بسم الله الرحمن الرحيم

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College of Graduate Studies

Physicochemical, Microbiological, Sensory and Microstructure Properties of Camel Milk Cheese with Added Gum Arabic

الخصائص الفيزيكوكيميائية والميكروبيولوجية والحسية والتركيب الدقيق لجبنة لبن الإبل المضاف لها الصمغ العربي

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قال تعالى:

(أَفَلَا يَنْظُرُونَ إِلَى الْإِبِلِ كَيْفَ خُلِقَتْ)

صدق الله العظيم

سورة الغاشية الآية (17)

Dedication

This thesis is dedicated to

My mother Islam Ali Shakkak

My father Omer Hasab El Nabi

My husband Badr eldin El khalifa

My children Mohammed ,Islam ,Omer and Mobarak.

My sisters and brothers Mohammed el Mobrak ,Israa ,Walaa, Abdo allah, Abrar ,Lina and Ahmed.

And My grandmother Fatima Sakkak

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Abstract

This study was conducted to evaluate the effect of addition of gum Arabic to the manufacture of cheese from camel milk and storage period on the physicochemical, microbiological properties, microstructure, syneresis and sensory properties of cheese. Camel milk cheese was formulated using calcium phosphate (0.3%), and gum Arabic at levels of 0.5%, 1%, 1.5% and 2%. Cow milk cheese was manufactured by the traditional method. Physiochemical, microbiological, syneresis and microstructure of cheese were determined. The study showed an increase in the moisture content by increasing storage time and decrease in moisture content by increasing the percentage of gum Arabic .The highest moisture content was 43.42% recorded for blank sample in the third month, while the lowest one was 28.99% which was recorded for camel milk cheese with 2% gum Arabic added in zero time. The lowest protein content was in the sample of camel milk cheese without gum Arabic in the third month which was 18.96 % .The highest protein content was in the sample of camel milk with 2% gum Arabic at the first month which was 25.25%, The highest percentage of fat content was in the sample of camel milk cheese with 2% gum Arabic at zero time which was 35.40% and the lowest one was in the blank sample in the third month, 29.52%. The highest percentage of ash content in camel milk cheese with 2% gum Arabic at zero time which was 10.79% and the lowest percentage in the blank sample in the third month which was7.98%. Total soluble solid decreased by increasing the storage period and increased by increasing the amount of gum Arabic. Lactose appeared only in a blank sample and a sample of cow milk. pH-value decreased by increasing the storage period and by increasing the amount of gum Arabic. Titratable acidity of cheese increased by increasing the storage period and amount of gum Arabic. The total bacterial count (log_{10}cfu/ml) of raw milk for cow and camel was 3.64 and

5.63 respectively, while coliforms (MPN/ml) were 21.67 and 19.4 respectively, *Staphylococcus* (log_{10}cfu/ml) was 2.13 and 3.4 respectively, and *E. coli* bacteria were found in the camel milk sample 5.5, whereas *Brucella*, *Salmonella*, *Shigella* and yeasts and moulds were not detected in all samples of raw milk. The average total viable bacterial count (log_{10}cfu/g) was 3.5, the average number of *Staphylococcus aureus* (log_{10}cfu/g) in cheese was 3.1 . Yeasts and moulds, *E. coli, Salmonella, Shigella* and *Brucella* were not detected in cheese samples. The colour of camel milk cheese containing 1% and 2% gum Arabic was less acceptable, camel milk cheese without gum Arabic obtained moderate acceptance and cow milk cheese obtained the highest acceptance. Taste of sample containing 1% gum Arabic found the acceptance of the panelists while the sample containing 2% gum Arabic was not accepted by the panelists. Flavour of cheese contained 0.5% gum Arabic was moderately bland while that of sample containing 1% gum Arabic was moderately intense. Texture of the camel milk cheese with 1% gum Arabic was soft, camel milk cheese without gum Arabic was to some extent hard. The general acceptance of camel milk cheese containing 1% gum Arabic was more acceptable than the sample containing 2% gum Arabic and cow milk cheese. Syneresis of cheese increased by increasing the storage period and amount of gum Arabic, the highest ratio of whey was in camel milk cheese without gum Arabic sample which was 56% when the lowest one was in the sample with 1% gum Arabic 49.33%.

The use of gum Arabic in the manufacture of camel milk cheese at1% gum Arabic led to an improvement in some sensory and physicochemical properties of cheese.

Making cheese from camel milk with added gum Arabic helps to get rid of some pathogenic microbes such as *E. coli*. Porosity of camel milk cheese was decreased by increasing the ratio of gum Arabic.

ملخص الدراسة

102 أجريت هذه الدراسة لمعرفة تأثير إضافة الصمغ العربي في صناعة الجبنة من لبن الإبل واثر التخزين على الخصائص الفيزيوكيميائية، الميكروبيولوجية، التركيب الدقيق, نسبة التصافي والخواص الحسية للجبنة. صنعت جبنة لبن الإبل باستخدام فوسفات الكالسيوم بنسبة 0.3%,أضيف الصمغ العربي بنسب 0.5%,1%,1.5% و2% .جبنة لبن الأبقار صنعت بالطريقة التقليدية .تم تقدير الخواص الالفيزيوكيميائية ,الميكروبيولجية,نسبة التصافي والتركيب الدقيق للجبنة. أظهرت الدراسة زيادة في محتوى الرطوبة بزيادة زمن التخزين وانخفاض محتوى الرطوبة بزيادة نسبة الصمغ العربي ،وكان أعلى محتوى للرطوبة 43.42٪ مسجلاً لجبنة لبن الإبل بدون صمغ عربي في الشهر الثالث ،وكان أقلها 28.99٪ التي سجلت لجبنة لبن الإبل مع 2٪ صمغ عربي بعد التصنيع مباشرة. كان أقل محتوى للبروتين في عينة جبنة لبن الإبل في الشهر الثالث الذي كان 18.96٪. كان أعلى محتوى بروتين في عينة جبنة لبن الإبل مع 2٪ من الصمغ العربي في الشهر الأول وهو 25.25٪ ،وكانت أعلى نسبة من محتوى الدهون في عينة جبنة لبن الإبل مع 2٪ من الصمغ العربي بعد التصنيع مباشرة. 35.40٪ وأقلها كان في عينة جبنة لبن الإبل بدون إضافة الصمغ العربي في الشهر الثالث و كانت 29.52 أعلى نسبة للرماد في جبنة لبن الإبل مع 2٪ من الصمغ العربي بعد التصنيع مباشرة كان 10.79٪ وأقل نسبة كانت في جبنة لبن الإبل بدون صمغ عربي في الشهر الثالث من التخزين حيث كانت النسبة هي7.98٪. إجمالي المواد الصلبة اظهر زيادة بزيادة نسبة الصمغ العربي وقلت بزيادة زمن التخزين .اللاكتوز وجد فقط في عينة جبنة لبن الإبل بدون إضافة الصمغ العربي و في عينة لبن الأبقار. الأس الهيدروجيني انخفض بزيادة نسبة الصمغ العربي وبزيادة زمن التخزين، الحموضة زادت بزيادة نسبة الصمغ العربي و بزيادة زمن التخزين العد الباكتيري الكلي (log_{10}cfu/ml) للبن الخام للأبقار والإبل كان 3.64 و 5.63 على التوالي، بينما كان الكوليفورم (MPN/ml)21.67 و19.4 على التوالي , كان الاستافيلوكوكاس 2.13 و 3.4 على التوالي، وقد وجدت باكتيريا الاليشيريشيا كولاي في عينة لبن الإبل بمقدار 5.5 بينما لم يكن هناك وجود لكل من البروسيلا والسالمونيلا والشيقيلا والخمائر والفطريات في كل عينات اللبن الخام. متوسط العدد الباكتيري الكلي (log_{10}cfu/g) في الجبنه كان 3.5, كان متوسط عدد الاستافيلوكوكاس اورياس (log_{10}cfu/g) في الجبنة 3.1. لم يكن هناك وجود لكل من البروسيلا والسالمونيلا والشيقيلا و الخمائر والفطريات في كل عينات الجبنة. لم يكن لون عينات الجبنة المحتوية على 1%و 2% مقبولا بينما حصلت العينة الغير محتويه على صمغ عربي على قبول معتدل بينما حصلت عينة جبنة لبن الأبقار على أعلى قبول.أما بخصوص الطعم وجد أن العينة المحتوية على 1% صمغ عربي قد وجدت القبول من المحكمين بينما

العينة المحتوية على 2% صمغ عربي لم تجد قبولا من قبل المحكمين .فيما يخص النكهة كانت الجبنة المحتوية على 0.5% صمغ عربي معتدلة بينما كانت نكهة العينة المحتوية على 1% صمغ عربي قويه نوعا ما و كذلك كان قوام جبنة لبن الإبل المحتوية على 1% صمغ عربي طريه و كانت جبنة لبن الإبل الخالية من الصمغ العربي قاسية القوام.أخيرا كان القبول العام لجبنة لبن الإبل المحتوية على 1% صمغ عربي أكثر قبولا من العينة المحتوية على 2% صمغ عربي ومن جبنة لبن الأبقار. نسبة تصافي الجبنه زادت بزيادة زمن التخزين و نسبة الصمغ العربي أعلى نسبة للشرش كانت في عينه جبنة لبن الإبل الخالية من الصمغ العربي حيث كانت65% في حين كانت اقل نسبة في العينة المحتوية على 1% صمغ عربي حيث كانت49.33%.استخدام الصمغ العربي بنسبة 1% في صناعة جبنة لبن الإبل أدى إلى تحسين بعض الخواص الحسية والفيزيوكيميائية للجبنة .صناعة الجبنة من لبن الإبل مع إضافة الصمغ العربي ساعد علي التخلص من بعض الميكروبات الممرضة مثل الايشيريشيا كولاي. انخفضت مسامية الجبنة بزيادة نسبة الصمغ العربي .

CHAPTER ONE

INTRODUCTION

The 17th verse of Surat AL-Kashia, which is "do they not look at the camels, how they are created?" mentions an animal that has to be carefully examined and thought about. In the holy Quran the camel is several times mentioned as a blessed animal given to man (Knoes, 1977).

As estimation of FAO (2013) the total population of camel in the world is believed to be 25.89 million heads, of which 89% are one-humped dromedary camels (*Camelus dromedarius*) and the remaining 11% are the two-humped (*Camelus bactrianus*) that generally found in the cold deserts of Asia while more than 60% of the dromedary camel population is concentrated in the arid areas of North East African countries like Somalia, Sudan, Ethiopia and Kenya. Ethiopia ranks third in the world by the number of camel herd after Somalia and Sudan (Simeneh, 2015).

Sudan has the second largest number of camels in the world after Somalia with about 4.7 million heads (Ministry of Animal Resource and Fishers, 2012).Camels are considered to be a good source of milk, meat and used for other purposes such as transportation and sport racing (Omer and Hamad, 2010).

Increase in human population of the world has arisen the issue of food security, hence, there is need to explore new food resources, and camel can serve the best useful addition to the food supply chain in terms of milk, meat and other products (Ahmad *et al.*, 2010).

Camel milk is consumed as a major staple food, mainly by the desert nomad tribes because it is one of the most readily available raw materials, which contains all the needful nutrients required in the dry conditions of the desert. Moreover, camel milk like any other human consumable milk consists

of fat, proteins (soluble proteins and caseins) and one major carbohydrate (lactose) as major components (Farah and Fischer, 2004). It also contains minerals and vitamins as minor components, to abridge; camel milk can be titled as a nutritious source of all the required essentials of a complete diet.
The development of the processing technology in producing camel milk cheese will prolong the shelf-life and facilitate storage and handling (Mustafa, 2011).

White cheese (Jibna-beida) is particularly the most common kind of cheese available in Sudan, and is thus, referred to simply as Jibna (Dirar, 1993).The Sudanese Jibna-beida has a unique, very originated and traditional technology, and can be categorized as white-brined soft cheese. White-brined soft cheese is made in many countries of Eastern Europe, and has different names in each country Jibna-beida production has been introduced to in the Sudan by migrated foreign families who then settled mainly at El-Dueim area, in the Blue Nile province. In the meantime, production has been practiced throughout the country, especially in El-Dueim, White Nile Province (El Obeid), North Kordofan province (Nyala), South Darfur, Darfur province and other localities in the country. Jibna-beida is unique among cheese varieties it contains the high concentration of sodium chloride. It is manufactured from raw cow milk, sheep milk, goat milk, or a mixture from them (Mustafa, 2011).

Production of cheese converts highly perishable milk to a less perishable product. Several characteristics contribute to the preservation of cheese (ICMSF, 2005). The product is obtained mainly through lactic acidification and limited dehydration. However, the processing of camel milk into cheese is technically more difficult than milk from other domestic dairy animals. This is mainly due to its low total solids content, unique composition and casein properties. Its suitability for cheese making decreases significantly in the hot season, when camel milk production is influenced by water and

feed availability. Under water shortage conditions camel milk contains abnormally low milk solids and its cheese processing ability is poor. In spite of the above difficulties, efforts were made to produce cheese from camel milk. (Khan *et al*, 2004).

Most attempts to make cheese from camel milk have revealed major difficulties in getting the milk to coagulate. Initially was increased the rennet concentration compared with the usually used for clotting cow milk by 50 to 100 times (Wilson, 1989). Moreover, to overcome the difficulties of coagulation of camel milk, some additives were used such as soluble dietary fiber which was investigated on the milk coagulation kinetics of cow milk, gum Arabic, pectin and inulin were used. The investigation result in improved coagulum properties, besides reduction in coagulation time of cow milk (Fagan *et al*., 2005).

Gum Arabic is a dried exudate obtained from stems and branches of *Acacia Senegal* trees which are cultivated in the Sudan as a cash crop in agro forestry systems .The international specifications used to assess the quality of gum Arabic in the world market are based on the Sudanese gum obtained from *A. senegal variety Senegal* (Lelon *et al*., 2010). The major use of *Accasia Senegal* gum is in the food additive because it is nontoxic, odorless, colorless, tasteless and completely water soluble and does not affect the flavor, color of the food to which is added .In confectionary gum Arabic is used to retard crystallization of sugar , and to act as an emulsifier and stabilizer in frozen dairy product , such as ice cream because of it is water – absorbing properties (Karamalla *et al.*, 1998). Gum Arabic is emulsifying agent and a very good emulsion stabilizer for flavor oil-in-water emulsions. Gum is used for emulsification of citrus, other essential oils, and imitation flavors used as baker emulsions and concentrations for soft drinks (Fennema, 2005).

Microstructure is not a static concept; it evolves, instead, along the food processing chain, and eventually leads to major transformations relative to the original microstructure of the milk feedstock itself. This realization thus encompasses specific molecular compositions and spatial arrangements (Pereira and Caibson, 2002).

General objective:

To study the effect of gum Arabic on different properties of cheese produced from camel milk.

Specific objectives:

1- To determine physicochemical properties of camel milk and camel milk cheese.
2- To make camel milk cheese with added gum Arabic and compare its yield with that of cow milk cheese.
3- To determine the microstructure and texture of camel milk cheese.
4- To determine microbiological properties of camel milk and camel milk cheese.
5- To determine the sensory properties of camel milk cheese.

CHAPTER TWO

LITERATUREREVIEW

2.1 Definition of milk

Milk is an indispensable food item and is considered as nature's perfect food for human beings as well as other animals. Mammals secretes milk for the nourishment of their young ones and milks7 of animals like cattle, buffalo, goat, sheep, camel, yak, llama, etc are being used as food for human beings (NZFSA, 2003).

2.2 Importance of milk and milk products in diet

Fluid milk is not only nature's food for a new born infant, but also 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 B_2), which helps promote healthy skin and eyes (Dairy Facts, 2003). Dairy products such as yogurts, cheeses and ice creams contain nutrients such as proteins, vitamins and minerals. Consumption of dairy products been associated with decreased risk of osteoporosis, hypertension, colon cancer, obesity and insulin resistance syndrome (IRS) (Weaver, 2003).

2.3 Sudan cattle breeds and their milk productivity

Sudan cattles belong to the species *bos indicus* which include humped cattle (zebu) of Asia and Africa. Sudanese cattle are broadly classified into two breeds, Nilotic cattle, and North Sudan zebu cattle. There are six main indigenous zebu cattle among which Kenana and Butana are known for their high productivity. The milking potential of other breeds, namely Baggara, Nilotic, Umbararo and Nuba is low. The profitability of a dairy enterprise is mainly related to obtaining as much milk as possible within the prevalent nutritional environment, relative to the maintenance cost of animals. Among the cattle population, Kenana and Butana are promising indigenous milk breeds, which under improved feeding and management in research stations yield more than 1500 kg milk per lactation relative to international standard (Mus and Gubartalla ,2005). Through experience, many herds men have come to understand that the best results are obtained by crossing the best local cattle (usually Kenana and Butana) with exotic breeds (usually Friesian) (Musa and Gubartalla, 2005).

2.4 Camel milk

Camels are considered to be a good source of milk, and are used for other purposes such as transportation and sport racing. Camel milk has an important role in human nutrition in the hot regions and arid countries. This milk contains all the essential nutrients found in bovine milk (Farah and Fisher, 2004). Fresh and fermented camel milks have been used in different regions in the world including India, Russia and Sudan as a treatment for a series of diseases such as dropsy, jaundice, tuberculosis, asthma and leishmaniasis or kala-azar (Dirar, 1993).

2.4.1 Camel population in the world

It is difficult to exactly determine the number of camels in the world, firstly, because it is mainly an animal of nomadic people and pastoralists who are moving frequently, and secondly, because camels are not usually subjected to obligatory

vaccination. So, an exhaustive census for the camels is quite difficult.

According to FAO statistics the world population of camels is about 20 million animals, mainly in arid zones, of which 15 million camels live in Africa and 5 million in Asia (GLIPHA, 2007). In 2001, the total camel population was 19 million of which 17 million were dromedaries (*C. dromedarius*) and 2 million were Bactrian camels (*C. bactrianus*) (Farah and Fisher, 2004).

2.4.2 Camel population in the Sudan

The population of Camels on the earth are about 19 million camels of which 17 million are dromedary (one humped) and the remainder Bactrian (two humped) about 15 million in the horn of Africa including Somalia, Sudan, Kenya, Eritrea, and Djibouti (Bkele, 2010) .

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 Fishers, 2012).Camels are considered to be a good source of milk, meat and used for other purposes such as transportation and sport racing (Omer and Hamad, 2010).

Sudan ranks first among Arabian countries and second in Africa with respect to camel population, having more than four million (Eltanany *et al.*, 2011).

The camel population in Sudan was estimated at 4.7 million head according to the Ministry of Animal Resource and Fisheries (MOARF, 2004). The majority of this number is kept by migratory pastoralists "Abbala" in arid and semi-arid zones of Sudan, where camel pastoralists prevail with limited resources in subsistence production systems. The mobility is the primary means by which Abbala compensate for the spare resource (Schwartz and Dioli, 1992). However, some herders around Khartoum State keep not more than three "Nagas" (she camel) with dairy cattle in their farms as milk producer, mostly, for special family use. Camels in Sudan are of single-humped type, or dromedary (*Camelus dromedarius*). They are mainly owned by the nomadic tribes and migratory pastoralists. Therefore, camel production in Sudan is classified principally into nomadic and sedentary systems (Eisa and Mustafa, 2011).

2.4.3 Camel types

The camel belongs to the kingdom Animalia, phylum Chordata, class Mammalia, order Artiodactyla and family Camelidae. The family can be further divided into two subfamilies Camelini and Lamini whereas the camel belongs to the former one of genus Camelus. Three species belong to the camelus genus; *Camelus bactrianus* (the domestic Bactrian camel), *Camelus dromedaries* (the dromedary camel), and Camelus ferus (the wild Bactrian camel). The domestic Bactrian camel is also called the two-humped camel. The name camel meaning "to bear" originate from latin; camelus and has homophonic sound in different languages like, greek; kamelos, Hebrew; gamal, or Arabic; jamala. The origin of the name bactrian is the latin word bactriana corresponding to Persian bakhtar that means "the west". The dromedary has other common names like dromedary, Arabian camel and one-humped camel. The name Dromedary probably comes from the greek word

dromas that means “running” and the wild Bactrian camel reflects the original name ferus meaning wild (Peters *et al.,* 1997**)**.

2.4.4 Production of milk

After giving birth a female camel can produce milk for several years. Dromedary can maximum produce 20 liters/day while Bactrian only produces 5 litres/day (Bannikov, 1976). For dromedary camels the amount produced depends largely on breed, stage of lactation, feeding and management system (Cardellino *et al.,* 2004). According to FAO both species of camel produce around 5.3 million ton of milk per year. 4 million ton milk is consumed by the calves and the remaining by the humans. The largest production of camel milk takes place in Somalia followed by Saudi Arabia (FAO, 2008).The camels are ideal animals in extreme dry areas where the conditions are harsh as they have the capability to produce more milk than any other species and also for a longer period of time (Farah *et al.,* 2007). About 1000-2000 L of milk is produced by each camel during one lactation period which last for 8-18 months (FAO, 2006).

2.4.5 Nutritional value of milk

2.4.5.1 Protein

Protein availability is defined as the amount of protein available to be absorbed and utilized in the human body, to the protein intake. Casein and whey proteins are the two major types available in milk in a ratio of 80 % to 20 % (Konuspayeva *et al.,* 2009). The total protein content in camel milk is estimated to 2.15 - 4.90 %, breeds and seasonal conditions play a role for the protein content. The protein in camel milk consists of casein and whey proteins. In camel milk the major part of the protein is casein. It constitutes about 52-87% of the total proteins, Figure1. Camel milk contains high percentage of beta-casein and this can be the reason for the higher

digestibility rate and lower allergy incidence in the guts in children. Beta-casein has shown to be more sensitive to peptic hydrolysis than the alphas casein (Abou- Soliman, 2005).

2.4.5.1.1 Whey proteins

"Whey" protein is a general term used to refer to milk proteins that are soluble at pH 4.6 at 20^{o}C. Proteins in the whey fraction include β-lactogolobin, α-lactalbumin, serum albumin, and immunoglobuls. In addition, the whey fraction includes fragments of β-casein and other heat-stable polypeptides, β-lactoglobin is the major whey protein, representing 50% of the whey proteins (Farrell, 1988), followed by α-lactalbumins constituting 25% of the whey proteins (George and Lebenthal, 1981).

2.4.5.2 Fat

Milk fat is a concentrated form of energy and protects the body by insulating it against temperature and environmental changes. Milk fat is a carrier for fat soluble vitamins and essential fatty acids, in dromedary camel milk, the fat content is about 1.2-6.4 % (Konuspayeva *et al.,* 2009). Camel milk contains a smaller amount of short chain fatty acid and lower content of carotene compared to bovine milk that makes it whiter in colour (Stahl *et al.,* 2006). Dromedary camel milk has higher unsaturated fatty acid values compared to bovine milk but lower compared to human milk (Haddadin *et al.,* 2008).

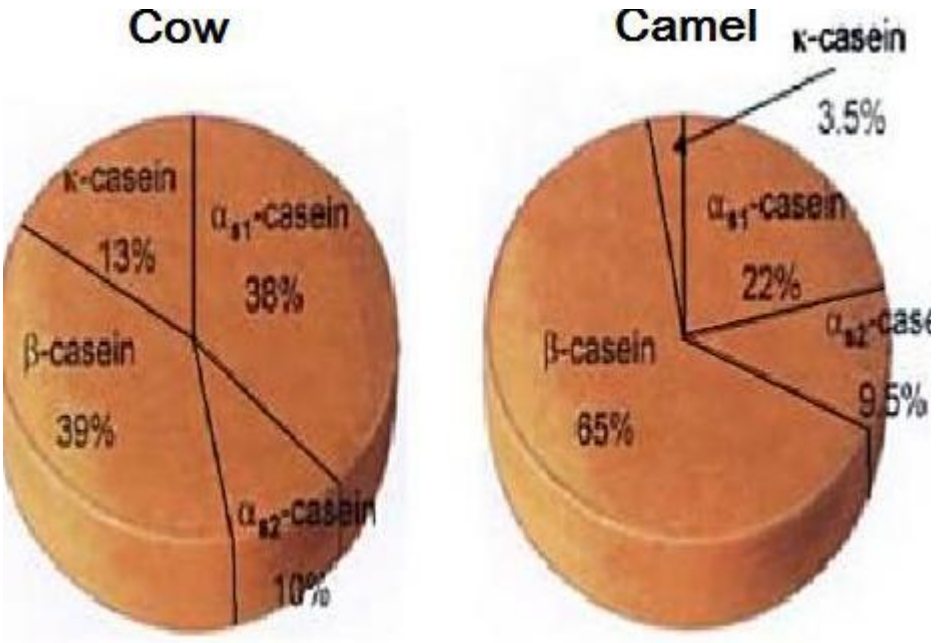

Figure 1: Relative amounts of caseins in cow and camel milk (Farah and Fisher, 2004).

2.4.5.3 Lactose

Lactose in milk has comparatively lower glycemic index compared to glucose or sucrose thereby making it suitable for diabetic people (Adolfson *et al.,* 2004). In camel milk the lactose content is about 2.40-5.80% (Konuspayeva *et al.,* 2009). Chemically lactose is composed of one molecule each of glucose and galactose, (Fig2). The camel consumes plants that contain different amounts of lactose, causing the wide variations in the milk (Khaskheli *et al.,* 2005). Lactose seems to be the only component in the milk composition that stays stable during the season (Haddadin *et al.,* 2008).

2.4.5.4 Minerals

Milk contains a number of minerals; however, the total concentration is less than1%. Mineral salts occur in solution in milk serum or in casein compounds. The most important salts are those of calcium, sodium, potassium and magnesium (Saxelin *et al.,* 2003).The minerals expressed in total ash are between 0.6-0.9 percent (Konuspayeva *et al.,* 2009). The variations are found to be due to breed types, feeding systems and water intake (Haddadin *et al.,* 2008). Chloride is found in rich amount in camel milk due to the feed stuff (Yagil, 1982). During dehydration there is a loss of milk components and increase amount of chloride may contribute to the salty taste of the camel milk (Yagil, 1982). Compared to bovine milk

The levels of sodium, potassium, iron, cupper and manganese have been found to be significantly higher in camel milk (Mehaia *et al.,* 1993). Iron is important in several biological systems like oxygen transport and storage, and DNA synthesis while manganese has an essential role in cellular metabolism for the function of several enzymes (Al-Attas, 2008). Mn also plays a role in the function of enzymes protecting the cell from damage caused by free radicals (Combs *et al.,* 1997).

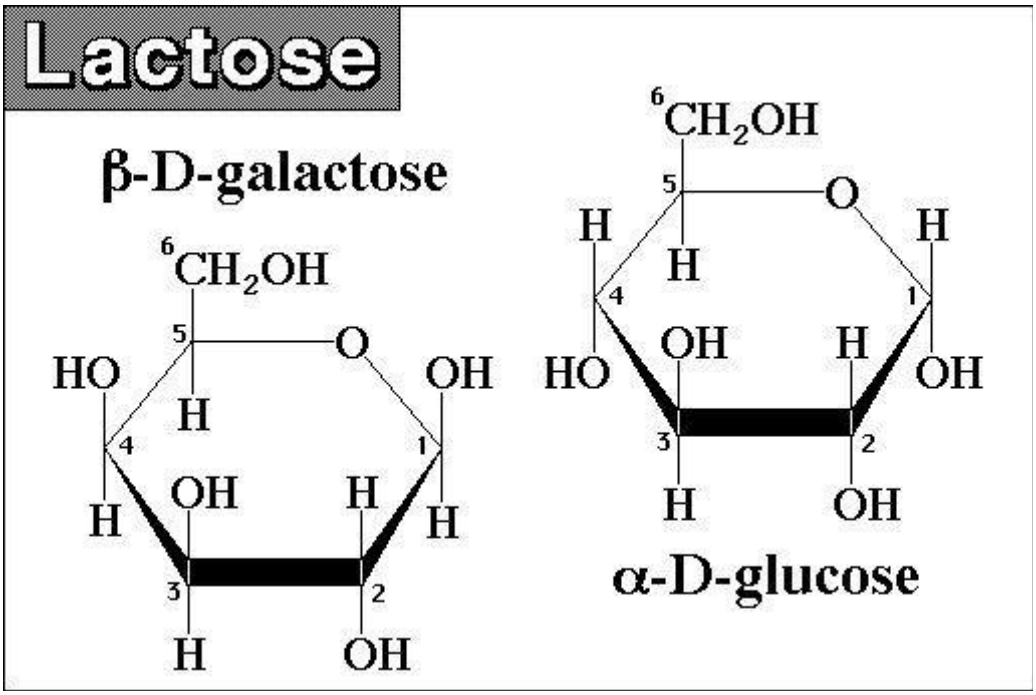

Figure 2: Molecular structure of lactose. Source (Coultate, 2002).

2.4.5.5 Enzymes

Indigenous milk enzymes are found in, or associated with various, casein micelles, milk fat globule membrane, milk serum or somatic cells and may originate from blood, the milk fat globule membrane (MFGM) or the cell cytoplasm. Important indigenous milk enzymes, e.g. plasmin, lipoprotein, lipase, alkaline, phosphatase and lactoperoxidase (Tamime, 2009).

2.4.6 Health benefit of camel milk

For a long time, milk was considered to only provide nutritional components such as essential amino acids (Abdurahman, 1995). In the last decades, several studies have shown that milk is an import ant nutritional and functional source and could provide particular health benefits due to the presence of bioactive substances in milk. Fresh and fermented **(**Agrawal *et al*., 2003). Dromedary camel milk have been acknowledged for a long time in different parts of the world to provide a potential treatment for a series of diseases such as dropsy, jaundice, tuberculosis, asthma, and leishmaniasis or kala-azar (Breitling, 2002). According to the USDA (2009), Dromedary camel milk (250 mL) provide an adult with about 15.5% of cobalamin (B_{12}), 8.25% of riboflavin (B_2), 5.25% of vitamin A and 10.5% of ascorbic acid (C), thiamin (B_1) and pyridoxine (B_6) of the Recommended Daily Intake (RDI). By comparison, bovine milk (250 mL) provide an adult with about 43.5% of cobalamin (B_{12}), 36% of riboflavin (B_2), 11.5% of pyridoxine (B_6), 3.5% of ascorbic acid (C) and 9% of vitamin A and thiamin (B_1) of the RDI.

Table 1: Some physical and chemical properties of camel milk compared with cow milk

Property	Camel milk	Cow milk
pH	6.6	6.5
Density	1.029g/ml	1.032g/ml
Lysozyme	648µg/100ml	120µg/100ml
Lactose	5.5	4.6
Vitamin C	Very high	Low
Water	86.5	87.3
Casein	2.7	2.6
Whey proteins	0.9	0.6
Fat	4	3.9
Ash	0.8	0.7
Short chain fatty acids	None	Present
Saturated SFA	62.5	62.5
Carotine	Very little	High

Source: Farah (1996) and Cardak *et al*. (2003).

2.4.6.1 Camel milk for diabetic people

The intake of camel milk reduced the excessive need for insulin as it contains high levels of insulin or insulin like protein, which can pass through the stomach easily without getting destroyed. Stomach acidity would normally destroy the insulin taken, but one can take camel milk to avoid this. Oral insulin is worth the try (Breitling, 2002). Long term effects of camel milk are yet to be researched, but yet it is considered to be useful for controlling the glucose levels in the blood as of now. Camels are generally looked upon as animals to travel upon in the deserts, but no one has become more aware of the importance of camel milk in the control of Diabetes (Breitling, 2002). The milk contains high insulin and insulin-like protein, which can help in regulating the blood glucose levels. This was so in the case of type I Diabetes and it was observed that drinking a pint of camel milk daily helped to improve the glucose levels (Agrawal *et al* ., 2003). Camel milk does not form coagulum in acidic environment, which allows the camel milk to pass quickly through the stomach with the specific insulin and remain in the intestine for absorption. The radio immuno assay levels of camel milk are on the higher side **(**Agrawal *et al.,* 2003). The solution to a Diabetic problem could lie in having more of camel's milk. The milk may not be tasty but has ingredients that help a Diabetic to find solutions to his insulin problem (Breitling, 2002).

2.4.6.2 Angiotension I-converting enzyme (ACE) inhibitory activity

ACE is one of the major regulators of blood pressure Smith and Vane, (2003). ACE (peptidyldipeptide hydrolase, EC 3.4.15.1) was defined by Pan *et al* (2005) as "an exopeptidase that cleaves dipeptides from the C-terminal ends of various peptide substrates and regulates the activity of several endogenous bioactive peptides". ACE-inhibitory peptides are present in the primary structure of various food protein sources including milk proteins

(Jang and Lee, 2005).These peptides are also found in fermented Dromedary camel milk (Quan *et al*., 2008). To produce these bioactive peptides, which have been reported to have health benefits, milk proteins (casein and whey) were hydrolyzed by proteolytic digestion, such as by lactic acid bacteria (probiotic) or proteolytic enzymes (Pan *et al.*, 2005).

2.4.6.3 Hypocholesterolaemic effect

Coronary heart disease is one of the major causes of death in the industrialized countries (Pereira and Gibson, 2002). Elevated levels of blood and dietary cholesterol are considered to be a major risk factor for coronary heart diseases (Elayan *et al.*, 2008). Fermented camel milk (Gariss) and Gariss containing Bifidobacteriumlactis (BB-12) administration have been reported to possess a hypocholesterolaemic effect in vivo in rats (Elayan *et al.*, 2008). This strain was previously shown to reduce cholesterol in bovine milk and MRS broth as well as in trypticase- peptone yeast extract medium (Alhaj *et al.*, 2006). The hypocholesterolaemic mechanism of camel milk is still unclear, but different hypotheses have been proposed, including: interaction between bioactive peptides derived from camel milk proteins and cholesterol which result in cholesterol reduction (Seelig and Seelig, 1996), and the presence of orotic acid in camel milk which is thought to be responsible for lowering cholesterol level in human subjects (Pereira and Gibson, 2002) and in rats (Rao *et al.*, 1981).

2.4.6.4 Hypoglycaemic effect

Camel milk consumption also provides effective management for patients with type 1 diabetes as well as for rats (Sahani *et al.*, 2005). These were related to various factors, including the presence of high concentration of insulin/insulin like substances in camel milk, such as halfcystine (Beg Bahr *et al.*, 1985). The effect of small size immunoglobulins of camel milk on cell

and the lack of coagulation of camel milk in the human stomach have also contributed to the hypoglycaemic effect (Agrawal *et al.,* 2003).

2.4.6.5 Antimicrobial effect

Camel milk was reported to have an antimicrobial effect against Gram positive and Gram negative bacteria, including *Escherichia coli, Listeria monocytogenes*, *Staphylococcus aureus* and *Salmonella typhimurium* (Agrawal *et al.,* 2003).This inhibitory activity was attributed to the presence of antimicrobial substances in camel milk, including lysozyme, hydrogen peroxide, lactoferrin, lactoperoxidase and immunoglobulins (El-Agamy *et al.*, 1992).The inhibitory action of camel milk against L. monocytogenes, *S. aureus* and *E. coli* might be attributed to the presence of lacto peroxidase, hydrogen peroxide and lysozyme respectively, the growth of Sal typhimurium was inhibited by lactoferrin in camel milk through binding iron and making it unavailable for its growth (Ochoa and Cleary, 2009).The amounts of lysozyme, lactoferrin and immunoglobulins were found to be greater in Dromedary camel milk than bovine or buffalo milk these antimicrobial agents were reported to completely lose their activity in camel milk if heat-treated at 100 ℃ for 30 min (Ochoa and Cleary, 2009).This property has been shown to be a disadvantage in yoghurt production. The growth of yoghurt culture in camel milk is delayed due to the presence of lysozyme which prolongs the gelation process (Jumah *et al.,* 2001). However, compared with bovine milk, the molecular masses of lactoferrin (79.5 kDa) and lactoperoxidase (78 kDa) were found to be higher in Dromedary camel milk, whereas lysozyme (14.4 kDa) was found to be similar (Jumah *et al.,* 2001).

2.4.6.6 Hypoallergenicity effect

Mothers' milk provides the ideal nutrition for newborn infants during the early stage of life, however, some infants are only partly breast-fed, or not

at all. Hence, different alternatives to human milk can be employed, such as soy milk and extensively hydrolyzed milk protein formulae (El-Agamy, 2007). Researchers report that children (10 -20%) possessing allergenicity to bovine milk are also not tolerant to soy derivatives El-Agamy *et al.*, (2009). Dromedary camel milk was recently suggested as a food alternative to children with allergenicity to bovine milk. El-Agamy *et al.* (2009) undertook an in vitro study based on human sera prepared from 40 blood samples of children allergic to bovine milk or its products. The authors reported that camel milk could be a new protein source for children allergic to bovine milk. It is expected to cause little hypersensitivity reactions because camel milk protein percentages are similar to that found in human milk.

2.4.6.7 Camel milk antimicrobial properties

Barbour *et al*., (1984), studied the ability of camel milk to inhibit the growth of bacteria. They used four protective milk proteins, lysozyme, Lactoferin (lf), lactoperoxidase (lp) and immunoglobulin G (IgG) and assayed them against *Lactococcus lactis* sub sp. *cremoris*, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhymurium* and rotavirus. The antibacterial activity spectrum of camel milk lysozyme was similar to that of egg white lysozyme but higher than bovine lysozyme. The camel Lactoperoxidase system (LP) was bacteriostatic against gram-positive species of bacteria and bactericidal against Gram-negative species of bacteria. Antibody titer against rotavircus was higher in camel than cow milk. Lysozyme has bactericidal effect, as it is capable of degrading the gram-positive bacterial cell wall, preservation of raw camel milk may possibly be due to lysozyme, which naturally occurs in camel milk in large amounts (Farah, 1996).

2.5 Fermented milk

The International Dairy Federation (IDF 1992a)published general standards of identity for fermented milks that could be briefly defined as follows: ‘Fermented milks are prepared from milk and/or milk products (e.g. any one or combinations of whole, partially or fully skimmed, concentrated or powdered milk, butter milk powder, concentrated or powdred whey, milk protein (such as whey proteins, whey protein concentrates, soluble milk proteins, edible casein and caseinates), cream, butter or milk fat-all of which have been manufactured from raw materials that have been at least pasteurized) by the action of specific microorganisms, which results in a reduction of the pH and coagulation. Many traditional fermented milk products were made in Asia, Africa, the Middle East, and northern and eastern Europe (Ghana standard, 2003).

2.5.1 Dairy fermentation in Sudan

The various sources of fresh milk in Sudan shaped the different traditional dairy products. Dirar (1993) divided the Sudanese fermented dairy products into two major groups: the truly indigenous which include Rob, Gariss, Biruni and Mish and the quasi-indigenous which include Zabadi and Gibna beida. Methods of preparation are different slightly from one part of the country to another. The most important traditional products are Rob (fermented milk product mainly of cow’s), Zabadi (local name of yogurt), Gariss (fermented camel's milk product), Gibna Bayda (white cheese), Gibna Mudaffra (White pickled cheese) and Mish (fermented milk product with spices) (Dirar, 1993: Abdel Gadir *et al.*, 1998). Ginba (cheese) production in Sudan has been started in the early eighteenths by the Greek families who migrated to Sudan. They settled mainly at El Dueium in the White Nile State, El Obeid in North Kordofan state and other localities in the country (ELTayb, 1986). Gibna making is the major preservation method for surplus milk in

rural areas. The highest production is during the rainy season (ELOwni and Hamid 2007).The major types of cheese are Gibna Bayda and Gibna Mudaffara (El-Sheikh, 1997; ELOwni and Hamid 2007). They vary in composition, texture, color, taste and flavor. The variation is due to composition of milk, methods of production, microbial flora, type of package, microbial activity during ripening and ripening conditions. Cheese manufacturing is influenced by product composition, processing, and packaging and storage conditions. Control of temperature and humidity and transportation are dynamic aspect of health hazards (El-Diam and E l-Zubeir, 2006).

2.5.2 Health benefit of fermented milk

Fermented milk products have been reported to have a positive effect on the human digestive system and are also implicated in the control of serum cholesterol, Both milk protein and lactose in fermented milk are more easily digestible than those in the original milk (EUFIC, 1999). Proteins are partly degraded by the action of the bacterial proteolytic system. The lactose content is lower than in the parent milk, as part of it is converted to lactic acid and/or alcohol. Lactic acid gives rise to the characteristic sour taste associated with fermented products. Yoghurt and fermented milks may contain more floated than the original milk because some strains of lactic acid bacteria also synthesize folate (Mckinley, 2005). The introduction of fermented milk products such as cheeses and yogurts in to the diet of man is thought to date back to the dawn of the civilization (Mckinley, 2005). Consumption of fermented-milk products is associated with several types of human health benefits partly because of their content of lactic acid bacteria. Several experimental observations have indicated a potential effect of lactic acid bacteria (LAB) against the development of colon tumors (FAO, 2013). Recently, the role of fermented milks containing lactic acid bacteria (LAB),

such as *Lactobacillus, Bifidobacterium* and *Streptococcus thermophilus*, has been studied (Tamime, 1983). A wide range of other health benefits, including improved lactose digestion, diarrhea prevention, immune system modulation and serum cholesterol reduction, have been ascribed to fermented milkconsumption (FAO, 2013).

2.6 White ccheese

Cheese is the curd or hard substance formed by the coagulation of milk of certain mammals by rennet or similar enzymes in the presence of lactic acid produced by added or adventitious microorganisms from which part of the moisture has been removed by cutting, warming and/or pressing, which has been shaped in a mould and then ripened by holding for some time at suitable temperatures and humidity (Castillo, 2001).

2.6.1 Cheese in the world

Cheese making began about 8000 years ago and now there are about 1000 cheese varieties in worldwide, each unique in terms of its flavor and form (Beresford *et al.*, 2001). Manufacture of most cheese varieties involves combining four ingredients including milk, rennet, microorganisms and salt, which are processed through a number of common steps such as gel formation, whey expulsion, acid production and salt addition, followed by a period of ripening (Scott, 1986).Variations in ingredients and following processing have led to the evolution of all these cheese varieties. While variations in processing parameters such as temperature and curd handling techniques play a major role in determining the characteristics of each cheese type, the cheese microflora plays a critical role in the development of the unique characteristics of each cheese variety. Milk composition and the influence of ripening are also important on the quality of cheeses (Beresford *et al.*, 2001).

2.6.2 Cheese in Sudan

Sudanese Gibna beda is unique among cheese varieties in that high concentrations of table salt (Sodium Chloride) is added to the milk before processing Osman, (2005). It is manufactured from raw or heated milk Ibrahim, (2003). During processing under tropical conditions cheese deteriorates rapidly before it ripens thus salting before renting becomes essential for its preservation Alla Gabo, (1986).Generally, Sudanese White cheese is widely consumed by people of all socioeconomic classes; most of it is made in houses and some private farm. Sudanese white cheese is delivered to the market immediately after processing, under inadequate conditions, poor handling technique, inappropriate packaging materials and lack of adequate storage facilities; however, essential dairy products including cheese must be safe, acceptable and meet consumer's satisfaction Ibrahim, (2003). As a result, cheese production must be protected from pathogenic and spoilage microorganisms, as well as from decaying both on the sites of production and consumption Scott, (1986). The organisms may find their way into cheese as a result of environmental contamination during processing and packaging. The quality of cheese depends on a variety of factors among which raw milk composition, technological process parameters, bacteria species, storage, transportation and delivery conditions (Rotaru *et al.,* 2008).

2.6.3 Classification of cheese

The criteria for classifying cheese depends on the type of coagulation, type of cheese making (industrial or farmstead), cheese-making technique, method, shape, geographical origin, mixed milk content, exterior aspect (colour, moulds), consistency (soft or hard) and current legislation (Rotaru *et al.*, 2008). Ibrahim (2003) reported that the moisture content of hard cheeses and semi-soft cheeses to be in the ranges of 30-40% and 50-75% respectively. Codex standard (2000) has classified cheese as indicated in Table 2.

2.6.4 Processing of white cheese

Cheese making is the process of removing water, lactose and some minerals from milk to produce a concentrate of milk fat and protein. The essential ingredients for cheese are milk, rennet, starter cultures and salt. The semi-firm gel is formed by adding rennet that causes the milk proteins to aggregate at a certain pH; then, it is cut into small curds. Then, the whey (mostly water and lactose) begins to separate from the curds. Acid production by bacterial culturesis essential to aid in the expulsion of whey from the curd and largely determines the final cheese moisture, flavor and texture (Rotaru *et al.*, 2008).

Table 2: Classification of cheese according to fat content

Type of fat	**Fat content (%)**
High Fat	<60
Full Cream	45-60
Half Fat	25-45
Low Fat	10-25
Skimme	<10

Source: Codex standard (2000).

2.6.4.2 Addition of the starter culture

In modern practice bacteria of the group commonly referred to as lactic acid bacteria (LAB) are added to milk as starter cultures, the key role being the production of lactic acid by fermentation of lactose (Eugenia, 2003). Lactic acid is responsible for the fresh acidic flavor of un ripened cheese and is of importance in the formation and tenderizing of the curd (Hansen, 2002). Starters play other essential roles: the production of volatile flavor compounds such as diacetyl and aldehydes, and the synthesis of proteolytic and lipolytic enzymes involved in the ripening of cheese and the suppression of pathogenic and some spoilage microorganisms Beresford (*et al*., 2001). Acid production

in milk and flavor development during ripening are both related with proteolytic activity of the starter. Proteolytic activity of LAB aims to produce amino acids (Beresford *et al*., 2001). Although LAB shows low proteolytic activity when compared with *Bacillus*, *Pseudomonas*, *Enterococcus*, this activity has an important role in cheese ripening. LAB have proteases bound their cell wall which enables them to hydrolyze big protein molecules into small peptides (Eugenia, 2003). Oligopeptides which are not longer than 6 amino acids are taken into cell and are hydrolyzed into amino acids. Peptidases are still active in ripened cheeses (Parente and Cogan, 2004).

2.6.4.2.1 Characteristics of starter cultures used in white cheese production

- Should produce good taste and smell in desired dose and combination,
- Should not have high proteolytic activity in order to avoid fast ripening and bitterness.
- Should have high antagonistic activity to inhibit pathogens,
- Should be resistant to phages.
- Should have resistance against antibiotics.
- Should grow at cheese production temperature.
- Should be resistant to certain salt concentration (Hansen, 2002).

2.6.4.3 Protein coagulation

Casein is the major protein in milk. During cheese production, rennet, a coagulating enzyme, is stirred into the milk. Under certain acid condition, rennet then separates the casein from the whey and causes the individual cells of the casein to clump together to form the gel network (Morr, 1975).

2.6.4.3.1 Chemical changes during curd formation

Conversion of milk from a fluid to a gel (coagulation) is a basic step common to all types of cheese (Ibrahim, 2003). Gel formation is a consequence of protein destabilization and may be brought about either by acid proteases such as chymosin, the active component of rennet, quiescent acidification to a pH value close to the iso-electric point of the proteins, or by a combination of acidification and heating (Fulya, 2006). Rennet coagulation involves two distinct stages, a proteolytic stage in which the casein micelle is destabilized by hydrolysis of K-casein to yield para-Kcasein micelles, and a secondary, calcium mediated, stage in which paracasein micelles undergo limited aggregation (Ibrahim, 2003). The secondary stage requires quiescent conditions and a temperature in excess of 20 °C. Hydrolysis of K-casein primarily involves cleavage of the peptide bond, which is uniquely sensitive to hydrolysis by acid proteinases (Fox and McSweeney,1996). This cleavage yields a para- K-casein, common to all caseins and macro peptide unique to each component. After addition of rennet, usually 30 minutes later for most cheese types, curd is firm enough to be cutted. After cutting curd is subjected to different treatments according to cheese type (Topcu, and Saldamli, 2006).

2.6.4.4 Cutting

Proper cutting is extremely important to both quality and yield. The small curd particles could be lost by the improper cutting and handling of the curd. Both early cutting when the curd is fragile and late cutting when the curd is brittle cause losses of particles. Curd size has a great influence on moisture retention, so the cutting wire should be chosen carefully (Ahmed, 2009).

2.6.4.5 Pressing

The cheese was shaped into the metal hoops which are lined with muslin cloth. The curds are allowed to form a continuous mass. Pressing the mass helps to form loose curd particles into a compact mass and expel whey. The cheese is pressed overnight with low pressure initially and then gradually increasing the pressure (Ahmed, 2009).

2.6.4.6 Draining

The curd must be separated from the whey, which is accomplished by draining the whey from the vat through a sieve-like strainer. The typical pH of the rennet whey upon draining is about 5.6-5.8. Consequently, much of the calcium insoluble at this pH will be retained in the cheese. Sometimes the curd is pressed. The partial removal of water from the protein solution leads to increased concentration of all non-aqueous constituents resulting in protein-protein, protein-carbohydrate and protein-salt interactions causing extensive aggregation (Fulya, 2006).

2.6.4.7 Salting

Salt is a flavoring preservative and it is responsible for certain functional properties in foods (Fulya, 2006). In cheese, sodium chloride reduces curd moisture, suppresses unwanted micro-organisms, modifies flavor and texture and regulates the breakdown of protein (Wolf *et al*., 1983). For proper flavor, there has to be some control of the ripening and further whey expulsion. The amount of salt used and the salting process add another important variable differentiating the cheese varieties. The purpose of salting is as follows: to inhibit the growth and activity of pathogenic and food-poisoning microorganisms; inhibit the activity of various enzymes in cheese; reduce the moisture of cheese; change cheese proteins which influence cheese texture and protein solubility; and affect cheese flavor (Ahmed, 2009).

2.6.4.8 Ripening

Cheese ripening is a very complex biochemical process by which the rubbery or elastic curd is converted into a smooth bodies and fully flavored cheese. Flavor and texture are considered the two main criteria in determining the acceptability of the aged cheese (Topcu and Saldamli, 2006).

2.6.4.8.1Chemical changes during cheese ripening

Cheese is chemically, microbiologically and enzymatically a complex and dynamic system. This makes the process of cheese ripening highly complex (Topcu, and Saldamli, 2006). Cheese contains a defined microbiological starter flora and an undefined, highly variable, adventitious flora. The diversity of the micro flora involved in cheese ripening adds to the complexity of the process; individual reactions in that process are catalyzed by different enzymes (Morris,1978).The nature of the substrate, which consists essentially caseins, fat and carbohydrate in milk; the variety of agents involved in biochemical transformations; the diversity of modifications undergone by constituents of cheese; and large number of products formed all contribute to flavor development in ripened cheese (Fox, 1989). The major biochemical changes involved during cheese ripening are proteolysis, lipolysis, lactose fermentation and production of volatile compounds(Figure 3), (Fox, 1989). Although lipolysis and lactose metabolism are fundamental processes in cheese making, their contributions to the texture and intensity of flavor of the finished product are somewhat difficult to define for some cheese varieties. Proteolysis, however, plays a direct role in development of the desired texture, aroma, and intensity of background flavor in most matured cheeses (Perez, 2000). Lipolysis in most varieties of cheese is not extensive, but some hydrolysis occurs during cheese ripening. Lipolytic activity in cheese may come from milk lipase, starter bacteria, adventitious bacteria, or enzyme preparations added to milk. Milk lipase is only active in

cheeses made from raw milk (Fox, 1989). Lipolysis and proteolysis are important in cheese flavor. *Lactobacillus bulgaricus*, produced greater quantities of amino acids and peptides(Beresford *et al.*, 2001).Cultures are non starter lactic acidbacteria, consisting mainly of *Lactobacillus* sp., which are used in addition to astandard mesophilic starter to improve and to enhance the flavor of cheese (Beresford *et al.*, 2001).The role of the starter in cheese ripening to be maximized, the intracellular enzymes must be released from the cells into the cheese matrix, which explains much of the attention given to cell autolysis during ripening (Perez, 2000).

2.6.5 Packing of cheese

Packaging or packing of cheese is one of the more important steps in the long journey from the producer to the consumer, since most of the cheese plants are far away from the consumption. Packaging of natural cheese must afford general protection of the product from mechanical damage and poor environmental conditions during handling and distribution (Abdalla, 2007). The package may also serve as a processing aid for instance the metal can be used in heat sterilization of many food items. Also may prevent moisture loss, improve appearance, protect against microorganisms, and prevent oxygen transmission also may serve as a marketing tool, which provide useful information about the producer name, brand size, variety, net weight, count, shipper and country of origin. Also the nutrition information, recipes, and shelf life also become an important part of point of sale displays. (Sacharow and Grffin, 1980).

2.6.7 Shelf life of cheese

Consumers demand products that are minimally processed, nutritious, safe, with longer shelf-life and good taste. Because of this reason, industry

and researchers have studied and developed new processing and preserving technologies (Evert-Arriagada *et al.,* 2012).

Almost all groups of microorganisms under some conditions can contribute to spoilage of foods (Gram *et al.,* 2002). The growth of microorganisms in cheese depends on the availability of nutrients, water activity, pH, ionic strength and temperature and atmosphere composition of the headspace. Cheeses are open to microbial spoilage because of the high moisture content, low concentration of salt and pH close to natural, and consequently they have a limited shelf-life (Dermiki *et al.,* 2008).Some microbiological spoiling observed in cheese is also a result of lipolytic and proteolytic activities of some microorganisms. Yeasts can contribute to taste, smell, and aroma formation in ripening process of cheese; otherwise, they can cause spoiling. They cause organoleptic change by hydrolysing fats when they reach 10^7–10^8 cfu/g in cheese.Another important microorganism group that is often isolated in cheese is mesophilic microorganisms. They come from different sources and contaminate the product during production and ripening of cheese (Var *et al.,* 2006).Microbiological method is one of the factors which are used to determine the shelf-life of the products (Evert-Arriagada *et al.,* 2012). In order to prevent the growth of pathogenic and spoilage microorganism in cheeses, the effects of different technologies including lactic starter inoculation in cheese modified atmosphere or vacuum packaging, surface pasteurization and usage antimicrobial agents are applied (Evert-Arriagada *et al.,* 2012).Factors such as heat, oxygen, light and certain metal ions, notably iron and copper, also play a part in the occurrence of oxidation. In addition, lipid oxidation leading to rancidity is often a decisive factor determining the shelf life of food products (Arslan *et al.,*2009). Despite the importance of microorganisms in food spoilage, the definition and assessment of spoilage rely on sensory evaluation are the factors for determining the shelf life of many food products (Gram *et al.,* 2002). Sensory

evaluation is used for measuring and quantifying the relationship between the sensory characteristics of a food and its consumer preferences. The end of shelf life can be determined from sensory data by various graphical methods (Arslan *et al.*, 2009).When performing shelf-life studies, the food is evaluated at different times, from fresh to deteriorated and different sensory attributes have been used including off-odor or flavor, overall acceptability, quality and deviations of typical flavor. These attributes can be subjective (Hough *et al.*, 2007).

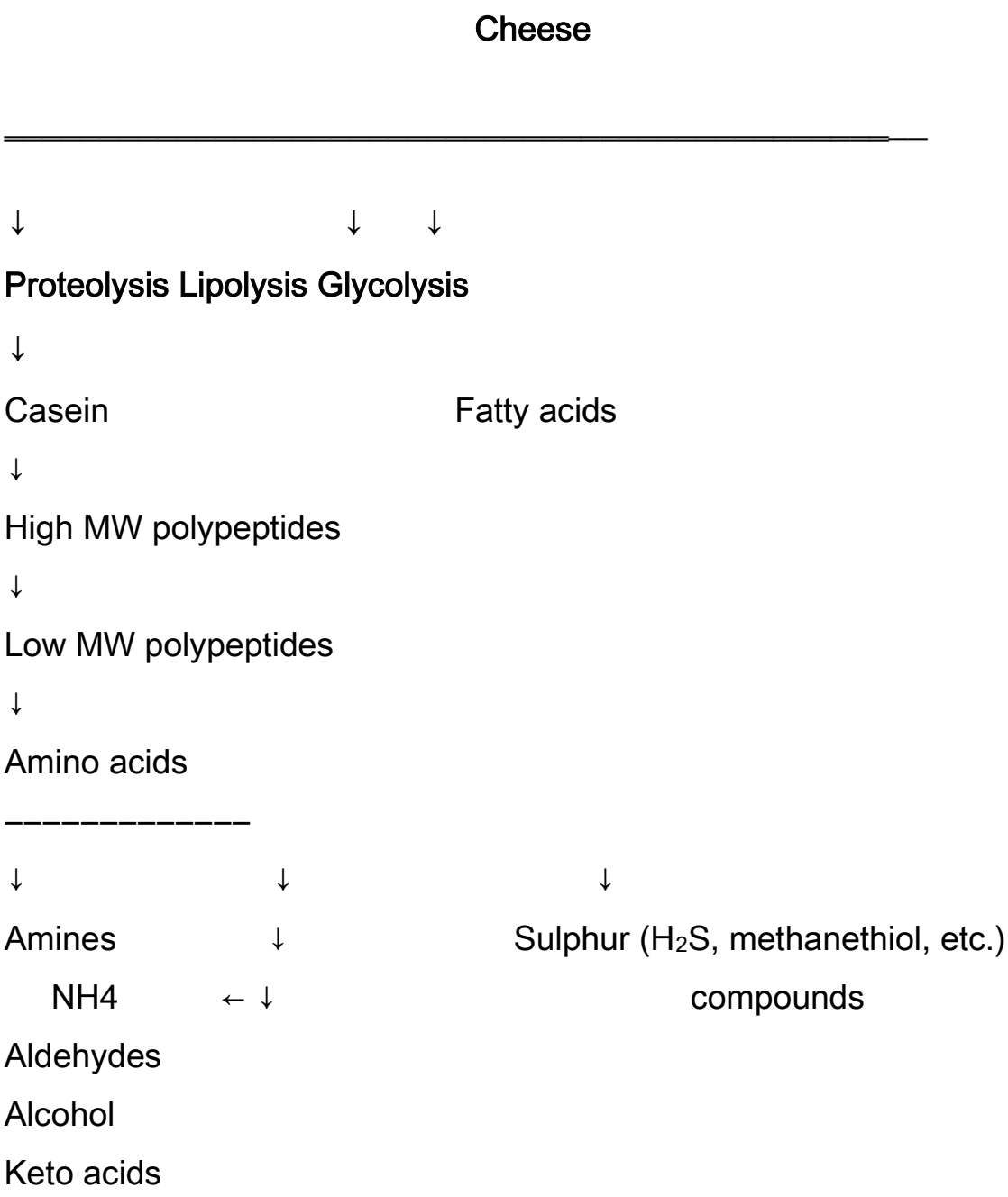

Figure 3: Chemical changes during cheese ripening

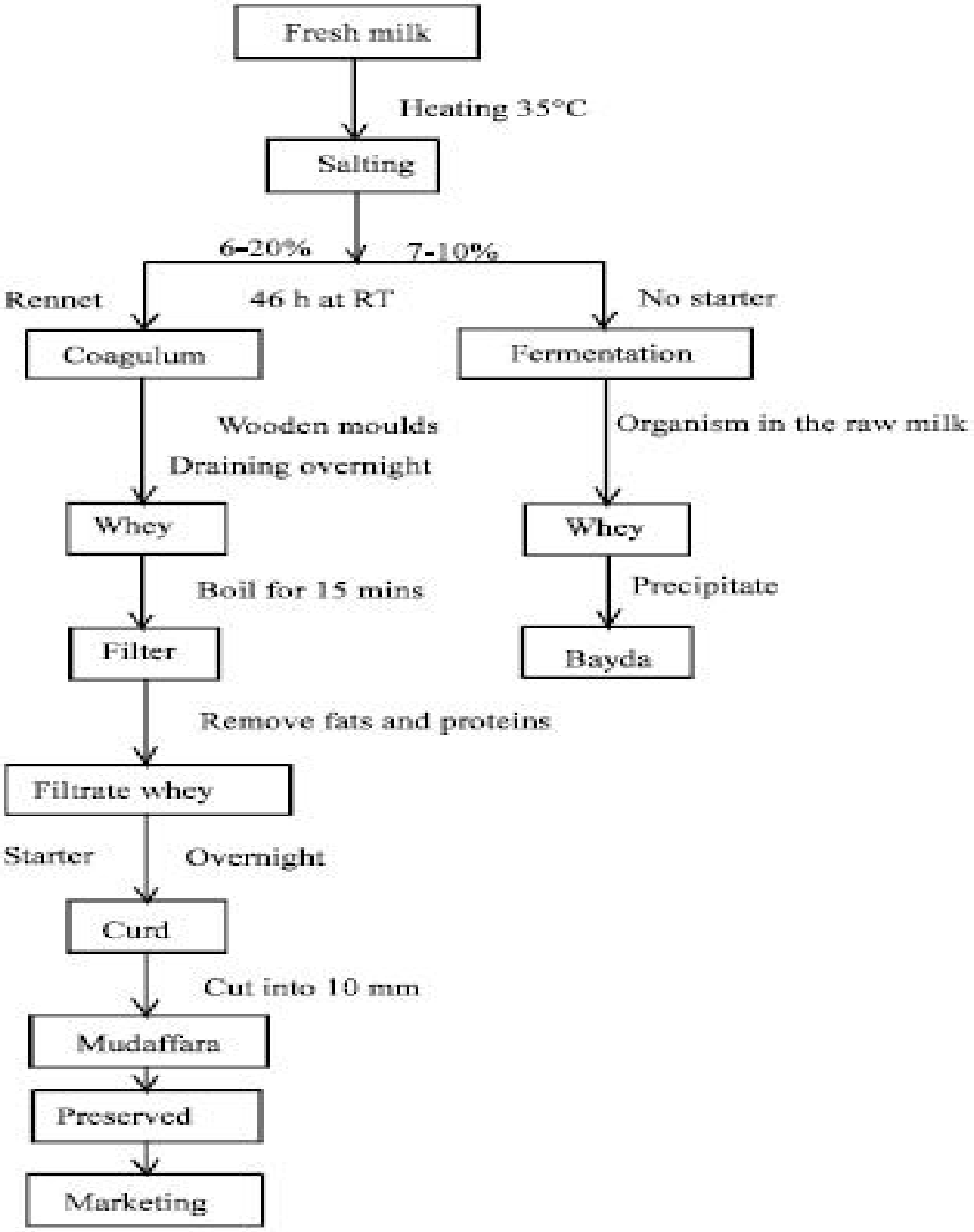

Figure 4: Cheese processing procedure

Fox (1989).

2.6.8 Cheese microbiology

Milk makes an excellent substrate for many microorganisms, including many food borne pathogens, and it is believed that cheese making was first developed as an attempt to store milk in an appropriate way for a long time. During cheese making, highly perishable milk is converted into a less perishable product by acidification with starter culture, rennet coagulation, followed by dehydration and salting (Fox and McSweeney, 1996). The microbiological status of cheese depends on the quality of the milk, possible contamination during processing and cheese type. Raw milk can contain spoilage organisms as well as pathogens, and therefore many dairies prefer to pasteurize the milk before cheese making.

2.6.8.1 *Escherichia coli*

Escherichia coli is a member of the family *Enterobacteriaceae*, the bacterium is Gram negative, non-spore forming straight rods. It can also grow in media with glucose as the sole organic constituent. It ferments lactose producing acidand gas (Abdalla *et al*, 1993). During manufacture and ripening of ripened cheese there was growth of *E. coli* O157:H7 to a level that permitted survival during an extended storage of the cheese (Ahmed, 2009). Spano *et al.,* (2003) showed that curd at 8^{o} C, for 5 minutes resulted in the loss of culture ability of *E. coli* O157: H7 during the production of cheese.

2.6.8.2 *Staphylococcus aureus*

This species belongs to the family Micrococcaceae that consist of twenty-three species and four sub-species (ANSES, 2010).They are Gram positive cocci and they are catalase positive, Moreover, staphylococci are non-motile, spores are not produced, colonies are smooth and colonial pigment is variable from gray or gray-white with yellowish tint. The natural habitat of *S. aureus* is warm-blooded animals including humans. Moreover,

10 to 40% of people are asymptomatic carriers of *S. aureus* mostly in the mucosal membrane. Moreover, enterotoxin producing staphylococcal species (*S. aureus* in particular) are the leading cause of food-borne disease (Warsama, 2003).

2.6.8.3 *Salmonella*

It belongs to the family *Enterobacteriaceae*, only five species are recognized, they are Gram negative, short rods that are aerobic and don't produce pigment on culture media, most of species ferment glucose and other sugars with the production of acid and gas, they don't ferment lactose (EC, 2005). Salmonella food poisoning is a bacterial food poisoning caused by Salmonella bacterium and responsible for about 15% of all cases of food poisoning. It can occur when someone drinks unpasteurized milk or eat any food contaminated during preparations; poor hygiene can also allow such carrier to spread the infection to others (Carson and Dewitt, 2002). Salmonellae continue to be a major concern for the dairy industry, since these bacteria have caused recent outbreaks of illness and have been isolated from various dairy products in the market places (Warsama, 2003).

2.6.8.5 Yeasts and moulds

Mould contamination not only causes deterioration of food and feeds can adversely affect the health of humans and animals as well since they are capable of producing toxic Metabolites known as mycotoxins causing cases of food poisoning and liver cancer in human (Mossel, 1982; Foster *et al.*, 1983).

2.7 Polysaccharides

The term 'hydrocolloid' embraces the very many polysaccharides that are extracted from plants, seaweeds, and microbial sources, and modified biopolymers made by the chemical or enzymatic treatment of starch or

cellulose. As proteins are known for their emulsifying and foaming properties, polysaccharides are identified for their water-holding and thickening properties (Huang *et al.,* 2007). These make up an important group of materials in food, cosmetic, biomedical or pharmaceutical applications. Polysaccharides play an important role as hydrating, thickening, emulsifying, and suspending polymers. From a general view point, they are principally important in the category of water-soluble polymers (Dumitriu, 2004). Polysaccharide gums are mostly hydrophilic polymers and do not exhibit significant surface activity (Dickinson and Stainsby, 1988). They are not considered to be strong surface active agents or emulsifiers. However, as a stabilizer in food emulsions and foams, some gums are found to migrate slowly to the air–water and oil–water interfaces and exhibit some surface and interfacial activities. Researchers have further investigated that hydrocolloid gums, although water-soluble, rigid and very hydrophilic, can precipitate/ adsorb onto oil droplets and sterically stabilize emulsions against flocculation and coalescence (Rinaudo, 2008).

2.7.1 Hydrocolloids

Hydrocolloids are defined as "a macromolecular substance such as a protein or polysaccharide which swells by absorption of water, in some cases forming a stiff gel" (Huang *et al.,* 2007). A wide variety of different hydrocolloid emulsifiers are utilized in food manufacturing. Each type of emulsifiers vary in their efficiency to produce small oil droplets during homogenization, and their ability to prevent droplet aggregation under different environmental stresses, such as pH, ionic strength, thermal and non-thermal processing etc. There is no single emulsifying agent that is ideal for use in every type of food emulsion (Aoki *et al.,* 2005). Various emulsion based food products principally contain proteins and polysaccharides which contribute to their stability and texture. Amongst all the emulsifiers, the most

common used in the emulsion preparations are amphiphilic proteins, polysaccharides, phospholipids and small molecule surfactants (Guzey and McClements, 2006). Food hydrocolloids, or food gums, have high molecular weights when compared to carbohydrate ingredients, such as sugar or corn syrup (Kuntz, 2002). Food gums are usually added to food systems/products for specific purposes, such as thickening agents, stabilizers, emulsifiers, gelling, etc (Hoefler, 2001). Hydrocolloids ultimately alter the rheological properties in a desired fashion for food systems (Klahorst, 2002).

2.7.1.1 The basic structure of hydrocolloid

The typical structure of a food hydrocolloid includes a sugar backbone with protruding substituent's (Kuntz, 2002). The backbone can vary in length from several hundred to several thousand sugar units long (Hoefler, 2004). These sugar units are most commonly linear in form, but branched backbones have been seen. The backbone provides pertinent information such as the acid stability of the particular hydrocolloid. The type, number, and distribution of substituent's protruding from the backbone determine whether a gum is a thickening agent or a gelling agent (Klahorst, 2002).

2.7.1.2 Viscosity modification upon adsorption

The main stabilizing action of food polysaccharides is via viscosity modification or gelation in the aqueous continuous phase. The incorporation of polysaccharide into oil in water emulsions retards the upward droplet creaming by enhancing the viscosity of the continuous phase, which produces desirable textural characteristics (Dumitriu, 2004). Sufficiently high concentrations, polysaccharides form a three-dimensional network of interacting or entangled molecules that traps the droplets and effectively inhibits their movement. At this concentration, creaming is retarded because even though the droplets might have aggregated they are incapable of moving

owing to the high viscosity or the gel-network formed by the polysaccharides (Aoki *et al.,* 2005). The influence of polysaccharides on the creaming stability of emulsions is not straightforward and depends on the characteristics of the system. For instance, polysaccharides are also capable of promoting droplet flocculation in emulsions through a depletion mechanism (Kuntz, 2002).Over an intermediate polysaccharide concentration, droplet flocculation may cause creaming instability because the increase in effective size of the particles which promotes creaming more than compensates for the increase in continuous phase viscosity which hinders creaming (Rinaudo, 2008).

2.7.2 Gum Arabic

Gum Arabic, otherwise known as Acacia Gum is a naturally occurring gum that is prepared from an exudate from Acacia trees. These trees are harvested predominantly in Sub Saharan Africa. The production of the gum, in a process known as gummosis, is a natural response of the tree to injury of bark. The gum exudes as nodules which are then removed by farmers as a raw product. Generally there are two varieties of the acacia tree that it is harvested from, these being *Acacia senegal*and *Acacia seyal* (Abdel Magid, 2008). Gum Arabic in a more refined form has many diverse commercial uses including use as a water colour thickener for artists, in the pharmaceuticals industry and in cosmetics amongst many others. However, its main uses are as an emulsifier in the food industry, and in carbonated drinks to reduce the surface tension of fluids and increase fizzing. Being almost completely soluble in water it makes it an ideal product for use as a stabilizer, emulsifier and thickening agent in foodstuffs (Sanchez *et al.,* 2002). JECFA, (1999) mentioned that the safety of Gum Arabic when used in food. A review of the then available literature recommended that Gum Arabic should be "Generally Regarded as Safe"- GRAS. It is accepted as a food additive in the European Union (E414) (Directive 99/77/EC) and by Codex Alimentarius (INS414).

Gum arabic is now also officially recognized as a dietary fiber in the EU directive 2008/100/EC (Codex, 2008). Gum Arabic also has a prebiotic action. A prebiotic is defined as:

“non-digestible food ingredients which beneficially affect the host by selectively stimulating the growth and / or activity of one or a limited number of bacteria in the colon and thus improve the host health”.

2.7.2.1 Production areas in Sudan

The Gum Arabic belt spans over 12 states of Sudan (around one fifth of the country’s total surface or 500.000 km2), principally in the traditional rainfed areas of western and central Sudan. It is estimated that 6 to 8 % of the gum belt is under acacia tree cover. The Kordofan region produces more than half of the Sudanese gum. Darfur, with around 20 percent of the national production (and most of Sudanese talha), is also an important gum producing region. However, Darfur’s gum production potential, comparable with Kordofan, is limited by its remoteness and the current conflict. Generally acacia trees are resistant to periods of low rainfall, however the combination of severe droughts of the mid-seventies and mid-eighties, civil conflict, population movements and change in farming practices have negatively impacted gum Arabic production in North Kordofan and North Darfur. As a result, the gum Arabic belt is moving south, towards clay soil areas with better rainfall patterns; acacia cover is expanding in Blue Nile and Upper Nile and the southern parts of Southern Kordofan (Yasin,2008).

Figure 5: *Accasia Senegal* Tree

Figure 6: Gum Arabic Source, Abdel Magid and Badi (2008).

2.7.2.2 Chemical composition of gum Arabic

Chemical composition of gum Arabic. It is a complex and variable mixture of arabinogalactan, oligosaccharide, and glycoprotein. Depending on source, the glycan component contains a greater proportion of L-arabinose relative to D-glactose in Acacia seyal or D-glalactose relative to L-arabinose in Acacia sengal, also contain significantly more glucuronic acid than from Acacia sengal (William and Phillips, 2000). Gum Arabic consists of a mixture of lower molecular weight polysaccharide (M.wt.~0.24×10 major component) and higher molecular weight hydroxyl proline-rich glycoprotein (M.wt~2.5×10 miner component) (Goodrum *et al.*, 2000).Nutritional, chemical composition of gum Arabic are presented in Table 3.

2.7.2.3 Health benefit of gum Arabic

Medically gum Arabic is used as demulcent to smooth irritation, especially of the mucous membranes and has been shown to lower the cholesterol levels in the blood of the laboratory animals (Behairy, 2003). Gum Arabic has been used for the treatment of low blood pressure caused by haemorrhage or surgical shock (Ali, 2000). Intravenous saline injections alone were not successful because the salt escaped too rapidly from the blood vessels. The addition of a 7% gum Arabic solution reduced the dissipation rate of the sodium chloride solution, and this treatment was successfully used in the 1920's. In plastic surgery, a 5% gum Arabic adhesive has been used successfully in grafting destroyed nerves (Behairy, 2003). In 1933, intravenous injections of gum Arabic solutions were recommended for the treatment of nephritic oedema. Some reports cited consequent liver and kidney damage, whereas other reports; in which as much as 330g of gum Arabic were administered; presented no evidence of hepatic or renal damage but stated only that the treatment was successful in alleviating or eliminating the oedema under treatment (Ali, 2000). It is used in the treatment of chronic

Table 3: Chemical composition of gum Arabic component

Component	Percent %
D.M	87
Crude protein	2.5
Arabinose	25
Lactose	14
Rhamose	14
Methoxy	2.5
Methyl glucognic acid	1.5
Ash	3.6

Source: Elkhalifa (1998).

renal failure diseases since it decreased serum nitrogen concentration and increased feaecal nitrogen excretion Gum Arabic also used in cosmetics, inks, lithography, paper, paint, adhesives, and textiles industry and inhibit metal corrosion (David, 2012).

2.8 Transmission Electron Microscopy -TEM:

Transmission electron microscopy (TEM) is an imaging technique where a beam of electrons is focused onto a specimen causing an enlarged version to appear on a fluorescent screen or layer of photographic film. The first practical TEM was built by Albert Prebus and James Hillier at the University of Toronto in 1938 using concepts developed earlier by Max Knoll and Ernst Ruska (Wikipedia, 2006). Scanning electron microscope (SEM) is a technique of electron microscope to produce high resolution images of a sample surface. Due to the manner in SEM the image is created; its images have a characteristic three-dimensional appearance and are useful show the surface structure of the target sample.

TEM and SEM are widely used in material science, metallurgy sicence and life science researches. An electron passing through a solid could be

scattered for once (single scattering), several times (plural scattering), or very many times (multiple scattering). Each scattering event might be elastic or inelastic. The scattered electron is most likely to be forward scattered but there is a small chance that it will be backscattered. The probability of scattering is either as an "interaction cross-section" or a mean free path.

Single scattering is an electron undergoes only one scattering event as it passes through a specimen. Plural scattering is an electron undergoes more than one scattering event but less than 20 as it passes through a specimen. Multiple scattering is an electron undergoes more than 20 scattering events as it passes through a specimen. Elastic scattering is the scattering of an electron if a negligible amount of energy is lost by the primary electron in the process. The direction of the electron may change, but the energy not. Inelastic scattering is a process by which the primary electron loses a significant amount of energy.

When the solid specimen is thicker than about twice the mean free path, plural scattering happens. This can be modelled using the Monte Carlo technique. The important features are the fraction of electron scattering forward and backwards and the volume of the specimen in which most of the interactions happen (Hongbao,2006).

Figure 7: Transmission electron microscope

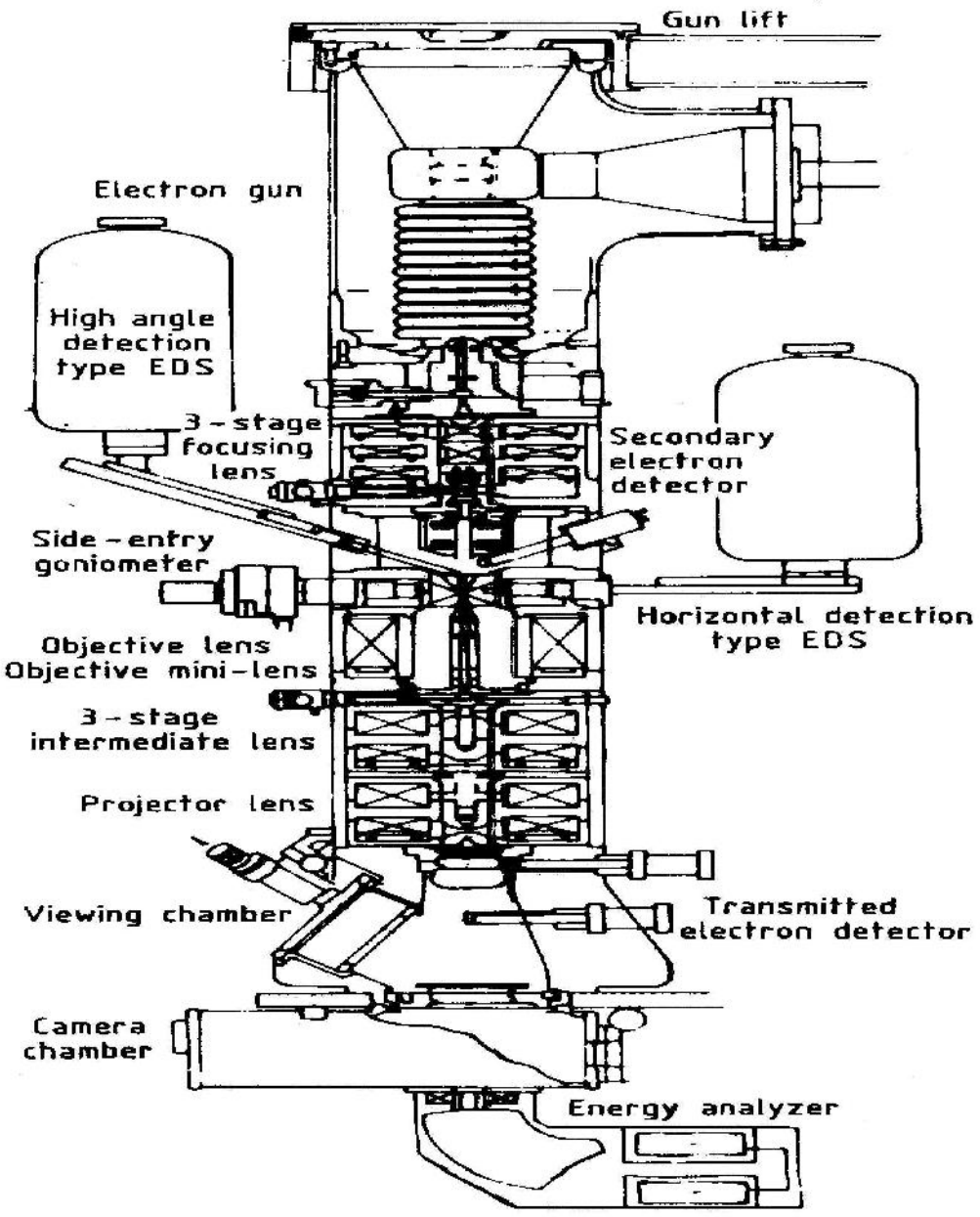

Figure 8: Transmission electron microscope

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

Fresh camel and cow milk were brought from Kamal's farm at Alkadaru area –Khartoum North .Sudan.

Gum Arabic was brought from Elie group company, Khartoum Sudan. Starter culture (Chris.Hansen's Holding A/S Denmark) was brought from a local dairy factory.

Rennet (Chris.Hansen's Laboratory, Denmark) was purchased from a pharmacy at Kharoum North .Clean fine sodium chloride was purchased from the local market.

Plastic containers made from polypropylene (PP) with a size of 500 gm were brought from the local market.

3.2 Methods

3.2.1 Cheese making

Milk samples were transferred immediately in sterilized containers in ice boxes, milk was filtered through cheese cloth to remove any foreign object that might have been carried with milk ,calcium phosphate was added to camel milk at level of 0.3% ,gum Arabic was added at level of (0%,0.5%,1%,1.5% and 2%), milk was heated to 39°C then starter culture was added at level of 0.1 gm per 10 liters 10. Rennet powder (1g /50 liter milk)was dissolve in 25 ml tap water in beaker, and the solution was added to the warm mixture the container was placed in incubator for 2 to 3.30 hr. for milk coagulation .After coagulation ,the cured was cut into approximately 2

cm³ using stainless steel knife to allow whey separation the curds were transferred to wooden moulds covered with cheese cloth (50×50×20 cm)the cured was pressed using a flat wooden cove (49×49×2 cm) which was put on the top of wood frame(using weights of about 15 kg) for whey draining , left for about 6 hr . Then the cloth were removed off the pressed cured .The whey was collected and sterilized after it was salted using 10% of salt . The molded cured was then cut into rectangular blocks (400-500 gm) and it were put in containers and about 200 ml of salted whey was added to the cured in each container. Samples were transferred to the lab for analyses to represent zero time .After packaging containers were stored at room temp 36±1°C for 6 days to ripening and then stored in refrigerator at 4±1°C for 3 months the analyses were carred out at 1,2 and 3 months. After ripning the containers were opened and cheese was judged.

Cow milk cheese was manufactured by traditional method (Ibrahim, 1970)

3.2.1 Physicochemical analysis of cheese

3.2.1.1 Determination of moisture

The moisture content was determined according to the standard method of the Association of Official Analytical Chemists (AOAC, 2003).

Principle:

The moisture content in a weighed sample is removed by heating the sample in an oven (under atmospheric pressure) at 105 ± 1Cº.Then, the difference in weight before and after drying is calculated as a percentage from the initial weight.

Procedure:

A sample of 5 gm ± 1 mg was weighed into a pre-dried and tarred dish. Then, the sample was placed into an oven (Kat-NR.2851, Elektrohelios, Sweden) and left to dry at 105± ^{o}C until a constant weight was obtained. After drying, the covered sample was transferred to a desiccator and cooled to room temperature before reweighing. Triplicate results were obtained for each sample and the mean value was reported to two decimal points according to the following formula:

Calculation:

$$\text{Moisture content [\%]} = \frac{[m2-m3]}{[m2-m1]} \times 100$$

Where:

m1 = mass of dish + cover
m2 = mass of dish + cover + sample before drying
m3 = mass of dish + cover + sample after drying

3.2.1.2 Determination of protein

The crude protein was determined by the micro-Kjeldahl method according to AOAC (2003) as follows:

Digestion:

Procedure: 10 gm sample was accurately weighed and transferred together with 2-3 glass pellets, kjeldahl catalyst (No 33064, BDH, England) and 25 ml concentrated sulphuric acid (No 18474420, Mark AG, Germany) into kjeldahl digestion flask. After that, the flask was placed into a kjeldahl digestion unit (Tecator, Sweden) for about 3 hours, until a colorless digest was obtained. Following, the flask was left to cool to room temperature.

Distillation:

The distillate was received in conical flask (100ml) containing ten ml of 2% boric acid (2 %) plus 3 drops of indicator (bromocresol green + phenolphthalein red). The distillation was continued until the volume in the flasks was 75 ml.

Titration:

The content of the flask were titrated against 0.01 N HCL. The titration reading was recorded.

$$CP = CN\ \% \text{ x. } 3.38$$

$$CN\% = T \text{ X } 0.10.014 \text{ X } 100 / W$$

Where:

CP=crude protein

CN= crude nitrogen

T= Titration reading

N= HCl normality (0.1)

Ws= sample weight

1000= to convert to mg

3.2.1.3 Determination of fat

Fat content was determined by Gerber method as described by AOAC (2003).Ten ml of Sulphuric acid (specific gravity 1.820 at 155^{o}C) were measured into Gerber butyrometers, and mixed well , 10.94 mL of milk sample was slowly added into butyrometers tube. One ml of amyl alcohol was

added and lock stopper was inserted securely with the stoppers end up .the Gerber tube was grasped and shacked with precaution until the sample was completed digested, the Gerber tube were centrifuged at 1100 rpm for 4minutes. Butyrometer was then placed in a water bath at 65°C for at least 3 minutes. The fat percent was finally read out directly from the Colum.

3.2.1.4 Determination of lactose

One ml of sample was pipetted into a 500 ml 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/100ml) was calculated as follows:

$$\text{Lactose g/100ml} = \frac{\text{O.D of sample} - \text{O.Dof blank}}{\text{O.D of standard} - \text{O.D of blank}} \text{x} 4.75$$

Where:

O.D (S) = Optical density of sample.

O.D (SD) = Optical density of standard.

O.D (B) = Optical density of blank.

3.2.1.5 Determination of ash

The ash content was determined by gravimetric method AOAC (2003).five grams of the samples were weighed in crucibles, and then placed in a muffle furnace at 550-600℃ for 3 hrs. until ashes were carbon free. The

crucibles were then cooled in desiccators and weighed. The ash content was calculated using the following equation:

$$\text{Ash\%} = \frac{W_1}{W_2} x100$$

Where:

W_1= Weight of ash

W_2=Weight of sample before ashing

3.2.1.6 Determination of total solids

Total solids (TS) content was determined according AOAC (2003). A clean aluminum moisture dishes were dried at 105 ^{o}C for 3 hrs. Five grams of the sample 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 3 hrs. The dishes were transferred to desiccators cool and weighted. Heating, cooling and weighting were repeated several times until the difference between successive weighting was less than 0.1mg .the total solids (T.S) content were calculated as follows:

$$\text{T.S\%} = \frac{W_1}{W_2} \text{ x } 100$$

Where:

W_1= Weight of sample after drying

W_2=Weight of sample before drying

3.2.1.7 Determination of solid-non fat

Total solids - fat (SNF) content was determined from the following equation:

$$\text{SNF (\%)} = \text{T.S \% - Fat \%}$$

3.2.1.8 Determination of pH

The pH of cheese was determined according to AOAC (2003). Ten grams of cheese were weighed and placed in a conical flask and distillate water at 40 ℃ was added until the volume in the flask was 105 ml. The sample was then vigorously agitated and filtered. Then pH of the filtrate was measured by using a recalibrated pH meter model (HI 8521 microprocessor bench pH / MV / ℃ meter). This has been calibrated with two standard buffers pH 4, the pH meter was placed into the sample, and the pH was directly read.

3.2.1.9 Determination of titrable acidity (Ta)

Ten grams of cheese were weighed and placed in a conical flask and distillate water at 40 ºC was added until the volume in the flask was 105 ml. The sample was then vigorously agitated and filtered. 25 ml of the filtrate were pipette into porcelain dish and 3-4 drops of phenolphthalein indicator were added. The sample was titrated against 0.1N NaOH until a faint pink color. The acidity calculated from the following equation:

$$\text{Acidity \%} = T \times 4 / W$$

Where:

T= Titre value

W=Weight of sample.

3.3 Microbiological analyses of cheese

3.3.1 Preparation of serial dilutions

One gram of each sample was weighed aseptically and added to test tube containing 9 ml of sterile diluents and well mixed to give 10^{-1}; using sterile pipette 1ml of the last dilution was transferred to test tube containing

9ml of sterile diluents and well mixed to give 10^{-2} in the same way continued to the prepare other serial dilution (Harrigan, 1998).

3.3.2 Sterilization of glassware

Glassware were washed thoroughly, left to dry and sterilized in a hot air oven at 160 C^0 for at least 3 hours (Harrigan, 1998). Instruments such as loops, needles, forceps, spoons and Knives were sterilized by flaming directly after dipping in spirit.

3.3.3 Culture media used

3.3.3.1 Nutrient agar (Oxoid)

The nutrient agar was used for growth of bacteria. Twenty- eight grams of dehydrated nutrient agar were suspended in a liter of distilled water, steamed to dissolve completely, the pH was adjusted to 7.4 then the medium was sterilized by autoclaving at 121˚C for 15 minutes manufacture instruction.

3.3.3.2 Plate count agar (Oxoid)

The plate count agar medium was used to determine total bacterial count. Seventeen and half grams of this media were suspended in a liter of distilled water, dissolved by bringing to boiling with frequent stirring, mixed and distributed into conical flasks sterilized by autoclaving at 121˚C for 15 minutes (Harrigan, 1998).

3.3.3.3 MacConkey broth (Oxoid)

The MacConkey broth medium was used for the primary isolation of coliform bacteria. Forty grams of this media were suspended in a litter of distilled water, the medium was distributed in test tubes with inverted Durham

tubes, the pH was adjusted to 7.0 and then the medium was sterilized by autoclaving at 121˚C for 15 minutes (Harrigan, 1998).

3.3.3.4 Brilliant green bile lactose broth (Oxoid)

The brilliant green bile lactose broth medium was used to confirm the presence of coliform bacteria by multiple tube technique. Forty grams of dehydrated media were suspended in a liter of distilled water, the pH was adjusted to pH7.4, distributed in the test tubes with inverted Durham tubes and then the medium was sterilized by autoclaving at 121˚C for 15 minutes (Harrigan, 1998).

3.3.3.5 Eoisn methylene blue agar (oxoid)

The eoisn methylene blue agar medium was used for the differentiation of *Escherichia coli* and *Aerobacter aerogenes.* Thirty seven and half grams of dehydrated Eoisn methylene blue agar were suspended in a liter of distilled water, steamed to dissolve completely, the pH was adjusted to 6.8 and then the medium sterilized by autoclaving at 121 ˚C for15 minutes (Harrigan, 1998).

3.3.4 Microbial tests

3.3.4.1 Total bacterial count

One ml of each serial dilution was transferred aseptically in to sterile Petri dishes. 15ml of plate count agar were added. The inoculums was mixed with medium and allowed to solidify. The plates were then incubated at 37˚C for 24 hrs. Plates were examined and the colonies on every plate were counted then the total viable count was determined as colony forming unit per ml (cfu/ml) (Harrigan, 1998).

3.3.4.2 Total coliform count (Presumptive test)

The examination was carried out using the most probable number technique (MPN) describes by Harrigan (1998). One ml of each dilution (10^{-1} , 10^{-2}, 10^{-3}) was added in triplicate into the tubes of filled with 9 milliliters of sterile MaConkey Broth, Durham tube was inserted into these tubes, then incubated at 37^{o}C for 48 hours. Tubes producing gases and acid were positive results and recorded using (MPN) technique.

3.3.4.3 Confirmed coliform test

All fermentation tubes from the presumptive test showing gas with 24 hrs. at 37˚C were utilized in the confirmation test. The medium used in this test was Brilliant Green Bile lactose broth BGB. Each tube contained 10 ml of medium fitted with Durham tubes. Presumptive test tubes were transferred to each BGB tubes, and then incubated at 37˚Cfor 48 hrs. Faecal coliform were calculated from the most probable number (MPN) tables (FAO, 1992).

3.3.4.4 Isolation of *E.coli*

For further confirmation of fecal coliform in tubes giving positive reaction on *Escherichia coli* media EC at 44.5˚C for 28 hrs. were streaked on Eosin Methylene Blue (EMB). Colonies with green metallic shine gave a positive test (Harrigan, 1998).

3.3.4.5 Yeast and moulds

One ml from each serial dilution was transferred aseptically in to sterile Petri dishes. 15ml of potato dextrose agar were added to Petri dish. The inoculums was mixed with medium and allowed to solidify. The plates were then incubated at 25°C for 72 hrs. The colonies were counted to determine the viable count of yeast and moulds (Harrigan, 1998).

3.3.4.6 *Salmonella*

Twenty –five grams of sample were weighed aseptically and mixed well with 225 ml of sterile Nutrient broth. This was incubated at 37 ˚C for 24 hours. Then 10 ml were drawn aseptically and added to 100 ml of sterile selenite cysteine broth .the broth was incubated at 37 ˚C for 24 hours . then with a loopful streaking was done on dried Bismuth Sulphite agar plates .The plates were then incubated at 37 ˚C for 72 hours .Black metallic sheen discrete colonies indicated the presence of Salmonella. (Harrigan, 1998).

3.3.4.4 *Shigella*

The enrichment procedures for shigella are the same s are those for salmonella .after enrichment the culture s should be streaked on salmonella – shigella agar and incubated for 24 hr. at 35 ˚C. On this media shigella colonies are colorless and transparent .typical colonies are transferred to triple sugar iron agar slants, incubated at 35 ˚C and observed after 24 hr. on this medium the slant is alkaline (purple) and the butt acid (yellow). (Harrigan, 1998).

3.3.4.8 *Brucella*

0.03 ml of B. abortus Bang ring antigen was mixed with 1 ml of whole milk on test tube then the mixture was incubated at 27 ˚C foe 1 hr. the positive result shows a blue ring at the top of the tube and the negative result shows the blue color distributed in the entire tube. (Alton *et al.*, 1988).

3.5 Sample preparation for Transmission Electronic Microscope (TEM)

Milk coagulum was prepared in triplicates, each cheese samples was transferred to a petri dish by placing a petri dish on top of the beaker containing the coagulum, and then both petri dish and beaker inverted . The coagulum was cut into three large pieces (right, center and left) with a sharp

razor blade. Each piece was cut into nine sample pieces. One sample piece was taken randomly from each of the right, center and left large pieces .Approximately 1 mm^3 and 10 mm^3 slices were cut from each of the sample pieces for TEM examination. Preparation of samples for TEM was by a modification of the procedure described by Kalab (1981). The samples were put into different vials and fixed with 4% glutaraldehyde in 0.1 M sodium cacodylate buffer ,pH 6.6 , for 24 hr at 4 ˚C. Washed with 0.1 M sodium cacodylate buffer, pH 6.6 for three changes of 10 min each .Post fixed in 1% osmium tetroxide for 24 hr at 4 ˚C . Washed with 0.1 M sodium cacodylate buffer, pH 6.6 for three changes of 10 min each . Dehydrated in a series of ethanol 35%,50%,75%,95% for 10 min each and 100% for tree changes of 15 min each.

Dehydrated TEM specimens were infiltrated with 1:1 acetone and resin mixture of agar 10 Resin ,dodoenyl succic anhydride ,methyl nadic nhydride, and n-benzyldimenthylamine for 1 hr ,then with 1:3 aceton and resin mixture for 2 hr .They were infiltarated with 100% resin overnight followed by 100% resin for 2 hr . infiltrated specimens were embedded by placing into beamcapsules and the capsules were filled up with resin. They were polymerized in oven at 60 ˚C for 48 hr .Specimens were cut into 1 µm thick sections using a glass knife and ultramicrotome, placed into glass slide, stained with tolioden blue and dried on a hot plate .the sections were then washed with distilled water,examined under light microscope and ultra-thin sections (70nm) were cut with a dimond knife. Section were picked with a grid ,dried with paper (Whatman no .1) the sections were stained with saturated alcoholic nrunyl acetate for 10 min, and then washed with 50%filtered ethanol . sections were lead stained for 10 minand washed with duble distilled water . stained sections were viewed at ×30.000 using Hitachi Transmission Electronic Microscope .nine micrografes were preparedfor coagulum of each of samples .Kodak electron microscope film

3.5.1 Porosity of the milk coagulum

Was determined by quantification of pores fractional area of TEM micrographs by using a 24 x 16 rectangular test grid according to Gundersen *et al*. (1988) The result was transferred to Arcsine value.

3.6 Sensory evaluation

Sensory profiling of cheese from camel milk and cow milk was conducted, using conventional profiling by 30 panelists (23 male and 7 female in the range. of 28 - 49 years old) selected among the NFRC employee and university student. Every treatment was given a code, the samples were placed in plastics trays having a code of sample. Tap water was available for rinsing of mouth after tasting each sample. The panelists were giving an 8-point hedonic. Scale with 8 = dislike extremely and 1=like extremely (Larmond, 1977) which was used for rating color, texture, taste, flavor, and over all acceptability.

3.7 Syneresis

The degree of syneresis was controlled by estimating test volume and after that estimating the volume of whey that could be isolated from the coagulum by filtration .A funnel containing Whatman number 4 channel paper (Whatman Corp.,USA)was set mouth down on best of the receptacle containing the sample. The pipe and container were then altered and whey was permitted to deplete into a 100 ml-estimating chamber . the volume of the gathered whey was contrasted with the first volume of the example to decide degree of syneresis (Smith and McMahon,1996).

3.8 Statistical analysis

The data collected were subjected to analysis of Variance and whenever appropriate the mean separation procedure of Duncan was employed (Steel and Torrie, 1980).The SAS program (SAS, 2002**),** was used to perform the general liner model (GLM**)** analysis.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Physicochemical properties of cow milk

Table (4) shows the physicochemical properties of cow milk the results were as follows, fat content was 3.57%, SNF. 12.38%curde protein 3.57%, lactose content 4.83%, ash content 0.67% and total soluble solids was 11.74%. These results are very similar to the results mentioned by Siddig *et al*(2016).

4.2 Physicochemical properties of camel milk

Table (5) shows the physicochemical properties of camel milk the results were as follows, fat content was 3.1%, SNF. 9.2%curde protein 3.6%, lactose content 4.9%, ash content 0.7% and total soluble solids were 9.8%. These results were lower than that reported by Siddig *et al*(2016).These results are somewhat similar to those reported by Eisa and Mustafa (2011).

Table 4: Physicochemical properties of cow milk

Parameter	Mean±SD
Fat content (%)	3.57 ±0.12
SNF (%)	12.83 ±0.06
Crude protein (%)	3.57 ±0.12
Lactose content (%)	4.83 ±0.06
Ash content (%)	0.67 ±0.06
Total soluble solids (%)	11.90^{b} ±0.20

Values are mean±SD.

Key: A ≡ Sample 1 B ≡ Sample 2 C ≡ Sample 3

Table 5: Physicochemical properties of camel milk

Parameter	Samples			$Lsd_{0.05}$	SE±
	A	B	C		
Fat content (%)	3.32^{a} ±0.42	3.05^{a} ±0.02	3.07^{a}±0.02	0.4853^{NS}	0.1402
Sn. F (%)	9.23^{a} ±0.07	9.13^{a} ±0.06	9.19^{a}±0.01	0.1094^{NS}	0.03162
Crude protein (%)	3.57^{a} ±0.03	3.53^{c} ±0.02	3.56^{b}±0.01	0.00063^{*}	0.000183
Lactose content (%)	4.96^{a} ±0.04	4.89^{b} ±0.02	4.93^{ab}±0.01	0.0632^{*}	0.01826
Ash content (%)	0.637^{c} ±0.00	0.667^{a}±0.01	0.660^{b}±0.01	2.978^{**}	0.8606
Total soluble solids (%)	9.67^{b} ±0.58	10.00^{a}±0.00	9.67^{b}±0.58	0.3915^{*}	0.1740

Values are mean±SD.

Mean(s) bearing different superscript(s) in a row are significantly different ($P \leq 0.05$) according to DMRT.

Key: A ≡ Sample 1 B ≡ Sample 2 C ≡ Sample 3

4.3 Microbiological features of raw cow milk

Table (6) shows microbiological properties of cow milk. No growth was recorded for yeasts and moulds, *E. coli*, *Brocella*, *Salmonella* and *Shigella* (log10cfu/ml). These findings are consistent with SSMO (2011).The total coliforms and *Staphylococcus aureus* (log10cfu/g) were 21.67, 2.13 respectively and these results were higher than that reported by Suleiman *et al*, (2016). Total viable count of bacteria (log10cfu/g) was 3.46 and not compliant with SSMO (2011). These results may be due to the milking area air had high total bacterial count showing possibility of milk contamination during milking and storage .The milking area was also dusty and hence possibility of contamination with microorganisms from soil and milkers' hands (Younan and Abdurahman, 2004; Musinga *et al*., 2008).

4.4 Microbiological features of raw camel milk

Table (7) shows microbiological properties of camel milk. No growth was recorded for *Brucella*, *Salmonella and Shigella*. These results are consistent with SSMO, (2011). These results are not compliant with SSMO (2011) and less than that detected by El-ziney and Al-turki (2007) these results may be due to the presence of antimicrobial impact in camel milk against Gram positive and Gram negative microorganisms. The inhibitory activity of camel milk may be credited to the nearness of lactoperoxidase, hydrogen peroxide, lactoferr in what's more, immunoglobulins and lysozyme . The total viable count of bacteria (log_{10}cfu/ml) was 5.63this result was higer than that reported by El-ziney and Al-turki (2007). ,yeasts and moulds (log_{10}cfu/ml) was 1.81 it was lower than that reported by El-ziney and Al-turki (2007), *Staphylococcus aureus* (log_{10}cfu/ml) was 3.04 it was lower than that reported by El-ziney and Al-turki(2007), total coliforms (MPN/g) was 19.4 it was lower than that reported by El-ziney and Al-turki(2007), and *E. coli* was 5.3 it was lower than that reported by El-ziney and Al-turki(2007), .

It is therefore clear that, many interactive factors con-tributed to poor hygienic quality of the camel milk sold at the markets. Younan and Abdurahman,(2004).

4.5 Coagulation time and yield:

Table (8) shows the Coagulation time and yield of cheese the minimum coagulation time was 2 hr. and 24 min in camel milk cheese with 1% gum Arabic this result was lower than that reported by Nasr *et al*. (2013) and the maximum coagulation time has been recorded was 3 hr. and 27 min in camel milk cheese without gum Arabic, this result was in a good agreement with Nasr *et al.* (2013). This variation may be due to using gum Arabic which was reduced the coagulation time. about the yield of cheese the yield increased by increasing the amount of gum Arabic for camel milk cheese. The lowest yield was in camel milk cheese without gum Arabic which was and the highest yield was in camel milk cheese with 2% gum Arabic this variation may be due to added of gum Arabic make bridges bind the milk components together preventing the loss of solid ingredients in whey. All the result of the camel milk cheese yield were higher than those mentioned by Shahein *et al.* (2014) which was 12 this variation may be due to addition of gum Arabic make bridges bind the milk components together preventing the loss of solid ingredients in whey.

Table 6: Microbiology of cow milk

Parameter	**Mean±SD**
Total viable count of bacteria (log_{10} cfu/g)	3.46±0.03
Salmonella	Nil
Staphylococcus aureus (log_{10} cfu/g)	2.13±0.02
Coliforms (MPN/cell/ml)	21.67±0.00
E. coli	Nil
Brocella	Nil
Yeats and moulds	Nil
Shigella (cfu/g)	Nil

Values are mean±SD.

Table 7: Microbiological features of raw camel milk

Parameter	Mean±SD
Total viable count of bacteria (log_{10} cfu/g)	5.63±1.08
Yeasts and moulds (log_{10} cfu/g)	1.81±1.58
Staphylococcus aureus (log_{10} cfu/g)	3.04±0.58
Total coliforms (MPN/g)	19.4±9.64
E. coli (MPN/g)	5.3±5.34
Shigella (cfu/g)	Nil
Salmonella	Nil
Brocella	Nil

Values are mean±SD.

Table 8: Coagulation time and cheese yield

Cheese	Coagulation time (hrs.)	Yield (%)
Control (Without gum Arabic)	3.27^{a} ±0.02	12.88^{e} ±0.16
0.5%gum Arabic	3.22^{a} ±0.02	15.74^{d} ±0.31
1%gum Arabic	2.24^{a} ±1.66	17.70^{c} ±0.30
1.5% gum Arabic	3.14^{a} ±0.05	20.07^{b} ±0.95
2% gum Arabic	2.37^{a} ±0.46	21.22^{b} ±0.53
Cow milk	3.02^{a} ±0.02	27.36^{a} ±0.42
$Lsd_{0.05}$	1.255^{NS}	1.397^{*}
SE±	0.4074	0.4535

Values are mean±SD.

Mean(s) bearing different superscripts in a column are significantly different ($P \leq 0.05$) according to DMRT.

4.6 Effect of addition of gum Arabic and storage on moisture content (%) of cheese:

Table (9) shows the effect of addition gum Arabic and storage period on moisture content (%) of cheese it was increased by increasing the storage period .on the other hand it was decreasing by increasing the percentages of gum Arabic. Significantly variation were observed, the highest moisture content (43.42%) which recorded for control sample in the third month, while, the lowest one (28.99%) which recorded for camel milk cheese with 2% gum Arabic added in zero time. The result was lower than that reported by Abd EL-Salam and Alichanidis (2004), while, the lowest one (28.99%) which recorded for camel milk cheese with 2% gum Arabic added in zero time. The result was lower than that reported by Mehaia.(1993) and Khan *et al.* (2004).This difference in moisture content may be due to more calcium is transferred from the cured into the whey and this transfer has been reported to affect increase moisture content of cheese and make the cheese softer.

4.7 Effect of addition of gum Arabic and storage on crude protein (%) of cheese:

Table (10) shows the effect of addition gum Arabic and storage period on protein content (%) of cheese the crude protein was decreased by increasing the storage period and it was increased by increasing percentages of gum Arabic. The lowest protein content was in in the sample of camel milk cheese in the third month which was 18.96 % this result is lower than that reported by Khan *et al.* (2004). The highest protein content was in in the sample of camel milk with 2% gum Arabic at the first month which is was 25.25% this result is lower than that reported by Hssab Elnabi. (2011),EL Zubeir and Jabreel (2008). This variation of protein content may be due to the addition of gum Arabic to the cheese. And it refers to decrease on total

solid in samples during storage period and breakdown of amino acids by starter culture.

4.8 Effect of addition of gum Arabic and storage on fat content (%) of cheese

Table (11) shows the effect of addition gum Arabic and storage period on fat content (%) of cheese Fat content was decreased by increasing the storage period and it was increased by the increasing percentages of gum Arabic. The highest percentage of fat content was in the sample of camel milk cheese with 2% gum Arabic at zero time it was 35.40% and the lowest one was in the control sample in the third month it was 29.52% this result was higher than those reported by Mehaia (1993), Hassab elnabi (2011) and Khan *et al.* (2004). This variation may be due to the lactation period .and to decrease on total solid in samples during storage period and may be due to lipolysis of cheese.

4.9 Effect of addition of gum Arabic and storage on ash content (%) of cheese

Table (12) shows the effect of addition gum Arabic and storage period on ash content (%) of cheese. The ash content decreased by increasing the storage period and it was increased by increasing gum Arabic the amount of gum Arabic. The highest percentage of ash in camel milk cheese with 2% gum Arabic in at zero time which was 10.79% and the lowest percentage in the control sample in the third month was7.98% this result was in a good agreement with Ahmed and Ahmed (2017). And lower than the result reported by Khan *et al.* (2004).This variation may be due to increase on moisture content that let to dilution of T S. content.

Table 9: Effect of addition of gum Arabic and storage on moisture content (%) of camel milk cheese

Cheese	Storage period (month)			
	0	**1**	**2**	**3**
Control (Without gum Arabic)	37.47 ± 0.25^{fg}	38.39 ± 0.46^{e}	39.68 ± 0.24^{c}	43.42 ± 0.35^{a}
0.5%gum Arabic	33.82 ± 0.23^{m}	34.27 ± 0.25^{l}	35.28 ± 0.17^{j}	37.71 ± 0.21^{f}
1%gum Arabic	31.65 ± 0.19^{p}	32.14 ± 0.27^{o}	33.20 ± 0.15^{n}	36.59 ± 0.22^{h}
1.5% gum Arabic	30.25 ± 0.22^{q}	30.09 ± 0.28^{q}	30.48 ± 0.20^{q}	34.83 ± 0.28^{k}
2% gum Arabic	28.99 ± 0.15^{rs}	28.63 ± 0.21^{s}	29.22 ± 0.24^{r}	32.46 ± 0.19^{o}
Cow milk	36.01 ± 0.31^{i}	37.11 ± 0.26^{g}	36.19 ± 0.27^{d}	41.60 ± 0.24^{b}
$Lsd_{0.05}$	0.4249^{**}			
SE±	0.1494			

Values are mean±SD.

Mean(s) bearing different superscript(s) in columns and rows are significantly different ($P\leq0.05$) according to DMRT.

Table 10: Effect of addition of gum Arabic and storage on crude protein (%) of camel milk cheese

Cheese	Storage period (month)			
	0	**1**	**2**	**3**
Control (Without gum Arabic)	21.57 ± 0.18^{k}	21.30 ± 0.24^{l}	21.07 ± 0.21^{m}	18.96 ± 0.25^{o}
0.5%gum Arabic	23.60 ± 0.16^{g}	23.57 ± 0.22^{g}	23.30 ± 0.17^{h}	22.56 ± 0.28^{i}
1%gum Arabic	23.91 ± 0.11^{f}	23.86 ± 0.29^{f}	23.51 ± 0.22^{g}	22.56 ± 0.21^{i}
1.5% gum Arabic	24.62 ± 0.14^{c}	24.43 ± 0.18^{d}	24.13 ± 0.25^{e}	23.18 ± 0.20
2% gum Arabic	24.82 ± 0.20^{b}	25.25 ± 0.14^{a}	25.16 ± 0.21^{a}	23.97 ± 0.26^{f}
Cow milk	21.87 ± 0.15^{j}	21.68 ± 0.26^{k}	21.35 ± 0.23^{l}	20.03 ± 0.27^{n}
$Lsd_{0.05}$	0.1272^{**}			
SE±	0.04472			

Values are mean±SD.

Mean(s) bearing different superscript(s) in columns and rows are significantly different ($P\leq0.05$) according to DMRT.

Table 11: Effect of addition of gum Arabic and storage on fat content (%) of camel milk cheese

Cheese	Storage period (month)			
	0	**1**	**2**	**3**
Control (Without gum Arabic)	31.71 ± 0.44^{j}	31.61 ± 0.29^{j}	31.02 ± 0.22^{k}	29.52 ± 0.24^{m}
0.5%gum Arabic	33.69 ± 0.41^{f}	33.50 ± 0.33^{f}	33.20 ± 0.20^{g}	31.61 ± 0.30^{j}
1%gum Arabic	34.70 ± 0.38^{cd}	34.59 ± 0.25^{d}	34.22 ± 0.21^{e}	32.22 ± 0.32^{i}
1.5% gum Arabic	34.82 ± 0.31^{bc}	35.02 ± 0.19^{b}	35.33 ± 0.18^{a}	32.58 ± 0.31^{h}
2% gum Arabic	35.40 ± 0.25^{a}	35.36 ± 0.21^{a}	35.41 ± 0.27^{a}	33.54 ± 0.35^{f}
Cow milk	33.13 ± 0.29^{g}	32.78 ± 0.26^{h}	32.02 ± 0.24^{i}	30.59 ± 0.24^{l}
$Lsd_{0.05}$	0.2077^{**}			
SE±	0.07303			

Values are mean±SD.

Mean(s) bearing different superscript(s) in columns and rows are significantly different ($P\leq0.05$) according to DMRT.

Table 12: Effect of addition gum Arabic and storage on ash content (%) of camel milk cheese

Cheese	Storage period (month)			
	0	**1**	**2**	**3**
Control (Without gum Arabic)	8.46 ± 0.13^{i}	8.29 ± 0.14^{j}	8.13 ± 0.14^{kl}	7.98 ± 0.10^{m}
0.5%gum Arabic	8.77 ± 0.14^{h}	8.69 ± 0.11^{h}	8.25 ± 0.17^{jkl}	8.12 ± 0.12^{l}
1%gum Arabic	9.70 ± 0.17^{e}	9.45 ± 0.16^{f}	9.07 ± 0.19^{g}	8.73 ± 0.13^{h}
1.5% gum Arabic	10.31 ± 0.20^{c}	10.46 ± 0.21^{b}	10.02 ± 0.24^{d}	9.41 ± 0.16^{f}
2% gum Arabic	10.79 ± 0.22^{a}	10.77 ± 0.23^{a}	10.19 ± 0.22^{c}	10.00 ± 0.20^{d}
Cow milk	8.27 ± 0.18^{jk}	7.89 ± 0.13^{m}	7.30 ± 0.11^{o}	7.70 ± 0.11^{n}
$Lsd_{0.05}$	0.1374^{**}			
SE±	0.0483			

Values are mean±SD.

Mean(s) bearing different superscript(s) in columns and rows are significantly different ($P\leq0.05$) according to DMRT.

4.10 Effect of addition of gum Arabic and storage on lactose (%) of cheese

Table (13) shows the effect of addition gum Arabic and storage period on lactose content (%) of cheese. The lactose appeared only in a control sample and a sample of cow milk all this result was lower than the result reported by Khan *e, al.* (2004).which was 2.53 this result may be because of added gum Arabic to cheese which acts as a prebiotics that activate lactic acid bacteria which metabolize lactose

4.11 Effect of addition of gum Arabic and storage on total soluble solids (%) of cheese

Table (14) shows the effect of addition gum Arabic and storage period on total soluble solids (%) of cheese. It was decreased by increasing the storage period and increased by increasing the amount of gum Arabic The highest percentage of total soluble solids(%) in camel milk cheese with 2% gum Arabic in at zero time which was 71.01% and the lowest percentage in the control sample in the third month which was 56.58%.all these result are higher than those reported by Inayat *et al.*(2016).which was 29.54.and although higher than those reported by Khan *et al.* (2004). this difference may be due to the addition of gum Arabic to the cheese and increasing the moisture content of cheese by increasing the storage period

Table 13: Effect of addition of gum Arabic and storage on lactose (%) of camel milk cheese

Cheese	Storage period (month)			
	0	**1**	**2**	**3**
Control (Without gum Arabic)	0.80 ± 0.05^{a}	0.41 ± 0.05^{b}	0.11 ± 0.03^{c}	0.10 ± 0.01^{c}
0.5%gum Arabic	ND	ND	ND	ND
1%gum Arabic	ND	ND	ND	ND
1.5% gum Arabic	ND	ND	ND	ND
2% gum Arabic	ND	ND	ND	ND
Cow milk	0.73 ± 0.0^{4a}	0.56 ± 0.03^{b}	0.13 ± 0.0^{2c}	0.10 ± 0.01^{c}
$Lsd_{0.05}$	0.15^{*}			
SE±	0.05			

Values are mean±SD.

Mean(s) bearing different superscript(s) in columns and rows are significantly different ($P\leq0.05$) according to DMRT.

ND=Not detected

Table 14: Effect of addition of gum Arabic and storage on total soluble solids (%) of camel milk cheese

Cheese	Storage period (month)			
	0	**1**	**2**	**3**
Control (Without gum Arabic)	62.53 ± 0.41^{lm}	61.61 ± 0.44^{n}	60.32 ± 0.41^{p}	56.58 ± 0.39^{r}
0.5%gum Arabic	66.07 ± 0.48^{g}	65.73 ± 0.40^{g}	64.72 ± 0.46^{i}	62.29 ± 0.47^{m}
1%gum Arabic	68.35 ± 0.51^{d}	67.97 ± 0.39^{d}	66.80 ± 0.47^{f}	63.41 ± 0.41^{k}
1.5% gum Arabic	69.75 ± 0.53^{c}	69.91 ± 0.42^{c}	69.52 ± 0.50^{c}	65.17 ± 0.45^{h}
2% gum Arabic	71.01 ± 0.55^{ab}	71.37 ± 0.54^{a}	70.78 ± 0.53^{b}	67.54 ± 0.40^{e}
Cow milk	63.99 ± 0.42^{j}	62.89 ± 0.41^{l}	60.84 ± 0.52^{o}	58.40 ± 0.38^{q}
$Lsd_{0.05}$	0.4185^{**}			
SE±	0.1472			

Values are mean±SD.

Mean(s) bearing different superscript(s) in columns and rows are significantly different ($P\leq0.05$) according to DMRT.

4.12 Effect of addition of gum Arabic and storage on SNF (%) of camel milk cheese

Table (15) shows the effect of addition gum Arabic and storage period on SNF (%) of cheese. It was decreased by increasing the storage period and increased by increasing the amount of gum Arabic the lowest percentage of SNF% of cheese was in third month for the control sample which was 27.38% this result was similar to the result of Inayat *et al.* (2016) which was 28.66% . This difference may be due to the addition of gum Arabic to the cheese. The highest percentage of SNF (%) in camel milk cheese with 2% gum Arabic in the first month which was 36.01% this result was higher than that reported by Inayat *et al.*(2016) this difference may be due to the addition of gum Arabic to the cheese and increasing the moisture content of cheese by increasing the storage period.

4.13 Effect of addition of gum Arabic and storage on pH-value of camel milk cheese:

Table (16) shows the effect of addition of gum Arabic and storage period on total pH-value (%) of cheese. It was decreased by increasing the storage period and also decreased by increasing the amount of gum Arabic the pH value of control sample at zero time was the highest one (4.69) this result was similar to that reported by Khan *et al.* (2004).this variation of pH value may be due to the activity of lactic acid bacteria.

4.14 Effect of addition of gum Arabic and storage on titratable acidity (as % lactic acid) of camel milk cheese:

Table (17) shows the effect of addition gum Arabic and storage period on titratable acidity of cheese. It was increased by increasing the storage period and amount of gum Arabic the lowest level of titrable acidity of camel milk cheese was in the control sample at zero time which was 0.921 And the highest level of titrable acidity of cheese was in third month in 2% gum

Arabic added which was 2.11 All of this result was lower than that reported by Hailu *et al.* (2014). This variation may be due to lactic acid bacteria and addition of gum Arabic which acts as a prebiotics that activates lactic acid bacteria which metabolize lactose.

4.15 Syneresis

Table (18) shows the effect of addition of gum Arabic on syneresis of cheese from the result shown in the table the samples of the camel milk cheese the highest ratio of whey was in control sample (56%) while the lowest one was in the sample with 1% gum Arabic (49.33%). This results was lower than that reported by Mikulce *et al.* (2015). This difference may be due to the addition of gum Arabic to the cheese which make bridges which bind the milk components and prevent the loss of solid ingredients in whey, in blank sample high whey volume may be due to loss of some milk ingredients in whey. The linkage made by gum Arabic led to increased pressure in the curd leading to increased syneresis and this increased the strength of curd (Walstra, *et al*.,1987).

Table 15: Effect of addition of gum Arabic and storage on SNF (%) of camel milk cheese

Cheese	Storage period (month)			
	0	**1**	**2**	**3**
Control (Without gum Arabic)	30.82 ± 0.25^{g}	29.99 ± 0.21^{i}	29.27 ± 0.21^{j}	27.38 ± 0.26^{k}
0.5%gum Arabic	32.37 ± 0.29^{e}	32.23 ± 0.33^{e}	31.59 ± 0.26^{f}	30.66 ± 0.27^{gh}
1%gum Arabic	33.66 ± 0.30^{cd}	33.38 ± 0.25^{d}	32.61 ± 0.29^{e}	31.19 ± 0.29^{fg}
1.5% gum Arabic	34.93 ± 0.33^{b}	34.91 ± 0.24^{b}	34.19 ± 0.30^{c}	32.54 ± 0.25^{e}
2% gum Arabic	35.61 ± 0.38^{a}	36.01 ± 0.22^{a}	35.61 ± 0.24^{a}	34.05 ± 0.24^{c}
Cow milk	30.87 ± 0.24^{g}	30.11 ± 0.23^{hi}	28.75 ± 0.19^{j}	27.73 ± 0.28^{k}
$Lsd_{0.05}$	0.5987^{**}			
SE±	0.2106			

Values are mean±SD.

Mean(s) bearing different superscript(s) in columns and rows are significantly different ($P\leq0.05$) according to DMRT.

Table 16: Effect of addition of gum Arabic and storage on pH-value of camel milk cheese

Cheese	Storage period (month)			
	0	**1**	**2**	**3**
Control (Without gum Arabic)	4.69 ± 0.13^{ab}	4.60 ± 0.11^{abc}	4.29 ± 0.15^{cde}	3.86 ± 0.19^{fghij}
0.5%gum Arabic	4.58 ± 0.11^{abc}	4.40 ± 0.16^{bcd}	4.21 ± 0.19^{cdef}	3.72 ± 0.11^{hij}
1%gum Arabic	4.47 ± 0.12^{abcd}	4.26 ± 0.19^{cde}	4.08 ± 0.21^{defgh}	3.59 ± 0.10^{ij}
1.5% gum Arabic	4.28 ± 0.10^{cde}	4.14 ± 0.17^{defg}	3.98 ± 0.24^{efghi}	3.66 ± 0.15^{ij}
2% gum Arabic	4.15 ± 0.09^{def}	3.90 ± 0.14^{efghij}	3.81 ± 0.26^{fghij}	3.57 ± 0.17^{j}
Cow milk	4.83 ± 0.15^{a}	4.75 ± 0.18^{ab}	4.43 ± 0.28^{bcd}	3.75 ± 0.18^{ghij}
$Lsd_{0.05}$	0.3444^{*}			
SE±	0.1211			

Values are mean±SD.

Mean(s) bearing different superscript(s) in columns and rows are significantly different ($P\leq0.05$) according to DMRT.

Table 17: Effect of addition of gum Arabic and storage on titrable acidity (as % lactic acid) of cheese

Cheese	Storage period (month)			
	0	**1**	**2**	**3**
Control (Without gum Arabic)	0.921 ± 0.05^{n}	0.987 ± 0.06^{mn}	1.089 ± 0.11^{lm}	1.677 ± 0.12^{de}
0.5%gum Arabic	1.133 ± 0.09^{kl}	1.255 ± 0.05^{ij}	1.344 ± 0.10^{hi}	1.833 ± 0.10^{bc}
1%gum Arabic	1.222 ± 0.11^{jk}	1.389 ± 0.08^{gh}	1.489 ± 0.13^{fg}	1.889 ± 0.08^{b}
1.5% gum Arabic	1.266 ± 0.12^{ij}	1.533 ± 0.09^{f}	1.600 ± 0.15^{ef}	1.922 ± 0.06^{b}
2% gum Arabic	1.522 ± 0.08^{f}	1.733 ± 0.10^{cd}	1.710 ± 0.17^{d}	2.111 ± 0.05^{a}
Cow milk	0.916 ± 0.04^{n}	0.968 ± 0.05	0.988 ± 0.06^{n}	1.566 ± 0.09^{f}
$Lsd_{0.05}$	0.1038^{*}			
SE±	0.03651			

Values are mean±SD.

Mean(s) bearing different superscript(s) in columns and rows are significantly different ($P\leq0.05$) according to DMRT.

Table 18: Syneresis (100ml)

Cheese	Mean±SD
Control (Without gum Arabic)	56.00 ± 0.00^{b}
0.5%gum Arabic	52.67 ± 0.58^{c}
1%gum Arabic	49.33 ± 0.58^{d}
1.5% gum Arabic	50.67 ± 1.53^{cd}
2% gum Arabic	50.33 ± 058^{cd}
Cow milk	88.00 ± 3.00^{a}
$Lsd_{0.05}$	2.551^{*}
SE±	0.8278

Means having different superscripts are significantly different ($P\leq0.05$).

4.16 Effect of addition of gum Arabic and storage on total viable bacterial count (log_{10} cfu/g) of cheese:

Table (19) shows the effect of addition of gum Arabic and storage on total viable bacterial count (log_{10}cfu/g) of cheese. There are no significant differences; the average total viable bacterial count (log_{10}cfu/g) was 3.5. These results are similar to that reported by Salim (2017) and not compliant with SSMO (2011). These result may be due to the inhibition factor of microorganisms by the salt and lactic acid (Kosikowski, 1977; Walstera, 1999).

4.17 Effect of addition of gum Arabic and storage on *Staphylococcus aureus* (log_{10} cfu/g) of cheese:

Table (20) shows the effect of addition of gum Arabic and storage on *Staphylococcus aureus* on cheese .There are no significant differences, the average number of *Staphylococcus aureus* (log_{10}cfu/g) was 3.1. These results are higher than that reported by Menendez *et al*, (2001) and Salim (2017) and not compliant with SSMO (2011).) presence of *Staphylococcus aureus* in food products indicated the contamination from skin, mouth and nose of employees.

4.18 The Effect of addition of gum Arabic and storage on *yeasts* and *moulds E. coli, Salmonella, Shigella* and *Brucella* of cheese

Yeasts, moulds, *E.coli*, *Salmonella, Shigella* and *Broucella* were not detected.

This results shows the effect of the addition of gum Arabic and storage to *Salmonella*, *Shigella* ,*Brocella* ,*yeasts* and *moulds* and E. coli, where no growth in all cheese samples this results were in a good agreement with SSMO,(2013). The presence of antimicrobial substances such as lactoperoxidase, hydrogen peroxide and lysozyme of camel milk can reduce

the counts of pathogens, also the presence of lactic acid bacteria and salt in cheese prevent the growth of pathogenic microbes.

4.19 Sensory evaluation:

Table (21) shows sensory evaluation of cheese samples about colour camel milk cheese control sample was moderately acceptable and in sample with 1% this result was in a good agreement with the finding by EL Zubeir, (2008) and was 2 %. unacceptable this result were not similar to those reported by Hssab Elnabi (2011), about the taste the mean score in the sample with 1% gum Arabic was moderaty acceptable this result was in a good agreement with the finding by EL Zubeir (2008).and in camel milk cheese sample with 2% gum Arabic was moderately unacceptable this result were not similar to those reported by Hssab Elnabi (2011). About flavor the mean score in the sample with .5% gum Arabic was moderately bland and in sample with 1% gum Arabic was .moderately intense this result was in a good agreement with the finding by EL Zubeir, (2008). . about the texture the mean score in the control sample was Slightly Tough this result were not similar to those reported by EL Zubeir, (2008)., on the other hand the sample with 1% gum Arabic was soft. And about general acceptability the mean score in the sample with 2% was. moderately unacceptable this result was not similar to those reported by EL Zubeir, (2008) while in the sample with 1% gum Arabic the mean score was. moderately acceptable this result was in a good agreement with the finding by Ramet (1999).

Table 19: Effect of addition gum Arabic and storage on total viable bacterial count (log_{10} cfu/g) of cheese

Cheese	Storage period (month)			
	0	1	2	3
Control (Without gum Arabic)	3.564±0.15[a]	3.569±0.10[a]	3.561±0.14[a]	3.556±0.17[a]
0.5%gum Arabic	3.559±0.11[a]	3.566±0.15[a]	3.560±0.11[a]	3.558±0.12[a]
1%gum Arabic	3.563±0.14[a]	3.568±0.19[a]	3.560±0.12[a]	3.556±0.11[a]
1.5% gum Arabic	3.448±0.10[b]	3.565±0.13[a]	3.562±0.10[a]	3.557±0.10[a]
2% gum Arabic	3.563±0.12[a]	3.569±0.16[a]	3.562±0.13[a]	3.556±0.14[a]
Cow milk	3.559±0.13[a]	3.564±0.17[a]	3.563±0.15[a]	3.557±0.16[a]
$Lsd_{0.05}$	0.07342*			
SE±	0.02582			

Values are mean±SD.

Mean(s) bearing different superscript(s) in columns and rows are significantly different (P≤0.05) according to DMRT.

Table 20: Effect of addition gum Arabic and storage on *Staphylococcus aureus* (log_{10} cfu/g) of cheese

Cheese	Storage period (month)			
	0	**1**	**2**	**3**
Control (Without gum Arabic)	3.139 ± 0.12^{a}	3.170 ± 0.15^{a}	3.137 ± 0.14^{a}	3.130 ± 0.18^{a}
0.5%gum Arabic	3.153 ± 0.16^{a}	3.172 ± 0.12^{a}	3.142 ± 0.19^{a}	3.135 ± 0.14^{a}
1%gum Arabic	3.136 ± 0.13^{a}	3.157 ± 0.18^{a}	3.137 ± 0.17^{a}	3.123 ± 0.16^{a}
1.5% gum Arabic	3.151 ± 0.17^{a}	3.163 ± 0.16^{a}	3.143 ± 0.18^{a}	3.132 ± 0.11^{a}
2% gum Arabic	3.136 ± 0.20^{a}	3.159 ± 0.11^{a}	3.134 ± 0.12^{a}	3.123 ± 0.12^{a}
Cow milk	3.150 ± 0.19^{a}	3.158 ± 0.09^{a}	3.142 ± 0.11^{a}	3.132 ± 0.15^{a}
$Lsd_{0.05}$	0.05191^{NS}			
SE±	0.01826			

Values are mean±SD.

Mean(s) bearing different superscript(s) in columns and rows are significantly different ($P\leq0.05$) according to DMRT.

Table 21: Sensory evaluation of cheese samples

Cheese	Quality attributes				
	Colour	Taste	Flavour	Texture	General acceptability
	Scores				
Control (Without gum Arabic)	2.14±0.69^{c}	3.33±0.06^{d}	3.85±0.04^{b}	6.54±0.06^{a}	3.40±0.18^{a}
0.5%gum Arabic	4.22±0.01^{b}	3.60±0.07^{c}	4.95±0.04^{a}	3.47±0.01^{e}	3.50±0.27^{a}
1%gum Arabic	4.41±0.13^{b}	2.44±0.09^{e}	2.57±0.11^{d}	2.27±0.07^{f}	2.37±0.02^{a}
1.5% gum Arabic	6.25±0.01^{a}	4.23±0.01^{b}	3.35±0.11^{c}	4.88±0.09^{d}	4.62±0.06^{a}
2% gum Arabic	6.52±0.14^{a}	5.24±0.06^{a}	3.35±0.03^{c}	5.92±0.06^{c}	5.49±0.24^{a}
Cow milk	1.54±0.38^{d}	3.68±0.01^{c}	3.88±0.01^{b}	6.26±0.03^{b}	3.67±0.01^{a}
$Lsd_{0.05}$	0.59*	0.1125*	0.1258*	0.09744*	0.2923*
SE±	0.1915	0.03651	0.04082	0.03162	0.09487

Values are mean±SD.

Mean(s) bearing different superscript(s) in a column are significantly different ($P \leq 0.05$) according to DMRT.

Values are mean±SD.
Mean(s) bearing different superscript(s) in a column are significantly different ($P \leq 0.05$) according to DMRT

4.20. Porosity of cheese samples using transmission electron microscopy (TEM) micrographs:

Table (22) shown the quantification of coagulum interior porosity using TEM micrographs it revealed that no significant difference. The high coagulum porosity were in camel milk cheese with 0.5% and 2% gum Arabic respectively and the lower porosity were in camel milk cheese with 1 and 1.5% gum Arabic, respectively these results may be due to the performance of gum Arabic which make bridges by gum Arabic which bind the milk components and lead increased pressure and expulsion of larger amount of whey, causes the reduction of pores of milk coagulum (Idris, 2000;Calleros *et al*.2008).

4.21 Microstructure

TEM micrographs of cheese samples are shown in Figure 7,8,9,10,11 and 12 respectively. Pores of milk coagulum of camel milk cheese with 1% and 1.5% appear smaller than those of other samples. The results showed that the porosity was decrees by increasing the ratio of gum Arabic .These results may be due to the effect of gum Arabic in the cured which make bridges which bind the milk components and lead increased pressure and expulsion of larger amount of whey, causes the reduction of pores of milk coagulum (Idris, 2000; Calleros *et al*.2008).

Table 22: Porosity of cheese samples using transmission electron microscopy (TEM) micrographs

Cheese	Coagulum porosity (arcsine value)
Control (Without gum Arabic)	53.71^{a} ±0.00
0.5%gum Arabic	58.92^{a} ±13.73
1%gum Arabic	49.42^{a} ±11.06
1.5% gum Arabic	49.81^{a} ±14.12
2% gum Arabic	58.42^{a} ±0.56
Cow milk	53.84^{a} ±6.96
$Lsd_{0.05}$	1.255^{NS}
SE±	0.4074

Values are mean±SD.

Mean(s) bearing different superscript(s) in a column are significantly different ($P \leq 0.05$) according to DMRT.

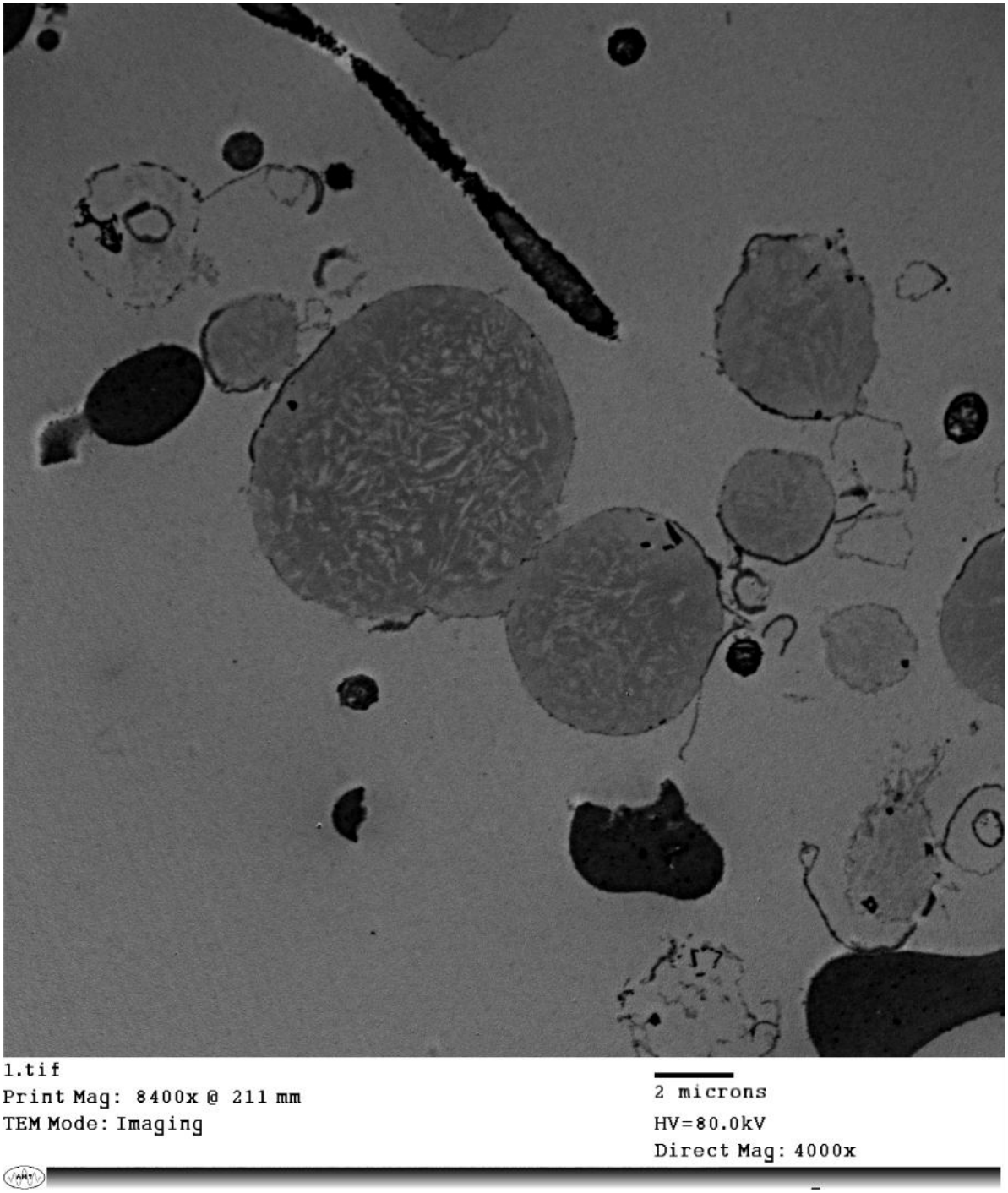

Figure 9: TEM micrograph of Camel milk cheese (without gum Arabic).

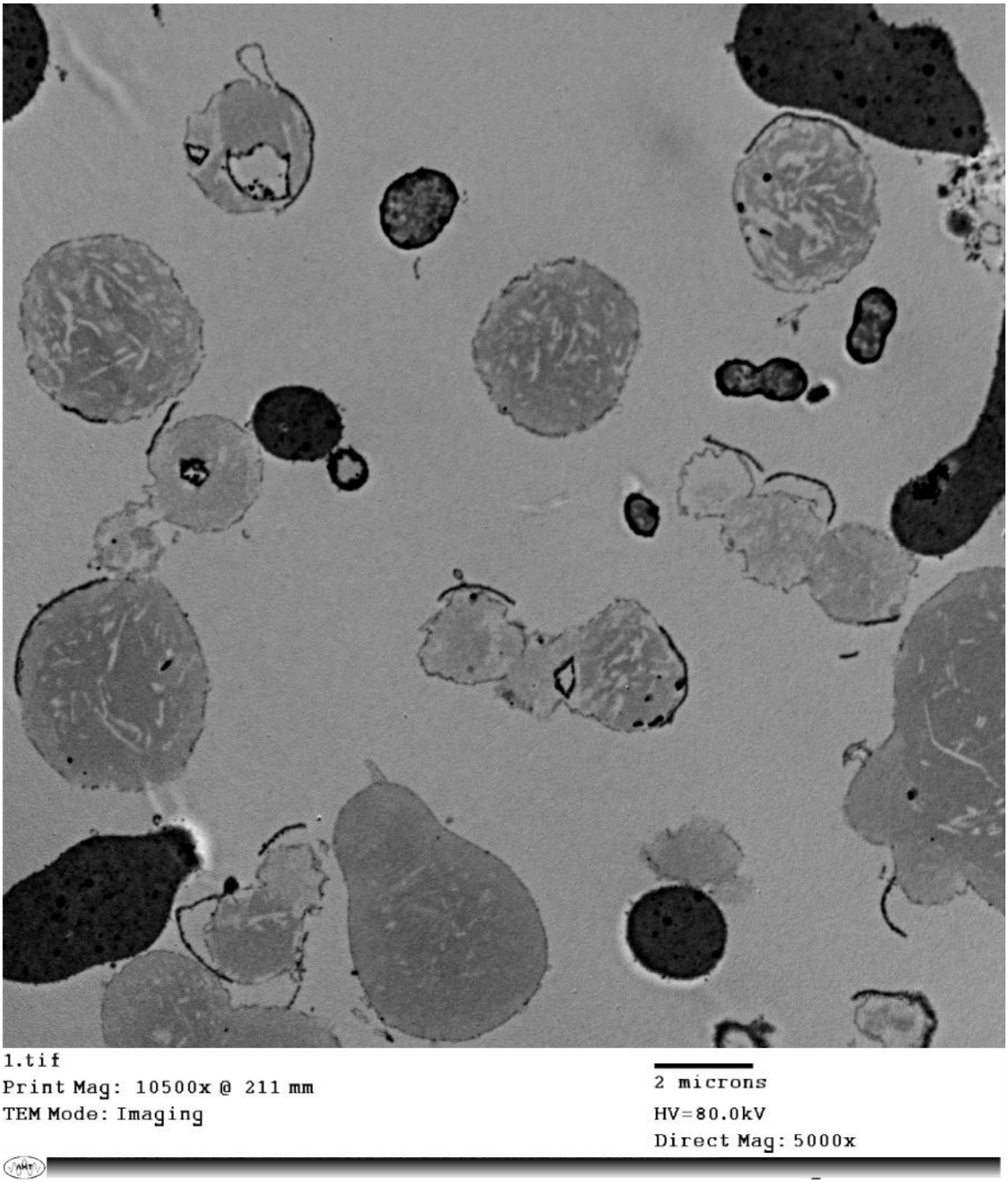

Figure 10: TEM micrograph of Camel milk cheese with (0.5% gum Arabic).

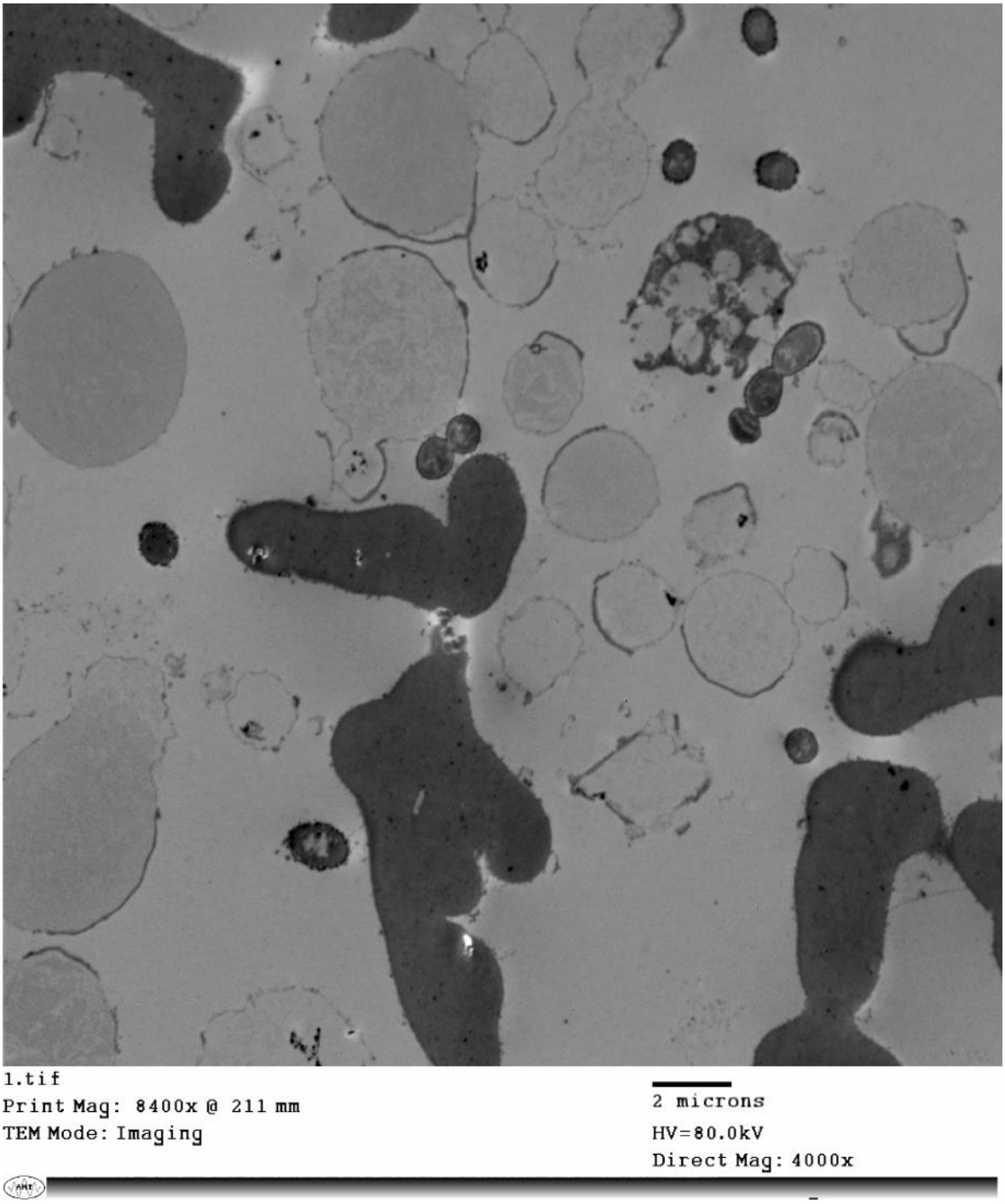

Figure 11: TEM micrograph of Camel milk cheese with (1% gum Arabic)

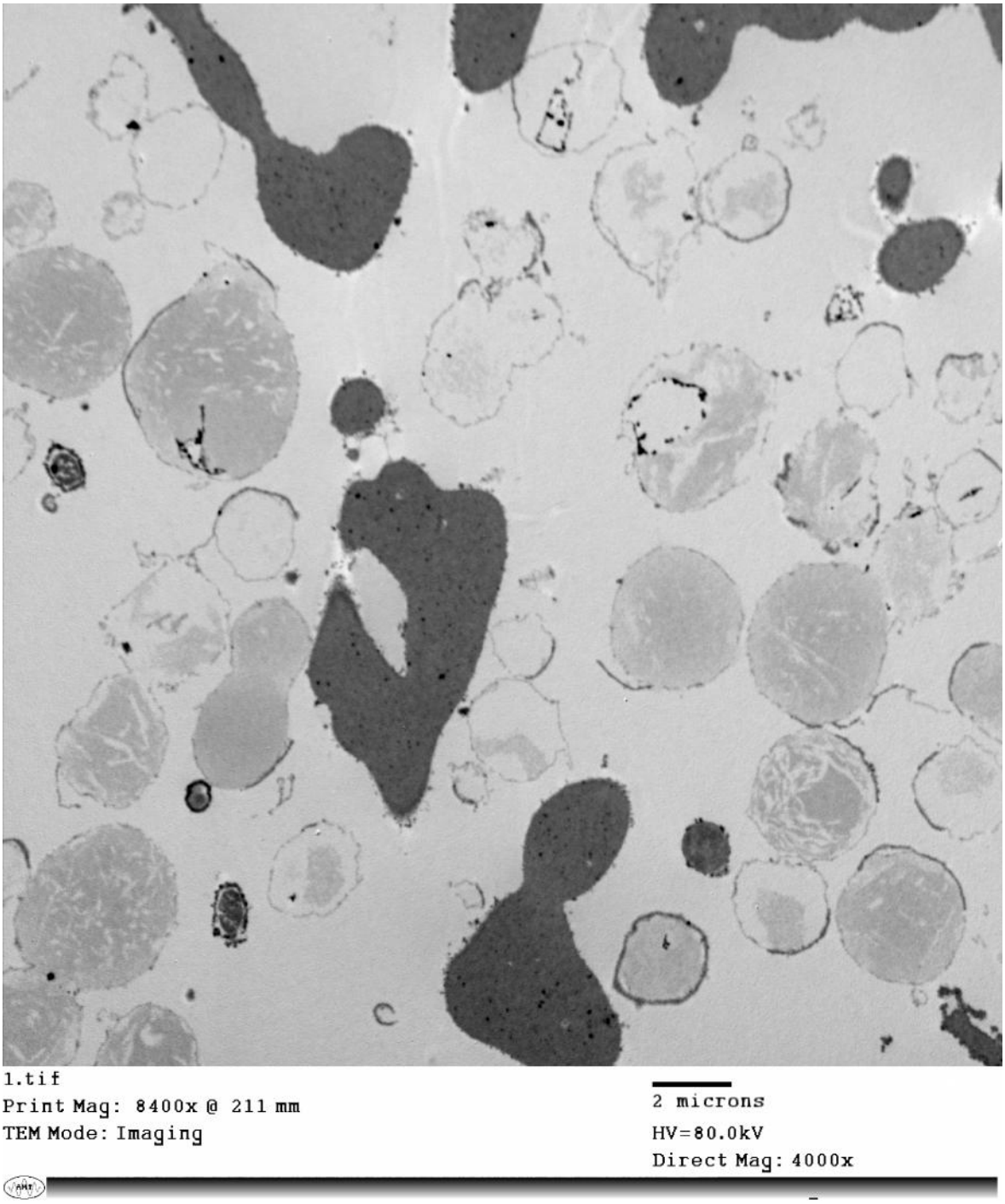

Figure 12: TEM micrograph of Camel milk cheese with (1.5% gum Arabic)

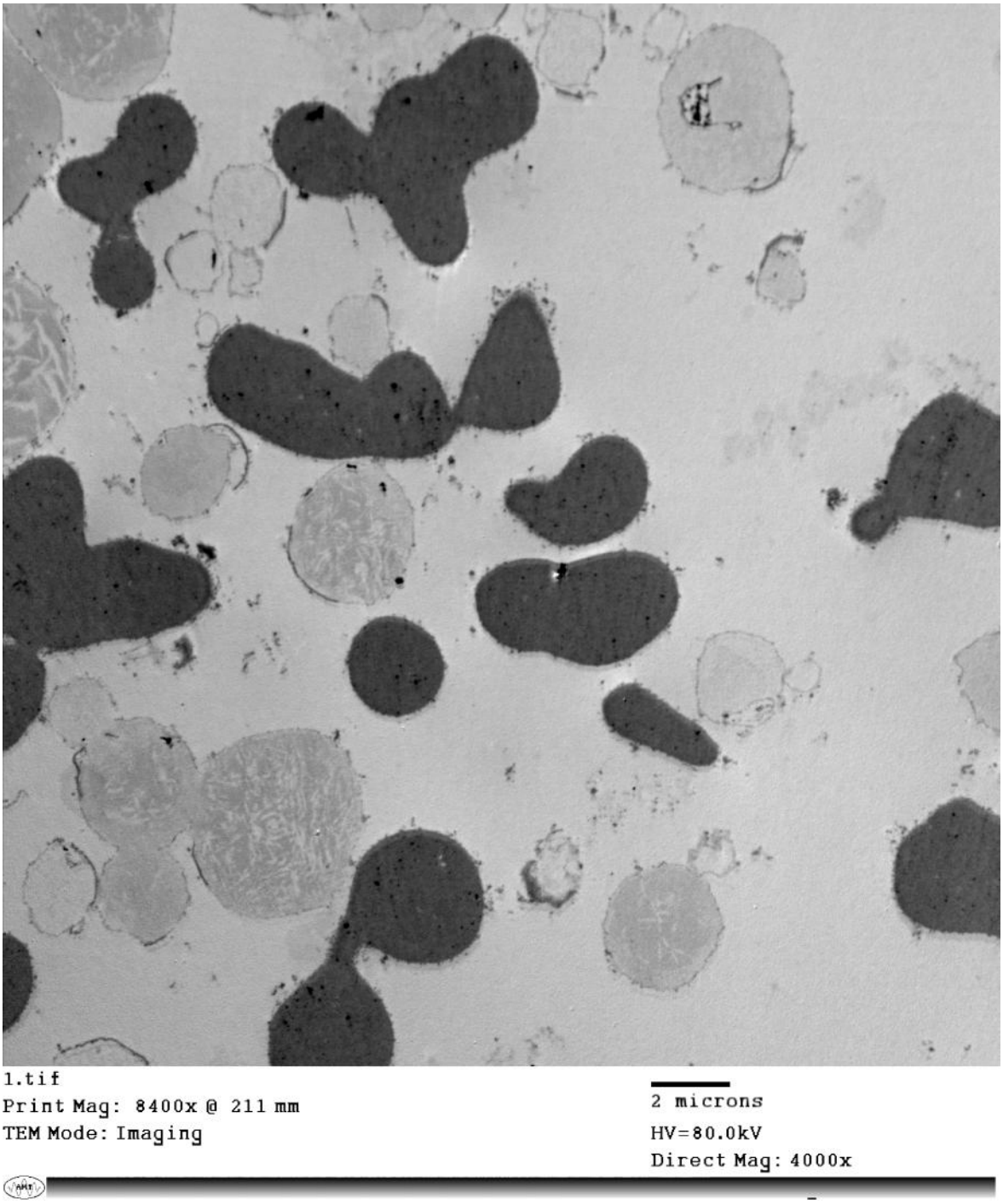

Figure 13: TEM micrograph of Camel milk cheese with (2% gum Arabic).

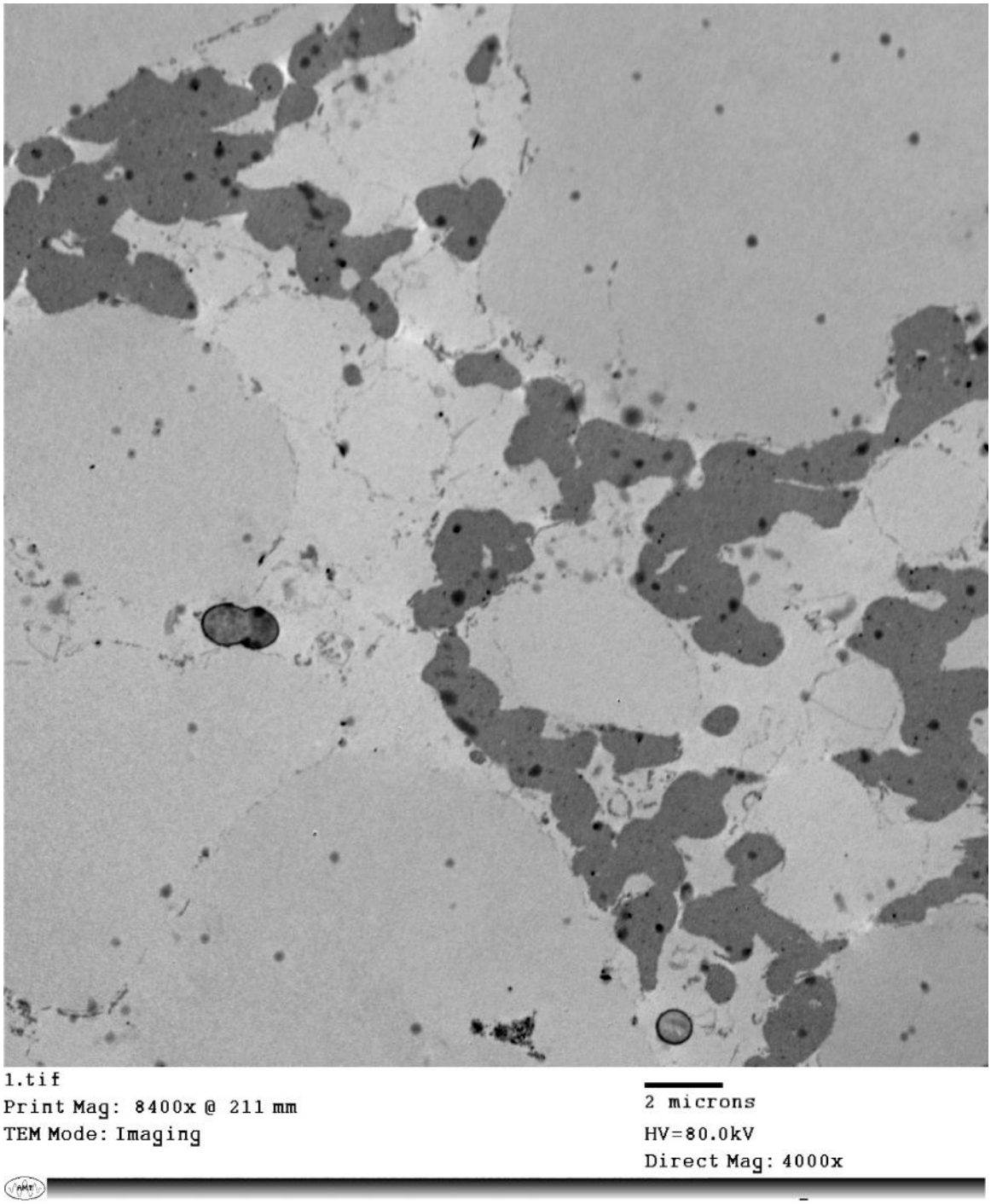

Figure 14: TEM micrograph of Cow milk cheese

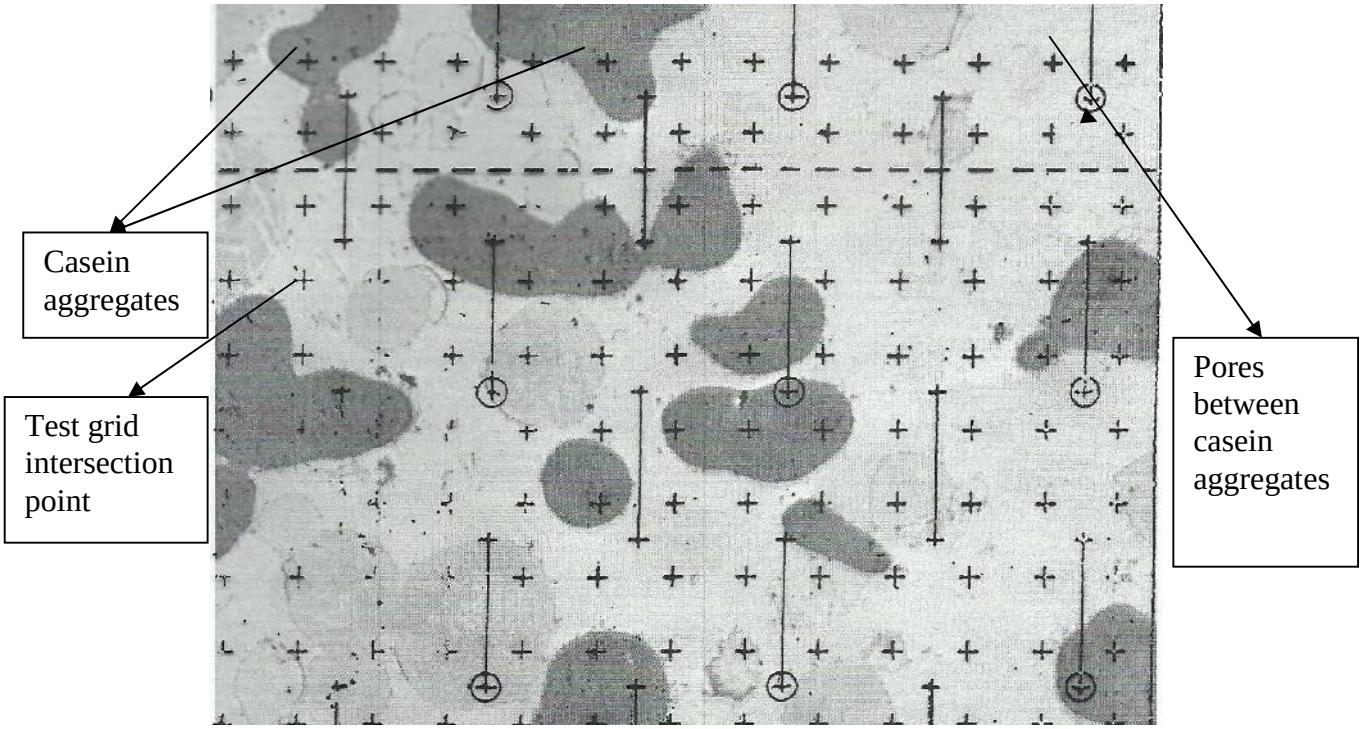

Figure 15: Test Grid superimposed on TEM micrograph of camel milk cheese

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Addition of gum Arabic increased camel milk cheese yield significantly. Gum Arabic leavels and the storage period influenced the physicochemical properties of the camel milk cheese moisture content (%) of cheese it was increased by increasing the storage period and it was decreasing by increasing the percentages of gum Arabic .On the other hand the crude protein, fat content ,ash content total soluble solid and TNF was decreased by increasing the storage period and increased by increasing the amount of gum Arabic. The lactose appeared only in a blank sample and a sample of cow's milk. pH-value was decreased by increasing the storage period and also decreased by increasing the amount of gum Arabic. The titratable acidity of cheese. It was increased by increasing the storage period and amount of gum Arabic. Making cheese from camel milk helps to get rid of some pathogenic microbes such as *E.coli* .The use of gum Arabic in the manufacture of camel milk cheese at1% gum Arabic gave the desired flavor taste, texture and general acceptability in cheese. Porosity of camel milk cheese was decrees by increasing the ratio of gum Arabic.

5.2 Recommendations

Use of gum Arabic as an additive to produce cheese from camel milk. Conduct further research on the manufacture of cheese from camel milk and the addition of gum Arabic during the manufacture of camel milk cheese for its obvious contribution in improving some of the properties of camel milk cheese. Using gum Arabic to improve the quality of camel milk cheese.

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APPENDICES

Sensory Evaluation Sheet

Name :……..

/ / Date :

Over all acceptability	Texture	Taste	Flavor	Color	Sample code
A					
B					
C					
D					
E					
F					

Key

Color, Taste and Over allacceptability	Flavor	Texture
1.Highiy acceptable	1. Extremely intense	1.Very Soft
2. Moderately acceptable	2. Intense	2.Soft
3.Slightly acceptable	3.Moderately intense	3.Slightly soft
4. Slightly Unacceptaple	4. Slightly intense	4.Slightly Tough
5. Moderately unacceptable	5. Moderately bland	5. Tough
6. unacceptable	6. Slightly bland	6.Very Tough