**Sudan University of Science and Technology**

**College of Graduate Studies**

# Physio-Chemicals Characteristics of Yoghurt from Camel's Milk and Cow's Milk in Different Ratios

**الخواص الفيزيائية و الكيميائية للزبادي من لبن الإبل و لبن الأبقار بنسب مختلفة**

**A thesis Submitted in Partial Fulfillment of the Requirements for The Degree of Master of Science in Animal Production**


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بسم الله الرحمن الرحيم

# "وإن لكم فى الأنعام لعبرة نسقيكم مما فى بطونه

# من بين فرثٍ ودمٍ لبناً خالصاً سائغاً للشاربين"

صدق الله العظيم(سورة **النحل**) (٦٦)

# DEDICATION

To my Family,

Teachers

and Colleagues.

***MAHAMOUD***

# Acknowledgement

*Firstly, all praise is to Allah for his unlimited support. Peace and blessing of Allah be to The Prophet and Messenger and his pious companion and followers.*

*Then I would like to express my sincere gratitude to my supervisor\,**Dr. Bhagiel Taifour Bhagiel Ibrahim.** For his kind support, supervision, guidance, valuable recommendations and continuous encouragement through my hardest times. Thanks and gratitude to teacher Randa for her keen and valuable help throughout processing days; and to all animal production laboratory staff, and a very grateful thanks extended to the staff of Animal production department s.*

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# Abstract

This study was carried out to assessment yoghourt produced by camel's milk and cow's milk, From September to November (2014),Camel milk was collected from camel research center University of Khartoum ( Shambat),and cows milk are collected from animal production dairy farm college of agriculture studies, Sudan University of science and Technology (Shambat). Fresh camel and cows milk were analyzed and increased their total solids to 15% by skimmed powder milk to improve the coagulation characteristic and divided to 5 treatments pure camel milk portion and pure cow milk portion as a controls and camel milk mixed with cow milk by 75% , 50% and 25% respectively. After pasteurization at 85℃ for 30 min. Inoculation and incubation at 43℃ for 3h cow milk yoghurt and 4h for the mixed milk yoghurt between camel and cow milk 75% and 50% cow milk and 6h the camel milk yoghurt and 75%camel milk yoghurt, the physiochemical properties of yoghurt were analysis and pH , acidity analysis after incubation , 24h and after 10 days and panel taste was done. The results showed significant differences between camel and cow milk at ($p \leq 0.05$) in protein, SNF, and density But there were no significant differences ($p \geq 0.05$) in moisture, fat, ash, lactose, total soil (TS), Ph, acidity, $Ca^{++}$ and phosphorus. Protein and SNF in cow milk were higher than that found in camel milk, while the density of camel milk is higher in comparison to the density of cow milk. The treatments effect of pure and mixture of camel and cow milk yoghurt on physiochemical characteristics result in highly significant differences at ($p \leq 0.05$). Pure cow milk yoghurt has higher percentage of protein, fat, lactose, SNF, Ph, Calcium and phosphorus. While Pure camel milk yoghurt showed high moisture, ash and acidity percentages,75% cow milk +25% camel milk

yoghurt has superiority in protein ,fat ,lactose ,T.S and S.N.f percentages after pure cow milk yoghurt, followed by 50%cow milk +50% camel milk yoghurt .The effect of storage period for camel and cow milk yoghurt was highly significant on Ph acidity. The high value of Ph was observed after incubation followed by after 24hr then after 10 days while the acidity is higher after 10 days of storage followed by after 24 hr then after incubation. The sensory evaluation of pure and mixed camel and cow milk yoghurt treatments were appeared high significant ($p \leq 0.05$) on taste, flavor, smell, texture, and overall acceptability, but had no significant differences ( $p \geq 0.05$) recorded on the color. The best value for taste, flavor, smell, texture and overall acceptability were obtained by yoghurt made from pure cow milk followed by the 25% camel milk +75%cow milk yoghurt treatment then 50% camel milk + 50% cow milk yoghurt ,then 75% camel milk + 25%cow milk yoghurt and the last one was the pure camel milk yoghurt treatment.

# الخلاصة

اجريت هذه الدراسة لتقييم الزبادي المنتج من لبن الإبل وبعد خلطه بلبن البقر. تم جمع عينات لبن الإبل من مركزبحوث الإبل جامعة الخرطوم (شمبات) وعينات لبن البقر من لبن من مزرعة الانتاج الحيواني كلية الزراعة جامعة السودان للعلوم و التكنولوجيا فى الفترة من سبتمبر إلى نوفمبر( ٢٠١٤) . تم تحليل اللبن الطازج و رفعت جوامده الكلية الي ١٥% بإضافة مسحوق لبن منزوع الدسم لتحسين خواص التخثر، وتم تقسيم اللبن الي خمسة عينات كالاتي :لبن ابل صافي و لبن بقر صافي كعينات تحكم و تم خلط لبن الإبل بلبن البقر بنسب ٧٥% ،٥٠% و٢٥% علي التوالي بعد إخضاعه للبستره لمدة ٣٠ دقيقة في ٨٥ درجة مئوية وإضافة البادي له وادخاله الحضان في درجة حرارة ٤٣ درجة مئوية ،وتم الحصول على زبادي لبن البقر في ٣ساعات والخليط بنسبة ٧٥% و٥٠% لبن بقر في ٤ ساعات و زبادي لبن الابل والخليط ٧٥%لبن ابل في ٦ ساعات وحللت عينات الزبادي لمعرفة الصفات الفيزيائية والكيميائية كما تم عمل اختبار التذوق .أظهرت النتائج فروقات معنوية بين لبن الابل والبقر($p\geq0.05$) في البروتين والجوامد الصلبة اللادهنية و الكثافة حيث تفوق لبن البقر في البروتين والجوامد الصلبة اللادهنية و أظهر لبن الإبل كثافة اعلي و لكن ليس هنالك فروقات معنوية في باقي مكونات اللبن لكل من البقر و الإبل. وأظهرت نتائج تحليل الزبادي فروقات معنوية ($p\geq0.05$ ) حيث تفوق زبادي لبن البقرفي البروتين ،الدهن،اللاكتوز،PH ،الجوامد الصلبة اللادهنية ،الكالسيوم و الفسفور بينما تفوق زبادي لبن الابل في الرطوبة ،الرماد و الحموضة أما الزبادي الخليط كان نسبة ٧٥% لين بقر +٢٥% الأ فضل ويليه ٥٠% لبن بقر +٥٠%لبن إبل واخيرا ٧٥% لبن إبل+٢٥%لبن بقر. و ظهرت فروقات معنوية في الpH و الحموضة بعد الحضان ،٢٤ساعة وبعد ١٠ ايام حيث كان قيمة الpH اعلى بعد الحضان وتليه بعد ٢٤ ساعة ثم بعد١٠ايام والعكس صحيح في الحموضة. أظهرت النتائج فروقات معنوية فى التذوق($p\geq0.05$) حيث كان زبادي لبن البقر الأفضل في القوام الطعم و النكهة و الرائحة و القبول العام و ويليه ٧٥% لبن بقر + ٢٥%لبن

إبل ثم ٥٠% لبن بقر +٥٠% لبن إبل ثم ٧٥%لبن إبل +٢٥% لبن بقر وأخيرا زبادي لبن الإبل الصافي

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# CHAPTER ONE

## Introduction

The livestock population in Sudan was estimated to be about 29,618,000 cows, 39,296,000 sheep, 30,649,000 goats and 40,715,000 camels the total is 104,278,000 head according to Federal Ministry for Animal Resources Fishery and Range (2012).

The market now offers a vast array of yoghurts to suit all palates and meal occasions which can be consumed as a snack or part of a meal, as a sweet or savory food, this versatility, together with their acceptance as a healthy and nutritious food, in addition to their widespread popularity across all population subgroups (Mckinley, 2005).

The population of Camels on the earth are about 19 million camels of which 17 million are dromedary (one humped) and the remainder Bactrian (tow humped)about 15 million in the horn of Africa including Somalia, Sudan, Kenya, Eritrea, and Djibouti(bkele2010) .

The Sudan mentions the second largest number of camels in the world after Somalia with about(4.7) million heads (ministry of animal resource and fishers2012).camels are considered to be a good source of milk ,meat and used for other purposes such as transportation and sport racing(omer,et.al2010).

The total milk production in the Sudan in (2014) estimated 4,361,000 tonnes, where the target production of milk for consumption is 4,426,000.731 tonnes .the available production of milk for consumption is 2,705,000.68 tonnes, so the deficit is 1,721,000.051 tonnes. (Ministry for Animal Resources Fishery and Range 2014).

The individual consumption for the year (2014) is 79.5 liters, where the target amount of milk for individual consumption per year 120 litres (Ministry for Animal Resources Fishery and Range 2014).

Camel milk is very important source of nutrient for human in several arid and semi- arid zones .it's complex mixture of fat, protein, lactose, mineral and vitamins miscellaneous constituent dispersed in water (salam.etal2010)

Camel milk is extremely popular and widely consumed by nomadic tribes in Sudan both as fresh raw milk and as soured milk especially in the east and west regions (Abelrahman *et. al.*, 2010). Daily milk yield varies from 3.5L under desert condition to 40L under intensive management. feed and availability of water can affect the chemical composition and taste of camel milk , which contains 2.9 to 5.5 % fat, 2.5 to4.5%protein,2.9 to5.8% lactose, 0.35 to 0.90% ash, 86.3 to 88.5% water and 8.9 14.3%sNF(Hashim *et. al*., 2009) .

Yohgurt is a product of the lactic acid fermentation of milk by adding of a starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*. In some countries less traditional microorganisms, such as *Lactobacillus helveticus* and *Lactobacillus delbrueckii* ssp lactic, are sometimes mixed with the starter culture (McKinley, 2005).

Although fermented milk products such as yoghurts were originally developed simply as a means of preserving the nutrients in milk, it was soon discovered that, by fermenting with different microorganisms, an opportunity existed to develop a wide range of products with different flavors, textures, consistencies and more recently, health attributes. (McKinley, 2005).

It is difficult to process to form coagulum from camel milk due to very specific casein micelle composition characterized by low proportion of kappa casein of 0.5% from total casein compared with 13.6% in cow milk (Mahamoud, 2009). Producing fermented camel milk products may be difficult because of problem of coagulation (Hashim *et. al*., 2009).

Yoghurt texture is a very important characteristic that affects it is quality such as appearance, mouth feel and over all acceptability, so that this study conducted to study the possibility to improve the of camel, milk yoghurt characteristics by mixing it with cow milk.

**Objectives:**

- To determine the possibility of manufacturing yoghurt from camel milk.
- To provide camel milk as acceptable, palatable and easy digestible product to consumer through manufacturing it to yoghurt.
- To determine the effect of mixing caw milk with camel milk to improve the characteristic of yoghurt produced from camel milk.

# CHAPTER TWO

## Literature Review

### 2.1 History, Classification and distribution of camel:

#### 2.1.1 History of camel:

#### 2.1.2 Bactrian history:

The Bactrian is generally along-haired sturdy animal, powerfully built and adapted to rigorous, cold climates. It is capable of marching in snow-covered mountains, and in the extremely cold northern deserts (Fazil, 1977).

Bulliet (1975) suggested that the first home land of the Bactrian was the border of Iran (Khorassan) and (Turkmenistan) and estimated that the date of domestication probably reached back to before 2500 B.C. From this early domestication, the Bactrian spread far and wide. It still exists today in central Asia Mongolia.

Bulliet (1975) also made the significant observation that in areas where the Bactrian has disappeared, the dromedary exists in substantial numbers. Similarly, the dromedary is rare in those areas where the Bactrian still exists.

**2. 1 .3. Dromedary history**

Mason (1979) suggested that the dromedary is sometimes referred to the Arabian camel, after the area in which it is thought to have been domesticated and probably most extensively employed and domesticated in Southern Arabia around 3000 B.C.

**2.1.4 Classification of camel**

The dromedary or one-humped camel (*Camelus dromedaries*) is one of two species within the genus Camelus, the other being the Bactrian or two-humped camel (*Camelus bactrianus*). Camels and lamas are the two genera comprising the camelidae family. The camelidae belong to the ruminate suborder placentary subentry subclass of mammalian vertebrates. Among the living ratio dastyls the camelidae family is the only one within the tylopoda group (Fernandez-Baca 1978 and Mason 1979).

Class Mammalia

Sub class placentara

Order Artiodactyla

Sub order Ruminantia

Group Tylpode

Family Camelidae

Genus Lama Camelus

Species 1.*L. glama* (Llama) 1. *C. dromedaries* (dromedary)

2. *L. pacos* (alpacta type) 2. *C. bactrianus* (Bactrian)

(i) Suria

(ii) Huacaya

3. *L. fuanicoe* (guanco)

4. *L. vicugna* or vicugna (vicuna)

**Fig. (2.1): The classification of the dromedary and other Camelidae as defined by (**Fernandez-Baca 1978 and Mason 1979).

**2. 1.5 Distribution of camel in the world**

The world population of camels is increasing very rapidly, with decrease in numbers in the non tropical area (Williamson and Pa1978).

However, 70% of the world camels are still found within the tropics and over 90% of the African herds are present in this region .The African population is thought to be increasing slightly, especially within tropics. It is noteworthy that the five neighboring countries of Somalia, Sudan, Ethiopia, Kenya and Djibouti together own 84% of African camels and half (60.1%) the world camels population, while Africa as a whole own 72% (William-son and Payne, 1978).

Epstein (1971) indicated that the dromedary was introduced into North Africa (Egypt) from South West Asia (Arabia and Persia). He indicated that occasional shipments were also made to Spain, Italy, France, the Canaries, North America and Australia.

Bulliet (1975) viewed that the camels of the horn of Africa are more likely to have come across the sea from the Arabian Peninsula than spread south ward from Sudan and Egypt.

### 2. 1.6 Distribution of camels in Sudan

The distribution areas of camels in Sudan are mainly in the arid and semiarid parts of the country north of about 12°N to 16°N. these are the areas where rainfall is less than 350mm and, because of the drought in the northern parts of the country, the areas extend south of this line. However, migration to the southern part of the country is limited by diseases (Aisha, 2009).

## 2.2 Definition of milk

Milk is the natural secretion of mammals to feed their offspring. It is defined as a dynamically balanced mixture of protein, fat, carbohydrates, salts, and water co-existing as emulsion colloidal suspension and solution (Hargrove and Alford, 1980) The available estimate of milk production in the Sudan varies widely and no accurate statistics are kept. The (AOAD, 2002) gave an estimate of annual milk production of 20249.91 million tons obtained from cow, goat, sheep and camel.

### 2.2.1 Importance of Milk and Milk Products in Diet

In dairy Facts (2003) stated that the fluid milk is a source for a whole range of dairy products consumed by mankind. Fluid milk is about 87% water and 13 % solids. The fat portion of the milk contains fat-soluble vitamins. The solids other than fat include proteins, carbohydrate, water-soluble vitamins, and minerals. Milk products contain high quality proteins. The whey proteins constitute about 18% of the protein content of the milk. Casein, a protein found only in milk, contains all of the essential amino acids and accounts for 82 % of the total proteins in milk. Milk also contains calcium, phosphorus, magnesium, and potassium. The calcium found in milk is readily absorbed by the body; Vitamin D plays a role in calcium absorption and utilization. Milk is also a significant source of riboflavin (vitamin B2), which helps promote healthy skin and eyes and also stated that the dairy products such as yogurts, cheeses and ice creams contain nutrients such as proteins, vitamins and minerals(Sharma, *et al* 2006).

Consumption of dairy products has been associated with decreased risk of osteoporosis, hypertension, colon cancer; obesity and insulin resistance syndrome, besides its main dietary source of calcium and vitamin D are dairy products (Weaver, 2003).

### 2.2.2 Camel milk production

According to FAO (2006) camel is the animal of dairy product of the future and it will give a lot of money to productive country.

Camel milk is extremely popular and widely consumed by nomadic tribes in Sudan both as fresh raw milk and as soured milk especially in the east and west regions (Abedrahaman. *et. al.,* 2010). Daily milk yield varies from 3.5L under desert condition to 40L under intensive management. Feed and availability of water can affect the chemical composition and taste of camel milk, which contains 2.9 to 5.5 % fat, 2.5 to4.5%protein,2.9 to5.8% lactose, 0.35 to 0.90% ash, 86.3 to 88.5% water and 8.9 to 14.3% S N F (Hashim *et. al.*, 2009).

Milk for human consumption is usually drunk raw and immediately after milking and also consumed as fermented milk it is difficult to process to form coagulum from camel milk due to very specific casein micelle composition characterized by low proportion of kappa casein of 0.5% from total casein compared with 13.6% in cow milk (Mahamoud 2009).

According to the result from several authors, Bremaud (1968), Dhal and Hjort (1976) and Leupold ($1968_a$) the lactation periods vary from 9 to 18 months, with annual milk yields of between 800 and 3600 liters. Mean daily milk production is reported to range from 2 to 6 liters under desert conditions and up to 12 to 20 liters under more intensive breeding systems. These large difference can be explained by the fact that measurements have been often made under local condition without taking into account local factors that might influence milk production, furthermore, camel breeds or individual animals probably exist with significantly different milk-producing potential that has not been fully exploited because the selective pressure of human on the camel has been minimal compared with other domestic animals (Gerard and Richard, 1989). Nutritional factors also influence milk production. Diets enriched with green forages such as alfalfa, bersim or cabbage greatly increase milk yield (Knoess, 1977; Knoess *et.al.*, 1986; Richard and Gerard, 1989).

The amount of milk is only marginally decreased when drinking-water is restricted, while total solids are significantly lowered (Yagil and Etzion, 1980; Yagil *et al*., 1984; Ramet, 1987; Farah, 1993).

### 2.2.3 Factors affecting camel milk yield

The milk production potential depends on purpose of camel rearing, density and quality of pasture and the season (Wardeh, 1989). Generally, camels are milked from 2-4 times a day (Hartley, 1980) but sometimes 6-7 times (Knoess, 1977).

Ramet (2001) studied camel's milk production factors such as: camel breed, nutritional factors and stage of lactation and milking practices such as calf suckling, milking frequencies, milking performance method and availability of drinking water.

### 2.2.4 Camel Milk Composition

Camel milk is an important factor in the capability of many nomads to make use of the dry areas and indeed in the desert zones where no other animals can produce milk there. They may be absolutely dependent on the camel for their survival. Camel milk has a well-balanced composition suitable for the human consumption especially in deserts (Mukasa-Magerwa 1981).

Camel milk is generally opaque white, it has sweet, and salty tastes sometime. The change in taste is caused by fodder and availability of drinking water. The differences among data on composition of camel milk reflect differences in breed and state of lactation (Farah, 1993).

The nutritional value of camel milk is basically related to its chemical composition (Mohamed, 1990). The most important factor affecting the overall composition of camel milk is water content. It has been clearly demonstrated that experiments which restricted drinking-water caused an increase in water content and subsequent-decrease in total solids (Yagil and Etzion, 1980; Yagil, 1986; Yagil *et al.*, 1986). Seasonal climatic variation and water and feed availability has a similar effect (Knoess *et.al.*, 1986; Ramet, 1987; Ramet 1994[a]).

### 2.2.5 The main constituents of camel milk

Although overall composition of camel milk is similar to cow's milk some differences exist in the molecular compositions of proteins, lipids and in the mineral balance as follows:

#### 2. 2.5.1.1 Protein

The mean composition of protein and nitrogen fraction of camel milk are generally similar to those of cow's milk, the average values for the casein and whey protein content vary from 1.9 to 2.3 percent and 0.7 to 1.0 percent, respectively. The nitrogen content of casein is a little lower than cow's milk reaching 71 to 79 percent of total protein nitrogen compared with 77 to 82 percent (Jenness and Sloan, 1969; Mehaia, 1987; Farah, 1993).

Casein fractions have been isolated in camel milk and found to be homologous with bovine casein. The balance between the different casein fractions is very different and mainly identified by a low amount of kappa casein of only about 5 percent of the total casein compared with about 13.6 percent in bovine casein. (Jardali, 1988; Jardali and Ramet, 1991; Farah, 1993). The molecular weight and amino acid composition of the casein fractions are different from those of cows' milk (Sawaya *et al.*, 1984; Larsson-Raznikiewicz and Mohamed, 1986; Farah and Ruegg, 1989; Mohamed, 1990; Farah, 1993).

The state of the casein micelle structure has seldom been investigated. Most results, however, conclude that the size distribution of casein particles in camel milk is significantly broader than in cow's milk exhibiting a greater number of large particles. The average micelle diameter of camel milk was found to be about double that of cow's milk at 320 nm and 160 nm respectively (Sawaya *et.al.*, 1984; Larsson-Raznikiewicz and Mohamed, 1986; Farah and Ruegg, 1989; Jardali and Ramet, 1991; Jardali, 1994).

The quantity of whey protein is higher in camel milk than cow milk, at 0.9 to 1.0 percent and 0.7 to 0.8 percent respectively. Individual fractions have been identified according to chromatographic and electrophoretic mobility and to the primary sequence of their amino acid chains. Two types of alpha-lactalbumin similar to bovine milk have been isolated. Beta- lacto-globulin has not been clearly identified (Conti *et.al.*, 1985; Beg *et.al.*, 1987; Farah, 1986).

Two novel camel milk whey proteins, unlike any known bovine milk whey proteins have been separated and characterized (Beg *et al.*, 1987). The heat stability of camel milk whey proteins was found to be considerably higher than in cow's milk (Farah, 1986; Farah and Atkins, 1992).

**2.2.5.2 Water content**

The most important factor in camel milk is water content. Young camels, and specially the humans living in drought areas, are in need of fluid to maintain homeostasis and thermo neutrality. The water content of camel milk fluctuates from 84 percent (Knoess, 1977) to 90 percent (Ohri and Joshi, 1961). When examining only the effects of lack of drinking water in camel milk, the diet remaining unchanged throughout the year, great change in water content of camel milk were found (Yagil and Etizon, 1980). The camels were allowed *libitum* drinking water only during the winter. From spring until the end of summer the mothers and claves were allowed to drink only once a week for one hour. With water freely accessible the water content of the milk was 86 percent, but when water was restricted the water content of milk rose to 91 percent.

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 time of drought. This could be a natural adaptation in order to provide not only nutrients, but necessary fluid to the dehydrated calf. Another explanation can be found when examining the mechanism of sweating in man when exposed to heat.(Ingram and Mount, 1975).

Adaptation to heat causes secretion of a profuse watery sweat. This is caused by secretion of endogenous ADH (Anti Diarectic Hormone) secreted from the neurophyophysis because man produces the same water sweat when injected with ADH. Thus man loses water from his sweat glands, allowing him to maintain thermo neutrality. As the mammary gland have the same embryonic origin as the sweat gland, and as ADH secretion is evaluated in the dehydrate camel (Yagil and Etizon, 1979), it could happen that the loss of water into the milk is due to the action of this hormone. Injection of ADH into lactating laboratory rats exposed to heat for 8 hours a day also caused increased water content in milk (Yagil and Etzion, 1980).

### 2.2.5.3 Lactose Content

Lactose is the characteristic sugar of milk, and for most purposes can be considered as the only carbohydrate present (Johnson, 1987). Lactose content range from 2.9-5.8% (Yagil, 1987), from 3.3 - 5.8 (Wilson, 1984), and 4.4%, 5.6% according to Saway *et al*. (1984) and Sohail, (1983) respectively.

Abu-Leiha (1989) observed that at parturition lactose content was 2.68% and gradually increased to reach 4.4% at the third day, it continued to increase slightly after the third day of lactation until it reached 5.58% at the tenth day.

### 2.2.5.4 Fat Content

Farah and Ruegg (1991), illustrated that the creaming of camel and cow milk and the fat content of camel milk varies greatly from 1.10-5.50 percent depending on the breed and feeding condition

Studies on the structure and composition of globules revealed two main characteristics. Whereas previous results have found small fat particles in camel milk (Gouda *et al*., 1984; Knoess *et.al*. 1986), other work indicates that fat globule size distribution is similar to cow's milk, with an average of 2.9 micrometer (Wahada *et.al.* 1988; Farah and Ruegg, 1991; Farah, 1993). The fat membrane appears to be thicker than in other types of milk and closely bound to proteins (Rao *et al*,.1970; Knoess *et.al*. 1986; Farah, et.al.1990; Farah and Ruegg, 1991). The creaming properties of camel milk fat globules are poor, resulting from a deficiency in agglutinin that cause very slow creaming rate at all temperature (Farah and Ruegg, 1991).

A factor specific to camel milk fat is the low percentage of short chain $C_4$ to $C_{12}$ fatty acids. The concentration of long chain fatty acids such as palmitic and stearic are however, relatively high. As a consequence, the physical properties of the triglycerides are characterized by much higher melting and crystallization points than cow's milk (Abu-Leiha 1987; Abu-Leiha, 1989; Farah, et.al.1989; Farah and Ruegg, 1991; Abu-Leiha, 1994).

### 2.2.5.5 Minerals

The concentrations of the major salt are slightly lower than cow's milk. The salt balance between the soluble and the colloidal forms of calcium, phosphorus and magnesium is very similar to that measured in cow's milk. The percentage of the soluble fractions reaches 30 percent of the total content (Farah and Ruegg, 1989).It also seems that the proportion of soluble calcium and phosphorus increases up to 61 and 75 percent respectively when milk is collected in the hot season from animals managed along traditional extensive lines.

### 2.2.5.6 Vitamins Content

Camel milk is rich in vitamin C (Knoess, 1979). This is important from the nutritional stand point in areas where fruits and vegetables containing vitamin C are scarce.

Kheraskov (1961), found that vitamin C content of camel milk to vary between 5.7 and 9.8mg percent, and as a lactation progresses, vitamin C content increases (Bestuzhera, 1964). 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 decline from 3.9mg/100g at 1.5 months lactation to 2.3mg/100g at the fourth month of lactation ( Bestuzheva, 1964). Vitamin $B_2$ content in camel milk is also higher than in goat milk, but the vitamin $B_1$ is lower in camel milk. Carotene concentrations in the camel milk decline from 0.46 mg/kg at 1.5 month lactation to 0.16 mg/kg at 4 months lactation ( Bestuzheva, 1964). The vitamin A content has been reported as being as little as 0.037mg percent (Kherashov, 1961). Khan and Appona (1965) found an average of 7.57µg/ml of vitamin A and 9.4mg/ml of carotene.

**2.2 .6 Factors Affecting Camel Milk Composition**

Yagil *et al.*, 1984, Ramet 1987, Farah 1993, reported that the composition of milk depends on many factors, such as season, variation in seasonal climatic affect water content, in hot season the camel loses some of its water to milk to fulfill the needs of the dehydrated calf, as a result the water content increases whereas the total solids decreases Also, hot season affect composition and size of casein micelles, during hot season the micelles are lager and lower in kappa casein and this reduced the ability of milk to coagulate compared with winter milk, on the other hand, during cold season the micelles are richer in kappa casein, coagulate faster and produces stronger curd (Larsson, Ranzinkiewicz, 1986, Niki and Arima 1984, Sher, 1988). Also season affect mineral content and it is affected with drought (Yagil and Etzion, 1980). Lactation period, during the early stage of lactation period the protein tends to increases to fulfill the nourishment of the young calf (Farah, 1993), feeding conditions and water availability (Mohammed and Hijrot, 1993).

Seasonal climatic variations of water resource and feeding availability showed similar effects on milk composition (Knoess *et al.*, 1986; Ramet, 1987).

Several factors affect milk composition including the genetic factors, physiological factors and age, the stage of lactation (Omer, 2001), type and standard of pasture (Gera, 2007).

### 2.2.7 Physical Properties of Camel Milk

#### 2.2.7.1 Acidity (pH)

Fresh camel milk has a high pH about 6.5 (Ohri and Joshi 1961[a]). The pH of milk is between 6.5–6.7 (Shalash, 1979). This is similar to the pH of sheep's milk. When camel milk is left to stand, the acidity rapidly increases (Ohri and Joshi 1961). The lactic acid content increases from 0.03 percent after standing 2hours to 0.14 percent after 6 hours.

#### 2.2.7.2 Specific Gravity

The mean specific gravity of camel milk is 1.0305 (Shalash, 1982), is lower than that of water, buffalo, cow or sheep milk.

#### 2.2.7.3 Freezing Point

Camel milk has a greater freezing point depression (-0.576°C); a fact which may be explained by its comparatively high chloride content (Shalash, 1982).

#### 2.2.7.4 Boiling Point

The boiling point of camel milk is 100.6°C, while the boiling point of cow's milk is 100.17°C, higher than boiling point of water,( Mehaia and Al-Kahnal, 1992).

### 2.2.8 Keeping Quality of Camel Raw Milk

The most important property of camel milk is that it can be kept for longer periods than cattle milk when refrigerated and even with the desert heat it does not spoil very soon, and it remains quite stable at room temperature and takes a comparatively longer time to become sour (Dukwal *et al*., 2007).

Nagy *et al.* (2007) defined high quality camel milk according to the following: produced by healthy camels in good body, condition given controlled diet, milking is carried out in hygienic conditions with properly maintained machinery, milk if free of potential human pathogenic bacteria, antibiotic and chemical residues.

The keeping quality of raw milk depend on the number of bacteria in milk (Kenyanjui *et al*., 2003), and the contamination of milk from the healthy udder occurs from various sources, such as the skin of the udder, ticks and wounds in teats, milker's hands, dust and flies at milking sites and dirty water used for cleaning the milk container.

Camel milk is a rich source of protein with potential antimicrobial and protective activities (Wernery, 2003). These proteins are not found in cattle milk or found only in minor amounts. The most important one is alpha lacto albumin, which is similar to the enzyme Lysozme (LZ), which inhibits the growth of bacteria (Wernery, 2003).

Insulin, vitamin C, niacin and some unsaturated fatty acids are higher in camel than cattle, and lactose intolerance against camel milk does not exist (Wernery, 2007). Also protein and carbohydrates content of camels was significantly higher as compared to cattle milk (Dukwal *et al*., 2007).

### 2.2.9 Camel Milk Products

Milk from a lactating camel provides nourishment for its young calf as well as human thus not much is left for any milk products processing. It was previously held that the composition of camel milk does not allow for making some of the accepted products that were and made from cattle, sheep and goat's milk but this belief is recently defeated.

New techniques and technologies were and are now introduced to produce high quality camel milk and products such as ultra violet (UV) treatment for maintenance of hygiene of raw camel milk (Joshi *et al.*, 2007) and milking in high technology dairy farms (Wernery, 2007).

#### 2.2.9.1 Pasteurized Camel Milk

Wernery (2007) reported that camel milk could be pasteurized at 72°C for 5 minutes. Abaderrahman (1997) studied pasteurization at 72°C for 15 seconds had been found to be inadequate, but by pasteurizing at 80°C for 20 seconds the bacterial counts dropped to the best European standard levels, provided extreme hygiene is observed. Milk flavor was not badly affected by the heat treatment.

#### 2.2.9.2 Fermented Products of Camel Milk

##### 2.2.9.2.1 Fermented Milk {Garis}

Fermented products have different names in various parts of the world (Aggrawalda and Sharma, 1961). In the Caucus it is called 'Kefir', in America 'Motzoon', in India and Bulgaria 'yoghurt', in Syria and Egypt 'Lehben' and in the Sudan 'Garris' (Abdelgadir *et al.*, 1998)

Fermented milk products are known for their taste, nutritive value and therapeutic properties. Fermented milk are products prepared from milks, whole, partially or fully skimmed, concentrated or milk substituted from partially of fully skimmed dried milk, either homogenized or non-homogenized, pasteurized or sterilized and fermented by means of specific microorganisms (Kroger *et. al.*, 1989).

Fermented camel milk has a high biological value due to the high content of antimicrobial factors such as lysozme, lactose and immunoglobins (Elagamy *et al*., 1994).

There are many types of fermented camel milk. In Mongolia, 'Tarag' is cultured milk which is similar to yoghurt, while 'Unda' is a product produced by lactic and alcoholic fermentation of camel and other animals milk (Yagil, 1982).

Burntse (2002) stated that Ngurunit community produces cultured camel milk by straining the milk to remove dirt particles, boiling, cooling to ambient temperature and eventually culturing the fresh milk.

In the Sudan "Gariss" is a special kind of fermented camel milk prepared solely under more or less continuous shaking (Dirar, 1993). The product is prepared and consumed by camel herders commonly in eastern Sudan (Elagab and Elfaki, 2002), also indicated that in Kassala and Tambol the products is called "*roub*".

Sulieman *et al*. (2006) investigated some of the chemical and microbiological characteristics of "Gariss" and found that lactic acid bacteria (LAB) dominated the microflora of "Gariss" samples and the major genera were *Lactobacillus* (74) %, followed by *Lactococcus*

(12)%, *Enterococcus* (10)% and *Lenconostucs* (4)% and that the fermentation process of "Gariss" is a yeast lactic fermentation.

El-Hofi and El-Tanboy (2006) used pasteurization for improving the keeping quality of yoghurt manufactured from camel milk from growth of yeasts and by using heat shock treatment (60°C for 2.5 minutes).

### 2.2.9.2.2 Camel Milk Cheese

Camel milk is difficult to coagulate by rennet and it is less suited for cheese manufacturing compared to cattle, goat or buffalo milk (Bayoumi, 1990).

Mehaia (2006) investigated manufacturing procedures and compositional characteristics of fresh soft cheese manufactured from camel milk by using ultra filtration (UF) and found that it was higher in moisture and ash contents, whereas the protein and fat contents were lower compared to cheese manufactured by the traditional methods. For sensory evaluation, the scores for texture and overall acceptability of the cheese manufactured by (UF) process were higher than those scores for the cheese manufactured by the traditional method.

El-Mayda *et al*. (1995) reported that cheese from camel milk had a fragile texture and lower yield in comparison with cattle milk. Melted cheese from camel milk had better taste, aroma and spreading quality than that of cattle milk.

Pant and Chandro (1980) reported that manufactured casein can be made from camel milk but not for human consumption and could be used as a glue and gum.

### 2.2.9.2.3 Camel milk butter

Some authors described a butter being made from camel milk (Shalash, 1979), while others (Granet *et al.*, 1991) reported that butter could not be easily extracted from camel milk.

The preparation of butter is not as easy as from milk of other animals owing to the unique milk fat properties of camel milk. The fat is distributed as small globules in the milk (Yagil and Elzion, 1980).

El-Bashir (1997) reported that butter can be produced after shaking the camel milk for 15-20 minutes or 3-4 hours at 24-25°C. He also stated that it was difficult to keep butter fresh and for that it was heated at 100-120°C for 30 minutes to be converted it into "Ghee".

Yagil (1982) observed that butter could be obtained after 15-20 minutes churning: whereas Shalash (1979) reported that it could be made only after 4 hours churning.

Butter from camel milk contains higher percentage of non-saturated fatty acids than those from cattle milk and can be used by elderly people, but it has unaccepted taste and also it could be used for cooking and cosmetics (Izzaddin, 2002).

### 2.2.9.3 Sweet camel milk (not fermented product from camel milk)

El-Bashir (1997) reported that Al-Khawa is a sweet product from camel milk after evaporating it at high temperature with continuous moving of the milk until it becomes semi-solid. It is, then sweet and can be kept for 200 days and even for more days when adding sugar to the camel milk.

Abeiderrahman (1997) reported that Mauritania also produced sweetened camel milk which can be drunk directly

### 2.2.9.4 Camel Milk Ice Cream

Mercer (2006) reported that camel milk ice cream had been launched first in the United Arab Emirates (UAE) at Al-Ain. The product was healthy and could be an alternative to other ice cream fat, compared to that between 6 to 9% for standard ice cream and added to that it was safe for consumers with lactose intolerance and contained three times more vitamin C than cattle milk ice cream.

### 2.2.10 Medical properties and uses of camel milk

Wernery (2003) reported that recent data suggested that camel milk contained medicinal properties to treat different ailments such as auto immune disease, juvenile diabetes, booster of immune system, stress, peptic ulcers and skin cancer. In addition and for patients with chronic hepatitis, camel milk improved liver function and was often being treated with camel milk (Yagil, 1982).

Camel milk was also given to the sick, the elderly and the very young due to the belief that it is not only health giving, but does work especially well in bone formation (Yasin and Walid, 1957).

The belief among the Bedouins of the Sinai peninsula was that an internal disease could be cured by drinking camel milk (Yagil, 1982), and that the milk is believed to be of such strength and to have such health properties that all the bacteria are driven out of the body; however, this belief is only for camels that eat certain shrubs and bushes.

Benkerroum *et al.* (2004) studied the antimicrobial activity of camel milk against pathogenic strains of *Escherichia coli* and *Listeria monocytogenes* and found that the camel milk and colostrums samples had *Bacteriostatic* effect against them.

In the Sudan fermented camel milk is used to cure Leishmaniasis or Kalazar. The patient had to live on "Gariss" alone as food for weeks and months after which period it was claimed that he would be fully cured (Dirar,1993). Agrawel *et al.* (2005) mentioned utilization of camel milk for diabetic people.

### 2.2.11 Milk Consumption

Milk can be consumed fresh in the form of homogenized whole milk, fortified milk, flavored milk, low, fat milk and free fat milk (Webb *et.al.*, 1980).

Heat treatment applied to milk such as pasteurization and sterilization in order to enable its use for a period of time from some days (pasteurization) to some months [sterilization] (63-72$^{\circ}$C).

### 2.2.12 Fermented Milk Production

To overcome the perishable characteristics of the fresh milk and to preserve milk constituents such as protein, fat, minerals for long time as possible, it is important to decrease the water content of milk by adding microbial starter or enzymatic coagulant which act on milk sugar (lactose) and produce an acid (lactic acid) which lower pH and cause coagulation of protein and separation of whey in a process known as coagulation.

### 2.2.13 Coagulation definition

Coagulation is the formation of a gel by destabilizing casein micelles which then aggregated and form a network which partially immobilizes the water and traps the fat. And it can be achieved by enzymes, acid treatment. It is affected with milk pH, temperature and type of enzyme (Farah and Bachmann, 1987).

#### 2.2.13.1 Enzymatic coagulation of milk

Coagulation of casein micelles in milk can be achieved by various proteolytic enzymes obtained from animal, plant and microbial sources.

Enzymes traditionally used in the manufacture of cheese are chymosin and pepsin the former being extracted from calf stomach and the later from cow stomach.

In the coagulum formation process three phases can be distinguished (Dalgleish, 1992). In the primary phase the k-casein of the casein micelles is hydrolyzed by the protease to yield two peptides of different properties, a hydrophilic macro peptide which is split off from the micelle and the hydrophobic Para-k-casein- which remains in the micelle. The progressive hydrolysis of k-casein during the primary phase leads to the alteration of the properties of the casein micelle resulting in aggregation in the presence of $Ca^{++}$ as the secondary phase of the rennet coagulation. In the third phase of the process the firmness of the gel increases due to syneresis. Such process (coagulum formation) is very difficult when camel milk is used for cheese production due to camel milk composition.

##### 2.2.13.1.1 Primary phase

It is the attack of the proteolytic enzyme on K-casein. The main cleaving point is the peptide bond Phe 105-106 methionine. The k-casein is cut into two equal segments which are 1-105 segments (Para-k-casein) and 106-169 segment (glycomacropeptide). Enzymes specific in cleaving of this bond are aspartic proteases (e.g. chymosin).

Rennet hydrolysis of k-casein results in liberation of the charged glycomacropeptide which provides stability through, brownian motion, electro-static repulsion, and hydration. It also results in reduction of micellear surface electrical charge.

These changes lead to reduction in repulsive forces and increase in attractive forces. They also lead to increased sensitivity of Para-casein micelles to aggregation. Para-casein binds alpha s casein and Beta-casein. Casein –macro peptide passes into the whey.

##### 2.2.13.1.2 Secondary Phase

When around 86% of total k-casein is hydrolyzed the Para k-casein micelles begin to aggregate due to cross linking via calcium binding to serine phosphate groups. Individual micelles participate in aggregations only when around 97% of its k-casein is hydrolyzed. The coagulation is dependent on the critical calcium ion concentration. Addition of calcium will increase coagulation rate.

#### 2.2.13.2 Rennet as an Enzyme Coagulant

Rennet is one of the best known coagulants, which are used widely by cheese-maker for many varieties of cheese. Rennet is extracted from the stomach of a mammal or more usually from the fourth stomach of a calf.

A crude rennet extract may be obtained from the fourth stomach of the calves when they are about 4 weeks old calves that have been fed on milk and that are not required for breeding are usually used.

To obtain the rennet the fourth stomach of calf is washed and sliced into strips which are extracted in a sodium chloride (12-20% salt) solution. This salt solution of rennet enzymes strips is mixed well and allowed to settle for two to three days at room temperature. The mixture is then filtered through a coarse sieve and a fine mesh (muslin) cloth. Filtering through muslin cloth should be repeated a few times to obtain a clear filtrate.

#### 2.2.13.3 Camel Milk Coagulation

In traditional pastoral systems, camel milk is mainly used for feeding calves and for human consumption. Two quarters of the udder are usually selected for milking and segregated with ropes. While the calf suckles the other two quarters (Ramet 1987; Ramet, 1989; Ramet, 1994). Milk for human consumption is usually drunk immediately after milking. It can also be consumed as fermented milk made by natural lactic souring over several hours in skin or clay container. The fermented milk may sometimes be separated by vigorous shaking; the acid skimmed milk is drunk and the butter used for cooking or cosmetic or medical purposes (Yagil, 1982).

It is very difficult even impossible to prepare coagulum from camel milk (Gast *et al.*, 1969; Yagil, 1982; Wilson, 1984).

### 2.2.13.3.1 Action of clotting enzymes on camel milk

#### 2.2.13.3.1.1 Enzyme coagulation

Most attempts to make cheese from camel milk have revealed major difficulties in getting the milk to coagulate. Initial field attempts increased the rennet to concentration compared with that usually used for clotting cow's milk by 50 to 100 times (Gast *et al*., 1969; Wilson, 1984).

More recent attempts confirm that the rennet coagulation of camel milk is two to four times slower than for cow's milk treated under the same conditions (Ramet, 1985[a]; Farah and Bachmann, 1987; Ramet, 1987; Mohamed and Larsson-Raznikiewica, 1990).

This specific behaviour has been observed with most of the clotting enzymes used for coagulation. Significant difference, in the inhibition of clotting activity related to the origin of the enzyme have been noted, however, several observations (Ramet,1985[a]; Ramet, 1990) have shown that bovine pepsin coagulates camel milk well. Calf rennet has an effect similar to but lowers than bovine pepsin. Chymosin has the lowest effect. Up to the present, calf rennet has been used for clotting camel milk.

However, there are some reports in the literature that clotting enzyme from a particular species is more effective with milk of the same species. Rennet extracts from lamb were found to be more effective with ewe's milk than with cow milk (Herian and Kracl, 1971).

Pig chymosin and pig pepsin showed higher clotting activity with porcine milk than with bovine milk (Foltmann *et.al*., 1981). These results suggest an adaptation of the enzyme specificity of the gastric proteinases and the structure of the caseins. Therefore, camel rennet could be more effective in camel milk than calf rennet.

To look at the action of camel rennet on camel milk (Wanghoh *et al.*, 1993) extracted bovine and camel rennet from abomasa of young calves. The clotting activity was determined during extraction and activation. Both camel and bovine abomasal extracts were fractionated and the clotting activities of the fractions compared. Camel rennet coagulated camel milk slightly faster than cow milk, while cow rennet extract coagulated camel milk less readily than cow milk. The chymosin fraction of bovine calf rennet showed weak activity on camel, while the pepsin fraction coagulated camel milk much more readily than cow milk. The chymosin fraction of camel rennet coagulated cow and camel milk equally well, whereas the pepsin fraction showed higher clotting activity with camel milk.

It was concluded that the coagulation of camel milk by bovine rennet is primarily due to its pepsin content. The reported large variations in the ability of bovine rennet in coagulation of camel milk can be explained by the differing pepsin content of the rennet used. Camel milk should, therefore, be coagulated with camel rennet or bovine pepsin.

**2.2.13.3.1.2 Influence of total solids**

It is known that increased total solids of milk result in improved rheological properties of curd.

The component of dry-matter of camel milk varies according to the origin of the milk, similar variation exist in the fat and proteins contents. Generally, the casein content has the major role in coagulum formation.

**2.2.13.3.1.3 Influence of casein compositions**

Some recent research has shown that the kappa casein representing the micellar fraction which reacts with the clotting enzymes has a different electro-potential from cow's milk, which causes lower electrophoretic mobility (Farah and Farah-Riesen, 1985; Jardali, 1988 Mohamed and Larsson-Raznikiewicz, 1990; Farah, 1993; Larsson-Raznikiewicz 1994).

This unusual behaviour indicates a very specific casein micelle composition characterized by a low proportion of kappa casein, the average content of kappa casein in camel milk from various sources rises to only about 5 percent of total casein, compared with 13.6 percent in cow's milk (Jardali, 1994).

**2.2.13.3.2 Acid coagulation**

The acid coagulation of camel milk is governed by lactic acid bacteria which originate either from raw milk or from external inoculation of lactic starters (Ramet, 1985[a]). The ability of camel milk to acidify is in turn, dependent on several compositional factors which interfere with bacterial growth. With a near neutral pH, milk is a favorable medium for microbial growth. High water activity and a large variety of nutritive substance facilitate proliferation of cells including lactic acid bacteria. Lactose is the nutrient of prime importance. Although its content in camel milk may vary greatly depending on feeding and watering conditions (Yagil and Etzion, 1980; Yagil, 1994) it appears that lactose availability is always satisfactory, even in cases of strong acidity. A bibliographic review indicates that raw camel milk contains several antimicrobial agents that can limit microbial growth to a higher degree than in milk from other domestic animals. Significantly high level of lysozyme (Barbour *et.al.*, 1984; El Sayed *et al.*, 1992; Farah, 1993) and vitamin C (Kon and Cowie, 1972; Knoess, 1979; Yagil, 1982; Yagil, Saran and Etzion, 1984) are reported. More recently the antimicrobial activity of other natural proteins such as lactoferrin, lactoperoxydase and immouno-globulins was studied (Monnom *et.al*,, 1989; IDF, 1991; El Sayed *et.al*, 1992; El Agamy, 1994).

Each of these antimicrobial agents possesses a selective spectrum of activity against specific strains of bacteria and viruses. When fresh milk is allowed to sour, a bacteria static period is observed for the first few hours after milking. This lag phase is greater in camel milk (four to six hours). Acid development rates are slower throughout the inoculation period (Ramet, 1985; Ramet, 1987; Gnan *et.al*, 1994[a]). Heat treatment applied for camel milk using high pasteurization conditions, lead to partial inhibition persists because the antimicrobial factors could be rather more heat-resistant than in cows' milk (Rao *et.al*. 1970; Ramet, 1987; Farah and Bachmann, 1987).

### 2.2.14 Yoghurt

Yoghurt is a product of the lactic acid fermentation of milk by addition of a starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*. In some countries less traditional microorganisms, such as *Lactobacillus helveticus* and *Lactobacillus delbrueckii* ssp. *lactis*, are sometimes mixed with the starter culture (McKinley, 2005). Although fermented milk products such as yoghurts were originally developed simply as a means of preserving the nutrients in milk, it was soon discovered that, by fermenting with different microorganisms, an opportunity existed to develop a wide range of products with different flavors, textures, consistencies and more recently, health attributes. The market now offers a vast array of yoghurts to suit all palates and meal occasions. Yoghurts come in a variety of textures (e.g. liquid, set and stirred curd), fat contents (e.g. regular fat, low-fat and fat-free) and flavors (e.g. natural, fruit, cereal, chocolate), can be consumed as a snack or part of a meal, as a sweet or savory food. This versatility, together with their acceptance as a healthy and nutritious food, has led to their widespread popularity across all population subgroups (Mckinley, 2005).

Yoghurt was introduced to the American diet during the 1940s. By the 1980s, it had become the product for dieters, and the lunch of choice for young women. The use of yoghurt as a calcium source has made it one of the most rapidly growing dairy products, but presently it is more than just a calcium source. Yoghurt, Kefir, and similar fermented milk products are on the way to becoming major nutraceuticals aimed at treating a variety of disease conditions (Katz, 2001). Yoghurt's nutritional profile has a similar composition to the milk from which it is made but will vary somewhat if fruit, cereal or other components are added. Yoghurt is an excellent source of protein, calcium, phosphorus, riboflavin (vitamin B2), thiamin (vitamin B1) and Vitamin B12, and a valuable source of foliate, niacin, magnesium and zinc. The protein it provides is of high biological value, and the vitamins and minerals found in milk and dairy foods including yoghurt are bio-available. Yoghurt particularly the low-fat varieties, provide an array of important nutrients in significant amounts in relation to their energy and fat content, making them a nutrient-dense food. Eating dairy products, such as yoghurt, helps to improve the overall quality of the diet and increases the chances of achieving nutritional recommendations. (Mckinley, 2005). Vitamins and minerals may be added and often are for products given to children. Yoghurts may be spoonable or drinkable, and may be considered dietary supplements for infant consumption. So they cross the line between dietary supplements, medical foods, and conventional foods (Katz, F. 2001).

Yoghurt gels are formed by the fermentation of milk with thermophilic starter bacteria; milk is normally heated at high temperatures (e.g., 85°C for 30 min), which causes the denaturation of whey proteins. Denatured whey proteins interact and cross-link with κ-casein on the surface of casein micelles. There is increased casein-casein attraction as the pH of milk decreases from ~6.6 to ~4.6 during yoghurt fermentation, which results in gelatin as casein approach their iso-electric point. Physical properties of yoghurt gel++s, including whey separation play an important role in quality and consumer acceptance. An understanding of gelatin process during fermentation is critical in manipulating physical properties of yoghurt Lee and Lucey, 2004).

**2.2.14.1 Health benefits of yoghurt**

Yoghurt is not just a food accompaniment ,a desert or mainly diet food it is considered as health food because of it is therapeutic value . Increases yoghurt consumption enhances immune response which in turn increases resistance to immune related diseases(Mohammed, 2011). Digestive system in some people has an allergy to lactose , but lactose is transformed lactic acid in yoghurt and does not create allergy . On the other hand calcium of yoghurt is absorbed in body fast er than milk. Because lactic acid of yoghurt turns calcium to solution and absorption therefore yoghurt devotes calcium to body more than that of milk (Ariaii,ei al 2011).

The specific health benefits depend on the strain and viability of the culture in the yoghurt {Miller, 2008}. Yoghurt decreases event of bowel cancer remarkably and is more effective in absorbing minerals, proteins and vitamins of group B due to containing biological adequate conditions, (Mohammed ,2011 ) .Yoghurt contains vitamins of B,C,A,D,E and all ingredients and features of milk .Yoghurt strengthen abdomen and helps digestion of food and relax nerves due to containing vitamin B (Ariaii, et al ,2011). In Sudan it is believed that yoghurt (zabadi) is useful for treatment of stomach disturbances and the individuals with such complains are advised to take zabadi (Dirar, 1993).

### 2.2.14.2 Types of yoghurt:

Differentiation of yoghurt into divers types according to legal standards**,** technique of production, flavor and post incubation processing have been suggested, depending on method of production, the industries recognize two main types of yoghurt that is set and stirred. This classification is based on the system of manufacturing and physical structure of the coagulum (Abdelkarim , 2010 ).Based on flavor there are three different types of product namely natural or plain yoghurt which is the traditional type with sharp acidic taste. The second type is yoghurt with fruit made by addition of fruit and sweetening materials to the natural yoghurt. The third type is flavored yoghurt which the fruit component is replaced with synthetic and coloring compounds, (Mohammed, 2011). Based on post incubation processing, yoghurt can be differentiated into pasteurized yoghurt which is processed by conventional method of manufacture, in addition to this procedure the yoghurt undergoes heat treatment, to extend it is storage life. Frozen yoghurt which is prepared in a conventional mode, but is then deep frozen to -2$^{o}$ C. Concentrated and dried yoghurt contains total solids of about 24% and 90-94% respectively, other type of yoghurt in use are yoghurt cheese and acidophilus yoghurt (Abdelkarim, 2010).

### 2.2.14.3 Yoghurt starter culture

Diary starter are culture of active bacteria harmless grown in milk or whey which are used to impart certain characteristic and predictable qualities to various milk product. these culture may be strain of ones species of micro organisms ,called single strain culture or a number of strain and or species called multi – strain or mix strain culture . The starter cultures generally lyophilized and distributed in dry or frozen state, (Abdelkrim, 2010.)

### 2.2.14.4 Manufacturing of yoghurt

The process of yoghurt making is an ancient craft which date back thousands of years, and over the last few decades the process has become more rational due to improvements in such disciplines as microbiology, engineering and chemistry (Peiman, A. *et al.*, 2011).

### 2.12.4.1 The main processing steps of yoghurt making

The main processing steps in the manufacture of these products include milk standardization, heat treatment, homogenization, addition of starter culture and fermentation, next cooling and finally storage of end product. Many other processing steps e.g. (Addition of sugar or fruit) practiced for some products (Lucey, 2002).

#### 2.12.4.1.1 Standardization

In yoghurt production we have to consider important basics in manufacture, that is the fat content should be standardized to the level preferred by the market, and also the total solid is often being increased by adding dried skim milk, condensed milk or skim milk or liquid milk .this procedure gives high total solids (Smith and Hui, 2004), and the increase in milk solids is to get amore firm coagulum, (Hassan, 2010).

#### 2.12.4.1.2 Homogenization:

Tammie and Robinson (1999) reported that the use of homogenization prevents fat separation (creaming) during fermentation or storage, reduces whey separation, increases whitens, and enhances consistency of yoghurt.

#### 2.12.4.1.3 Heat treatment :

Heating of milk is an important processing variable for the preparation of yoghurt since it greatly influences the physical properties and microstructure of yoghurt. Also heat treatment of milk is also used to destroy unwanted microorganisms, which provides less competition for the starter culture. Yoghurt starter culture is sensitive to oxygen so heat treatment helps to remove dissolved oxygen assisting starter growth, (Lee and Lucey, 2010).

#### 2.12.4.1.4 Inoculation and incubation

After heat treatment , the milk base is cooled to the incubation temperature used for growth of the starter culture , an optimum temperature of the thermophilus lactic acid bacteria , streptococcus sub sp . thermophilus and lactobacillus delbrueckii sub sp. bulgaricus is around 40 - 45c , the inculcation amount vary between 0.5-5 % but the optimum value is 2% . Bacterial fermentation converts lactose into lactic acid, which reduces the ph of milk, during acidification of milk, the ph decreases from6.7 to $\leq$4.6 (Lee and Lucey, 2010).

#### 2.12.4.1.5 Cooling

When yoghurts have reached the desired ph. yoghurts are partially cooled $2^{o}$ C before fruit or flavoring ingredients are added. Yoghurt products are often blast chilled to 5c in the refrigerated cold store to reduce further acid development (Tamime and Robinson, 1999) and (Rehab, 2013).

### 2.12.5 Shelf life of yoghurt

The shelf life of fresh yoghurt may be only a couple of weeks for unprotected operations and up to 6 weeks or more for well – operated , ultraclean operations and short , even if stored at low temperatures this may be due to the sanitary problems usually associated with its production and due to unhygienic handling of the product, which increases microbial contamination (Multag and Hassan , 2008). The high microbial load of yoghurt, coupled with the packaging and storage conditions, result in the formation of off – flavors and undesirable physicochemical changes that eventually lead to rejection of the product (Muir and Banks, 2000). One of the most accepted ways extend the shelf life o perishable food products are through the use of bio- preservatives (Multag and Hassan, 2008).

### 2.12.6 Factors affecting the quality of yoghurt

There are many factors affecting the quality of yoghurt , but the most important factors are :types and composition of milk , heat treatment , starter cultures ,storage period of yoghurt and the additives In yoghurt .(Deeth et al., 1981).

### 2.12.7 Chemical composition of plain yoghurt

Kosikowski (1982) stated that the average composition of plain yoghurt was found to be fat 1.66%, protein 3.45%, T.S 10.98%, carbohydrate 5.15% and ash 0.75%.

In Sudan, Suleiman (1982) reported that the average composition of traditional yoghurt (zabadi) was found to be: fat 3.1%, protein 2.8%, lactose 2.7%, total solids 10.9%, Ash 0.7%, titratable acidity 1.9%, pH 3.6.

### 2.12.8 Camel Milk Yoghurt

Farah *et al*. (1990) studied the preparation and consumer acceptability tests of fermented camel milk (*Suusa*). They found that the consistency of fermented milk (under lab conditions) was thin and a precipitate in the form of flocks was formed rather than a coagulum after fermentation. These reports clearly show the difficulty of producing fermented camel milk products with high consistency due to the problem associated with milk coagulation. Camel milk contains good amounts of lysozyme, lactoferrin, Lactoperoxidase, immunoglobulin G and secretory immunoglobulin A; these antimicrobial factors were present at significantly greater concentrations in camel milk and were more heat stable compared with those in cow and buffalo milks (El-Agamy *et al*., 1992).

(Mortada et al., 2013) reported that the coagulation of camel milk required long time (16 h), also yoghurt made from camel's milk revealed a longer shelf life than any other milk, the natural antimicrobial agents in the camel's milk might increase its shelf life. Addition of skim milk powder improved some properties (viscosity) and sensory evaluation (flavour, overall acceptability) of camel's milk yoghurt.

**Table (2.1): Effect of storage period and different levels of skim milk powder on physicochemical analysis of camel milk yoghurt**

| Treatment parameters | Physicochemical composition% | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Storage period in days** | **Type** | **Total solid** | **Protein** | **Fat** | **Lactose** | **Ash** | **Viscosity** | **pH** |
| 0 | Control | 13.77 | 3.63 | 4.1 | 6.97 | 1.09 | 296.5 | 5.33 |
| | 5% | 13.8 | 3.6 | 4.1 | 7 | 1.12 | 372.5 | 5.33 |
| | 7% | 15.4 | 3.63 | 4.23 | 7.03 | 1.05 | 511.5 | 5.33 |
| 5 | Control | 15 | 3.63 | 4.03 | 5.37 | 1.07 | 231 | 5.2 |
| | 5% | 15.03 | 3.63 | 4 | 5.33 | 1.1 | 322 | 5.2 |
| | 7% | 15.1 | 3.63 | 4.03 | 5.17 | 1.17 | 421 | 5.13 |
| 10 | Control | 14.93 | 3.46 | 4 | 5.2 | 1.05 | 199.5 | 5.03 |
| | 5% | 14.97 | 3.5 | 4 | 5.13 | 1.1 | 226.5 | 4.9 |
| | 7% | 15.03 | 3.5 | 4.1 | 5.17 | 1.13 | 376 | 4.9 |
| Main effect | | | | | | | | |
| | Control | 14.32 | 3.62 | 4.14 | 7 | 1.09 | 393.50 [a] | 5.33[a] |
| Time | 5 | 15.04 | 3.63 | 4.02 | 5.29 | 1.11 | 324.67[b] | 5.18[b] |
| | 10 | 14.98 | 3.49 | 4.03 | 5.17 | 1.1 | 267.33[c] | 4.94[c] |
| Standard error | | 0.75 | 0.21 | 0.06 | 0.66 | 0.04 | 0.93 | 0.04 |
| p-value | | 0.75 | 0.86 | 0.25 | 0.11 | 0.91 | < 0.01 | < 0.01 |
| | Control | 14.57 | 3.58 | 4.04 | 5.84 | 1.07 | 242.33 [c] | 5.19 |
| Type | 5 | 14.6 | 3.58 | 4.03 | 5.82 | 1.11 | 307 [b] | 5.14 |
| | 10 | 15.18 | 3.59 | 4.12 | 5.79 | 1.12 | 436.17[a] | 5.12 |
| Standard error | | 0.75 | 0.21 | 0.06 | 0.66 | 0.04 | < 0.001 | 0.04 |
| P-value | | 0.81 | 0.99 | 0.48 | 0.99 | 0.69 | < 0.01 | 0.49 |

*Means with different superscript in the same column are significantly different at p <0.05*

*Source :( Mortada et al, 2013).*

**Table (2.2): Effect of Storage Period and Different Levels of Skim Milk Powder on Sensory Evaluation of Camel Milk Yoghurt Sensory Evaluation Characteristics Treatment Parameter**

| storage period in days | Type | Colour | Flavour | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|---|
| 0 | Control | 6.2 | 4.2 | 3.6 | 4.2 | 4.8 |
| | 5% | 6.2 | 4.4 | 4.2 | 3.6 | 4.6 |
| | 7% | 7 | 5.6 | 4 | 2.8 | 5.2 |
| 5 | Control | 6.4 | 4.6 | 3.4 | 2.8 | 4.8 |
| | 5% | 6.8 | 4.8 | 3.8 | 2.8 | 5.2 |
| | 7% | 6.6 | 5 | 4.2 | 2.8 | 5 |
| 10 | Control | 6.4 | 4 | 4 | 2.4 | 4.8 |
| | 5% | 6.6 | 5.4 | 4.2 | 3.2 | 5.6 |
| | 7% | 6.6 | 6.2 | 4.2 | 4.4 | 6 |
| Main effect | | | | | | |
| Time | 0 | 6.47 | 4.73 | 3.93 | 3.53 | $4.87^{b}$ |
| | 5 | 6.6 | 4.8 | 3.8 | 2.8 | $5.00^{b}$ |
| | 10 | 6.53 | 5.2 | 4.13 | 3.33 | $5.47^{a}$ |
| p-value | | 0.9 | 0.34 | 0.61 | 0.27 | <0.031 |
| Type | Control | 6.33 | $4.27^{b}$ | 3.67 | 3.13 | $4.80^{b}$ |
| | 5% | 6.53 | $4.87^{b}$ | 4.07 | 3.2 | $5.13^{ab}$ |
| | 7% | 6.73 | $5.60^{a}$ | 4.13 | 3.33 | $5.40^{a}$ |
| p-value | | 0.41 | <0.001 | 0.33 | 0.91 | < 0.04 |

*Means with different superscript in the same column are significantly different at p <0.05*

*Source :( Mortada et al, 2013).*

### 2.12.8.1 Nutritional Value of Camel Milk Yoghurt

Yoghurt is a pure, non-allergic, organic health product with anti-bacterial qualities. It contains non-saturated fatty acids, Vitamins B and C and iron. And the Approximate minimum per 100g value of camel yoghurt found to be energy 202kj, fat 2.5g, protein 3.0g Carbohydrate 4.8g and calcium 0.132g.(Price, Weston, 2008).

# CHAPTER THREE

## Material and Methods

### 3.1 Milk samples

Fresh camel milk was obtained from camel research center University of Khartoum (Shambat) and fresh cow milk was obtained from animal production department dairy farm, college of agriculture studies, Sudan university of Science and Technology (Shambat). Fresh milk samples were taken by clean plastic containers to national food research center laboratory for determination of physiochemical component. Skim powder milk was obtained from local market.

### 3.2 Methods

### 3.2.1 Physico-chemical analysis of milk and yoghurt

Chemical composition of milk and yoghurt and physical characteristics were analyzed at national food research center laboratory. The milk and yoghurt constituents (fat, protein, lactose, TS, SNF, Ash, Ca, P and moisture). Physical characteristics (pH, Acidity and density) were analyzed.

#### 3.2.1.1 Fat

The fat content was determined by Gerber method as described by AOAC (1995) Ten ml, of sulphuric acid (specific gravity 1.820 at 15.5$^{o}$ C were measured into Gerber butyrometer . And mixed well, 10 .94ml, of milk and yoghurt was gently added into the butrymeter tube. One milliliter of amyl alcohol was added and a lock stopper was inserted securely with the stopper´s end up .The Gerber tube was grasped and shacked with precaution until the sample of milk and yoghurt completely digested. The Gerber tubes were centrifuged at 1100 revolution per minute (rpm) for 4 minutes .The butyrometer was then placed in a water bath at 65$^{o}$ C for 3 minutes .The fat percent was finally read out directly from the column.

### 3.2.1.2 Protein

The protein content of samples was determined by kjeldahl method according to AOAC (1995) as follows:

**Digestion**:

10ml of milk and yoghurt were weighed and poured in a clean dry kjeldahl flask and 2 gm of $cuso_4$ added. Concentrated sulphuric acid [25ml] added to the flask. The flasks were heated until a clear solution was obtained [2-3 hrs] and left for another 30 min. the flasks were removed and allowed to cool.

Distillation: the digested sample was poured in a volumetric flask [100ML] and diluted with distilled water, then 15ml of 40% Na OH added to each flasks and the content of the flask was distillated. The distillate was received in a conical flask [100ml] containing 10 ml of 2 % boric acid plus 3 drops of indicator [bromocresol green plus phenolphthalein red], the distillation was continued until the volume in the flask 75ml,then the flask was removed from the distillator.

**Titration**: The distillate was titrated with 0.1N H Cl until the end point [red color] was obtained; the protein content was calculated from the following equation.

$$N\% = \frac{T \times 0.1 \times 0.014 \times 100}{W}$$

T= Reading of titration

W= weight of the original sample

Protein (%) =% NX×6.38

**3.2.1.3 Lactose Determination by Anthrone Method (Richard1959)**

**Preparation of solution:**

The standard solution was prepared by dissolving 5mg lactose in to 95ml of distilled water to give 5% (w/v) solution of monohydrate. One ml of this solution was diluted with 500ml volumetric flask to give 75mg lactose /ml standard solution. The Anthrone reagent was prepared by dissolving 150mg of Anthrone into 100 ml of 70% (w/v) sulfuric acid. The solution was then cooled and stored overnight.

**Procedure:**

One ml of milk and yoghurt was pipetted into a 500ml flask with distilled water. The solution was then mixed thoroughly and 0.5ml was transferred to boiling tube (sample) standard stock solution (0.5ml) was transferred to a second boiling( blank).To each tube 10ml ice cooled Anthrone reagent was added. The tube were then transferred to boiling water bath for 6 min then transferred to an ice bath and held for 30 min. The optical density (O.D) was read at 625nm Lactose content (in mg/100 ml) was calculated as follows:

$$\textbf{Lactose} = \frac{O.D(S) - O.D(B) \times 4.75}{O.D(SD) - O.D(B)}$$

Where: O.D (S) =Optical density of sample. O.D (SD) =Optical density of standard. O.D (B) = Optical density of blank

### 3.2.1.4 Total solids

Total solids (T.S) content was determined according to AOAC (1995). A clean aluminum moisture dishes were dried at 105$^{o}$ C for 3 hrs. Five grams of the dairy samples were weighed in dry clean flat bottomed aluminum dish and heated on a steam bath for 15 minutes . The dishes were placed into a forced draft oven at 100 $^{o}$ C for 3hrs. Then cooled in a desiccator and weighed quickly. Weighing was repeated until the difference between the two readings was <0.1mg. The total solids (T.S) content were calculated as follows:

$$T.S.\ \% = \frac{W1}{W2} X100$$

Where:

W1=Weight of sample after drying

W2=Weight of sample before drying

### 3.2.1.5 Solid-non fat:

Solids –non-fat (S.N.F) content was determined from the following equation SNF (%) = % T.S%-Fat%

### 3.2.1.6 Ash

The ash content was determined by gravimetric method AOAC (1995). Five grams of the sample were weighed in a crucibles ,then placed in a muffle furnace at 550-600 $^{o}$ C for 3 hours until ashes were carbon free. The crucibles were then cooled in desiccators and weighed. The ash content was calculated using the following equation:

$$Ash\ \% = \frac{w1}{w2}\ x100$$

Where: w1 = weight of ash, w2 = weight of sample

#### 3.2.1.7 Moisture

Moisture was determined according to AOAC (1995). Five grams of milk and yoghurt were weighed. The samples were dried in oven over night at 105 $^{o}$ C. After cooling in desiccator they were weighed. The different in weight before and after divided as following:

$$\textbf{Moisture \%} = \frac{\text{different in weight}}{\text{sample weight}} \times 100$$

#### 3.2.1.8 Calcium and phosphorus determination

The samples were analyzed after ashing briefly. Two grams of milk and yoghurt were weighted into platinum crucibles and ashed in the furnace at 550 $^{o}$ C for 16 hr. Calcium was determined using an atomic absorption spectrometer and phosphorus was measured at 400 nm by spectrophotometer.

#### 3.2.1.9 Density

Density of the milk samples were determined by milk analyzer using (Lacto scan Milkotronic LTD, Supply 230 VAC)( University of Khartoum ).

Milk sample was mixed thoroughly 4-5 times to avoid any air enclosure was taken in , sample holder one at time and put in the sample holder, with analyzer in the recess position. Then the starting button activated, the analyzer sucks the milk, makes the measurement, returns the milk in the sample holder and the digital indicator display show the specified results.

#### 3.2.1.10 Titratable Acidity

The acidity of milk and yoghurt was determined according to AOAC(1990).Ten milliliters of sample were placed in a white porcelain, and five drops of phenolphthalein indicator were added .Titration was carried out using 0.1 N Na OH until a faint pink color with lasts for 30 seconds was obtained. The titration figure was divided by 10 to get the percentage of lactic acid.

$$T.A\,\%\ \frac{9\times 0.1\text{ml of}NaOH}{\text{Milk weight}}$$

#### 3.2.1.11 The pH

pH was determined by electric pH meter (Hanna instrument pH, 209). 10 ml of milk and yoghurt were pipette into the tube, then the pH meter was adjusted with buffer pH 4, the PH meter was placed into the sample, and the pH was directly read .

### 3.3 The Procedure of Yoghurt production

Yoghurt prepared according to (Lee and Lucey, 2010) and ( Dirar 1993) Methods . Fresh camel and cow milk was filtered and increased total solids to 15% by skimmed powder milk. The milk pasteurized at 85 $^{o}$ C for 30 min as described by Dirar (1993), and rapidly cooled to 43 $^{o}$ C .Then the starter culture of *( streptococcus thermophilus , lactobacillus delbrueckii ssp.Bulgricus )* At the rate of 3% was added and blended thoroughly .

#### 3.3.1 Treatments of yoghurt

Milk divided in to five treatments (A, B, C, D and E).

### 3.3.1.1 Treatment A: 75% camel's milk +25%cow's milk.

After milk filtered, increased total solids to 15% by skimmed milk, pasteurized at 85 ºC for 30 min. As described by( Dirar 1993), and cooled to 43 ºC. Then the starter culture of (*thermophilus streptococcus lactobacillus delbrueckii ssp.Bulgricus)* at the rate of 3% added and blended thoroughly, 450ml camel's milk + 150ml cow's milk were measured and mixed ,then the amount of whole sample became 600ml, packed in plastic cups (200ml capacity) for analysis and (25ml capacity) for panel test and incubated at 43 ºC for 6 hours. Then the yoghurt transferred to refrigerator at 4 ºC for 2 days.

The yoghurt samples physiochemical component were analyzed and sensory evaluation done, replicated for each treatment.

Samples from each batch were storage for 10 days to determined their acidity and pH after storage period.

### 3.3.1.2 Treatment B : 50% camel's milk +50%cow's milk.

After milk filtered, increased total solids to 15% by skimmed milk, pasteurized at 85 ºC for 30 min. As described by( Dirar 1993), and cooled to 43 ºC. Then the starter culture of (*thermophilus streptococcus lactobacillus delbrueckii ssp.Bulgricus)* at the rate of 3% added and blended thoroughly, 300ml camel's milk + 300ml cow's milk were measured and mixed ,then the amount of whole sample became 600ml, packed in plastic cups (200ml capacity) for analysis and (25ml capacity) for panel test and incubated at 43 ºC for 4 hours. Then the yoghurt transferred to refrigerator at 4 ºC for 2 days.

The yoghurt samples physiochemical component were analyzed and sensory evaluation done, replicated for each treatment.

Samples from each batch were storage for 10 days to determined their acidity and pH after storage period.

**3.3.1.3 Treatment C :25% camel's milk +75%cow's milk.**

After milk filtered, increased total solids to 15% by skimmed milk, pasteurized at 85 ºC for 30 min. As described by( Dirar 1993), and cooled to 43 ºC. Then the starter culture of (*thermophilus streptococcus lactobacillus delbrueckii ssp.Bulgricus)* at the rate of 3% added and blended thoroughly, 150ml camel's milk + 450ml cow's milk were measured and mixed ,then the amount of whole sample became 600ml, packed in plastic cups (200ml capacity) for analysis and (25ml capacity) for panel test and incubated at 43 ºC for 4 hours. Then the yoghurt transferred to refrigerator at 4 ºC for 2 days.

The yoghurt samples physiochemical component were analyzed and sensory evaluation done, replicated for each treatment.

Samples from each batch were storage for 10 days to determined their acidity and pH after storage period.

**3.3.1.4 Treatment D :pure camel's milk (100%).**

After milk filtered, increased total solids to 15% by skimmed milk, pasteurized at 85 ºC for 30 min. As described by( Dirar 1993), and cooled to 43 ºC. Then the starter culture of (*thermophilus streptococcus lactobacillus delbrueckii ssp.Bulgricus)* at the rate of 3% added and blended thoroughly, 600ml camel's milk, packed in plastic cups (200ml capacity) for analysis and (25ml capacity) for panel test and incubated at 43 ºC for 6 hours. Then the yoghurt transferred to refrigerator at 4 ºC for 2 days.

The yoghurt samples physiochemical component were analyzed and sensory evaluation done, replicated for each treatment.

Samples from each batch were storage for 10 days to determined their acidity and pH after storage period.

### 3.3.1.5 Treatment E :pure cow's milk (100%).

After milk filtered, increased total solids to 15% by skimmed milk, pasteurized at 85 ºC for 30 min. As described by( Dirar 1993), and cooled to 43 ºC. Then the starter culture of (*thermophilus streptococcus lactobacillus delbrueckii ssp.Bulgricus)* at the rate of 3% added and blended thoroughly, 600ml cow's milk, packed in plastic cups (200ml capacity) for analysis and (25ml capacity) for panel test and incubated at 43 ºC for 3 hours. Then the yoghurt transferred to refrigerator at 4 ºC for 2 days.

The yoghurt samples physiochemical component were analyzed and sensory evaluation done, replicated for each treatment.

Samples from each batch were storage for 10 days to determined their acidity and pH after storage period.

### 3.3.2. Sensory evaluation of yoghurt

Sensory profiling of the milk samples was conducted, using conventional profiling, by panelists. Twelve panelists were selected among the staff and students of Animal Production Department, College of agriculture, Sudan University. The panelists were given a hedonic questionnaire to test taste, texture, color, flavor and overall acceptability of coded samples of different treatments.

## 3.4 Statistical analyses

Data generated was subjected to statistical analysis system (SPSS) program. Statistical package of social science version 11.5 using analysis of variance (Independent T test for fresh milk and ( CRD) completely randomized design for yoghurt and means separated by Duncan's test (DMRT) Duncan's Multiple range test.

# CHAPTER FOUR

## Result and Discussion

### 4.1 The Physical and chemical Composition of Camel milk compared with Cow Milk

The results of this study shown significant differences ($p \leq 0.05$) in physiochemical characteristics (protein, SNF, and density of fresh camel and cow milks. But there were no significant differences ($p \geq 0.05$) in moisture, fat, ash, lactose, total soil (TS), pH, acidity, $Ca^{++}$ and phosphorus of the camel and cow milk. Table (4.1) Protein and SNF in cow milk (3.62±0.24, 8.63±0.093) were higher than that found in camel milk (3.4±0.065, 8.4±0.557) respectively. While the density of camel milk (1.039±0.00) is higher in comparison to the density of cow milk (1.037±0.0003). Table (4.1) Figures (1, 2, 3). Numerically moisture, lactose, Ca and P were high in cow milk but fat, Ash, total solid and acidity were high in camel milk.

### 4.2 Chemical and physical analysis of camel milk

#### 4.2.1 Chemical analysis

##### 4.2.1.1 Moisture:

In the present study moisture content average was 86.9%. Its Lower than that reported by Ashia (2009), 88.7%, and Rehab (2013), 87.7 %. However, it is in the range which reported by Mahamoud (2009) 84 to 90%. The difference can be due to seasonal variations and availability of drinking water.

#### 4.2.1.2 Protein:

The average of Protein content in this study is 3.4% which is higher than that reported by Byoumi(1990) 3.3%. And similar to that estimated by Wilson (1984)3.4%. Elamin and Wilcox (1992) estimated protein content of Sudanese camel milk with 2.8. Generally, protein content rises during lactation period.

#### 4.2.1.3 Fat

The average of Fat content, in this study was 4.7% it's higher than that estimated by Ashia (2009) 3.7% and nearly similar to 4.6% reported by Mohamed (1990), and it is in the range of fat % estimated by Farah and Ruegg ( 1991), which was 1.1-5.5%, the difference can be due to difference in feeding condition and breed.

#### 4.2.1.4 Lactose

The average of Lactose in the present study was 4.2% its higher than that estimated by Ashia (2009) 3.28% and similar to that reported by Elamin and Wilcox (1992) 4.2%. Byoumi (1990) estimated it as 5.5%, the difference may be due to the stage of lactation period, as it was noticed that, lactose % increased gradually at parturition until it reached 5.58% at the tenth day (Abu-Lehia 1989).Generally lactose content of camel milk vary greatly depending on feeding and watering conditions (Yagil and Etzion, 1980; Yagil, 1994).

#### 4.2.1.5 Total solids

The average of Total solids in the present study estimated 13.1% its higher than that reported by Ashia (2009) 11.3% ,and lower than that estimated by Byoumi (1990) which was 13.4%, in general the total solids tend to be lower in hot season, as camel looses a considerable amount of its water to milk for the nourishment of young calves.

### 4.2.1.6 Ash

The average of Ash content was 0.76% which higher than that reported by Rehab (2013) 0.73%, and it's lower than that reported by Elamin and Wilcox (1992) 0.80%, generally ash is affected by drought (Yagil and Etzion 1980). However all approximate chemical camel milk constituents were in the range reported by (Hashim et al, 2009).

### 4.2.1.7 Calcium

The mean of Calcium in this study in camel milk was 68mg/100 ml, lower than that estimated by Aisha (2009) 116 mg and higher than that reported by Elamin and Wilcox (1992) 30 mg, the difference might be due to seasons.

### 4.2.1.8 Phosphorus

The mean of phosphorus in this study in camel milk was 66mg/100ml higher than that reported by Aishs (2009) 24m g and lower than that reported by Gorban and Izzeldin (1997) 76mg.

### 4.2.1.9 The acidity

The acidity mean was 0.2%higher than that reported by Aisha (2009)0.18%, and similar to that reported by Karim and Gook Lani (1987) 0.2%, the difference may be due to breed, lactation period and analytical procedure.

#### 4.2.1.10 pH

PH value in present study 6.7 in camel milk it is similar to that reported by Mahmud (2009) and higher than that reported by Rehab (2013) 6.40 differences may be due to breeds and analytical procedure.

#### 4.2.1.11 Specific gravity

The mean specific gravity of camel milk is 1.039 it's higher than 1.0305 (Shalash, 1982), differences may be due to breeds and analytical procedure.

**Table (4.1): Physical and chemical Analysis of Cow and Camel milk**

| Parameters | Treatments (Mean ± SE) | | Level Of Sig |
|---|---|---|---|
| | Cow Milk | Camel Milk | |
| **Moisture** | $87.020^{a}$ ± 0.3601 | $86.896^{a}$± 0.9022 | NS |
| **Fat** | 4.363± 0.2683 | 4.690± 0.3464 | NS |
| **Protein** | $3.623^{a}$± 0.2383 | $3.430^{b}$± 0.0650 | * |
| **Ash** | 0.570± 0.0602 | 0.763±0.0185 | NS |
| **Lacote** | $4.420^{a}$± 0.2100 | $4.220^{a}$± 0.5100 | NS |
| **T.S** | $12.980^{a}$± 0.3601 | $13.103^{a}$ ± 0.9022 | NS |
| **S.N.F** | $8.616^{a}$± 0.0928 | $8.413^{b}$± 0.5566 | * |
| **pH** | $6.733^{a}$ ±0.1201 | $6.733^{a}$ ± 0.2666 | NS |
| **Acidity** | $0.180^{a}$ ±0.0057 | $0.226^{a}$ ±0.0185 | NS |
| **Calcium** | 87.0±1.1547 | 68.0± 0.5773 | NS |
| **Phosphrus** | 72.333± 2.0275 | 66.0±0.5773 | NS |
| **Density** | $1.037^{b}$±0.0003 | $1.039^{a}$±0.0000 | * |

*For each mean parameters a>b , (p<0.0*

**The result of Chemical and physical analysis of yoghurt**

The treatment effect of pure and mixture of camel and cow milk yoghurt on physiochemical characteristics result in highly significant differences ($p \leq 0.05$) Table (4.2.)

Pure cow milk yoghurt has higher percentage of protein, fat, lactose, SNF, Ph, Calcium and phosphorus. While pure camel milk yoghurt showed high moisture, ash and acidity percentages. Figures (4.5.6)

75% cow milk +25% camel milk yoghurt has superiority in protein, fat, lactose, T.S and S.N.F percent after pure cow milk yoghurt Table (4.2.).

**Chemical analysis of yoghurt**

In this study the average of pure camel milk yoghurt fat was 4.27% its higher than that minimum level reported by (Price, Weston ,2008) 2.5% And its nearly similar to that estimated by ( Mortada et al ,2013) 4.1% and lower than that reported by Rehab (2013) 4.53%. And the average of protein 3.23% higher than that found by (Price, Weston , 2008) 3% And lower than that reported by ( Mortada et al, 2013) 3.63% . The lactose percent was 3.43% its lower than that reported by (Price, Weston, 2008) 4.8% and from that estimated (Mortada et al ,2013) 6.9%. The total solid was 11.83% its lower than that reported by (Mortada et al, 2013) 13.77%. The differences may be due to the availability of drinking water and breed.

The pH was 5.2 its nearly similar that reported by (Mortada et al ,2013) 5.3, and higher than that found by Rehab (2013) 4.13.

### 4.2.2 The effect of mixing different percentage of cow milk to the chemical composition of camel milk yoghurt

As shown in the Table (4.2) the percentage of fat, protein, lactose and T.S increase with the increase of cow milk percentage.

In this study the average of pure cow milk yoghurt fat was 5.33% its higher than that reported by (W.A D.V Weerathilake ,et al 2014) 3% and Suleiman (1982) reported 3.1% and the protein content was 4.7% its higher than that reported by Kosikowski (1982) 3.45% and lower than that reported by (W.A D.V Weerathilake , et al 2014) 5.7% and the lactose was 4.06% its lower than that reported by Kosikowski (1982) 5.15% , and by (W.A D.V Weerathilake et al 2014) 7.8%. The total solid was 15.37% its higher than that reported by Kosikowski (1982) 10.98% and by (W.A D.V Weerathilake et al 2014) .The differences may be due to breed , season , nutrition and the addition of skim powder milk. The pH was 4.35 after 10 days it’s higher than that reported by Suleiman (1982) 3.6.

**Table (4. 2): Physiochemical Analysis of Cow and Camel Milk Yoghurt**

| Parameters | Treatments (Means ± SE) | | | | | L.Sig |
|---|---|---|---|---|---|---|
| | **A** (75% camel +25%cow) | **B** (50% camel +50%cow) | **C** (25% camel +75%cow) | **D** (100% camel) | **E** (100% cow) | |
| Moisture (%) | $88.13^{a}\pm0.167$ | $86.23^{b}\pm0.233$ | $85.50^{c}\pm0.321$ | $88.17^{a}\pm0.176$ | $84.63^{d}\pm0.219$ | ** |
| Protein (%) | $3.57^{c}\pm0.133$ | $4.07^{b}\pm0.088$ | $4.33^{b}\pm0.088$ | $3.23^{d}\pm.0881$ | $4.67^{a}\pm0.088$ | ** |
| Fat (%) | $4.60^{bc}\pm0.208$ | $4.90^{ab}\pm0.153$ | $5.10^{ab}\pm0.115$ | $4.27^{c}\pm0.203$ | $5.33^{a}\pm0.145$ | * |
| Ash (%) | $0.83^{ab}\pm0.009$ | $0.80^{bc}\pm0.006$ | $0.78^{c}\pm0.006$ | $0.84^{a}\pm0.012$ | $0.74^{d}\pm0.009$ | ** |
| Lactose (%) | $2.80^{d}\pm0.058$ | $3.97^{b}\pm0.088$ | $4.027^{ab}\pm0.120$ | $3.43^{c}\pm0.291$ | $4.06^{a}\pm0.0881$ | ** |
| T.S (%) | $11.87^{d}\pm0.167$ | $13.77^{c}\pm0.233$ | $14.50^{b}\pm0.321$ | $11.83^{d}\pm0.176$ | $15.37^{a}\pm0.219$ | ** |
| S.N.F (% | $7.27^{c}\pm0.145$ | $8.87^{b}\pm0.120$ | $9.40^{ab}\pm0.208$ | $7.57^{c}\pm0.376$ | $10.03^{a}\pm0.088$ | ** |
| Ph | $5.33^{c}\pm0.033$ | $5.43^{c}\pm0.033$ | $5.63^{b}\pm0.033$ | $5.20^{d}\pm0.058$ | $5.83^{a}\pm0.033$ | ** |
| Acidity As lactic acid (%) | $0.76a^{b}\pm0.006$ | $0.75b^{c}\pm0.009$ | $0.73^{cd}\pm0.007$ | $0.78^{a}\pm0.007$ | $0.71^{d}\pm0.009$ | ** |
| $Ca^{++}$(mg/100g) | $81.67^{c}\pm1.333$ | $87.67^{b}\pm1.856$ | $92.0^{b}\pm2.082$ | $71.67^{d}\pm0.667$ | $98.0^{a}\pm2.08$ | ** |
| P (mg/100g) | $74.67^{d}\pm0.882$ | $81.33^{c}\pm0.6666$ | $84.33^{b}\pm0.333$ | $72.0^{d}\pm1.528$ | $87.67^{a}\pm0.882$ | ** |

*Different superscript letters (a to d) within the same raw showed significant differences among the groups (P<0.05).L.sig= Level of significant.*

The effect of different samples from camel and cow milk yoghurt result in no significant difference ($p \geq 0.05$) on Ph, but significantly affect the acidity of pure and mixture of camel and cow milk yoghurt treatments Table (4.3).

The high acidity is observed in pure camel milk yoghurt (0.81±0.0175) followed by 75% camel milk +25%cow milk yoghurt (0.79 ±0.0176), then 50% camel milk +50% cow milk yoghurt (0.78±0.0173) then 25% camel milk +75%cow milk yoghurt ($0.76^{ab}$±0.0153) and the last one is pure cow milk yoghurt (0.74±0.0163) Table (4.3). Figure (4.7).

**Table (4. 3): Effect of different samples of camel and cow yoghurt on pH and acidity.**

| Parameters | Treatments Means ±SE | | | | | Level of sig |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| **Ph** | $5.16^{a}$±0.2823 | $5.27^{a}$±0.2827 | $5.47^{a}$±0.2748 | $5.04^{a}$±0.2915 | **$5.63^{a}$**±.2553 | NS |
| **Acidity** | $0.79^{a}$±0.0176 | $0.78^{ab}$±.0173 | $0.76^{ab}$±0.0153 | **$0.81^{a}$**±0.0175 | $0.74^{b}$±0.0163 | * |

Different superscript letters (a to b) within the same raw showed significant differences among the groups (P<0.05).

**The effect of storage period on yoghurt**

The effect of storage period for camel and cow milk yoghurt was highly significant on Ph and acidity Table (4.4).

The high value of Ph was observed after incubation (6.26±0.041) followed by storage after 24hr (5.3±0.07) then storage after 10 days (4.4±0.08). While the acidity is higher after 10 days of storage followed by after 24 hr then after incubation with their corresponding values of 0.84±0.008, 0.75±0.005 and 0.74±0.007 respectively Table (4.4) Figure (8).

**Table (4.4): Effect of storage period on Ph and acidity from different samples of camel and cow yoghurt**

| Parameters | Treatments Means ±SE | | | Level of sig |
|---|---|---|---|---|
| | After incubation | After 24 hr | After 10 days | |
| **pH** | $6.26^{a}$±0.041 | $5.33^{b}$±0.070 | $4.35^{c}$±0.065 | ** |
| **Acidity** | $0.74^{b}$±0.007 | $0.75^{b}$±0.005 | $0.84^{a}$±0.008 | ** |

*Different superscript letters (a to c) within the same raw showed significant differences among the groups (P<0.05).*

### The Sensory Evaluation Analysis of Yoghurt

The sensory evaluation of pure and mixed camel and cow milk yoghurt treatments were appeared high significant ($p \leq 0.05$) on taste, flavor, smell, texture, and overall acceptability, but had no significant ( $p \geq 0.05$) recorded on the color, Table (4.5).

The best value for taste, flavor, smell, texture and overall acceptability were obtained by yoghurt made from pure cow milk followed by the 25% camel milk +75%cow milk yoghurt treatment then 50% camel milk + 50% cow milk yoghurt, then 75% camel milk + 25%cow milk yoghurt and the last one was the pure camel milk yoghurt treatment, Table (4.5) Figure (9).

### Table (4.5): Sensory Evaluation of Camel and Cow Milk Yoghurt

| Parameters | Treatment means± SE | | | | | Level of sig |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| Taste | $4.78^{c}$±0.016 | $5.88^{b}$±0.216 | $8.28^{a}$±0.303 | $3.79^{d}$±0.167 | $8.39^{a}$±0.398 | ** |
| Color | $6.39^{a}$±0.756 | 6.48a±0.419 | $8.49^{a}$±0.237 | $6.0^{a}$±0.982 | $8.12^{a}$±0.505 | NS |
| Flavor | $5.05^{b}$±0.144 | 5.80b±0.173 | $8.05^{a}$±0.419 | $4.98^{b}$±0.419 | $8.47^{a}$±0.376 | ** |
| Smell | $5.37^{bc}$±0.433 | 5.97b±0.203 | $8.25^{a}$±0.304 | $4.70^{c}$±0.058 | $8.67^{a}$±0.651 | ** |
| Texture | $3.49^{b}$±0.341 | $4.36^{b}$±0.151 | $8.70^{a}$±0.462 | $2.41^{c}$±0.384 | $9.13^{a}$±0.203 | ** |
| Overall acceptability | $4.47^{d}$±0.088 | $5.70^{c}$±0.058 | $8.75^{b}$±0.202 | $3.80^{e}$±0.231 | $9.40^{a}$±0.058 | ** |

*Different superscript letters (a to e) within the same raw showed significant differences among the groups (P<0.05*

# CHAPTER FIVE

# Conclusions and Recommendations

## 5.1 Conclusions

According to the findings of this study, it could be conclude that it is possible to manufacture yoghurt from camel milk with mixing by cow milk 75% and 50% respectively.

Mixing different levels from cow milk to camel milk has effect to chemical composition of yoghurt produced from mixed milk , the percentage of fat ,protein ,lactose , and total solid increasing with the increase of cow's milk levels.

The levels of the acidity of the mixed milk yoghurt increase with the increase of camel milk levels, while the pH doesn't affected.

The acidity and pH affected by the storage period, the high value of pH was observed after incubation followed by after 24hours then after 10days while the acidity is higher after 10 days of storage followed by after 24hours then after incubation.

The sensory evaluation of yoghurt appeared high significant differences on taste, flavor, smell, texture and overall acceptability of yoghurt.

The best value of these sensory obtained by yoghurt made from pure cow milk followed by the 25% camel milk +75%cow milk yoghurt treatment then 50%camel milk +50%cow milk yoghurt treatment then 75%camel milk +25%cow milk yoghurt treatment and the last one was the pure camel milk yoghurt treatment .

## 5.2 Recommendations

1- Its recommend to produce yoghurt from camel milk mixed with cow milk in different ratios, but the best levels are 75% and 50% from the whole amount of total milk.

2- Further investigation is needed to detect manufacturing of camel milk yoghurt mixing with other species milk

3- Further research will be needed to detect the shelf life and bacterial load of yoghurt produced by camel milk mixed with cow's milk to determine its best shelf life period.

4- Encouraging production of dairy product from camel milk.

5-Strengthening research in camel dairy production, processing and introduction of new bio-technologies.

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# APPENDIX

**Sudan University of Science and Technology**

**Collage of graduate studies**

**M.Sc. in animal production**

**Panel Taste form production of camel milk yoghurt supplemented with cow milk**

**Name ………………………………………………………………………..**

**Date: / /**

**The degree from (0-10)**

| Sample code | Taste | Color | Flavor | Smell | Texture | Over all Acceptability |
|---|---|---|---|---|---|---|
| A | | | | | | |
| B | | | | | | |
| C | | | | | | |
| D | | | | | | |
| E | | | | | | |

**Keys:**

**(0) is the worst and (10) is the best**

**10 - excellent , 9- highly acceptable , 8- acceptable ,7- moderately acceptable , 6- slightly acceptable , 5- slightly unacceptable , 4-Moderately unacceptable , 3- unacceptable ,2- highly unacceptable ,1 and zero are rejected.**

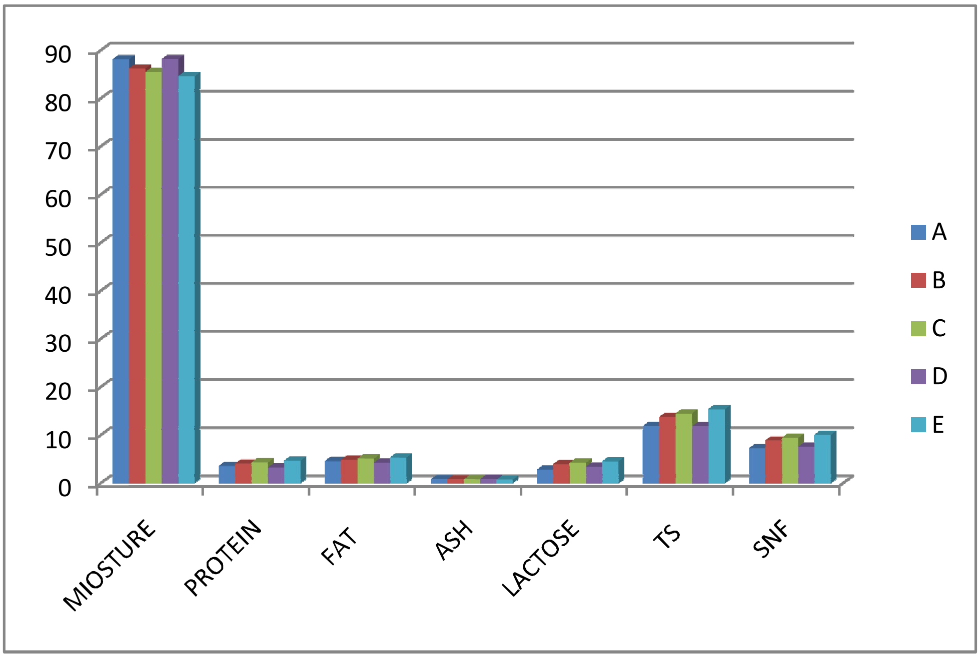


Figure (4.1): **Chemical Analysis of Cow and Camel Milk Yoghurt**

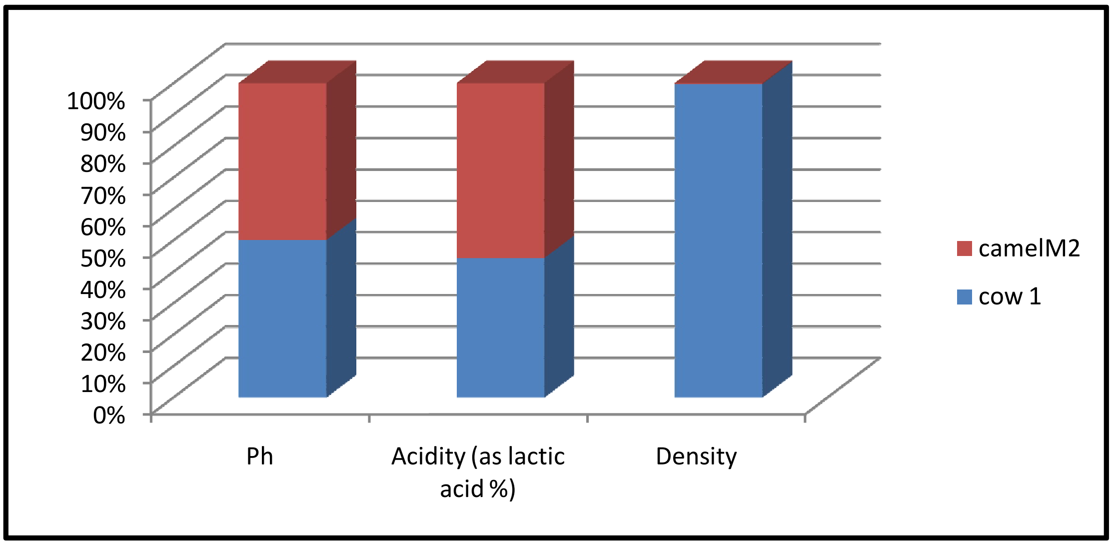


Figure (4. 2): **Cow and Camel Milk Analysis of Minerals**

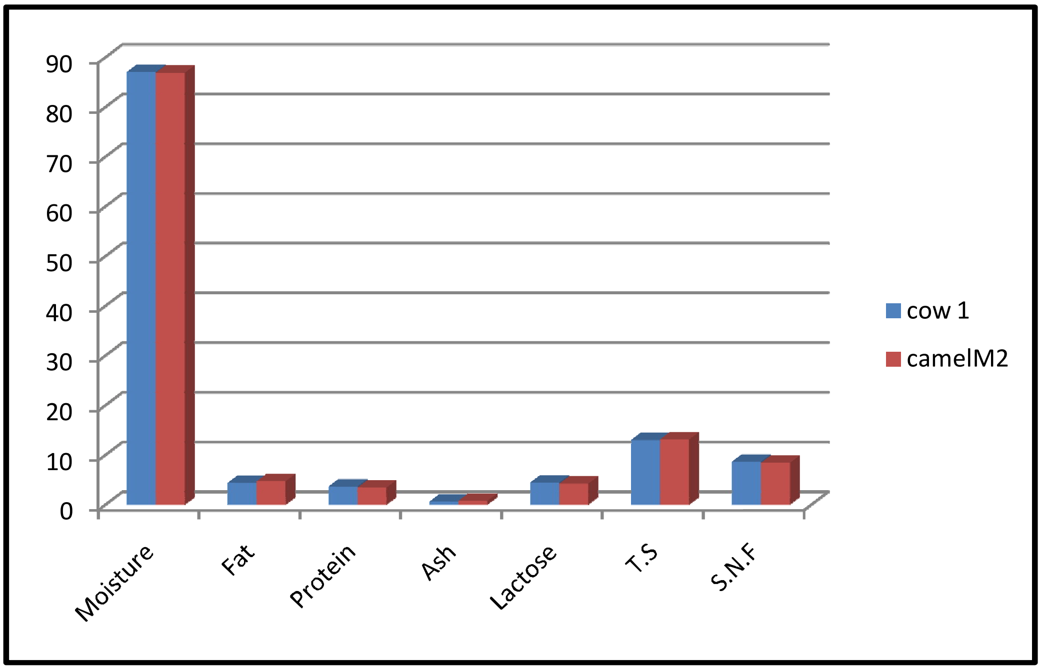


Figure (4.3): **Cow and Camel Physical Milk Analysis**

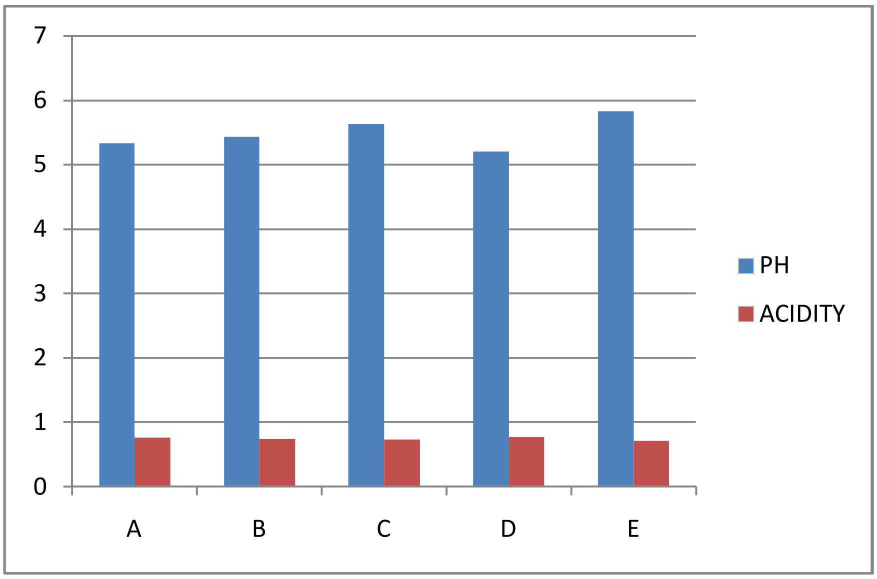


Figure (4.4): **Cow and Camel Milk Chemical Analysis**

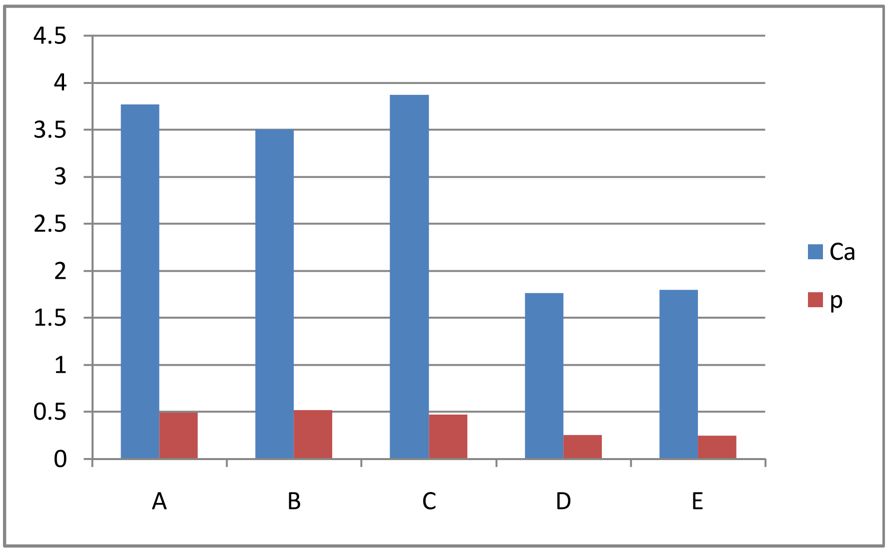


Figure (4.5): **Physical Analysis of Cow and Camel Milk Yoghurt**

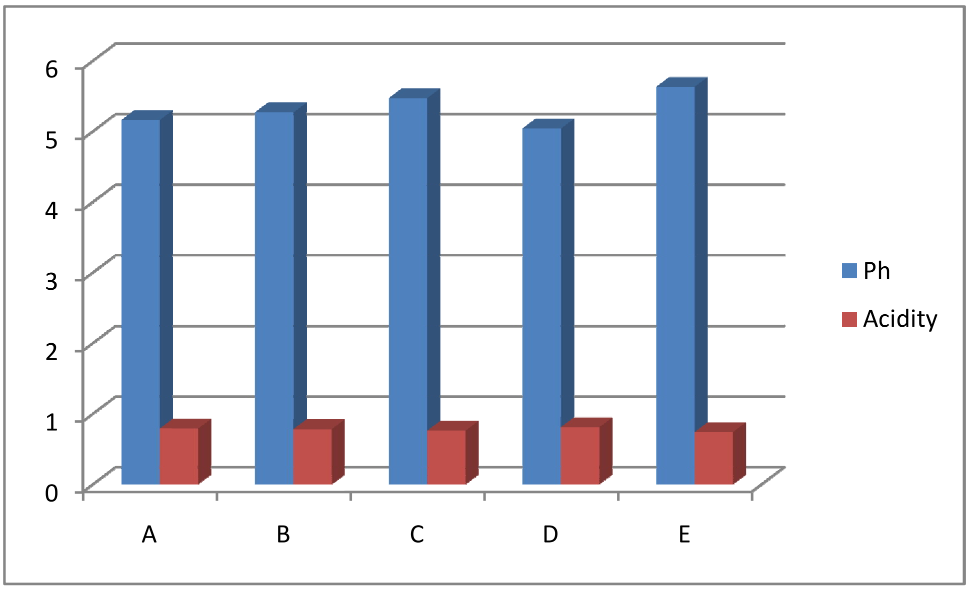


Figure (4.6): **Mineral Analysis of Cow and Camel Milk Yoghurt**

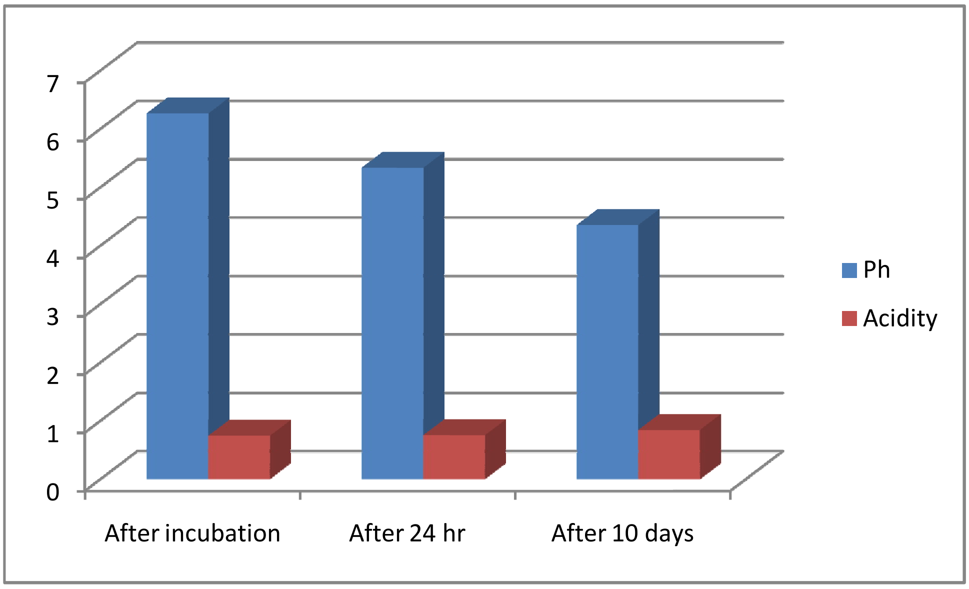


Figure (4.7)**: pH and acidity of camel and cow Milk yoghurt**

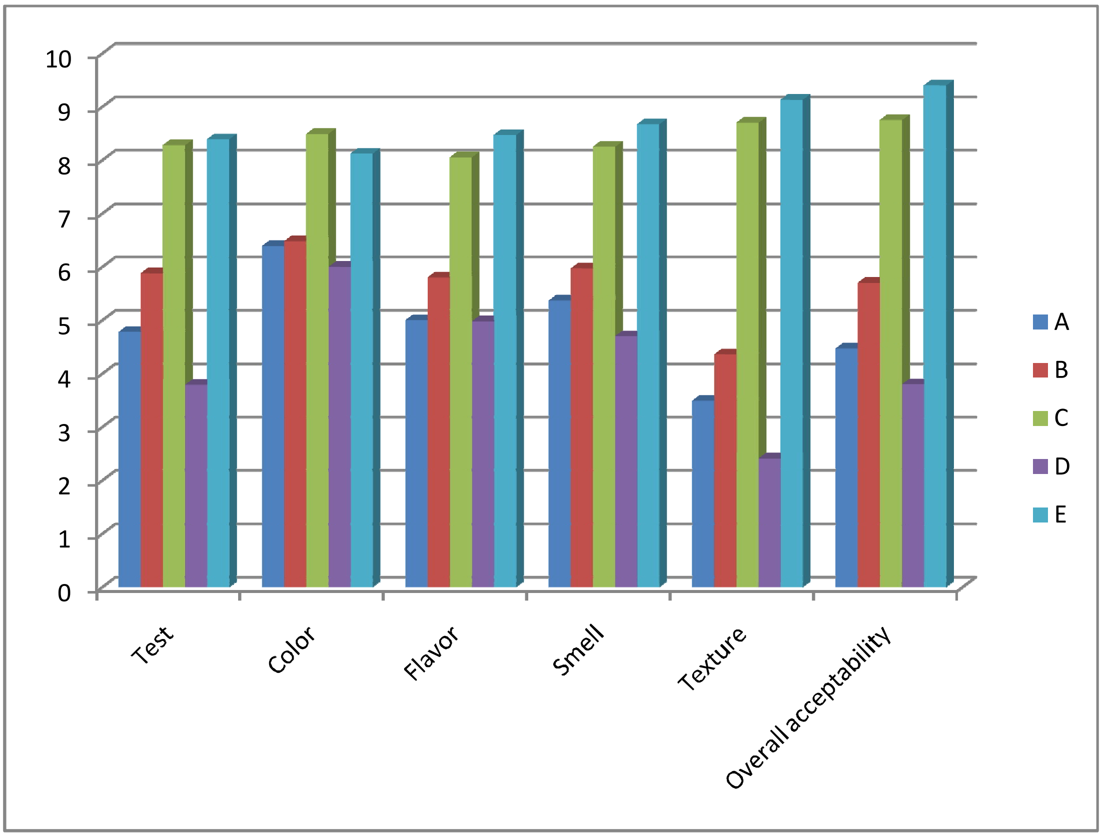


Figure (4.8): **Sensory Evaluation of Camel and Cow Milk Yoghurt**

Figure (4.9): Photos from Camel research centre ( Khartoum university farm

**Figure (4.9): Photos from Camel research centre ( Khartoum university farm)**