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Investigation on Nutritional and Microbiological Properties of Camel (*camelus dromedaries*) Milk: A case study of Mieso district, oromia region, Ethiopia

By
Awel Ahmed

A Thesis Presented to the School of Graduate Studies of the Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Food Science and Nutrition

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Declaration

I, the undersigned, declare that this thesis is my original work and that all sources of materials used for the thesis have been correctly acknowledged.

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Abbreviations

CSA	Central Statistical Agency
masl	meter above sea level
FAO	Food and Agricultural Organization of the united state
USD	United State Dollar
UAE	United Arab Emirates
GDP	Gross Domestic product
AOAC	Association of Official Analytical chemists
TPCA	Total Plate Count Agar
AMBC	Aerobic Mesophilic Bacterial Count
APHA	American Public Health Association
TLU	Tropical Livestock Unit

Abstract

This study was conducted in Mieso district in western Hararghe Zone of Oromia Regional State with the objectives of investigating the quality and microbiological properties of dromedary camel milk. Milk samples at various stages of lactation were collected and analyzed for physico-chemical and microbiological characteristics. The data were analyzed using computer package SPSS version 15. A wide variation was observed in the results of raw camel milk across the three lactation stages. pH ranged between 6.52 and 6.99 (6.84± 0.022) and acidity 0.2 and 0.61 (0.424 ± 0.027). Total solids, solid not fat, fat, protein, lactose and ash contents ranged between 9.2 and 16.4, 5.2 and 11.9, 3 and 4.5, 1.4 and 3.44, 2.17 and 8.05, 0.42 and 0.8 g per 100 g, respectively. Aerobic mesophilic count (AMBC) ranged between 7.4 and 9.5 (8.29± 0.133), coliform count (CC) 0 and 5.3 (2.78±0.309), Enterobacterceae 0 and 5.3 (3.052±0.289), yeast and mold count 0 to 7.4 (6.079±0.258). Iron (Fe) ranged between 0.35 and 2.25 mg/100 g, Zn 0.71 and 1.2 mg/100 g, Ca 9.1 and 10.5 mg/100 g and P 6.6 and 7.95 mg/100 g. Dromedary Camel milk of mieso district resembles with human milk in basic composition of fat, protein, total solid, lactose and pH. But higher composition of acidity, ash, Zn and Fe were observed when compared to human milk. A natural replacement of human milk with camel milk could be considered as an appropriate alternative. Results were analyzed using SPSS version 15. The designed used was completely randomized design (CRD) and the model used was linear model.

1. INTRODUCTION

Camels support the survival of millions of people in arid and semi-arid areas of the world. They possess remarkable abilities to exploit very limited resources because they are extremely well suited for life under harsh conditions of hot climates where water is frequently scarce. They provide milk almost all year around in quantities much greater than other animals living under the same conditions (Ripinsky, 1983).

The Dromedary (*Camelus dromedarius*) inhabits the hot, arid areas in Africa, Asia, and the Middle East. The name "Dromedary" is derived from the Greek *dromeus*, or "runner." The Dromedary is slim, long legged, and short-haired, and its habitats are the warm, arid, and semi-arid areas (Simpson, G.G. 1945). The two humped camel (*Camelus bactrianus*) inhabits and is adapted to cold and arid regions such as the frozen deserts of Mongolia, China, and the Commonwealth of Independent States (the former Soviet Union). This animal is slightly smaller than the Dromedary and is stockier, more short-legged, has two distinctive humps, and its wool is of good quality. The name "Bactrianus" refers to the area "Baktriana" in North Afghanistan where this type of camel is thought to have originated (Dong, 1979).

Camel milk is one of the most valuable food resources for pastoral people in arid and semiarid areas. In the last years milk consumption among urban population w as increasing (Farah, 2004; Chaibou, 2005). The fact that it is mainly consumed in its raw state (boiling of the milk is not common as it is known to remove its "goodness"), the high ambient temperature and the lack of refrigeration facilities in many arid areas are the main reasons for hygienic problems (Radwan *et. al.*, 1992; Semereab & Molla, 2001). Camel milk is considered a useful component of the diet for individuals that show allergic reactions to the protein fraction of cow, ewe or goat milk, as camel milk does not contain ß-lactoglobulin and the content of alpha-casein is much lower than in milk of the other herbivores mentioned (Restani *et al.*, 1999). A trial on patients with multi-resistant tuberculosis showed that camel milk (compared to cow milk) has a positive effect on the general condition of the tested individuals (Mal *et al.*, 2001). In addition, camel milk appears to have a reducing effect on blood sugar level and increases quality of life of people affected by type I diabetes mellitus allowing the reduction of the insulin dose if camel milk is consumed every day (Agrawal *et al.*, 2005).

The annual camel milk production in Ethiopia was estimated to be 75,000 tones (Felleke, 2003). In most pastoralists, camel milk is always consumed either fresh or in varying degrees of sourness in the raw state without heat treatment. The one-humped camel (*Camelus dromedarius*) plays an important role as a primary source of subsistence in the lowlands of Ethiopia. It lives in areas which are not suitable for crop production and where other livestock species hardly thrive. Because of its outstanding performance in the arid and semi-arid areas of eastern lowlands of Ethiopia where browse and water are limited, pastoralists rely mainly on camels for their livelihood. In these areas, camels are mainly kept for milk production and produce milk for a longer period of time even during the dry season when milk from cattle is scarce (Bekele *et al.,* 2002). Ethiopia possesses over 1 million dromedary camels which stands the country fourth in the world (FAO, 2002).

In Ethiopia, women and children are reported to face huge and complex nutritional problems where an estimated 1/4th of Ethiopian women are malnourished, and approximately 50% of children less than five years of age are moderately or severely stunted (CSA, 2006). As indicated by Burns, (2001) even in its milder forms, malnutrition is reported to directly or indirectly account for about 53% of under-five deaths in Ethiopia. This might be attributed to several factors. As reported by Burns, (2001) for instance, about a third of babies do not receive breastfeeding within one hour of birth. Meftuh *et al*. (1990) cited mothers getting back to business after maternity leave (40 %); not enough milk (32%); rejection by babies (19%); and illness of mothers (8%); to be the most important reasons for interruption of breast feeding. The remaining 1% are accounted by different factors such as death of mother or live away from the child. Therefore, while commercial milk replacements have become totally inaccessible due to cost, there is a need for another substitute of close composition and properties as human milk. A natural replacement like camel milk can therefore be considered an appropriate alternative. However, there is very limited research efforts so far carried out to characterize the content and microbiological properties of camel milk in Ethiopia for a potential use as safe and natural human breast milk substitute or its medical value.

This work will provide information on the nutritional composition as well as microbiological properties of camel milk. It also gives a basic background on the possible and potential use of camel milk as a substitute of human or cow milk. Due to various technical and non-technical reasons, most pastoral areas of Ethiopian have never been the focus of research and development activities of both Governmental institutions and Non-Governmental and International research and development partners as compared to highland areas. Results of such an effort can therefore be used as a baseline data for any future relevant improvement interventions.

2. OBJECTIVES

2.1 General objective

Assessing the physico-chemical, nutritional and microbial properties of dromedary camel milk in Mieso, Ethiopia.

2.2 Specific objectives

- Determine the chemical composition and nutritional value of camel milk
- Asses the microbiological properties of camel milk
- Evaluate the physical properties of camel milk

3. LITERATURE REVIEW

3.1 Camels as milking animals

3.1.1 Physiology of reproduction in dromedary camels

The sexual cycle of dromedary camels begins at 24 months (Puschmann, 1989). Different to ruminants, camels are seasonal polyoestrous animals. Usually the ovulation of the female dromedary is induced by copulation or the presence of a male (Wilson, 1984). Camel bulls show their sexual cycle during 3 - 4 months in winter season, beginning in December (Rao *et al.*, 1970; Fazil & Hofman, 1981). The mean gestation period is reported to be between 315 - 360 days (Puschmann, 1989) up to 370 - 375 days (Rao *et al.*, 1970; Fazil & Hofman, 1981; Arthur, 1992). Generally, 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 for pure milking camels. In most countries, it is customary to breed female camels in alternate years only (Hassan, 1967, Rao *et al.*, 1970; Arthur, 1992, Farah, 2004).

3.1.2 Dairy production system in Ethiopia

Zelalem Yilma, (2006) reported that, in Ethiopia, around 97-98% of the annual milk production is accounted by the traditional milk production system. Generally, the milk production system in East African countries in general and in Ethiopia in particular is dominated by smallholder dairy production system. Although Ethiopia holds the largest livestock population in Africa the total national milk production remains among the lowest in the world, even by African standard. The total annual milk production in Ethiopia from about 10 million milking cows is estimated at about 3.2 billion litters, and this translates to an average production of 1.54 liters/cow per day (CSA, 2008). The contribution of the different livestock species to the total production is about 81.2% from cattle, 6.3% from camels, 7.9% from goats and 4.6% from ewes (CSA, 2008). Total annual milk production increased at a rate of 1.2% for indigenous stock and 3.5% for improved stock (Redda, 2002). Per capita milk consumption in the country is about 16 kg/year (Saxena *et al.*, 1997). Hence, about 6 million tones of additional milk are required per annum to feed the population as per the world standard (Saxena *et al.*, 1997). In order to meet the growing demand in Ethiopia, milk production has to grow at least at a rate of 4% per annum (Azage, 2003).

However, different milk production system can still be identified based on various criteria such as agro-climatic condition, production objectives, land and cattle holding, and farming systems (Ahmed *et al.*, 2003). The overall milk production system in Ethiopia could be broadly classified as pastoral and agro pastoral, crop-livestock mixed and peri-urban and urban dairy production systems (Redda, 2001).

The lowland covers 60% of the total land area and is home for 12.2% of the total human population. Ecologically, it has arid (64%), semi-arid (21%) and sub-humid (15%) areas dominated by semi nomadic transhumance population whose economy is entirely dependent on livestock production (Felleke, 2003). Milk is the major source of food and income. Cattle dominate the population (55.4% of the TLU) followed by camels (15.3%), goats (13.7%) and sheep (6.4%) (CSA, 2008), and produce 27% of the total annual milk production (Felleke, 2003). However, information is very scantly on the milk production and marketing system in the lowland areas in general.

Over the last decades following the political changes in 1993, the dairy sector in Ethiopia has shown considerable progress. Total milk production grew at an estimated rate of 3 percent as compared to 1.8 percent during the period of 1975-1992, thus ending the long-time trend of declining per capita milk production in the country (Mohammed, 2004). The progress achieved is mainly due to technological intervention, policy reforms and population growth. The dairy sector in Ethiopia is expected to continue growing over the next one to two decades given the large potential for dairy development in the country, the expected growth in income, increased urbanization, and improved policy environment. The shift towards market economy is creating large opportunity for private investment in urban and peri-urban dairying. However, the main source of growth is expected to be the growth in demand for dairy products (Felleke and Geda, 2001; Azage, 2003).

3.1.3 Camel milk

Camel milk is one of the most valuable food resources for nomads in arid regions and can contribute to a better income for pastoralists, especially as in the last years milk consumption among the urban population was increasing (Farah, 2004; Chaibou, 2005). The fact that it is mainly consumed in its raw state (boiling of the milk is not common as it is known to remove its "goodness"), the high ambient temperature and the lack of refrigeration facilities in many arid areas are the main reasons for hygienic problems (Radwan *et al.*,1992; Semereab & Molla, 2001).

Camel milk is considered a useful component of the diet for individuals that show allergic reactions to the protein fraction of cow, ewe or goat milk, as camel milk does not contain ß-lactoglobulin and the content of alpha-casein is much lower than in milk of the other herbivores mentioned (Restani *et al.*, 1999). A trial on patients with multi-resistant tuberculosis showed that camel milk (compared to cow milk) has a positive effect on the general condition of the tested individuals (Mal *et al.*, 2001). In addition, camel milk appears to have a reducing effect on blood sugar level and increases quality of life of people affected by type I diabetes mellitus allowing the reduction of the insulin dose if camel milk is consumed every day (Agrawal *et al.*, 2005). The controlling effect on hyperglycaemia is probably due to the content of insulin and the slower coagulum formation in the stomach which results in a faster stomach passage (Yagil *et al.*, 1998; Agrawal *et al.*, 2003). However, in the investigation of Breitling, (2002) no blood sugar reducing effect was observed. There are few countries as the UAE, Saudi Arabia, Mauritania and Kazakhstan where camel dairies exist and camel milk and milk products are produced in pasteurized form for placing on the national market (Abeiderrahmane, 1997; Wernery *et al.*, 2002).

3.1.4 Camel milk products

Camel milk can be transformed into cheese with satisfactory organoleptic qualities. This way of conservation is widely used in industrial and manual production processes. Camel milk coagulates after addition of calf rennet or synthetic coagulating enzymes. As the ability of coagulation is much lower in camel milk than in the milk of cows, ewes or goats (Gast *et al.*, 1969; Ottogalli & Resmini, 1976), the concentration of the coagulating additives has to be four times higher than the concentration for cow milk, but can be reduced by adding calcium salts. One problem of the production of camel milk cheese is the high moisture content that contributes to a lower density of the cheese. As the quality can be improved by new technologies, camel milk cheese can be an important source of food in arid zones (Ottogalli & Resmini, 1976; Ramet, 1987; Ramet, 1989; Kamoun & Bergaoui, 1989).

3.1.5 Camel milk production in Ethiopia

In recent years, camel milk production is in the increase in many countries of both Asia and Africa being mainly driven by an increasing demand. The one-humped camel (*Camelus dromedarius*) plays an important role as a primary source of subsistence in the lowlands of Ethiopia. It lives in areas which are not suitable for crop production and where other livestock species hardly thrive. Because of its outstanding performance in the arid and semi-arid areas of eastern lowlands of Ethiopia where browse and water are limited, pastoralists rely mainly on camels for their livelihood. In these areas, camels are mainly kept for milk production and produce milk for a longer period of time (9-18 months) even during the dry season when milk from cattle is scarce (Bekele *et al.*, 2002). Ethiopia possesses over 1 million dromedary camels which stands the country fourth in the world (FAO, 2002). The majority of these camels are found in the eastern part of the country.

Camels produce a substantial amount of milk under extensive management (Knoess, 1979). As CSA, 2008 data the total annual camel milk production is contributed to 6.3 % of 3.2 billion liters. Under rain feed conditions, 13 kg per day can be milked (Knoess, 1979). It was found that some days the camels were milked 6-8 times a day, while other days they were not milked at all. According to Qureshi *et al., (*1986) Milk yield also varies with species, breed, stage of lactation, feeding and management conditions. The length of lactation can vary from 9 to18 months. This depends mainly on the husbandry practices, which are largely determined by the need for milk, more being required in the dry months than in the wet months when other sources of food are available. Yasin and Wahid, (1957) found that well fed and well managed dromedaries produced 9 to 14 liters milk daily and 2722 to 3629 liters in a lactation period of 16 to 18 months, while under desert conditions the average lactation yield varied from 1134 to 1588 liters milk in 9 months.

3.1.6 Lactation length and milk yield of camel in Ethiopia

Tefera and Gebreah, (2001) reported that the average lactation period of camels in eastern Ethiopia in general was one year. Baloch, (2002) also reported that lactation length for Pakistan camels to be 445.58 days. Tezera and Hans, (2000) also reported lactation length of camels in Jijiga was 15 months and that in Shinile Zone to be 13 months. Nevertheless, the present result is within the range of 8 months to 2 years reported for east African camels (Schwartz and Dioli, 1992). When discussing milk and lactation in general, two aspects must be taken into account. The first is the amount of milk produced per day and per lactation period. The other aspect, which is as important, is the type of milk produced. Animals living in cold areas or in the sea need a different quality of milk from those living in hot areas; this applies also to fast-growing animals as compared with slow-growing animals (Yagil & Etzion, 1980). Milk trials in the Awash Valley of Ethiopia were carried out for six days in various stages of lactation (Knoess, 1976).

As suckling stimulus is an integral part of milk production (Yagil *et al.*, 1975), it is obvious that in the short period of hand milking the maximum milk producing capabilities were not fully exploited. Even so, eight liters in two milking, or 2470 kg over 305 days were obtained. The daily average for twice-a-day milking was estimated at 7 kg. These animals grazed on irrigated pastures. Under rain fed conditions, 13 kg per day can be milked (Knoess, 1979). It was found that some days the camels were milked 6–8 times a day, while other days they were not milked at all. On the other hand the average daily milk yield of camel in eastern Ethiopia was 2.5 liters and lactation length was one year (Tefera and Gbreah, 2001). The lactation yield and lactation length of camel in Jijiga was 2009 kg/year and 15 months, respectively (Tezera and Hans, 2000). The same study reported lactation yield and lactation length of 1244 kg and 13 month, respectively for camels in Shinile Zone (Tezera and Hans, 2000). In the dry season the milk yield was about half that of the rainy season. This could be due to the lack of feed or to advanced stages of pregnancy (Lakosa, 1964).

As the report of Ahmed *et al.,* (2005) indicated the breeding practices of camels after parturition in Ethiopia is mostly done after they complete 300-365 days. Therefore, this has a positive effect on milk yield as reported by (Mukasa, 1981); breeding practices in early lactation of the dam will decrease milk yield as well as lactation length. Milk off take is reliable and consistent throughout the seasons (Elmi, 1991). In Pakistan Baloch, (2002), reported that milk yield and lactation length averaged 1894.93 liters and 445.58 days, respectively.

3.2. Nutritional value of camel milk

Milk is more than a drink; it is also a very complete food product. Milk contains virtually all the vital nutrients required for growth of young animals and humans. Milk contains 14 of 18 minerals and vitamins that humans need (Alhomida, 1996). Camel milk can certainly play a far more important role in the prevention of malnutrition than it does today. Camel milk is a staple food of desert nomad tribes and is richer in fat and protein than cow milk.

Camel milk characterized by very low content of short chain fatty acids and higher contents of long chain fatty acids, is similar in its chemical composition with human milk. However, it has more saturated fatty acids than human milk (El-Agamy, 2006). Camel milk can be considered as a good source of protein, calcium, phosphorus, vitamin C and niacin and can meet part of the daily needs of humans from these nutrients (Webb, 1983).

Camel milk can provide significant part of daily needs of humans from different nutrients especially amino acids(El-Agamy and Nawar, 2000). Camel milk is richer in immunoglobulin as compared to human milk. However, its lactoferrin and lysozyme contents are very low. El-Agamy and Nawar, (2000) reported that camel milk contains 1.64 mg/ml of immunoglobulin versus 0.67, 0.63, 0.55 and 0.86 for cow, goat, sheep and human milk, respectively. Milk lysozyme (inhibitory effect against some strains of bacteria and has a higher lysis value toward Salmonella typhimurium compared with other lysozymes) concentration various species to species (El-Agamy *et al*, 1989) . As indicated by El-Agamy *et al.,* (1997) camel milk contains higher content of lysozyme than that of cow, sheep and goat but lower content as compared to that of human and donkey milks. The same author said that camel milk contained also higher level of lactoferrin (0.22 mg/ml) than that of cow, sheep and goat but very low compare with that of human milk.

Literature values of physical properties and chemical composition of human and camel milk are compared as shown in Table 1.

Table 1. Physical properties and chemical composition of camel and human milks.

Constituents	Camel milk	Human milk
	Mean values ± SD	
Fat %	4.0 ± 0.21	2.1 ± 0.15
Protein%	3.46 ± 0.20	1.94 ± 0.14
Lactose (%)	4.86 ± 0.07	6.45 ± 0.08
Ash %	0.87 ± 0.07	0.22 ± 0.01
Total Solid (%)	13.2 ± 0.45	10.71 ± 0.11
Energy (kcal/ L)	759 ± 4.51	560 ± 3.51
pH	6.64 ± 0.05	6.89 ± 0.08
Acidity (%)	0.162 ± 0.007	0.072 ± 0.004
Specific gravity	1.033 ±0.015	1.027 ± 0.011
Ca (mg/100g)	109 ± 7.50	34 ± 3.50
P (mg/100 g)	76 ± 2.55	16 ± 0.85
Fe (mg/100 g)	0.21 ± 0.40	0.04 ± 0.00
Zn (mg/100 g)	0.19 ± 0.018	0.23 ± 0.016

Source: Shamsia, (2009) nutritional and therapeutic properties of camel and human milks.

3.3 Therapeutic properties of camel milk

One peculiar characteristic of camel milk is its therapeutic value against a number of human diseases. Camel milk in the raw state and its fermented products are used as therapeutic agents to treat stomach ulcer, liver disorders, diarrhea, constipation, and wounds as well as to enhance the female's ovary for ovulation (Yagil, 1987). Camel milk is also given to children suffering from biliary artesian and postpartum respiratory insufficiency. They are kept alive until a liver transplant can be performed and the lungs developed (Yagil, 1987).

Pastoralists claim that camel milk is used to treat a number of illnesses in human beings. It has medicinal properties (Yagil, 1983) suggesting that it contains protective proteins, which may have a possible role for enhancing the immune defense mechanism. In Russia, camel milk was used in sanitaria for treating tuberculosis (Urazokov and Banazarov, 1974). Apparently stomach upsets only occur when the milk is drunk while still warm. When it is cool, no ill effects have been noted (Gast *et al.*, 1969).

Patients suffering from chronic hepatitis acquired improved liver functions after drinking camel milk (Sharmanov, 1978). Camel's milk, administered before $AlCl_3$ exposure, minimized $AlCl_3$ associated hazards. Therefore, drinking camel's milk could be beneficial for alleviating aluminum toxicity. Among certain camel keepers in Ethiopia, camel milk is believed to have medicinal as well as aphrodisiac values (Rao, 1970). Some people believe that the curative powers of camel milk are enhanced if the camel's diet consists of certain plants.

3.4 Types of spoilage and shelf life of camel milk

According to Yagil *et al.,* (1984), fresh camel milk can be kept unspoiled for about 7 days. This is much longer than the shelf life of raw cows' milk, which usually ranges from 24-48 hours. Cow milk turns sour within 48 h; however, it took seven days for camel milk to sour. The natural antimicrobial system present in milk, the lactoperoxidase system, has been used to preserve raw milk quality in areas where it is not possible to use mechanical refrigeration for technical and/ or economic reasons (Seifu *et al.,* 2005). Lactoperoxidase (LP) which has a bacteriostatic effect against the Gram positive strains and bactericidal effect against Gram negative bacteria, are found in the camel's milk (Elagamy *et al.*, 1992).

Similarly, Talle, (1992) reported that while cows' milk spoils only after few days and become undrinkable, camel milk tastes well even after five or six days. The long shelf life of camel milk is of paramount importance to pastoralists living in desert areas where cooling facilities are not available. The better keeping quality of camel milk suggests that it probably contains compounds or substances with strong anti-microbial properties. The most common types of spoilage that occur in camel milk include formation of flakes or curd particles, whey separation (syneresis), ropiness and souring. These defects are similar to the types of spoilage that occur in cow milk.

3.5 Antimicrobial properties of camel milk

Raw milk contains a number of compounds that have some antimicrobial activity. Their purpose is to protect the udder from infection and also to protect neonates, but they may also have a role in the preservation of raw milk during storage and transport. Antibacterial and antiviral activities of these camel milk proteins have been studied by (El-Agamy, 2000), and camel milk destroys

Mycobacterium tuberculosis (Donchenko, 1975). The inhibition of pathogenic bacteria by camel milk was also observed (Barbour, 1984).

Lactoperoxidase is an enzyme found in milk. It has no inherent antimicrobial activity, but, in the presence of hydrogen peroxide (usually of microbial origin), it oxidises thiocyanate to produce inhibitors such as hypothiocyanite. This is referred to as the lactoperoxidase system, and it has bactericidal activity against many Gram-negative spoilage organisms, and some bacteriostatic action against many pathogens. For this reason it has been investigated as a possible means of extending the life of stored milk (Wolfson, 1993) Camel milk lactoperoxidase was purified and its inhibition activity against lactic acid bacteria. The LPS had a bacteriostatic effect toward both Lactococcus lactis and Staph. aureus. However, it was bactericidal against E. coli and Salmonella typhimurium (El-Agamy, 1992).

Lactoferrin is also found in milk and is a glycoprotein that binds iron so that it is not available to bacteria. The chelation of iron in the milk inhibits the growth of many bacteria. In addition to producing an iron-deficient environment, lactoferrin is thought to cause the release of anionic polysaccharide from the outer membrane of Gram-negative bacteria, thereby destabilising the membrane (El-Agamy, 1989).

Lysozyme acts on components of the bacterial cell wall, causing cell lysis. Gram-positive organisms are much more susceptible to lysozyme than Gram-negatives, although bacterial spores are generally resistant (Al- Kakhi and Barbour, 1984). Camel milk lysozyme had a higher lysis value toward Salmonella typhimurium compared with other lysozymes. Camel milk lysozyme had no effect on Lactococcus lactis subsp. cremoris, but the strain was highly affected by bovine milk lysozyme. All lysozymes were ineffective toward E. coli and Staph. aureus (El-Agamy, 1989)

Immunoglobulins of maternal origin are often present in milk, and colostrum is a particularly rich source. These proteins may inactivate pathogens in milk, but their significance in preservation is uncertain.

Milk allergies in children are often very serious and can lead to anaphylactic reactions. Lactose is present in concentrations of 4.8%, but this milk sugar is easily metabolized by persons suffering from lactose intolerance (Hanna, 2001). Camel milk is free of betalactoglobulin as is human milk and the ratio of whey protein to casein in camel milk is high, which results in soft curd and therefore easier digestibility (Kappeler, 1998). The proteins of camel milk are the decisive components for preventing and curing food allergies because camel milk contains no beta-lactoglobulin (Yagil, 2001) and a different beta-casein (Beg, Von-Bahr-Lindststrom , Zaidi, Jornvall, 1986).

3.6 Composition of camel milk

Data concerning the composition of milk vary greatly. This can be partly attributed to the inherited capabilities of the animals. Others such as the stage of lactation, age, and the number of calving also play a role. Of special significance to the quality of the produced milk are the feed and water quantity and quality. Most camel milk is drunk fresh. It is also consumed when slightly sour or strongly soured.

Camel's milk is generally opaque white (Dihanyan, 1959; Heraskov, 1953; Yagil and Etzion, 1980). Normally it has a sweet and sharp taste, but sometimes it is salty (Rao, 1970). At times the milk tastes watery. The changes in taste are caused by the type of fodder and the availability of drinking water (Rao, 1970). It is considered as having an unpleasant taste (Yasin and Wahid, 1957). It is frothy when shaken slightly (Shalash, 1979).

3.6.1 pH and acidity of camel milk

Fresh camels' milk has a high pH (Grigor'yants, 1954; Ohri and Joshi, 1961). The pH of milk is between 6.5–6.7 (Shalash, 1979). This is similar to the pH of sheeps' milk. When camel milk is left to stand, the acidity rapidly increases (Ohri and Joshi, 1961). The lactic acid content increases from 0.03 % after standing 2 hours to 0.14 percent after 6 hours.

3.6.2 Camel milk Colostrum

The first milk, the colostrum, is white and slightly diluted as compared with the colostrum of cow (Yagil and Etzion, 1980). Other studies on the composition of the milk, depending on the stage of lactation, confirm these data (Sestuzheva, 1958). It was found that 3 hours post-partum total solids (T.S.) averaged 30.4 percent. The T.S. declined to 18.4 percent during the first 2 days of lactation. This decline in T.S. was not caused by a variation in fat content, as initially the fat percentage was low, at 0.2 percent, and then greatly increased to 5.8 percent; rather the decline in total proteins and minerals was responsible (Sestuzheva, 1958).

3.6.3 Water content

The most important factor in camel milk is water content. The water content of camel milk fluctuates from 84 % (Knoess, 1976) to 90 % (Ohri and Joshi, 1961). When examining only the effects of the lack of drinking water on camel milk, the diet remaining unchanged throughout the year, great changes in water content of milk were found (Yagil and Etzion, 1980). With water freely accessible the water content of the milk was 86 %, but when water was restricted the water content of milk rose to 91 %. Water content of fodder would also affect water content of milk. Thus, it would appear that the lactating camel loses water to the milk in times of drought. This could be a natural adaptation in order to provide not only nutrients, but necessary fluid to the dehydrated calf (Yagil and Etzion, 1980)

3.6.4 Fat content of camel milk

With the increase in water content of milk produced by thirsty camels, there was a decrease in the fat content, from 4.3 to 1.1% (Yagil and Etzion, 1980). In different literatures, the percentage of milk fat of camels varies from 2.6 (Yasin and Wahid, 1957) to 5.5 % (Knoess, 1976). Again, the hydration status of the animals would determine the fat content of the milk, as well as the type of forage eaten. The milk fat is also different from that of other animals. When left standing, fat is distributed as small globules throughout the milk (Yagil and Etzion, 1980). The fat globules are very small 1.2–4.2 microns in diameter (Dong, 1981). The fat appears to be bound to the protein (Khan and Appara, 1967). This would explain why it is difficult to extract fat by the usual method of churning sour milk (Rao *et al.*, 1970). (Dhingra, 1934; Gast *et al.*, 1969) claim that the value of camel milk is to be found in the high concentrations of volatile acids and, especially, linoleic acid and the polyunsaturated acids, which are essential for human nutrition.

3.6.5 Protein content of camel milk

Milk protein content of camel milk ranges from 2 to 5.5 % (Yasin and Wahid, 1957). The total protein in camel milk is similar to that of cow milk. Dilanyan, (1959) reported the casein content of dromedary and Bactrian milk as 2.7 and 0.89 % respectively and that of albumin as 3.8 and 0.97 % respectively. Kherashov, (1961) examined four breeds of camels and found the value for total protein to vary from 3.5 to 3.8 % and casein from 2.7 to 2.9 %. Camel milk casein and their fractions were found to be poor in crude protein when compared with cow milk (Pant and Chandra, 1980). Milk from the dehydrated camel has a severely decreased protein percentage. (Yagil and Etzion, 1980). Again, this demonstrates the direct effect of drinking water on the composition of milk. It must be stressed that protein content of the feed will also directly affect that of milk.

3.6.6 Lactose content of camel milk

Sestuwheva, (1958) found that the lactose content of camel milk remained unchanged from the first months up to the end of lactation. The concentrations in milk vary from 2.8 percent to 5.8 percent (Yasin and Wahid, 1957). These were approximately the same range as found between the hydrated and dehydrated animals (Yagil and Etzion, 1980). The changes in lactose concentration would account for the milk being described as sometimes sweet and other times bitter.

3.6.7 Mineral composition of camel milk

The mineral content of milk is expressed as total ash. The total ash content of camel milk varies greatly, and the lowest percentage of ash was found in the milk produced by dehydrated camel (Yagil and Etzion, 1980). Camel milk is rich in chloride (El-Bahay, 1962). Although milk from the dehydrated camel showed decrease of fat, protein and lactose content, that of sodium and chloride increased (Yagil and Etzion, 1980). This would account for the salty taste. Both concentrations of calcium phosphate and magnesium decline in the milk of dehydrated camel. (Yagil and Etzion, 1980). However, these concentrations are still adequate for human nutrition and are similar to the values presented by (Kulier, 1959).

3.6.8 Camel milk Vitamins

Camel milk is rich in vitamin C (Knoess, 1959 and 1979). This is important from the nutritional stand point in areas where fruit and vegetables containing vitamin C are scarce. Kheraskov, (1961) found the vitamin C content of camel milk to vary between 5.7 and 9.8 mg. Bestuzheva, (1964) reported that as lactation progresses, the vitamin C content increases. The vitamin C levels are three times that of cow milk and one-and- half that of human milk (Gast *et al.*, 1969). Vitamin B_{12} in camel milk declined from 3.9 ug/l at 1.5 months lactation to 2.3 ug/l at the fourth month of lactation (Bestuzheva, 1964). Vitamin B_1 and Vitamin B_2 concentrations are adequate and are higher than those of Afar sheep (Knoess, 1976). Vitamin B_2 content in camel milk is also higher than in Afar goat milk, but the vitamin B_1 is lower in camel milk.

3.7 Microbial properties of camel milk

Provision of milk and milk products of good hygienic quality is desirable from consumer health point of view. This is one reason why milk testing and quality control include hygiene as well as microbial qualities in addition to testing for fat content and heat stability (Yilma, 2006).

Milk is an ideal habitat for the growth and multiplication of microorganisms due to its nutritional constitution which contain protein, carbohydrate, mineral and vitamins. All these components support the growth of many forms of bacteria. Raw milk aseptically drawn from a healthy animal usually contains a few bacteria. Beside that milk is an ideal medium for the growth of microorganisms from surrounding environment (Cousins and Barmle, 1981). In fact, most of camel milk is consumed in the raw state without any heat treatments or acid fermentation and kept at high ambient temperature coupled with lack of refrigeration facilities during milking and transporting. These conditions turn the milk to be unsafe, capable of causing food-borne diseases and it even spoil fast. In Ethiopia the consumption of raw milk and its derivatives is common (Yilma, 2003), which is not safe from consumer health point of view. As the initial micro flora of milk has a marked influence on the keeping quality of raw milk, once the milk comes outside the udder the contamination of various degrees occur mainly from milking, handling and from the environmental contamination (Anderson *et al.*, 1999).

4. MATERIALS AND METHODS

4.1 The study area

The study was conducted in Meiso district of Oromia region. Meiso is located 300 km east of Addis Ababa and at about 200 km east of Adama town. The rail way from Addis to Dire Dawa passes through the district. Meiso is located northwest of Somali Regional State and south and southwest of Afar Regional State. The total land area of the district is 196,026 ha (IPMS, 2006).

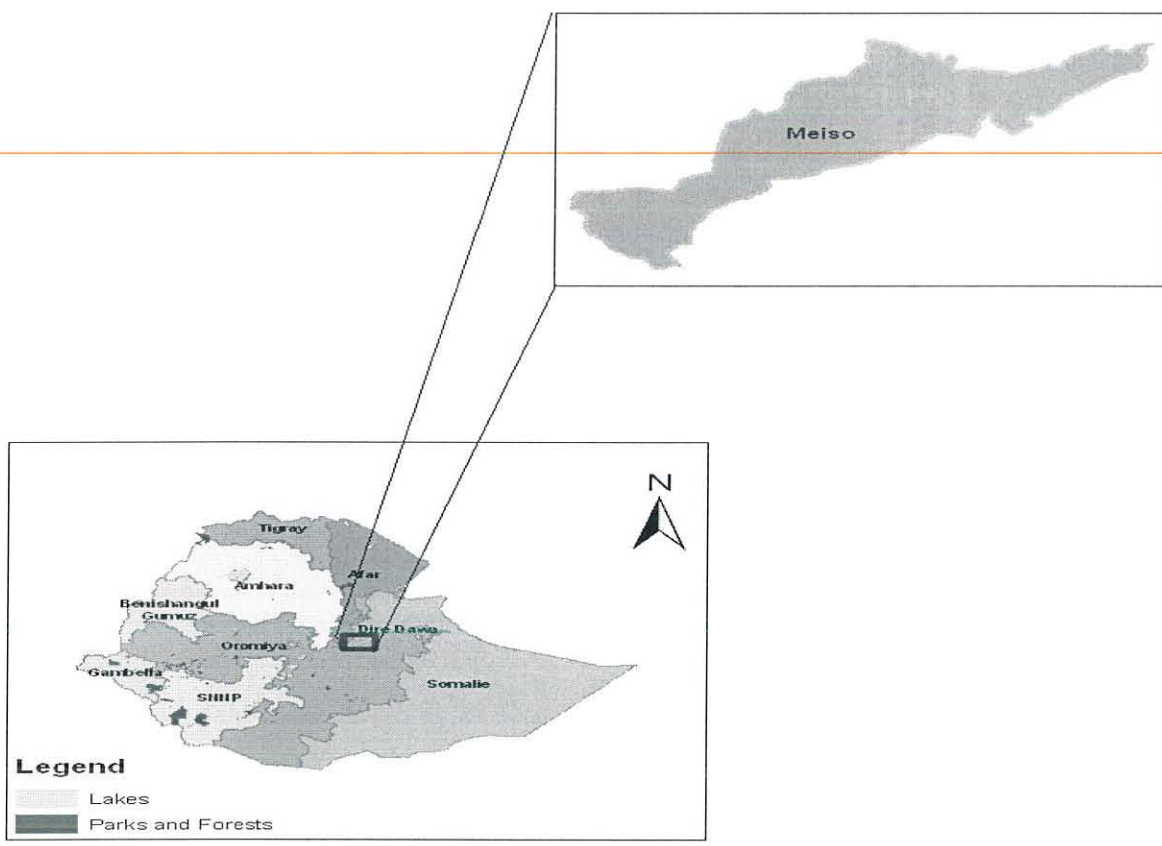

Figure 1. Elevation map of Mieso district, Oromia Region, Ethiopia.

4.2 Population and Agro-ecology

The total human population of the *woreda* is estimated at 145,775 and is composed of 22,012 agricultural rural households and 6785 urban households. The total rural population is 115,568, out of which 58,612 (51%) are male. Of the total rural households, 17,495 (80%) are male-headed households (IPMS, 2006).

Agro ecologically the district is classified as Kola (lowland). The mean annual rainfall ranges from 400 to 900 mm, with an average of about 790 mm (IPMS, 2006). Although the amount of rainfall seems relatively sufficient, the erratic nature and limit crop production. Most of the rain is received in only few months, and most of the months are dry. As a result relief aid is a regular source of livelihood for many rural families (IPMS, 2006).

4.3 Sample collection and handling

A total of 30 samples were collected in three lactation periods 1-3, 4-6 and 7-9 months in one Keble namely Fayo. In each lactation stage 10 samples were taken. Approximately 100 ml of milk sample were collected from each camel. Sample was collected through direct milking into a sterile test bottle from unwashed udder and transported to the laboratory within 8 hours using an ice box filled to maintain 4^0C. Samples were transported to Holetta Agricultural Research Institute laboratory. The sample was then be transferred to a deep freezer and stored at -20 ^{0}C until nutritional analysis was performed. But microbiological analyses were carried within 24 hours of milking. The stored sample was thawed before nutritional analysis. The procedure of liquefying the milk sample was performed according to (European Commission, 1991).

4.4 Sample preparation

4.4.1 Autoclaving and washing procedure

All the sampling bottle was autoclaved at 121^{0}c for 15 minute to make save for microbial analysis. To prevent contamination glass wares, the digestion and volumetric flasks were soaked in 20% nitric acid for at least 24 hours and rinsed with deionized water.

4.4.2 Wet ashing of milk samples

The milk sample needed for wet ashing brought in to clear solution for analysis by the Atomic Absorption Spectrophotometer. For this reason the liquid milk samples were digested by wet ashing method on electric hot plates. A liquid milk sample of 2 ml homogenate sample was accurately measured and transferred to each 100 ml round bottom flask and treated with 4.8 ml HNO_3 and 1.2 ml $HClO_4$ mixed and digested with Gallenkamp Kjeldahl Apparatus for 65 minute. The digest was transferred to 50 ml volumetric flask and diluted with distilled-deionized water to its mark. In order to avoid blocking of the nebulizer, all samples were filtered through Whatman filter paper. All samples were digested for duplicate run. Blanks, consisting of distilled de-ionized water and reagents (4.8 ml HNO_3 and 1.2 ml $HClO_4$) were subjected to a similar sample preparation and analytical procedure.

4.5 Physico-chemical analysis

pH

pH of the samples was determined using a digital pH meter. A rough estimate of pH was obtained using paper strips impregnated with an indicator. The measurement was done in duplicate for each milk samples (Foley, 1974).

Acidity test

The percentage of acid present in milk was a rough indication of its age and the manner in which it has been handled. Acidity of the milk was determined by filling the burette with 0.1N NaOH and make sure there were no air bubbles trapped in the lower part. Then adjust the level of NaOH in the burette to the top mark, the lowest reading being at the upper end. After this delivered 10 or 17.6 ml of milk into the porcelain dish and add 3 to 5 drops of phenolphthalein to the sample in the cup. Allowed the NaOH to flow slowly into the cup containing the sample and stired continuously. When a faint but definite pink colour persists, the end-point has been reached. The reading of the burette at the lowest point of the meniscus was taken. Subtract the first reading from the second to determine the number of milliliters of alkali (NaOH) required to neutralizing the acid in the sample (O'Connor, 1995).

Calculation

$$\text{Lactic acid (\%)} = \frac{\text{ml N/10 alkali X 0.009 X 100}}{\text{ml of sample}}$$

Total solid (TS)

Total solid was measured by gravimetric method (oven drying) according to AOAC (2000) official method 925.33 in which the sample was weighed and placed in pre-dried and weighed dish together with empty pre-dried and weighed dishes which serve as blank. Samples then transferred into an oven which was preheated to 100 ± 1°C for 4 h at 100 ± 1°C. Then, the dish was removed from the oven and let to cool to room temperature in desiccators for 30 min. Finally, the dish plus dry milk was weighed on same balance and the percentage of total solid was calculated as:

$$\text{Total solids, \%} = \frac{(W_2 - W) - B}{W_1 - W} \times 100\%$$

Where W= weight of dish; W_1 = weight of dish + milk test portion; W_2 = weight of dish + dry milk; and B = mean blank weight.

Determination of solids non-fat (SNF)

Solid non-fat (SNF) was determined as the difference of total solids and fat.

SNF (%) = Total solids (%) –Fat (%)

Protein

Protein content was determined by Kjeldahl method according to the AOAC (2003) as follows: Digestion: 10 grams of each sample were weighed in a crucible and transferred to a digestion flask. Two tablets of Kjeldahl catalyst (copper) and 3 ml of concentrated sulphuric acid (sp.g 1.84) were added to the sample. The flask was placed on the digestion apparatus, heated vigorously until the liquid becomes clear.

Distillation: The digested sample of milk and 15 ml of NaOH (40%) were added to kjeldahl distillation apparatus. 10 ml of boric acid (2%) and 3 drops of indicator (methyl red) were added to a receiving flask. The distillation was continued until the distillate in the receiving flask was 75 ml. Titration: The sample in the receiving flask was titrated against HCL (0.1N) until the color was changed to a faint pink.

Fat

Fat content was determined according to James *et.al*, 1995 in which the sample was thoroughly mixed at 38^0C to just liquefy the fat and then cooled to 20^0C. Then 10ml H_2SO_4 (SG = 1.820 – 1.825) was pipette into a Gerber butyrometer with an ordinary graduated 10ml pipette to which 10.77ml milk was carefully introduced down the side of the butyrometer to form a layer on the sulfuric acid. Then 1ml of amyl alcohol was added on to the layer of the sample and the butyrometers were sealed carefully with a plug and key. The sample was mixed with H_2SO_4 by carefully rolling the tube by hand at an angle of 45^0. Once all the milk was mixed the tube was inverted twice to complete mixing in the graduated stem. Then the butyrometer was placed in a water bath at 65^0C for 5 minutes and fit in the bushings of the centrifuge with the graduated stems pointing to the center. The mix then placed in Gerber centrifuge for 5 minutes at 1,100 revolutions per minute. Finally, the butyrometer was removed carefully from their bushings, incubated for 5 minutes at 65^0C in a water bath and the position of the fat column adjusted such that the lower fat line corresponds with one of the major graduations on the tube. The percentage of fat was read from this mark to the lowest point of the upper meniscus.

Ash

Ash was determined by gravimetric method according to AOAC (2000) official method 925.21 in which 5 g prepared test portion is placed into suitable Petri dish and evaporated to dryness on steam bath followed by ignition of the sample in furnace at 550°C until ash was carbon free (Pearson, 1976). Then the ash was cooled in desiccators weigh, and percentage ash was calculated as:

$$\text{Ash } (\%) = \frac{\text{Mass of Ash}}{\text{Weight of sample (g)}} X100\%$$

Lactose

Lactose was determined as the difference of total solids and the sum of protein, fat and ash

Lactose, % = Total solids (%) – [protein (%) + fat (%) + ash (%)] (AOAC, 2003).

Mineral analysis

Wet digestion: 2 ml of homogeneous sample was placed in a 100 mL tube, mineralized by addition of 6 mL HNO3-HClO4 (4:1) mixture and heated to 120°C for 65 min in a thermostat-controlled digestion block. After cooling, the resulting solution was diluted to 50 mL with demineralized water. Mineral measurements were carried out by direct aspiration into the air-acetylene fame in an atomic absorption spectrophotometer, following the recommended operating procedure (10 mA; a 0.7 nm spectral width was chosen to isolate the 285.2 nm line). Both samples and blanks were mineralized and diluted to duplicate, using the same procedure. Ca, Fe, P and Zn was measured by atomic absorption spectrophotometer (Laurent, 1981).

4.6 Microbiological analysis

4.6.1 Total plate count

It was determined according to the method described by Van den Berg, (1988) in which the sample was homogenized and serially diluted by adding 1mL into 9mL of sterile water containing 0.8% NaCl (common salt), until a solution was obtained that is expected to give a plate count between 30 and 300. One milliliter of the sample from a chosen dilution was placed on the Petri dish and pour plated with 10-15 ml molten plate count agar (at about 45°C) and allowed to solidify for 15 min and incubated for 48 hours at 37°C. Finally, the counts was made using colony counter. The plate counts were calculated by multiplying the count on the dish by 10^n, in which n stands for the number of consecutive dilutions of the original sample.

4.6.2 Coliform count

It was determined according to the method described by Richardson, (1985) in which, appropriate decimal dilutions were made by transferring 1 ml of the sample into 9 ml of peptone water for initial dilution and by transferring 1 ml of the previous diluting into 9 ml of peptone water after vertoxing the sample portion. After surface plating the appropriate dilution in duplicates on Violet Red-Bile Agar (VRBA), the plates were incubated at 32°C for 24 hours and counts were made on typical dark colonies from each plate into tubes of 2% Brilliant Green Lactose Bile Broth (BGLBB).

4.6.3 Entrobacteriaceae count

It was determined according to the method described by Richardson, (1985) in which, appropriate decimal dilutions were prepared by transferring 1 ml of the sample into 9 ml of peptone water for initial dilution and by transferring 1 ml of the previous dilution into 9 ml of peptone water after vertoxing the sample portion. After surface plating the appropriate dilution in duplicates on Violet

Red-Bile Agar (VRBA), the plates was incubated at 32°C for 24 hours and count was made on typical dark red colonies normally measured at least 0.5 mm in diameter on uncrowned plates.

4.6.4 Yeast and Mould count

Number of yeast was determined on acidified Potato Dextrose Agar (PDA) at pH 3.5 using acid tartaric at 10%. The plate was incubated at 25°C for 3 days (Richardson, 1985).

5. RESULT AND DISCUSSION

5.1 physico-chemical analysis

Physical characteristics of milk (pH and titratable acidity) are important parameters in studying its physicochemical aspects. Table 2 shows the two physical parameters of the dromedary camel milk samples. Murphy, (1982) documented that wide spread and longtime usage of pH has caused it to consider mathematically equivalent to other biological variables. Mcdowell, (1937) showed that in general the pH is lower (down to pH 6.0) in colostrums. However, Prouty, (1940) indicated that pH higher (up to 7.5) in cases of mastitis than in normal milk of mid–lactation. Robert *et al.*, (1974) reported that pH of cow's milk is commonly stated as falling between 6.5 and 6.7 with 6.6 the most usual value. Eckles and Macy, (2004) found that pH or hydrogen-ion concentration of fresh milk was 6.5 to 6.6. Mohamed, (2004) evaluated the quality of milk sold in Khartoum state and found a pH value of 6.50.

Table 2. Physical quality of dromedary camel milk

Attribute	Lactation stage	N	Minimum	Maximum	Mean $\pm$ SD
pH values	1^{st} - 3^{rd} Month	10	6.52	6.82	6.70 $\pm$ 0.097
	4^{th} – 6^{th} Month	10	6.84	6.89	6.86 $\pm$ 0.0169
	7^{th} – 9^{th} Month	10	6.88	6.99	6.95 $\pm$ 0.037
Average	-	30	6.52	6.99	6.84 $\pm$ 0.1199
Acidity (%)	1^{st} – 3^{rd} Month	10	0.58	0.61	0.6 $\pm$ 0.0094
	4^{th} – 6^{th} Month	10	0.20	0.32	0.25 $\pm$ 0.0340
	7^{th} – 9^{th} Month	10	0.38	0.48	0.43 + 0.0389
Average	-	30	0.2	0.61	0.424 $\pm$ 0.150

As indicated in Table 2, pH values of fresh camel milk was between 6.52 and 6.99 with an average value of 6.84 $\pm$ 0.022. These results are in agreement with results reported by (Khaskheli, Arain, 2005) 6.57 and 6.97 with an average value of 6.77 $\pm$ 0.07. These results were relatively similar to that of reported values (6.5-6.7) of (FAO, 1982), while higher than those of reported by (Ahmed, 1990) and (Sawaya *et al.*, 1984) that was 6.53 and 6.49 respectively. The gradual increment of pH from early lactation to late lactation may be due to the reduction of colostrums from early lactation to late lactation period.

The acidity in terms of lactic acid content (Table 2) varied between 0.2 to 0.61with an average of 0.424 $\pm$ 0.027. These results were not in line with those reported by (Ahmed, 1990) and Wilcox, (1992) (*i.e.* 0.13 and 0.15%, respectively). These results showed that the acidity of camel milk is too high. In addition the deviation from the previous result could be related with the age of milk until analysis. FAO, (1982) reported that when the milk is left to stand for 2-6 h. the lactic acid content rapidly increases from 0.03% after standing 2 h to 0.14% after 6 h. So the analysis of this result was conducted around 24 hours after milking and this might be the reason for its increment of acidity. As reported by AbdAlmageed *et. al.,* (2005) the mean value of acidity content in liquid goat and cow milk 0.18% and 0.18% respectively were not significantly different ($P \geq 0.05$) from camel milk 0.24% which is higher ($P \leq 0.05$) than both of them. The value reported of camel milk in this study (0.42) was higher than the previous reports of all milk acidity. Ibrahim, (1973) and Bulletin, (1983) found cow milk acidity 0.19 % and 0.18 % respectively. However, the acidity content in camel milk was still slightly higher than those obtained.

5.2 Chemical quality of dromedary camel milk

The dromedary camel milk samples were subjected to the determination of the amount of total protein, fat, lactose and moisture content. In addition the total solid (TS), solid not fat (SNF) and total ash were also analyzed as presented in Table 3. Results presented in (Table 3) showed a wide variation in the total solids content of camel milk. The values varied between 9.2 to 16.4 g per 100 g with an average of 12.0±0.339 g per 100 g in three lactation stages. The values are relatively higher than values report by (Khaskheli and Arain, 2005) 7.76 to 12.13 g per 100 g with an average of 9.74±0.49 g per 100 g and 9.45±0.24 for (Late lactation), 10.81±0.19 g per 100 gm (Mid lactation) and 11.66±0.15 g per 100 gm (Early lactation) values reported by (Zeleke, 2007). Ahmed, (1990) and FAO, (1982) also reported similar fluctuations (84 to 93 g per 100 g) in the moisture content of camel milk which is inversely proportional to TS content.

In this result also the moisture content was highly fluctuated from 83.6 to 91.8 g per 100 gm in all lactations. One of the reasons they reported was hot summer, during which the cow camel secretes highly diluted milk with low fat. This could be the natural phenomena by which the camel young ones are supplied with sufficient nutritional value and water for a superb adaptation in a desert environment. Secondly, water content of fodder would also affect water content of milk. The average moisture content and TS content of camel milk was 87.46 $\pm$ 0.306, 12.54 $\pm$ 0.306 (1^{st} -3^{rd} month), 86.49 $\pm$ 0.496, 13.51 $\pm$ 0.496 (4^{th} -6^{th} Month), 90.14 + 0.227, 9.97 + 0.156 g per 100 gm (7^{th} – 9^{th} month) respectively from this study as shown in Table 3. According to Khaskheli and Arain, (2005) report total solid of cow milk was 13.31 % and the lowest for camel milk was 11.47 %. If we compare the results of this study, the TS of cow milk was slightly higher than camel milk TS. But in line with the previous reports of lower value that is 11.47 percent.

Table 3. Chemical quality of dromedary camel milk

Components (g per 100 g)	Lactation Stage (Month)	N	Minimum	Maximum	Mean ± SD
Total Solid	$1^{st} – 3^{rd}$	10	11.1	13.9	12.54 ± 0.967
	$4^{th} – 6^{th}$	10	10.7	16.4	13.51 ± 1.5695
	7^{th} -9^{th}	10	9.2	10.8	9.97 ± 0.492
Solid Not Fat	$1^{st} – 3^{rd}$	10	6.9	9.7	8.46 ± 1.0167
	$4^{th} – 6^{th}$	10	7.2	11.9	9.66 ± 1.333
	7^{th} -9^{th}	10	5.2	7.3	6.29 ± 0.676
Fat	$1^{st} – 3^{rd}$	10	3.0	4.5	4.08 ± 0.432
	$4^{th} – 6^{th}$	10	3.2	4.5	3.85 ± 0.513
	7^{th} -9^{th}	10	3.0	4.2	3.68 ± 0.388
Protein	$1^{st} – 3^{rd}$	10	1.4	2.09	1.621± 0.2195
	$4^{th} – 6^{th}$	10	2.0	3.05	2.47 ± 0.375
	7^{th} -9^{th}	10	2.17	3.44	2.58 ± 0.356
Lactose	$1^{st} – 3^{rd}$	10	4.57	7.61	6.22 ± 1.023
	$4^{th} – 6^{th}$	10	4.53	8.05	6.53 ± 1.1686
	7^{th} -9^{th}	10	2.17	4.06	3.20 ± 0.78
Ash	$1^{st} – 3^{rd}$	10	0.55	0.68	0.62 ± 0.0489
	$4^{th} – 6^{th}$	10	0.50	0.80	0.66 ± 0.082
	7^{th} - 9^{th}	10	0.42	0.70	0.50 ± 0.083
M.C	$1^{st} – 3^{rd}$	10	86.1	88.9	87.46 ± 0.967
	$4^{th} – 6^{th}$	10	83.6	89.3	86.49 ± 1.5695
	7^{th} - 9^{th}	10	89.2	91.8	90.13 ± 0.717

As indicated in Table 3, the solid not fat (SNF) content of camel milk was higher 7.2 to 11.9 g per 100 gm with an average of 9.66 ±0.421g per 100 gm in the mid lactation period, this may due to the direct relationship with an increment of protein, lactose and ash values in the mid lactation stage than the early and late lactation stage. Different sources show that the values of camel milk SNF content was ranged from 6.6 to 9.7 g per 100 gm. The minimal value (6.29 ± 0.2137 g per 100 gm) was observed in the late lactation period.

Fat content of camel milk in the three lactation stage is ranged between 3.0 to 4.5 g per 100 g and with an average value of 3.87±0.084 g per 100 g. But the mean value of fat content was decreasing moving from early lactation to late lactation (4.08±0.137, 3.85 ±0.162, 3.68 ±0.123 g per 100 gm) respectively. This could be directly/indirectly related to the total solids content and moisture content of camel milk with irregular pattern across lactation to it as observed in (Table 3). In addition as reported by FAO, (1982), the hydration status of the animal as well as the type of forage eaten would also affect the fat content of the milk.

The result shows the total protein content of camel milk was in the range of 1.4 and 3.44 % with an average percentage of 2.22±0.098. The results also indicate that the amount of protein from the early stage of lactation 1.621 ± 0.069, to late lactation was increasing and the highest value was recorded in late lactation, 2.58± 0.113. Khaskheli and Arain, (2005) reported that the total camel milk protein was ranged from 1.8 to 3.2 % with average value of 2.54±0.19. This report is similar with the current work. The increment along the lactation stage could be related to the protein content of the feed as well as the water intake as reported by (FAO, 1982).

The lactose content of camel milk was higher in the early (6.22± 0.324 g per 100 g) and mid stage of lactation (6.53± 0.369 g per 100 g) (Table 3). The minimum value was observed in late lactation (3.20 ± 0.247 g per 100 g) with an average of the three lactation stage 5.32±0.330 g per 100 g. This is not agreed with camel milk lactose values reported by (Khaskheli and Arain, 2005), varied between 2.91 to 4.12 g per 100 g with an average of 3.65±0.16 g per 100 g. This wide variation could be due to the fact that camel usually grazed on halophillic plants for example Atriplex, Acacia etc. (FAO, 1982). Khaskheli and Arain, (2005) reported that goat milk had the highest lactose content. Statistically goat and camel milk had similar ($P \geq 0.05$) lactose contents. On the other hand cow and camel milk had similar ($P \geq 0.05$) lactose contents; however goat milk had higher ($P \leq 0.05$) lactose than cow milk (Khaskheli and Arain, 2005). Auq and AL-jiborry, (2002) and Iglesia *et al.,* (1994) reported higher lactose content in goat and camel milk i.e. 4.65% and 4.67% respectively. But our finding in this study were slightly similar to report of (Khaskheli and Arain, 2005) and higher to that of (EL-Hag *et al.,* 2003) and (Knoess, 1976) who cited 3.6% and 3.4% for the milk from goat and camel species respectively.

Ash content of camel milk was observed to vary in between 0.50 ±0.026 g per 100 g at the late lactation to 0.66± 0.23 g per 100 g at mid lactation and average value of 0.59±0.018 g per 100 g. These results were lower than those reported by (Khaskheli and Arain, 2005), between 0.85 to 1.0 g per 100 g and average 0.94±0.02 g per 100 g and (Knoess, 1982; Ahmed, 1990; Elamin & Wilcox, 1992), in between 0.75 to 0.83 g per 100 g. Ash content of this study was lowest than those reported by (Nabag, 2004) who found it to be 0.83%. Results showed that the ash value of this study was lower than the previously mentioned results.

5.3 Microbial analysis of dromedary camel milk

Result obtained from this study shows that the mean value of coliform count (CC) and Entrobacteriacea was less than the standards seated for cow milk (Marshall, 1992). But the values of total plate count (TPC) obtained from this study (8.3 log cfu/ml) were higher than values reported previously that was 5 log cfu/ml (El-Ziney, 2007). Even though the results indicate that the total plate count was beyond the standard, it was in line with a report of (Yilma et al., 2006) that was (8.3 log cfu/ml). Yeast and mold count of this study shows higher value than the previous report of raw milk. In the mid lactation stage almost all the values of microbial count were less than the other two lactation stages Table 4 shows the detail result. This is may be due to more aseptic sampling in the mid lactation stage. The mean, maximum and minimum results of dromedary camel milk microbial load were indicated in Table 4.

Table 4. Microbial quality of camel milk using descriptive analysis

Parameter	Lactation stage	N	Minimum	Maximum	Mean ± SD
AMBC (cfu/ml)	1st - 3rd Month	9	7.4	9.5	8.46 ± 0.904
	4th – 6th Month	10	7.5	8.0	7.73 ± 0.142
	7th – 9th Month	10	8.0	9.4	8.69 ± 0.536
CC (cfu/ml)	1st – 3rd Month	9	0	5.3	2.3 ± 2.480
	4th – 6th Month	10	0	3.9	2.3 ± 1.166
	7th – 9th Month	10	3	4.9	3.69 ± 0.617
Enter. (cfu/ml)	1st – 3rd Month	9	2.7	5.3	3.76 ± 0.735
	4th – 6th Month	10	0	5.2	1.87 ± 1.928
	7th – 9th Month	10	1	4.5	3.6 ± 0.999
YandM (cfu/ml)	1st – 3rd Month	9	5	7.4	6.19 ± 0.996
	4th – 6th Month	10	0	7.4	5.67 ± 2.143
	7th – 9th Month	10	5.9	7.0	6.39 ± 0.475

Aerobic mesophilic bacterial count (AMBC) were 8.3 log cfu/ml which was in line with reports of (Zelalem *et al.*, 2007) that was 8.3 log cfu/ml. The maximum limit of AMBC, which is commonly employed to indicate the sanitary quality of food, for raw milk intended for processing was 10^5 cfu/ml and for that intended for direct human consumption is $5x10^4$ cfu/ml (Bodman and Rice, 1996).

The mean of AMBC in collected samples was 8.3 log cfu/ml with a maximum of 9.5 log cfu/ml as indicated in Table 4. It was detected in 29 samples. These results were higher than the values reported by (El-Ziney, Al-Turki, 2007) mean value of 5 log cfu/ml with maximum of 7.15 log cfu/ml. The observed result also was much higher than results reported by (Mohizea, 1994) mean value of 5.4 log cfu/ml and (Semereab and Molla, 2001) 5.6 log cfu/ml in average. It is worth to mention that there are no microbiological standards concerning camel milk. Therefore, the microbiological limit value for cow milk was used to assess the quality of camel milk. In this study all of the results are beyond the accepted limit (5.3-5.6 log cfu/ml) of American public Health Association (APHA). This could be due to high contamination of bacteria from unwashed udder during milking and from the environment.

Coliforms were totally found in 25 samples, especially in the early lactation, only in 5 samples of milk were detected with a minimum average value of 0, maximum 5.3 log cfu/ml (Table 4) and a mean count of 2.8 log cfu/ml in the three lactation stages. The values somehow similar with results of maximum value 4.2 log cfu/ml reported by (El-Ziney and Al-Turki, 2007). Results of this study show that the maximum was detected in the first stage of lactation and the minimum value was observed in the mid lactation stage. This maximum value found in the early lactation stage could be an indication of high udder and hand contamination during milking.

Enterobacteriaceae were detected in 25 samples. As indicated in Table 4, the mean count was 3.1 log cfu/ ml, with a maximum value of 5.3 log cfu/ml for all lactation. These results are slightly in line with results reported by (El-Ziney and Al-Turki, 2007) mean value of 2.7 log cfu/ml, with a maximum of 6.82 log cfu/ml. Results of this study shows lower value than reported by (Zelalem *et al.*, 2007) that was 5.2 log cfu/ml.

Yeast and Molds were only detected in 28 samples with a mean and maximum value of 6.1 and 7.4 log cfu/ ml respectively as shown in Table 4. The values are at most similar in all the three lactation stages. The yeast and moulds content in Moroccan camel's milk was found to be low with an average down to 4.6 log cfu/ml (Benkerroum, Boughdadi, Bennani, Hidane, 2003). The current result is also much greater than values reported by (El-Ziney and Al-Turki, 2007), which was mean and maximum value of 1.9 and 5.65 log cfu/ml. The higher value may be due to high value of acidity in milk suppresses the bacteria and favored for yeast and mold growth.

5.4 Mineral analysis of dromedary camel milk

The minerals like Ca, P, Fe and Zn content of camel milk was analyzed using a composite sampling technique. One representative samples were prepared from each lactation (10 individual camel milk samples) and analyzed in duplicate. Results of major minerals found in camel milk were presented in Figure 2 below.

The concentration of Fe and Zn was higher than values reported by (Shamsia, 2009) which was 1.02, 0.92 higher than 0.21 and 0.19 mg/100 g, respectively. Ca and P value of this study (Figure 2) was significantly lower than values found by (Shamsia, 2009) which was 109 and 76 mg/100 g, respectively. The reason for higher reduction in P and Ca value could be due to their feeding status of the camel.

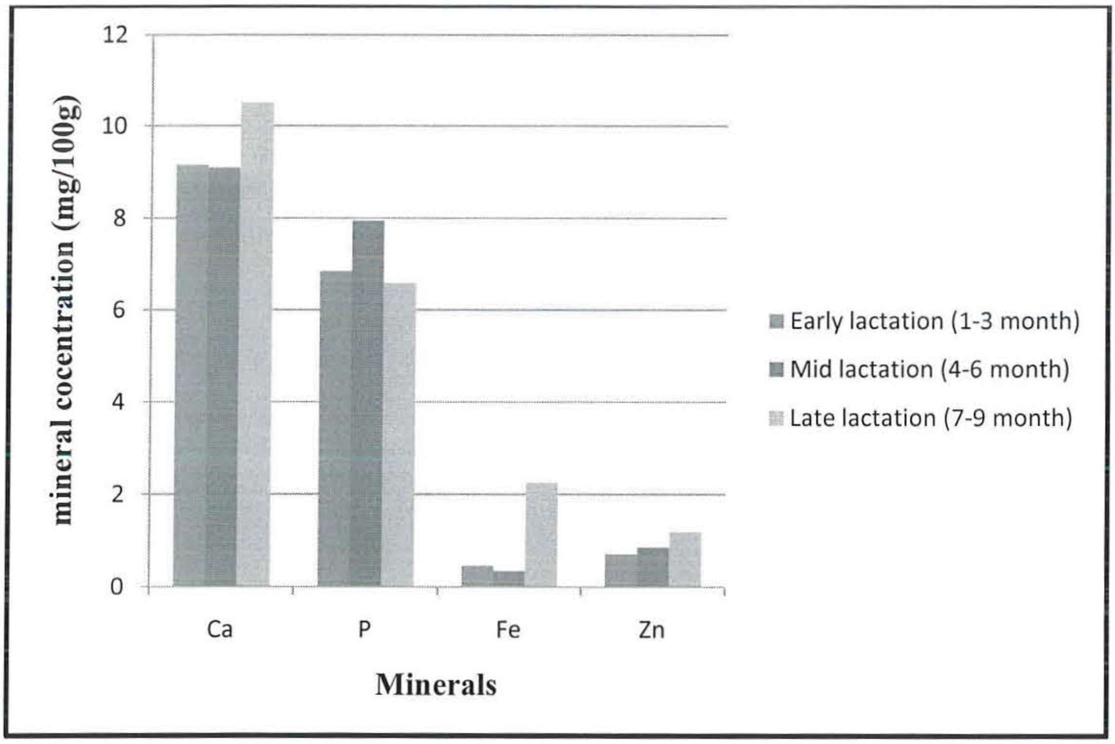

Figure 2. Mean values of camel milk mineral concentration in three lactation stages

6. CONCLUSIONS

In view of the observed results of the physicochemical properties of the camel milk, it could be concluded that She-camel produces nutritious milk for human consumption. The study shows the camel milk can substitute human and cow milk in its basic composition such as protein, fat and lactose. It has also high acidity and this makes the milk easily longer shelf life. Lactation stage and water availability strongly affects the composition of camel milk especially total solid and fat contents are directly affected.

The present study result obtained for dromedary camel milk closely resembles with existing literature value of She-camel composition except higher in pH and acidity and lower in lactose value. This result could contribute to the overall knowledge of camel as food source, but much still needs to be analyzed specially concerning its physicochemical composition affected by lactation stage, state of dehydration, feeding, season, partition, bread and milking frequency. The outcome of the present results suggests that the examined raw camel milk samples were produced and handled under poor hygienic conditions with high health risk to the consumers. The result shows that even though the sampling is aseptic using sterilized equipment and protected transportation until analysis the total plate count, coliform count and yeast and mold counts are a bet higher. The source of contamination could be from unwashed udder and hand during milking. Further studies is needed to know whether camel milk can have a potential antimicrobial activity for suppressing microorganisms to extend the shelf life, its therapeutic property for different diseases and pathogenic bacteria.

7. RECOMMENDATIONS

Based on these findings, it is strongly recommended that large-scale research studies regarding the quality of raw camel milk, milking protocols and sanitizing programs should be conducted. Such studies will help to understand the behavioral risk factors associated with raw milk production, consumption and that national standard protocols will be developed to address issues connected to consumption of raw camel milk. The physicochemical characteristics and especially the behavior of pathogens and spoilage microorganisms must be studied to explore the point of contamination and how these organisms are able to survive and contaminate raw camel milk under severely arid conditions. Additional samples need to be analyzed before any general conclusion regarding the chemical composition and microbial safety correlations across the three lactation stages.

- It is critical to develop protocols and implement compressive policy for camel milk and meat marketing to sustain the life of camel herds or pastorals.
- Governments, NGOs and other concerned bodies should focus on the camel milk marketing development and thereby use pastoralists and the whole population especially for children who are allergic to their mother's milk.
- Introduce technologies for the processing of camel milk.
- Examine the possibility of credit provision for improved dairy production, processing and marketing.

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Table 5. ANOVA table for physicochemical and microbial analysis of raw camel milk

			df	Mean Square	F	Sig.
Protein (%)	Between Groups		2	2.761	26.234	0
	Within Groups		27	0.105		
	Total		29			
Fat (%)	Between Groups		2	0.403	2.016	0.153
	Within Groups		27	0.2		
	Total		29			
Total solid (%)	Between Groups		2	33.462	27.567	0
	Within Groups		27	1.214		
	Total		29			
SNF (%)	Between Groups		2	29.176	26.797	0
	Within Groups		27	1.089		
	Total		29			
Total ash (%)	Between Groups		1	0.008	1.838	0.192
	Within Groups		18	0.005		
	Total		19			
Total ash (%)	Between Groups		2	0.068143	12.71946	0.000128
	Within Groups		27	0.005357		
	Total		29			
Lactose (%)	Between Groups		2	33.77886	33.53623	4.8E-08
	Within Groups		27	1.007235		
	Total		29			
pH	Between Groups		2	0.159	42.839	0
	Within Groups		27	0.004		
	Total		29			
M.C (%)	Between Groups		2	35.532	27.244	0
	Within Groups		27	1.304		
	Total		2			

AMBC	Between Groups		2	2.491	6.955	0.004
	Within Groups		26	0.358		
	Total		28			
Coliforms	Between Groups		2	6.329	2.536	0.099
	Within Groups		26	2.496		
	Total		28			
Enterobacteriacae	Between Groups		2	10.715	5.957	0.007
	Within Groups		26	1.799		
	Total		28			
Yeast and Mold	Between Groups		2	1.374	0.697	0.507
	Within Groups		26	1.972		
	Total		28			