Sudan University of Science and Technology

College of Graduate Studies

Comparative Study of Physicochemical Properties of Cow, Goat and Camel Milk

دراسة مقارنة للخصائص الفيزيائية الكيميائية للبن البقر والماعز والإبل

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الآية

بسم الله الرحمن الرحيم

قال تعالى:

(وَمَا مِنْ دَابَّةٍ فِي الْأَرْضِ وَلَا طَائِرٍ يَطِيرُ بِجَنَاحَيْهِ إِلَّا أُمَمٌ أَمْثَالُكُمْ مَا فَرَّطْنَا فِي الْكِتَابِ مِنْ شَيْءٍ ثُمَّ إِلَى رَبِّهِمْ يُحْشَرُونَ).

صدق الله العظيم

سورة الأنعام الآية (38)

Dedication

To soul of my Mother,

To my Father,

To my friends

Acknowledgment

Firstly and lastly thanks to **ALLAH** who gave me persistence, and patience to complete this work. No words can adequately express my deep gratitude to my supervisor **Dr. Ahmed Khalil Ahmed** for generously providing and for patience, constant support, advices and insight was invaluable to me. He is always available not only for consultation but also to solve any difficulties. Then I wish to express grateful thanks to administration of Sudan University of Science and Technology, College of Agricultural Studies for allowing me to conduct my research and providing any assistance requested. Gratitude also extended to all people and friends that assisted me in this research.

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List of Contents

List of Tables

List of Figures

Title **Page No.**

Abstracts

This study was carried out to evaluate and compare the physicochemical properties of milk samples from three types of animals: cows, goats and camels. The milk samples were collected from 3 animals, (3×3) (Cow, Goats and Camels) individually from East of the Nile,)Khartoum- State) and analyzed for physicochemical properties including: moisture, fat, protein, ash lactose, total solids, pH, total acidity, freezing point, Boiling point, and specific gravity.

The results showed that cow's milk contains 88.66% moisture, fat, 3.38% , 3.46% protein, 0.64% ash , 4.89% lactose, 11.33% total solid, pH value 6.43, total acidity 0.16%, freezing point -0.55 C°,, boiling point 91.33C° and specific gravity 1.034.

Goat milk had moisture, 90.40%, fat, 2.44% , 3.68%, proteins, 0.80% ash, 4.27% lactose, 9.53% total solids, and, pH value 6.47, total acidity 0.15%, freezing point – 0.54C°, boiling point 77C° and specific gravity 1.035.

While camel milk score 90.94% moisture, 2.91% fat, 2.71% protein, 0.70% ash, 3.18% lactose, 9.05% total solids, 6.59 pH, 0.18% total acidity, freezing point -0.53 C°, boiling point 86.33C° and specific gravity 1.034.

ملخص الأطروحة

أجريت هذه الدراسة لتقييم ومقارنة الخصائص الفيزيائية الكيميائية لعينات اللبن من 3 أنوع من الحيوانات (الأبقار- الماعز- الإبل) جمعت عينات اللبن لـ (3×3) (الأبقار- الماعز- الإبل) بالترتيب. من شرق النيل- ولاية الخرطوم وحللت الخصائص الفيزيائية الكيميائية التي تضم :الرطوبة، الدهن، البروتين، الرماد، اللاكتوز، الجوامد الصلبة، تركيز أيون الهدروجين (pH)، الحموضة الكلية، نقطة التجمد، نقطة الغليان والكثافة النوعية.

أوضحت النتائج أن لبن الأبقار يحتوي على88.66% رطوبة، 3.38% دهن، 3.46% بروتين، 0.64% رماد، 4.49% لاكتوز، 11.33% جوامد صلبة كلية، قيمة تركيز الهيدروجين (pH) 6.43، الحموضة 0.16%، نقطة التجمد 0.55- م^{0}، نقطة الغليان 91.33 م^{0} والكثافة النوعية 1.034.

لبن الماعز يحتوي على 90.40% رطوبة،2.44% دهن،3.68% بروتين،0.80% رماد، 4.27% لاكتوز، 9.53% جوامد كلية صلبة، وقيمة تركيز أيون الهيدروجين (pH) 6.47%، حموضة 0.15%، نقطة التجمد 0.54- م^{0}، نقطة الغليان 77 م^{0} والكثافة النوعية 1.035.

بينما كان محتوى لبن الإبل 90.94% رطوبة،2.91% دهن، 2.71% بروتين،0.70% رماد، 3.18% لاكتوز، 9.05% جوامد كلية صلبة، وقيمة تركيز أيون الهيدروجين 6.59، 0.18% حموضة، نقطة التجمد 0.53- م^{0} ، نقطة الغليان 86.33 م^{0} والكثافة النوعية 1.034.

CHAPTER ONE

INTRODUCTION

FAO (2015) Mentioned that milk provides essential nutrients and is an important source of dietary energy, high-quality proteins and fats. Milk can make a significant contribution to the required nutrient intakes for calcium, magnesium, selenium, riboflavin, vitamin B12 and panto thenic acid. Milk and milk products are nutrient-dense foods and their consumption can add diversity to plant-based diets. Animal milk can play an important role in the diets of children in populations with very low fat intakes and limited access to other animal source foods. The species of dairy animal, its breed, age and diet, along with the stage of lactation, parity (number of parturitions), farming system, physical environment and season influence the colour, flavour and composition of milk and allow the production of a variety of milk products.

Milk is an almost ideal food having high nutritive value. It supplies body building proteins, bone forming minerals and furnishes energy giving lactose and milk fat. Besides supplying certain essential fatty acids, it contains the above nutrients in an easily digestible (Vishweshwar *at al.,* 2005).

Cow milk fat constitutes approximately 3 to 4 percent of the solid content of cow milk, protein about 3.5 percent and lactose 5 percent, but the gross chemical composition of cow milk varies depending on the breed. For example, the fat content is usually higher in Bos indicus than *B. taurus* cattle. The fat content of milk from *B. indicus* cattle can be as much as 5.5 percent.Buffalo milk has a very high fat content, which is on average twice as high as that of cow milk. The fat-to-protein ratio in buffalo milk is about 2:1. Compared with cattle milk, buffalo milk also has a higher casein-to-protein ratio. The high calcium content of casein facilitates cheese making Camel milk has a similar composition to cow milk but is slightly saltier. Generally,

Camel milk is consumed raw or fermented. Sheep milk has higher fat and protein contents than goat and cow milk; only buffalo and yak milk contain more fat. Sheep milk also generally has higher lactose content than milk from cows, buffaloes and goats. The high protein and overall solid contents of sheep milk make it particularly appropriate for cheese and yoghurt making. Goat milk has a similar composition to cow milk. In Mediterranean countries and in Latin America, goat milk is generally transformed into cheese; in Africa and South Asia, it is usually consumed raw or acidified milk provides essential nutrients and is an important source of dietary energy, high-quality proteins and fats. Milk can make a significant contribution to the required nutrient intakes for calcium, magnesium, selenium, riboflavin, vitamin B12 and pantothenic acid. Milk and milk products are nutrient-dense foods and their consumption can add diversity to plant-based diets. Animal milk can play an important role in the diets of children in populations with very low fat intakes and limited access to other animal source foods. The species of dairy animal, its breed, age and diet, along with the stage of lactation, parity (number of parturitions), farming system, physical environment and season influence the colour, flavour and composition of milk and allow the production of a variety of milk products.(Raw milk facts,2012).

The specific objectives of this research are:-

- To Compare the Physicochemical Properties of the milk of the species of animal three (Cow, Goat and Camel).
- To analyze deference samples of cow, goat and camel milk for physicochemical properties.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition of Milk

Milk is a white creamy suspension secreted by all species of mammals to supply nutrition and immunological protection to their infants. In its processed form may be whole full fat, semi skimmed and low fat milk (Adolfson, 2004).

2.2 Importance of Milk 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 (Haung *et al.,* 2007). 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 (Adolfson, 2004). Milk also contains calcium, phosphorus, magnesium, and potassium. The calcium found in milk is readily absorbed by the body; Vitamin D plays a role in calcium absorption and utilization. Milk is also a significant source of riboflavin (vitamin B2), which helps promote healthy skin and eyes, the main dietary source of calcium and vitamin D are dairy products (Adolfson, 2004).

2.3 Sudan Cattle Breeds and their Milk Productivity

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 (Musa *et al.,* 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 *et al.,* 2005).

2.4 Milking animals

Milk provides essential nutrients and is an important source of dietary energy, high-quality proteins and fats. Milk can make a significant contribution to the required nutrient intakes for calcium, magnesium, selenium, riboflavin, vitamin B12 and pantothenic acid. Milk and milk products are nutrient-dense foods and their consumption can add diversity to plant-based diets. Animal milk can play an important role in the diets of children in populations with very low fat intakes and limited access to other animal source foods. The species of dairy animal, its breed, age and diet, along with the stage of lactation, parity (number of parturitions), farming system, physical environment and season influence the colour, flavour and composition of milk and allow the production of a variety of milk products (FAO, 2015).

2.4.1 Cow milk

Fat constitutes approximately 3 to 4 percent of the solid content of cow milk, protein about 3.5 percent and lactose 5 percent, but the gross chemical composition of cow milk varies depending on the breed. For example, the fat content is usually higher in Bos indicus than *B. taurus* cattle. The fat content of milk from *B. indicus* cattle can be as much as 5.5 percent (FAO, 2015).

2.4.2 Goat milk

Similar composition to cow milk. In Mediterranean countries and in Latin America, goat milk is generally transformed into cheese; in Africa and South Asia, it is usually consumed raw or acidified (FAO, 2015).

2.4.3 Camel milk

Similar composition to cow milk but is slightly saltier. Camel milk can be three times as rich in vitamin C as cow milk and represents a vital source of this vitamin for people living in arid and semi-arid areas, who often cannot obtain vitamin C from fruits and vegetables. Camel milk is also rich in unsaturated fatty acids and B vitamins. Milk from Bactrian camels has a higher percentage of fat than milk from dromedaries, but levels of proteins and lactose are similar. Generally, camel milk is consumed raw or fermented (FAO, 2015).

2.4.4 Buffalo milk

It has very high fat content, which is on average twice as high as that of cow milk. The fat-to-protein ratio in buffalo milk is about 2:1. Compared with cattle milk, buffalo milk also has a higher casein-to-protein ratio. The high calcium content of casein facilitates cheese making (FAO, 2015).

2.4.5 Sheep milk

Sheep milk has higher fat and protein contents than goat and cow milk; only buffalo and yak milk contain more fat. Sheep milk also generally has higher lactose content than milk from cows, buffaloes and goats. The high protein and overall solid contents of sheep milk make it particularly appropriate for cheese and yoghurt making. Milk from sheep is important in the Mediterranean region, where most of it is processed into cheeses such as pecorino, caciocavallo and feta (FAO, 2015).

2.5 Animal feed

Feeds have been the primary inputs affecting milk production and livestock nutrition. Inadequate livestock nutrition is a common problem in the developing world, and is a major factor affecting the development of a viable livestock industry. It is recognized that there is a significant role that improved animal feed and feeding practices can play in the long-term alleviation of rural poverty and their specific benefits to rural poor such as increased livestock productivity, household feed security and income (www.ifadorg.com, 2006). Poor nutrition can lead to morbidity and death of young calves, low milk yield, reproduction inefficiencies and short lactation period in milking cows. Because of the increased demand for animal feed new technologies and techniques need to be developed and transferred in order to avoid environmental deterioration or increase in the prices of animal feed and human food (Musa *et al.,* 2005).Therefore, dairy breeders should be aware of feeding and feeding management systems. The goal of most dairy breeders is to maximize milk production in a cost effective manner. Economically, it is important to maximize feed intake, improve efficiency of feed use, and lower feeding cost. Many dairy breeders fail to realize that, but successfully implementing management strategies to maximize feed intake will determine

how well a balance diet support milk production. An optional feeding programme usually consists of a balanced ration and management for maximal feed intake (www.ifadorg.com, 2006).

2.6 Chemical composition of milk

Milk is a major source of dietary energy, protein and fat, contributing on average 134 kcal of energy/capita per day, 8 g of protein/capita per day and 7.3 g of fat/capita per day in 2009 (FAOSTAT, 2012).

2.6.1 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 %. Whey proteins (20 % in milk) digested rapidly compared to casein proteins thus providing greater quantities of essential amino acids (Haug *et al.,* 2007). Evidence suggests that whey proteins found naturally in milk increase muscle protein synthesis which in combination with physical activity can enhance skeletal muscle (Tipton *et al.,* 2004). Alpha lactalbumin is a calcium binding protein enhancing calcium absorption and also supports biosynthesis of lactose which is an important energy source for newborn babies (De Wit, 1998). In addition to that, alpha lactalbumin is also an excellent source of the essential amino acids tryptophan and cysteine. Tryptophan helps to regulate the pain perception and appetite. Serum albumin binds free fatty acids in blood exhibiting immune enhancement (De Wit, 1998). Milk proteins (caseins) also have various physiological roles as ion carriers, lactose synthesis in mammary glands, immune modulation, immune protection, antimicrobial, antiviral, ant oxidative and ant carcinogenic agents (Saxelin *et al.,* 2003). Due to increasing free amino groups in yogurt and activity of proteolytic enzymes, the bacterial predigestion of milk proteins in

yogurt makes this product more easily digested than milk proteins. Yogurt also provided higher feed efficiency and a better growth compared to milk and other fermented milk products in rats (Tipton *et al.,* 2004).

There is no important difference in cow’s milk and goat’s milk protein composition. But the physical characteristics of the curd that these proteins formed under the action of rennin (the principal enzyme secreted by the newborn stomach) is significant. Generally, the softer the curd, the more easily it is digested. The curd of cow’s milk is harder than the curd of goat’s milk. Size also has something to do with its digestibility- and the curd of cow’s milk is large and dissolves more slowly. The finer curd of goat’s milk dissolves more rapidly. This means that for some people with digestive difficulties, goat’s milk may be more easily digested (Saxelin *et al.,* 2003). Casein fractions being isolated in camel milk were found to be homologous with bovine casein. However, the balance between the different casein fractions is very different; for example, the amount of kappa casein is only about 5 percent of the total casein in camel milk compared with about 13.6 percent in bovine casein. Also the molecular weights and amino acid composition of casein fractions differ from those of cow's milk (Tipton *et al.,* 2004).

2.6.2 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. Conjugated linoleic acid is an unsaturated fatty acid, containing isomers of linoleic acid found in the milk of cows, sheep and goats. Conjugated linoleic acids (CLA) are found in yogurts, they help to prevent colon and breast cancer as they are strong antioxidant constituents of milk fat (Hennessy *et al.,* 2007). CLA also helps reduce the risk of heart disease (De Wit, 1998). The high proportion of butterfat gives goat milk a greater energy value per unit volume than cow’s milk. Fat is a concentrated source of energy and in general, one unit of fat contains 2.5 times more energy than one unit of carbohydrate (Adolfson, 2004).The total free fatty acids (FFA) concentration in camel milk is 1.36 μmol/ml. Saturated fatty acids content is 62.5% of FFA and is the same as that of the cow milk. That of the goat milk is 74.5%. Camel milk lacks short chain (C4- C8) fatty acids (FA) while the middle chain (C9 - C14) FA are lower than those of goat and cow milk. The long chain (C16 - C20) FA content of the camel milk is higher than that of both goat and cow milk (Cardak *et al*., 2003). The natural antimicrobial proteins like lysozyme in camel milk, is higher (648 µg/100ml) than the cow's milk, which is 120 µg/100ml (Farah, 1996).

2.6.3 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). It also helps in the absorption of calcium and magnesium and is less carcinogenic compared to other sugars. Lactose prevents infection by stimulating bifidobacterium in the colon thus improving colon health (Adolfson *et al.,* 2004). Active cultures in yogurt help digest lactose thereby making it suitable for lactose intolerant people (Saxelin *et al.,* 2003). The lactose content of goat's milk is slightly lower than cow's milk. Lactose is a milk sugar and is the carbohydrate nutrient in milk. Since some people have difficulty digesting the lactose in milk, goat milk is less likely to cause this problem than cow's milk (Adolfson, 2004).The average lactose content of camel milk is slightly lower (4.62%) than cow's milk (4.80%). It seems, however, that the variability is higher, with extreme values between 2.90 to 5.80 percent in camel milk compared with 4.40 to 5.80 percent in cow's milk (Haug *et al.,* 2007). Chemically lactose is composed of one molecule each of glucose and galactose.

2.6.4 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). Goat's milk generally contains more calcium, phosphorus, chlorine, magnesium, and potassium than cow's milk or human milk. The amount of phosphorus in goat's milk helps people living on a diet of root plants, fruits, and green vegetables. It also contributes to the higher buffering capacity of goat milk, which makes it valuable in treating stomach ulcers. The high chloride content may have some bearing on its laxative properties (Haug *et al.,* 2007). For the adult milk-drinkers, goat's milk provides approximately twice the Vitamin A obtained from cow's milk. Vitamin B is concerned with nervous control. The human need of this vitamin is thought to increase with the intake of sugar and other carbohydrates; there is some evidence also that it plays a part in protein digestion and metabolism. Goat's milk is 50 percent richer in Vitamin B than cow's milk and four times as rich as human milk. Goat's milk is very high in riboflavin (Vitamin B2), which affects growth. Vitamin C and D are not present sufficiently in either cow's milk or goat's milk, and any child that is bottle-fed will need supplements (Hennessy *et al.,* 2007).

2.6.5 Milk 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, somatic cells, the milk fat globule membrane (MFGM) or the cell cytoplasm. These milk enzymes can be used as indices of animal health or thermal history of the milk, they can result in quality deterioration or induce desirable changes in milk and dairy products or they may also offer protective effects. Important indigenous milk enzymes, include plasmin, lipoprotein lipase, alkaline phosphatase and lactoperoxidase (Tamime, 2009).

2.7. Physical composition of milk

2.7.1 Density

Density is defined as an object's mass divided by its volume. It depends on the temperature of the object, composition of the material, and whether or not the object contains air. The density of milk products can be used to convert volume into mass and mass into volume, to estimate the amount of solids present in milk, and to calculate other physical properties. The density of cow's milk usually varies between 1.028 and 1.038 g/cm3 (Robert G.1995).

2.7.2 Appearance

The opacity of milk is due to its content of suspended particles of fat, proteins, and minerals (Robert G.1995).

The color varies from white to yellow depending on the carotene content of the fat. Skim milk is more transparent and has a slightly bluish color (Walstra, P., and Jenness, R. 1984.).

2.7.4 Freezing Point

The freezing point of milk is lower than the freezing point of water because of the dissolved components in milk. Measuring the freezing point is used as a legal standard to determine if milk has been diluted with water. The freezing point of milk is -0.552°C or 31°F (Robert G.1995).

2.7.5 The pH of milk

It higher, or more alkaline, outside of the cow than inside the cow due to loss of carbon dioxide to the air. The pH of milk is never determined immediately after milking because the processing milk removes dissolved gasses. The pH is determined after processing of the milk to assure that lactic acid is being produced at the desired rate by added microorganisms during the preparation of cheeses and fermented milk. The casein in milk forms into a curd or a gel at a pH of 4.6 (Ralph. 1998).

2.7.6 Titratable acidity

Titratable acidity is the amount of alkali required to bring the pH to neutrality. This property of milk is used to determine bacterial growth during fermentations, such as cheese and yogurt making, as well as compliance with cleanliness standards. Naturally, there is no lactic acid in fresh bovine milk, however, lactic acid can be produced by bacterial contamination, but this is uncommon. The titratable acidity is due to the casein and phosphates (Robert G.1995).

2.8 Composition of milks consumed by humans

The proximate compositions of cow, buffalo, and goat and sheep milks are given in while the mineral and vitamin contents of these milks are presented. Values for human milk have been included in the comparison. The proximate composition and mineral and vitamin contents of milk from minor dairy animals. The differences in protein, fat and lactose contents between milks from different species are illustrated in the utilization of vitamin D. Lactose also provides a ready source of energy for the neonate (Campbell, 1975).

2.9 Milk quality control

Milk has nutrients that make it suitable for the rapid multiplication of bacteria that cause spoilage. Unhygienic production, poor handling and undesirable practices such as addition of water or other substances can introduce bacteria or germs that cause spoilage. The resulting wastage can make you lose profits that you would have otherwise made. Unhygienic handling may introduce disease-causing bacteria into the milk and this can also adversely affect human health. In addition, regulatory authorities will likely require that you undergo a training course that covers the contents of this guide before they issue you with a licence to trade in milk. This course is therefore designed to provide the relevant knowledge and skills needed to handle milk hygienically. (FAO, 2004).

2.9.1 Milk hygiene

Milk should be harvested and stored under hygienic conditions. Equipment used to harvest and store milk should be suitable and well maintained. Milking is the defining activity of dairy farming. Consumers demand high standards of milk quality, so milking management aims to minimize microbial, chemical and physical contamination. Milking management covers all aspects of the process of obtaining milk from animals quickly and effectively, while assuring the health of the animals and the quality of the milk (IDF, 2011).The milk should be obtained from healthy animals under hygienic conditions. The animals may often suffer by mastitis and in 95% of the cases the pathogens held responsible were; *Staphylococcus aureus*, *Staphylococcus epidermis* and some *Micrococcus* strains (Arvanitoyannis, 2000).These microorganisms contaminate the nipple of udder because of their presence in environment and milk equipment. The preventive measures are cleaning the udder before and after milking with appropriate antiseptics, controlling the microbial load of milking equipment and the equipment at the industry by through cleaning using a CIP system (Clean In Place). An increase in somatic cells indicates an unhealthy animal. Then antibiotics should be given to the animal and its milk is considered inappropriate for collection for at least 72h (Arvanitoyannis, 2000). The potential existence of antibiotic residues in raw milk prevents the efficiency of starter culture. The animal feeding must be also controlled regarding its content in various metals or other elements (Pb, As, Se, Hg, F, Mb, and Cu), chemical organic substances (a flatoxins, chloride products) and presence of toxic plants (Schlundt, 1999). It is suggested that the animal should not be always fed with the same food. Another hazard at this point is the long exposure of milk to relatively high temperature and temperature variation during transportation. This may favor the growth of pathogens and the production of heat resistant metabolites (toxins, enzymes) (Schlundt, 1999). Other hazards include chemical substances (aflatoxins antibiotics, pesticide residues) and extraneous material. The filters must be frequently changed, because they can be covered with sediments which can act as milk contaminant (Abdalla, 1993).

2.9.2 Pasteurization of milk

The pasteurization process is carried as a continuous operation with the milk heated in a heat exchanger and then held in a prescribed time (Erkmen, 2000).The heat treatment aims at limiting public health hazards arising from pathogenic microorganisms associated with milk. An adequate pasteurization will destroy all the vegetative forms of bacteria, the psychotropic microorganisms, the yeasts and the moulds (Morgan *et al.,*2001).The surviving microorganisms are *Micrococcus*, *Streptococcus, Lactobacillus, Bacillus* and *Mycobacterium* which constitute indicators of hygienic condition of container or equipment (Erkmen, 2000).The procedure of pasteurization, however, can neither destroy nor eliminate the presence of toxins, bacterial agglomerations and residues of chemical and physical substances, such as antibiotics and metals (Erkmen, 2000). Therefore the existence of at least one critical control point before pasteurization is essential (e.g. the reception of raw milk). It was ensured that milk has been correctly pasteurized and afterwards not cross-contaminated by raw milk (Morgan *et al.,* 2001).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Collection of Samples:

Three fresh milk samples were collected in sterile of bottles from three animals (Cows, Goats and Camels), per each animal in three farms in east of the Nile –Khartoum state.

Milk samples were moved immediately to laboratory of the research center in Khartoum North –Shambat.

Physicochemical parameters: moisture %, protein %, fat %, lactose %, ash %, total solid % and: pH, Acidity, Total solid, Freezing point, Boiling point and specific gravity are determined.

3.2 Methods:

3.2.1.1 Moisture content

The moisture content was determined according to the standard method of the Association of Official Analytical Chemists (AOAC, 2003). A weighed sample is removed by heating the sample in an oven (under atmospheric pressure) at 105 ± 1C°. Then, the difference in weight before and after drying is calculated as a percentage from the initial weight.

Milk sample of 5 ml ± 1 ml 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±1C° 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:

Moisture content [%

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

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 Crude protein determination

The crude protein content was determined in all samples by micro-Kjeldahl method using a copper sulphate or sodium sulphate catalyst according to the Official Method of the AOAC,(2003).

The principle method consists of sample oxidation and conversion of nitrogen to ammonia, which reacts with the excess amount of sulphuric acid forming ammonium sulphate. The solution is made alkaline and the ammonia is distilled into a standard solution of boric acid (2%) to form the ammonia-

boric acid complex, which is titrated against a standard solution of HCL (0.1N). Accordingly, the crude protein content is calculated by multiplying the total N % by 6.38 as a conversion factor for protein.

Procedure: 10 ml of each 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 a clean dry kjeldahl digestion after that, the flasks were 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 for 30 min. The digested milk samples were poured into volumetric flasks (100 ml) and diluted with distilled water, then 15 milillters of 40% NaOH was added to each flask and the content of the flasks were distilled . The distillate was received in a conical flasks (100 ml) containing ten ml of 2% boric acid plus 3drops of indicator (bromoceresol green + phynolphalthein red). The distillation was continued until the volume in the flask was 75 ml, then the flasks were removed from distillator. The distillate was titrated with 0.1N HCL until the end point (red colour) was obtained. The protein content was calculated as follows:

Calculation:

Crude protein (CP %) = Crude nitrogen CN X 6.38

CN = T X N X 0.014 X 100/ W

P % = N % X 6.38

Where:

T = Titration figure

W = Weight of sample

N = Normality of HCL

CN = Crude nitrogen

CP = Crude protein

3.2.1.3 Fat content

The crude fat in the product was determined according to the standard analytical method of A.O.A.C (2003).

Procedure: Ten millitres of sulphuric acid (Specific gravity 1.820 at 155 C^{o}).Were measured into Gerber butyrometer. And mixed well, 10.94 millitres of milk was gently added into the butyrometer tube. One milliters of amyl alcohol was added and a lock stopper was inserted securely with the stoppers end up. The Gerber tube was grased and shacked with precaution until the sample (fresh milk) was completely digested. The Gerber tubes were centrifuged at 110 revolutions per minutes (rpm) for 4 minutes. The butyrometer was then placed in water bath at 65 C° for 3 minutes. The fat percent was finally read out directly from the column.

3.2.1.3 Ash content

The ash content was determined according to AOAC (2003). Two gram of the samples were weighed in a crucible, and then placed in a muffle furnace (Carbolite, Sheffeild, England) at 550-600 C° for 3 hours until ashes were carbon free. The crucible were then cooled in a desicator and weighed. The ash content was calculated using the flowing equation:

$$\textbf{Ash content [\%]} = W_1 / W_2 \times 100$$

Where:

W_1 =Weighed of ash

W_2 =Weighed of sample before a shing

3.2.1.5 Total solid content

Total solid content (TS) content was determined according to AOAC (2003). A clean aluminum moisture dishes were dried at 105 C° for 3 hrs. Five grams of the sample were weighed in dry clean flat bottomed aluminum dishes and heated on a steam bath for 15 minutes. The dishes were placed into a forced draft oven at 100 C° for 3 hrs. Then cooled in a desicator and weighed quickly. Weighing was repeated until the differences between the two reading was ≤ 0.1 mg. The total solids (T.S) content were calculated as follows:

$$\textbf{T.S \%} = W_1 / W_2 \times 100$$

Where:

W_1 = Weight of sample after drying.

W_2 = Weight of sample before a drying.

3.2.1.6 Lactose

The lactose content was determined by Anthrone Method (Richard, 1959). One ml milk was pipette in a 500 milliters volumetric flask and diluted to 500 milliters with distilled water. The sample was mixed well then 0.5 milliliters was transferred in boiling test tube (in duplicate) the sample were placed in an ice bath, and shacked while adding 10 ml of ice cold anthrone reagent the tube contents were mixed and then placed in a boiling water bath for 6 min, then transferred back to the ice bath for 30 min. The optical density of the colored solution was then read at 625 nm. A blank consisting of distilled water 0.5 milliters and anthron reagent and standard containing 100mg/ml of lactose and anthron reagent were included in each batch of analysis. The percentage of lactose was then calculated using the following formula:

O. D. of sample – O..D of blank /O.D of stander – O.D of blank × 4.75

O.D= Optical density

S= Sample

SD= Stander

B= Blank

3.2.1.8 pH

The pH of the samples was measured by using a recalibrated pH meter model (HI 8521 microprocessor bench pH / MV / C˚ meter). This has been calibrated with two standard buffers (6.8 and 4.0).

3.2.1.9 Titratable acidity

The acidity of the samples was determined according to AOAC (2003). Ten milliters of each sample were placed in a white porcelain dish and four drops of phenolphthalein indicator were added. Titration was carried out using 0.1N NaOH until a faint pink colour appeared. The titration figure was divided by ten to get the percentage of lactic acid (1milliters of 0.1 of 0.1N NaOH sodium hydroxide = 0.009 gm of lactic acid).

3.2.1.10 Boiling point

Milk was boiled and the temperature was measured by thermometer.

3.2.1.11 Freezing point

Freezing point was measured by using a high accurate thermometer (check temp.)To determine the exact point at which the freezing point of milk is started. The apparatus used was making it possible to obtain the extremely high accuracy in a very short period of time.

3.2.1.12 specific gravity

The specific gravity of different types of milk was determined by using lactometer device according to A.O.A.C,(2000). The lactometer is a special type of hydrometer. It is constructed and graduated so that the lactometer reading is related to the specific gravity of milk on the ratio of the milk to water weight of a unit volume at a specified temperature.

Procedure

- The milk must be kept cold (40-50°F) atleast 1-2 hour before being tested with the lactometer.
- The milk should be thoroughly mixed by being poured from one container to another until a homogenous mixture is obtained.
- The milk is then poured into a measuring cylinder having the same temperature.
- The diameter of the cylinder should be atleast 1 inch greater than the largest diameter of the lactometer and the capacity should be sufficient to float is the lactometer.

- The cylinder should be filled to such a point that when the lactometer is placed in the milk, the cylinder will over flow.
- All bubbles should be blown from the surface particularly around the stem.
- Note the reading from the lactometer when it becomes stationary.

Specific gravity = 1 + CLR/1000

(CLR- corrected lactometer reading)

3.2.1.11 Statistical analysis

The data obtained were analyzed using SPSS software (Version 16). One way (ANOVA) test. Duncan multiple range test was used to test the significance between means using standard error (S.E).

CHAPTER FOUR

RESULTS AND DISCUSSION

Table 1: Chemical Composition of Cow, Goat and Camel milk

Parameter	Mean ±SE			L.Sig
	Type of animal			
	Cow	Goat	Camel	
Moisture %	88.667	90.400	90.944	**
Protein %	3.456	3.689	2.711	**
Fat %	3.381	2.444	2.911	**
Lactose %	4.890	4.274	3.810	**
Ash %	0.644	0.8011	0.7011	**
Total solids %	11.333	9.533	9.056	**

NS: Not Significant**.**

***:** Significant (p≤ 0.05).

****:** High significant (p≤ 0.01).

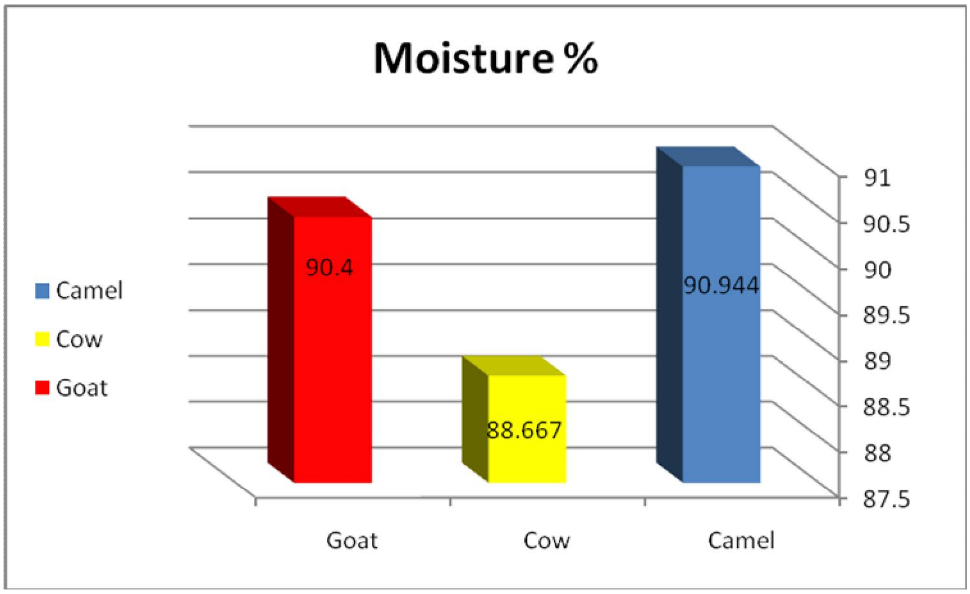
L.Sig= Level of Significance.

- abc Means ± SE values having different letters in the same row are significantly different (p≤ 0.05).
- Means ± SE values having same superscript letters raw are not significantly different (p≥ 0.05).

Statistical Analysis shows that there were significant differences (p ≤ 0.05) among different sources moisture content of milk from different species (Table1). The Moisture content of camel milk 90.94% was slightly higher than that of goat mike 90.40 %, and cow milk 88.66 %. The moisture content for cow milk was higher than the findings of Mohammed (2013), and Johnson (1980) those who found that cow milk moisture content were, 78.3%, 87.00 % respectively.

However slightly lower than that of Johnson (1980) found moisture content of 87.00 % and 87.20 % for goat and camel respectively, these variation may be due to different breeds and feeding condition.

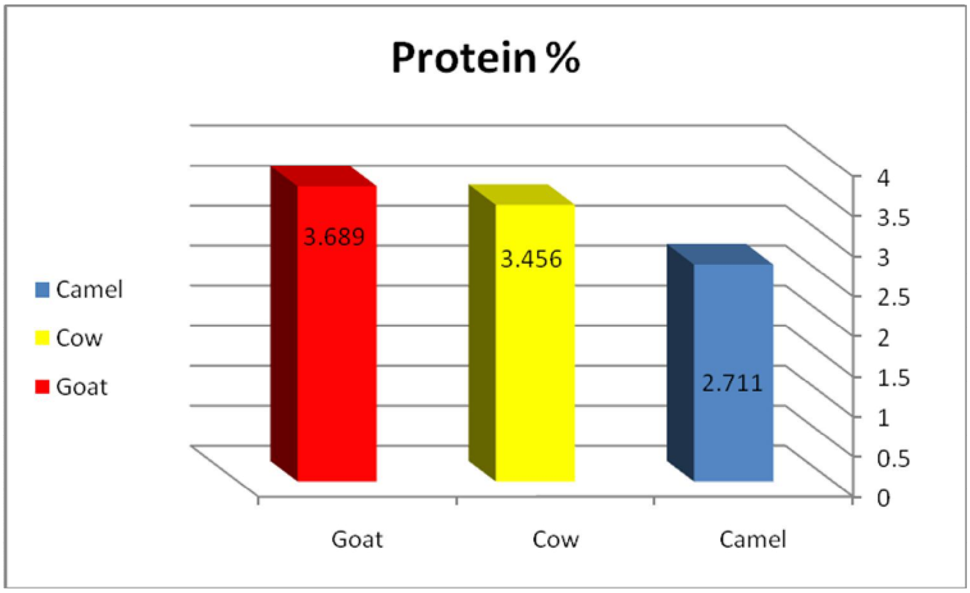
Figure 1: Moisture content in milk samples from Cow, Goat and Camel



Protein content:

For the protein content, there are significant differences ($p \leq 0.05$) among the samples under investigation. Camel milk had the lowest amount of protein content 2.71 % followed by cow milk 3.45 % and the highest was found in the goat milk 3.68%. This result is not far from that reported by Mohammed (2013) who indicated that protein content of cow, goat and camel milk were 4.49 %, 4.37% and 3.56% respectively. In addition, Hassen (2005) mentioned that the milk proteins have the high nutritional value and the principal component of the milk proteins is casein, which constitutes about 75% of all milk proteins.

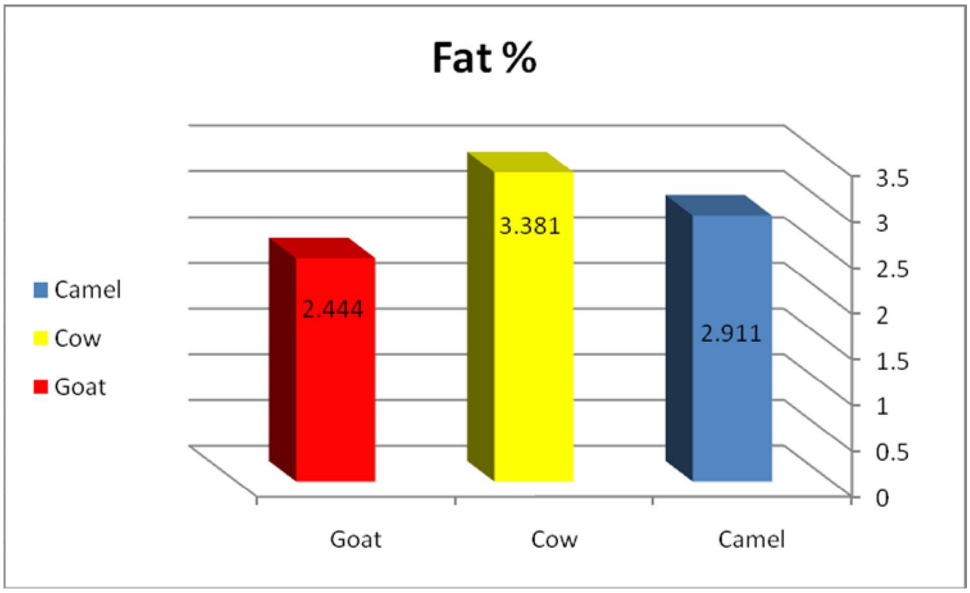
Figure 2: Protein content in milk samples from Cow, Goat and Camel



Fat content:

Table 1, shows that the change in fat content of milk as affected by source of milk. The highest fat content (3.38%) obtained from cow milk ($P< 0.05$). The lowest fat content (2.44%) was obtained from goat The difference in fat content of the different species was significant ($P< 0.05$). These results dis agreed with that reported by Johnson (1980) who found that fat content of caw milk was 3.70%, while for goat milk fat content was 5.38%. Our finding that camel milk has a fat content of 2.91% is in full agreement with an earlier finding by Anon (1980), who reported that the fat content of camel milk in various part of the world ranged between 2.90 % - 5.0%.

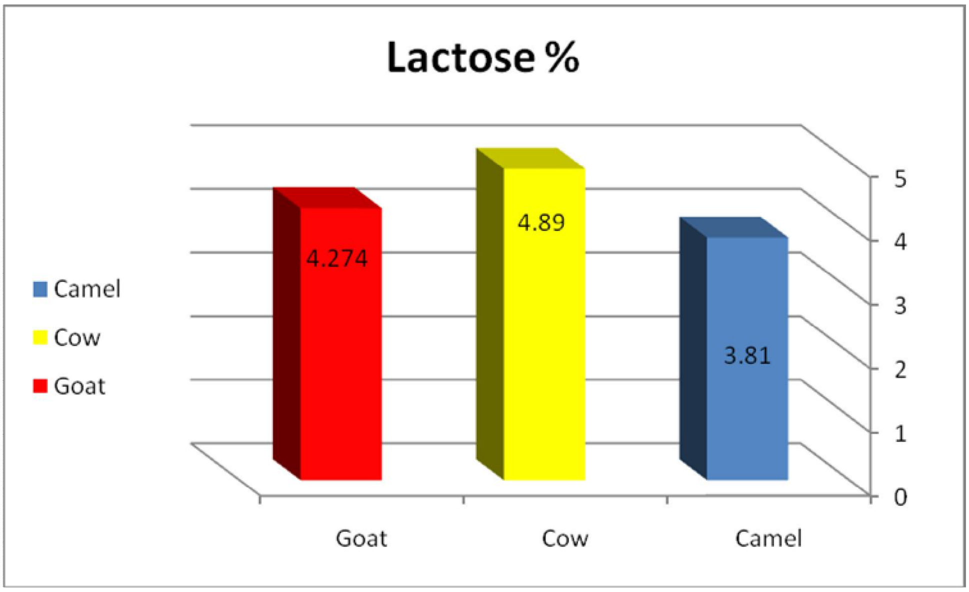
Figure 3: Fat content in milk samples from Cow, Goat and Camel



Lactose:

Results illustrated in figure 4, showed the significant differences ($P < 0.05$), among the different sources of milk in lactose content of cow, goat and camel milk. Cow milk has a higher score 4.89% followed by goat milk 4.27% finally camel milk was 3.81%.These result disagree with these reported by Mohammed (2013), who stated that lactose content of cow, goat and camel milk was 4.7%, 4.3% and 4.4% respectively. Our results were on line with those mentioned by Adolfson (2004),who stated that lactose content of goat's milk is slightly lower than cow's milk.

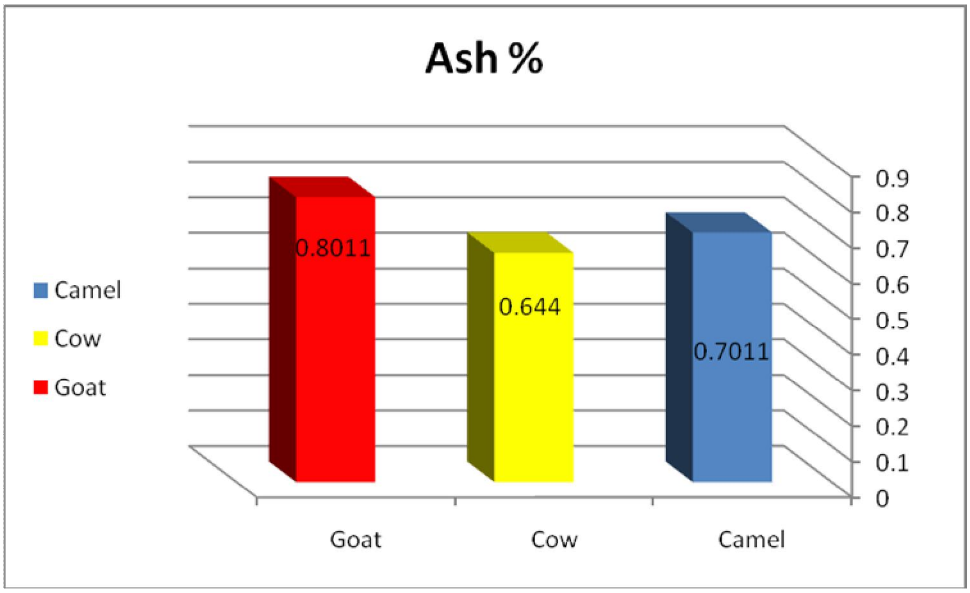
Figure 4: Lactose content in milk samples from Cow, Goat and Camel



Ash content:

Table (1) (Figure 5), indicate that the ash content was significantly different among the treatments ($P< 0.05$). Cow milk had the lowest ash content, 0.64%.While goat milk had the highest value 0.80%. Camel milk gave the second score 0.70%. These findings agreed with Mohammed (2013). who observed that ash content of goat milk had the highest score but cow had lowest score.

Figure 5: Ash content in milk samples from Cow, Goat and Camel



Total solids %:

Apparently, there are significant differences ($p \leq 0.05$) in (T.S) **co**ntent among different milk sources; as shown in Table (1). The highest total solid (TS) content was reported for cow milk 11.33 % then 9.53% recorded for goat milk the lowest for camel 9.05%. Mohammed (2013) reported that T.S of cow, goat and camel milk were 12.7%, 13.2% and 12.5% respectively. Which disagree with our finding. Our results are in line with those mentioned by Saxelin *et al.,* (2003), who stated that milk composition is affected by several factors like environment, feeding, physiological even within the same species. Generally the milk composition is affected by water availability, stage of lactation and availability of the green fodder as well as the differences in management system under which the herds are kept (Farah, 1996).

Figure 6: : Total solid T.S content in milk samples from Cow, Goat and Camel

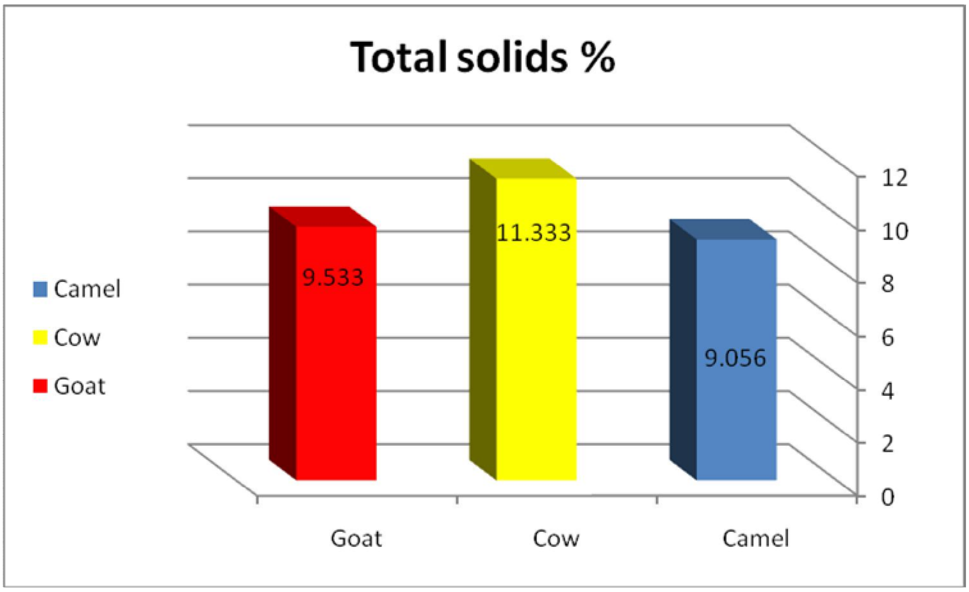


Table 2: Physical properties of Cow, Goat and Camel Milk

Parameter	Mean ±SE			L.Sig
	Type of animal			
	Cow	Goat	Camel	
pH value	6.43^{b}±0.017	6.47^{b}±0.017	6.59^{a}±0.020	**
Acidity	0.167^{b}±0.002	0.153^{c}±0.003	0.180^{a}±0.003	**
Freezing point	-0.550^{b}±0.003	-0.540^{ab}±0.003	-0.530^{a}±0.008	*
Boiling point	91.33^{a}±0.167	77.00^{c}±0.289	86.33^{b}±0.167	**
Specific gravity	1.0345^{a}±0.001	1.0350^{a}±0.001	1.0346^{a}±0.001	NS

NS: Not Significant**.**

***:** Significant (p≤ 0.05).

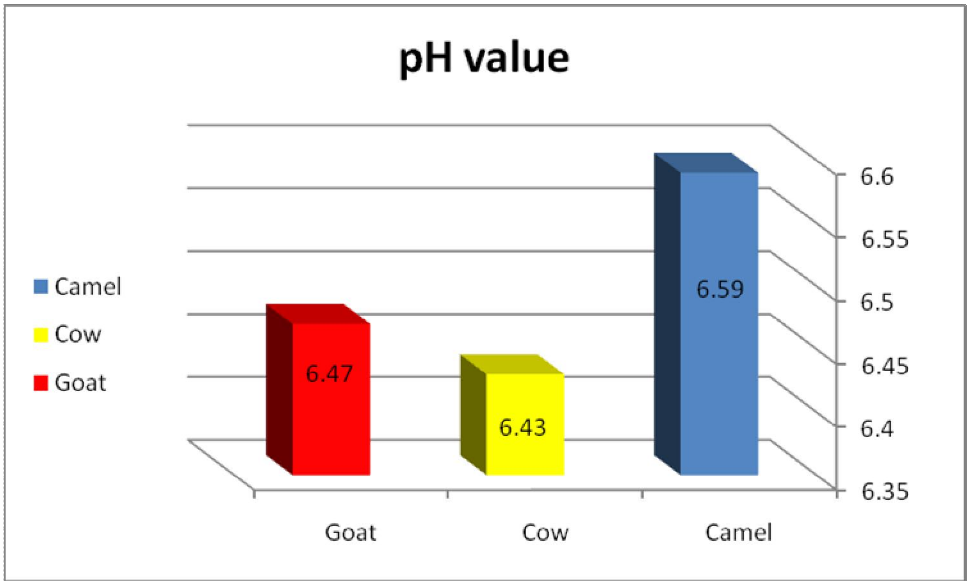
****:** Highly significant (p≤ 0.01).

L.Sig= Level of significant

- ^{abc} Means ± SE values having different letters in the same raw are significantly different (p≤ 0.05).
- ± SE values having same letters in the same raw are not significantly different (p≥ 0.05).

The results of Table 2, indicate that the pH values were significantly different among the treatments (P< 0.05). Cow milk had the lowest pH value 6.43, while camel milk had the highest value 6.59. Goat milk gave the second score 6.47. pH value for goat and cow milk were higher than the findings Imran (2008) also camel milk had lower pH value than that reported by Mohammed (2013).

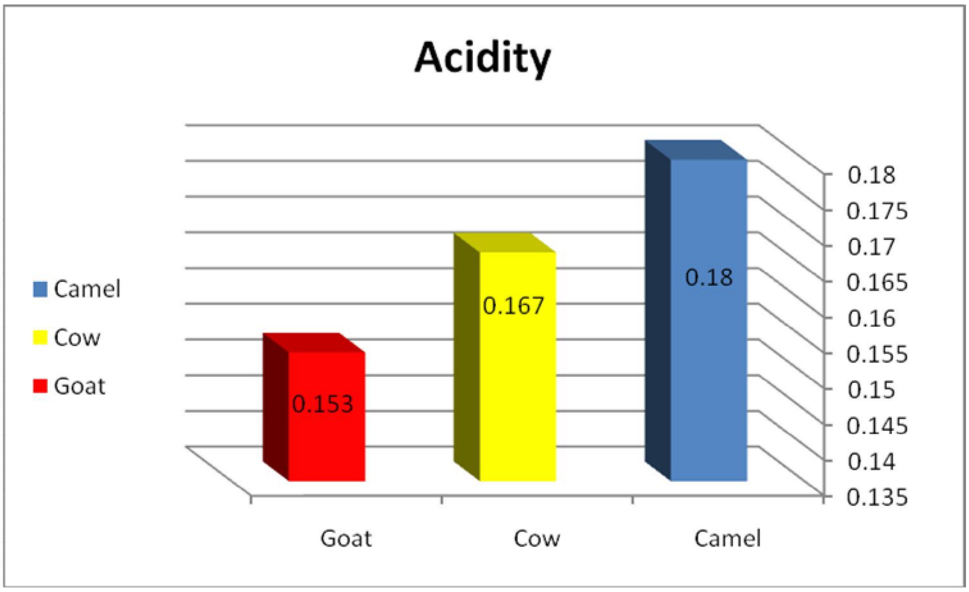
Figure 7: pH value in milk samples from Cow, Goat and Camel



Acidity%:

Table (2) Figure 8 show that there are significant differences (P< 0.05) in acidity among the different treatments. Camel milk had the highest value (0.18%), while goat milk the lowest values (0.15%). The value reported for cow milk in this study (0.16%) is slightly less than those reported by Imran (2008) and Jonson (1980). Who cited 0.20% and 0.19% respectively. However, the acidity content in camel milk was slightly higher than that obtained by Mohammed (2013) who recorded 0.14%.

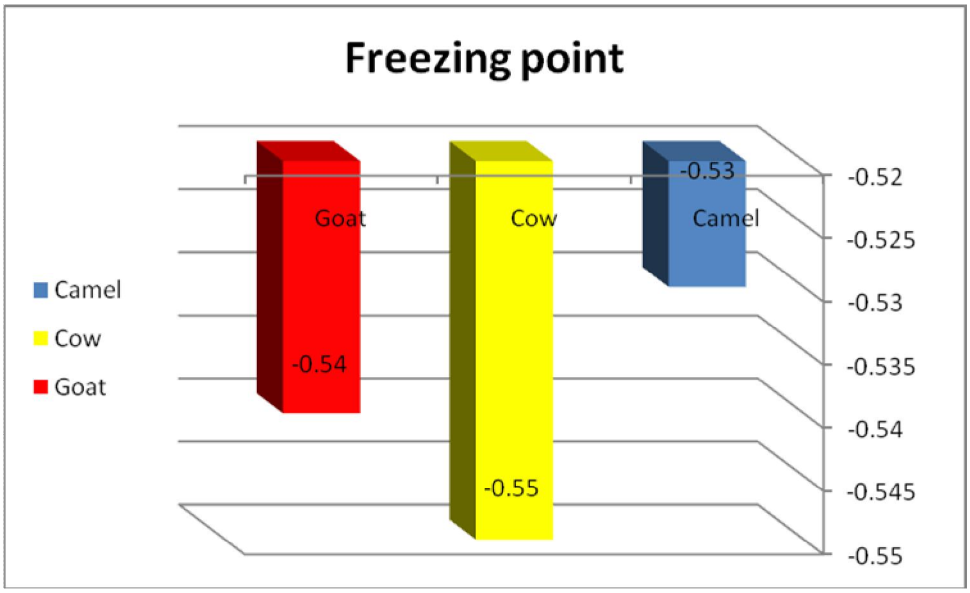
Figure 8: Acidity content in milk samples from Cow, Goat and Camel



Freezing point:

Measuring of freezing point is used as a legal standard to determine if milk has been diluted with water or not. The results of the freezing point (Table 2) indicate that the camel milk scored the highest values -0.530c°, while the lowest value was scored by the cow milk -0.550c°, as well as the freezing point of goat milk was -.0540c°, there are significant differences ($p \leq 0.05$) among the samples under investigation. The result obtained were similar to there reported by Neeru Gakkhar et al., (2015.) who stated that the freezing point of camel , goat and cow milk were , -0.535,- 0.542 and -0.547 respectively.

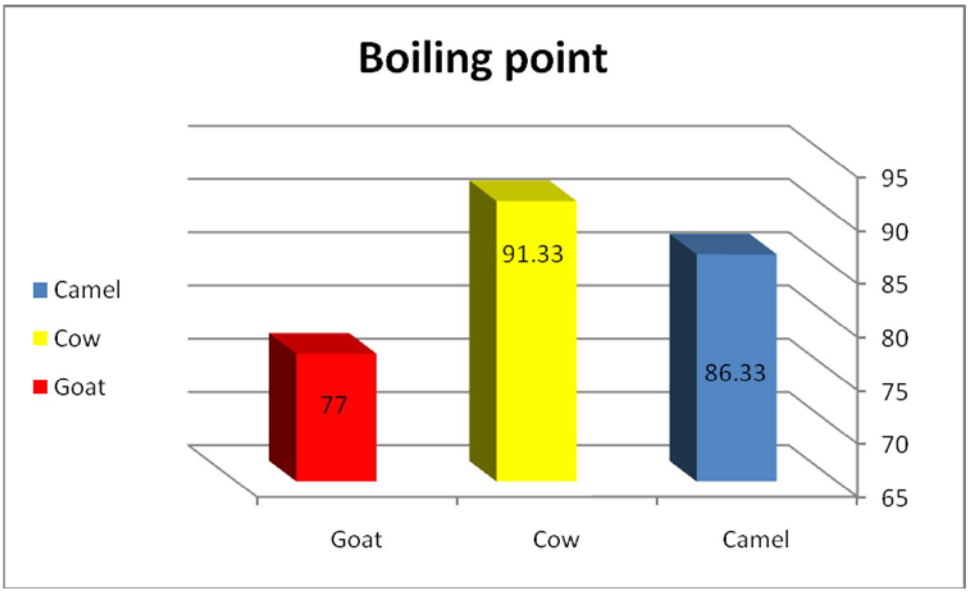
Figure 9: Freezing point value in milk samples from Cow, Goat and Camel



Boiling point:

Goat milk had the lowest value of boiling point (77.33C°) followed by camel milk (86.33C°) and the highest was found in the cow milk (91.33C°). the sample were significantly different ($P \leq 0.05$) in this boiling points as showed in Table (2).

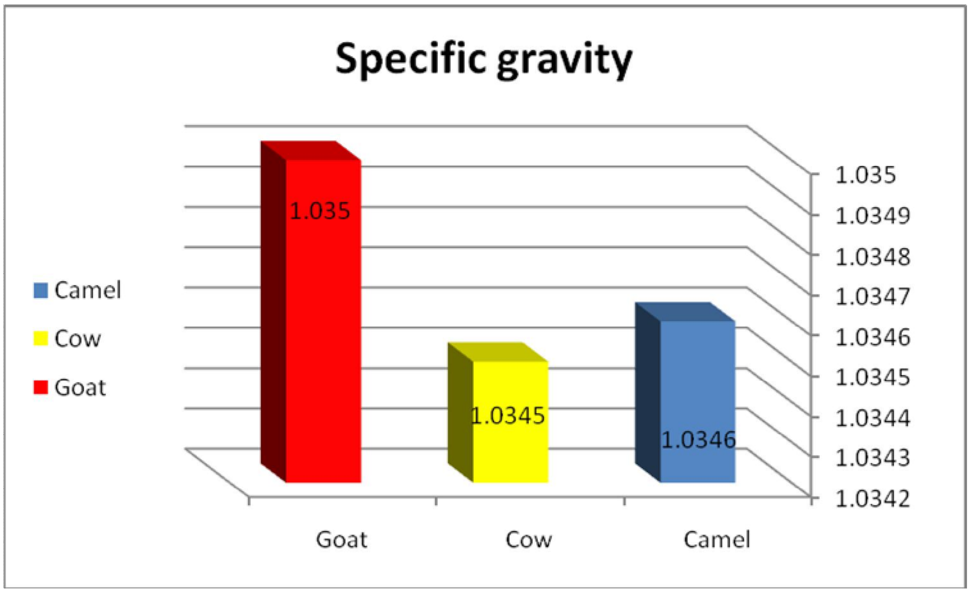
Figure 10: Boiling point value in milk samples from Cow, Goat and Camel



Specific gravity:

Table (2) (Figer 11) showed that there were no significant differences (P> 0.05), among the milk sources in specific gravity. Goat, cow and camel milk had homogenized variance; these results were far from that obtained by Mohamed (2013) who reported that cow, and goat and camel milk had specific gravity 1.030, 1.034 and 1.29 respectively.

Figure 11: Specific gravity in milk samples from Cow, Goat and Camel



CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

Conclusion:

The tested parameters were significant among different sources moisture content of milk from different species for the protein content, there were significant differences among the sample under investigation Camel milk had the lowest amount of protein content 2.71% followed by Cow milk 3.45% and the highest was found in the Goat milk 3.68%.

In the fat content of milk as affected by sources of milk. The highest fat content (3.38%) obtained from Cow milk. The significant deference, among the different sources milk I lactose content of Cow, Goat and Camel milk. Cow milk has higher 4.89% followed by goat milk 4.27%, Camel milk was 3.81.

The ash content significantly different among the treatments ($P< 0.05$). The cow milk had the lowest ash content, 0.64%.While the goat milk had the highest value 0.80%. The camel milk gave the second score 0.70%.

The highest total solid (TS) content was reported for cow milk 11.33 % then 9.53% recorded for goat milk the lowest for camel 9.05%.

The pH value was significantly different among the treatments ($P< 0.05$). The caw milk had the lowest pH value 6.43, while the camel milk had the highest value 6.59. The goat milk gave the second score 6.47. pH value for goat and cow milk were higher than finding.

The acidity of camel milk had significantly ($P< 0.05$), the highest value (0.18%), while goat milk the lowest values (0.15%). The value reported of cow milk in this study (0.16%)

The results of the freezing point (Table 2) indicate that the camel milk scored the highest values -0.530c°, while the lowest value was scored by the cow milk -0.550C°, as well as the freezing point of goat milk was -.0540C°, there are significant differences ($p \leq 0.05$) among the samples under investigation.

The lowest value of poling point content 77.33c° followed by camel milk 86.33c° and the highest was found in the cow milk 91.33C°.

Specific gravity there were no significant differences ($P > 0.05$), among the milk source. Goat, cow and camel milk had homogenized variance.

Recommendations

- As goat milk contains high amount of protein and low quantity of fat it is recommended to be used for children nutrition.

- Modern technologies should be introduced for the processing of camel and goats milk.

  More research is needed to investicate the different properties of Camel milk, especially medicinal properties.

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