2.1: Are you reared other species with camels? 1. Yes ( ) 2. No ( ).

2.2: Which type of animals?

(1) Cattle ( ). (2) Sheep and goat ( ) (3) Cattle +sheep and goat ( )

2.3: Purpose of rearing:-

(1) Milk ( ). (2) Hold ( ). (3) Race ( ). (4) Milk + hold ( ).

(5) Milk + race ( ). (6) Milk + hold + race ( ).

2.4: Herd size: ……………………………………………………………

2.5: Average age for different herd group:

(1) Less than 1 year ( ). (2) Between 1-4years ( ).

(3) Between 5-15years ( ). (4) More than15 ( ).

3- **<u>Field and management practices:-</u>**

3.1: Areas and plants (trees, bushes and grasses) preferred by camels in each season:

1- Areas in summer/winter:-

(1) ……………..……. (2) ……………….. (3) ………………………

(4) ………………….. (5) ……………….. (6) ………………………

2- Trees grazed by camels in summer/winter (order as priority):-

(1)……………..……. (2) ……………….. (3) ……………………..

(4) ………………….. (5) ……………….. (6) ……………………..

3- Bushes grazed by camels in summer/winter (order as priority):-

(1)…………………... (2) ……………….. (3) ……………………..

(4) ………………….. (5) ……………….. (6) ……………………..

4- Grasses grazed by camels in summer/winter (order as priority):-

(1)…………………... (2) ……………….. (3) ………………………

(4) ………………….. (5) ……………….. (6) ………………………

3.2: Rearing mode or management system:-

(1) Nomadic management system ( ). (2) Semi-nomadic system ( )

(3) Semi-sedentary system ( ).

3.3: Milking frequency:-

(1) Once ( ). (2) Twice ( ). (3) Three times ( ).

3.4: Average milk production:

(1) Less than 2.25 kg ( ). (2) 2.25-4.5 kg ( ).

(3) More than 4.5 kg ( ).

3.5: the amount of milk provided for calves:-

(1) One quarter ( ). (2) Two quarters ( ).

(3) More than two quarters ( ).

3.6: Are there any extension services? 1. Yes ( ) 2. No ( ).

3.6.1: Type of extension services:-

(1) Awareness about diseases ( ). (2) Maintain the range from over grazing ( ). (3) Raising the milk production ( ).

4- <u>Feeding and watering practices:-</u>

4.1: Are you providing additional feed? 1. Yes (   ) 2. No (   ).

4.2: the components of additional feed:-

(1)…………………... (2) ………………….. (3) ……………………

(4) ………………….. (5) ………………….. (6) ……………………

4.3: Watering interval in summer/winter

(1) Less than 3 days (   ). (2) Between 3-5 days (   ).

(3) More than 5 days (   ).

Automatic Milk Analyzer Device (Lactoscan™)