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MSc. THESIS

A COMPARATIVE ANALYSIS OF PHYSICOCHEMICAL PARAMETERS AND MINERAL CONTENT IN COW AND CAMEL MILK FROM AGA WAYU DISTRICT, GUJI ZONE, OROMIA, ETHIOPIA

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JUNE, 2025
HAWASSA UNIVERSTY

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BY

DINAOL BAYU

A MASTER THESIS SUBMITTED TO DEPARTMENT OF CHEMISTRY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN CHEMISTRY

ADVISOR: SINTAYEHU MANAYE (PhD)

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HAWASSA UNIVERSTY

DECLARATION

I do hereby declare that the thesis work entitled "A Comparative analysis of physicochemical parameters and mineral content in cow and camel milk from Aga Wayu district, Guji zone, Oromia, Ethiopia" is my original work and has not been submitted for a degree or diploma in any other universities by any other researchers or any students and that all sources of materials used for this thesis have been duly acknowledged.

Name: Dinaol Bayu

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This thesis has been submitted for examination with my approval as thesis advisor

Advisor: Sintayehu Manaye (PhD)

Signature: ____

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Approval sheet-1

This is to certify that the thesis entitled **"**A Comparative analysis of physicochemical parameters and mineral content in cow and camel milk from Aga Wayu district, Guji zone, Oromia, Ethiopia**"** submitted in partial fulfillment of the requirements for the degree of Master of Science in Chemistry of the graduate program of the Department of Chemistry, Hawassa University, and is a record of original research carried out by Dinaol Bayu (PG ChemK /008/11), under our supervision, and no part of the thesis has been submitted for any other degree or diploma. The assistance and help received during the course of this investigation have been duly acknowledged. Therefore, I recommend that it is accepted as fulfilling the thesis requirements.

Sintayehu Manaye (PhD) ____________________ _______________

Name of advisor Signature Date

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Approval sheet-2

We, the undersigned, members of the board of Examiners of the final defense by Dinaol Bayu have read and evaluated this thesis entitled **“** A Comparative analysis of physicochemical parameters and mineral content in cow and camel milk from Aga Wayu district, Guji zone, Oromia, Ethiopia**”** examined the candidate. This is therefore to certify that, the thesis has been accepted for partial fulfillment of the requirements for the degree of Master of Science in Chemistry.

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LIST OF ABBREVIATIONS

AOAC	Association of Official Analytical Chemists.
bp	Boiling point
CLR	Correct Lactometer Reading
DF	Degree of freedom
FAAS	Flame atomic absorption spectroscopy
mt	Metric tone
SE	Standard Error
SG	Specific gravity
SOFA	State of food and Agriculture
TS	Total solid
TA	Titrable acidity
USAID	United States Agency for International Development
UV-VIS	Ultra violate visible spectroscopy
WHO	World Health Organization

ABSTRACT

This study aims to analyze and compare the physicochemical properties and mineral composition of cow's and camel's milk. Milk samples were collected from the Aga Wayu district in the Guji zone of the Oromia region, Ethiopia, using a proportional random sampling method. The physicochemical parameters analyzed included pH, titratable acidity, ash content, specific gravity, protein content, fat content, moisture content, total solids, and boiling point. Additionally, the concentrations of selected minerals (phosphorus, sodium, calcium, and potassium) were measured. The results showed that cow's and camel's milk exhibited similar physicochemical properties, with comparable pH (5.8 ± 0.5), titrateble acidity (0.20 ± 0.01), ash content (0.84 ± 0.12%), specific gravity (1.04 ± 0.11), protein content (3.32 ± 0.43%)for cow, fat content (3.6 ± 0.48%) and boiling point (92.66°C)for camel. The concentrations of sodium (3.63 ± 1.23 mg/L) and phosphorus (2.43 ± 0.39 mg/L) were also similar in both types of milk. However, cow's milk had higher moisture content (85.13 ± 2.65%) and calcium levels (22.44 ± 2.41 mg/L) compared to camel's milk, which had lower moisture (82.83 ± 1.22%) and calcium (17.07 ± 1.38 mg/L). Conversely, camel's milk contained higher total solids (18.26 ± 0.50%) than cow's milk (14.82 ± 2.11%). In conclusion, camel's milk was found to have higher protein and lactose content than cows's milk, while cow's milk had a greater fat content. These findings highlight the distinct nutritional profiles of the two types of milk, which may have implications for their dietary applications.

Keywords: Cow's milk, camel milk, physiochemical analysis, minerals, milk quality

1. INTRODUCTION

1.1 Background of the study

Milk and dairy products are part of a healthy diet. Besides cow's milk, milk products include sheep's, goats and camels' milk [20]. Milk is a complex mixture of fats, proteins, lactose, carbohydrates, minerals, vitamins and other minor constituents dispersed or dissolved in water [26]. Milk has been recommended an important source of nutrients specially calcium for good bone and teeth health. Therefore, it is advisable to consume adequate amount milk and milk products [9].

Milk is an important nutrient that is secreted in the mammary glands of mammals, one of the most complex living groups, and contains a wide variety of nutritional components. Milk from various mammals are used for producing different dairy products including milk cream, butter, yogurt, ghee, sour milk, etc. Consumers always demand nutritionally enriched milk and dairy products [23]. Milk is considered a complete diet because it contains the essential nutrients such as lactose, fat, protein, mineral and vitamins in balanced ratio rather than the other foods [2].

Milk provides a complete source of proteins, lipids and carbohydrates to support the growth of the neonate until they are able to digest foods from other sources. Amongst mammals, humans are unique using milk from other species to feed their infants and young children [21]. The transition from cow milk to formula milk need to be properly established, due to a myriad of reasons, many children's fed milk formula manufactured from cow milk.

Animal milk can play an important role in the diets of children in populations with very low fat intake 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 [12]. Milk and milk products are known by their most diversified natural food statues in terms of composition which contains more than twenty different trace elements including copper, zinc, manganese and iron [22]. Trace elements are cofactors in many enzymes and play an important role in the physiological functions of human and animal body.

Camel milk is an important component of human diet in many parts of the world. It considered as an important source of protein for the people living in the arid lands of the world. Camel's milk is characterized with the high content of potassium, magnesium, iron, copper, manganese, sodium and with the lower content of lactose than cow's milk [16]. Historically, camel's milk has been used for a number of medical problems [31] as it has anti-cancer, hypoallergic and anti-diabetic properties [38]. Camel milk has better fat and protein digestibility and assimilation; significantly higher minerals & vitamins composition and lower incidence of allergy [15]. As camel milk has these therapeutic properties and nutritive value, many investigators studied its chemical composition and physical characteristics where these compositional changes, may alter the processing quality of camels milk. Milk quality has very broad meaning. It encompasses such milk characteristics as chemical composition, physical properties, microbiological and cytological quality, sensory properties, technological suitability and nutritive value. Physicochemical analysis is important tool to monitor the quality of dairy products.

1.2. Statement of the problem

The community of Guji zone, is pastoral and the people live on the milk of these animals. Guji zone especially Aga Wayu district is known for its potential population and production of cow's and camel's milk. The community of this district uses cow's and camel milk. The community of Aga Wayu and the neighboring district camel milk is very desirable in buying and selling. The mineral content of cow and camel milk may vary significantly, and understanding these differences is essential to determine their potential health benefits and risks for consumers, particularly those with specific dietary needs or restrictions. While both cow and camel milk are consumed in Ethiopia, comprehensive studies comparing their physicochemical and mineral content, particularly in specific areas like Aga Wayu, are lacking. Camel milk is known for its unique composition and adaptation to harsh environments. A detailed comparison with cow milk in Aga Wayu can provide valuable insights into how these differences in composition contribute to camel's resilience and suitability for the local climate. By comparing the two milks, we can better understand their potential contributions to the nutritional needs of the local population. The goal of this study was to analyze the physicochemical properties and determine the mineral content of milk in Aga Wayu district, Guji zone. This study aimed to answer the following basic research question.

1. Are there significant differences in the nutritional composition of milk samples obtained from cows compared to those from Camels?
2. What are the physicochemical properties of cow and camel milk in Aga Wayu District?
3. What are the levels of calcium and phosphorus, in cow and camel milk in Aga Wayu District?
4. How do the physicochemical parameters and mineral content of cow and camel milk in Aga Wayu District compare to each other and to established standards?
5. Does the environment of Aga Wayu influence the physicochemical and mineral composition of camel milk compared to cow milk, and if so, what specific adaptations can be observed.

1.3 Objective of the study

1.3.1. General objective of the study

The main objective of this study was to assess and compare the physicochemical parameters of milk samples collected from camel and cow of Guji zone, Aga Wayu district in Oromia region.

1.3.2. Specific objective of the study

1. To determine the amount of total solid, moisture, protein, fat and ash in cow or camel milk.
2. To measure the levels of calcium,sodium,potasium and phosphorus in cow and camel milk in Aga Wayu district.
3. To provide baseline data for the consumption of cow and camel milk in Aga Wayu district based on their nutritional quality and potential health benefits.
4. To evaluate the nutritional differences between cow and camel milk based on their physicochemical and mineral composition.

1.4. Significance of the study

The study will provide insights into the effects of different local environment and local feed sources on the physicochemical properties and mineral content of cow and camel milk. The study will contribute to the body of knowledge on dairy science and nutrition, providing valuable information for researchers, policymakers, and industry stakeholders. It provides valuable data for stakeholders (farmers, policymakers, etc). The study also help to identify any differences in the physicochemical properties and mineral content between cow and camel milk, which can guide consumer choice and inform dairy farming practices. The results of this study will provide use full base line data on the about cow's or camels milk physicochemical comparison milk for further studies and give information for the concerned institution and organization to take some necessary actions for the wellbeing of the society based on the finding.

1.5. Scope and limitation of the study

The study focused only on cow and camel milk, excluding other types of milk such as goat milk that are available in the area. It would have been better to assess the more type of milk;however, due to resource and time constraints, only cow and camel milk were taken as the case study. Depending on the sample size of cow and camel milk analyzed, the findings might not fully represent the entire population. Larger sample sizes from various farms and production systems could enhance representativeness. This study offer a snapshot of the milk composition. Analyzing seasonal variations or changes over time could provide richer insights into environmental influences and adaptation mechanisms. The study investigated only the physicochemical properties and mineral content of cow and camel milk, and did not consider other nutritional factors such as vitamins and fatty acids. The study was limited to Aga Wayu District, and therefore may not be representative of other regions in Ethiopia or other places with different dairy farming practices and feed sources.

2. REVIEW OF RELATED LITERATURE

2.1 Definition of milk

Milk is a complex biological fluid and it is the largest source of animal source food used for improved nutritional and health outcomes in developing countries predominantly for children. It is playing a vital role in every body's life, for getting good health and give energy to work without getting tired. We can get more minerals, vitamins, calcium, from milk [29]. Ethiopia milk production has increased significantly since 2000.

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. World milk production (81% cow milk, 15% buffalo milk, and 4% for goat, sheep and camel milk combined) grew by 1.3% in 2019 to about 852 metric tons. In India, the largest milk producer in the world, production increased by 4.2% to 192 metric tons, although this had little impact on the world dairy market as India trades only marginal quantities of milk and dairy products [33].

East African countries have milk production levels ranging from one to five litres per cow per day. For instance, Kenya produces five litres per cow per day whilst Tanzania produces nearly two litres per cow per day [13]. Ethiopia has the largest cattle population in Africa, at 52 million, including 10.5 million dairy cattle [35]. The Central Statistics Agency estimated that national milk production was 1.2 billion liters in 2000, 3.2 billion liters in 2007, and 3.3 billion liters in 2012. High amount of milk produced from cattle (81.2%) followed by goat (7.9 %,), camel (6.3%) and sheep (4.6%). Even though, Ethiopia production of milk increased from time to time, the per capital milk consumption was much lower (19 kg/year kg) than other African countries [17]. Report indicate that, in Ethiopia 68% of the total milk produced used for human consumption in the form of fresh milk, butter, cheese and yoghurt, while the remaining is given to calves and wasted in the process. Butter is the most widely consumed milk product in the country. Of the total milk produced, 40% is converted to butter while only 9% is reserved for cheese [10].

Camel milk has been consumed for centuries by nomadic peoples for its nutritional value and medicinal properties. Currently, pasteurized camel milk is produced and sold only in a few countries including Saudi Arabia, United Arab Emirates, Kazakhstan, Mauritania and Algeria [27]. According to Food and Agriculture Organization (FAO) of the United Nations statistics, there are about 19 million camels in the world, of which 15 million are found in Africa and 4 million in Asia. Approximately 15 million dromedaries, representing two-thirds of the world camel population, are living in the arid areas of Africa, particularly in Northeast Africa (Somalia, Sudan, Ethiopia, and Kenya) [3].

2.2 Importance of milk in diet.

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 [14]. 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 [1]. 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 [34].

2.3 Milking animals

World milk production is almost entirely derived from cattle, buffalos, goats, sheep and camels. Other less common milk animals are yaks, horses and donkeys Milk from goats, sheep, and cows has been consumed by humans since prehistoric times. When different kinds of animal milk are sold commercially, they are named specifically, such sheep milk and goat milk. Milk, the natural production of the breast, is extracted from the mammary glands after one or two actions, with nothing added or taken away, and is then consumed as is or processed further. Milk is practically a complete food since it contains all the essential nutrients, including protein, fat, and important minerals [11].

2.3.1 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 [30].

2.3.2 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 it 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 [30]

2.4 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 from improved animal feed and feeding practices. It 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. 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 [14] 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 programmed usually consists of a balanced ration and management for maximal feed intake [7]

2.5 Physicochemical properties of milk

2.5.1 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.

2.5.2 Freezing point of milk

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 [17].

2.5.3 The pH of milk

It is 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.

2.5.4 Titratable acidity

Titratable acidity is the amount of alkali required to bring the pH to neutrality. The pH of milk is more dependent on temperature than that of buffers, such as phosphate; since milk is a complex buffer system and variation in temperature cause many changes. Differences in pH and buffering between individual lots of fresh milk reflect compositional variation [18].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.

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 (The British Nutrition Foundation, Oils and Fats in the Diet, 2009) [7] .

2.6.1 Protein

Proteins are among the most complex of organic substances that contain carbon, hydrogen, oxygen, nitrogen, sulphur and sometimes phosphorous [32]. Milk is generally considered as important source of protein in the human diet providing approximately 32 g of protein per liter. Its protein fraction can be soluble whey protein (20% of milk protein fraction) or insoluble caseins (represents 80%) [8].

2.6.2 Fat

Milk fat is often called "butter fat" is commercially the most valuable constituent of milk and is a great importance from the standard point of food value of the milk [8]. Fat provides our bodies with energy. It is a carrier of fat soluble vitamins and is responsible for their absorption. The nature of the fat depends on the types of fatty acids that it contains. The two types of fatty acids are saturated fatty acid and unsaturated fatty acids which are described by how the molecules in the fatty acid are joined together.

Milk fat is one of the most complexes of all common fats, composed of many fatty acids mainly saturated (66%), mono unsaturated (30%) and polyunsaturated (4%). All short chain (4:0 to 10:0) and half of the medium chain (12:0 to 17:0) fatty acids in milk fat are synthesized from acetate and β-hydroxy butyrate in the mammary gland epithelial cells. The other half of medium chain and almost all long chain (18:0 and longer) fatty acids are derived from blood plasma fatty acids of dietary origin or from mobilization of stored body fat. Milk fat contains substantial amount of short chain fatty acids, making it unique compared to other fats. These short chain fatty acids especially butyric acid (4:0) are important for flavor development in some cheese and fermented dairy products [24]. Milk fat contains approximately 400 different fatty acids which make it the most complex of all natural fats.

2.6.3 Lactose

Lactose in milk has comparatively lower glycemic index compared to glucose or sucrose thereby making it suitable for diabetic people [8]. 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 [8]. Active cultures in yogurt help digest lactose thereby making it suitable for lactose intolerant people [19]. The lactose content of goat's milk is slightly lower than cow's milk. Since some people have difficulty digesting the lactose in milk, goat milk is less likely to cause this problem than cow's milk [1]. 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 [14]. 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 than 1%. Milk is good source of minerals like calcium, magnesium, phosphorous, potassium, selenium and zinc. Many minerals in milk are associated together in the form of salts such as calcium phosphate. Mineral salts occur in solution in milk serum or in casein compounds. The most important salts are those of calcium, sodium, potassium and magnesium [19]. Cow's milk has long been considered a highly nutritious and valuable human food and is consumed by millions daily in variety of products. The low quantity of ß-casein and the lack of ß -lactoglobulin are linked to the hypo-allergic effect of camel milk [25]

3. MATERIALS AND METHODS

3.1. Description of the study area

This study was conducted on determination of minerals and physicochemical of milk from cow and camel in Aga Wayu district, Guji Zone, Oromia Regional State, Ethiopia. The woreda was bordered on the south by the Magado, on the west by Melka soda, on the north by Seba Boru, on the East by Shakiso. For administrative purpose the woreda is divided into 12 village kebele and 2 town kebele.The district lies at approximately 7°52'0''N latitude and 37°02'0''E longitude with elevations ranging from 1,800 to 2,900 meters above sea level and it is 454 Km from the capital city, Addis Ababa.

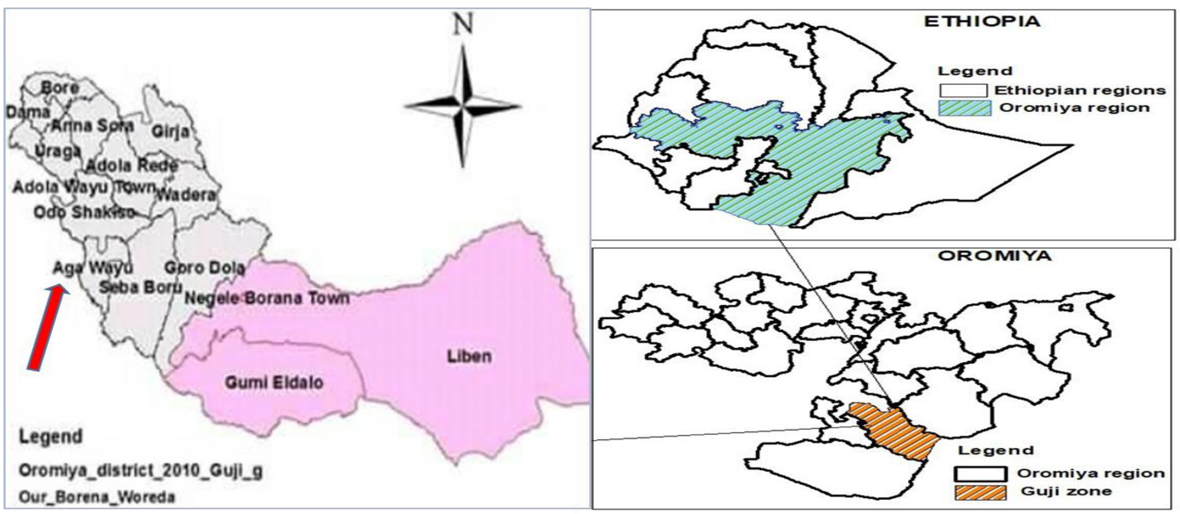

Figure 1: Location map of the Aga Wayu woreda Guji Zone, Oromia Region, Ethiopia

3.2. Sample size and Technique

The sample size of the study were determined using the technique described by (Daniel, 2009) .

$$n = \frac{N \times z^2 \times p(1-p) =}{e^2(N-1)} \frac{10{,}000(1.96)^2 \times 0.05(1-0.05)}{(0.05)^2(10{,}000-1)} = \frac{1{,}824.95}{24.9975} = 73.00$$

Where:

n = number of sample size,

N=number of camel population(N=10,000)

z =Standard normal deviate (1.96) which corresponds to 95% confidence interval,

p= prevalence of milk ,because there is no report were recorded for prevalence of milk production practice in the Aga Wayu woredas, P value were taken as 5%$(p = 0.05)$

e= precision/marginal error were taken as 5% $(d = 0.05)$

Despite the calculation discrepancy, 48 representative milk samples were collected by systematically selecting from three kebeles. For subsequent chemical analysis, the 5 or 6 milk samples from each kebele were pooled to create a composite sample. Chemical analysis was then performed on these composite samples, with results reported for the replicates obtained from each sample type.

3.2. Sample collection

Milk samples were collected from three different kebeles locations of Aga wayu woreda Guji Zone, Oromia Regional State, Ethiopia. The three kebeles (Meda sodu, Buri Ejersa, and Cekata Kojoha) was selected purpose sampling out of the 12 kebele in Aga Wayu woreda, where milk production widely practiced. From the three Kebeles samples were collected from three different sub-sites to provide biological replicates. After selection of the first unit, systematic sampling method was applied to draw sample at regular interval. The samples was collected at the same area in the same day and was preserved using bottles. Finally, equal volumes of the samples were mixed in volumetric flask and prepare for digestion and other parameters.

Cow and camel milk samples were collected in the morning from various kebeles in the Aga Wayu district, Guji zone, Oromia region. The samples were collected using plastic bottles .

Prior to collection, the polyethylene bottles were thoroughly washed and cleaned. To minimize contamination, the bottles rinsed with a small amount of the respective milk sample before being filled and sealed; ensuring no air bubbles remained inside. After collection, the samples were promptly transported to the Hawassa University Laboratory for further analysis. In the laboratory, the milk samples were subjected to a range of physicochemical analyses to evaluate their properties.

3.3 Instrument and apparatus

This study utilized various laboratory equipment and materials, including Duran (Germany) measuring cylinders and beakers for liquid handling; Whatman (Germany) funnels and filter papers for filtration; Pyrex (USA) pipettes and micropipettes for accurate liquid measurement and transfer, including sample solutions, acid reagents, metal standard solutions, diluted samples, and standard solution preparation; a Hitachi (Tokyo, Japan) refrigerator for sample storage; a Mettler Toledo (Switzerland) AG250 digital analytical balance (±0.0001 g precision) for weighing milk samples; a Digit heat (J. P. Selecta, Spain) drying oven for moisture content determination; and a Carbolite (England) S33 6RB muffle furnace (up to 1300 °C) for ash content analysis.

3.4 Chemicals and reagents

All reagents and chemicals used in the analysis were of analytical grade. Anhydrous magnesium sulfate, acetic acid and sodium acetate was obtained from Merck (China). A concentrated nitric acid (69-72% HNO_3, UNI-Chem, India) and 30% H_2O_2 (UNI-Chem. Chemical Reagent) were used in digestion of milk samples. Throughout the experiment deionized water was used for sample preparation, dilution and rinsing apparatus before analysis.

3.5. Methods

3.5.1 Determination of moisture content

The moisture content was determined according to the standard method of the Association of Official Analytical Chemists [5]. A weight of sample is removed by heating the sample in an oven (under atmospheric pressure) at 105 ± 1 ºC. Then, the difference in weight before and after drying is calculated as a percentage from the initial weight.

3.5.2. Determination of Fat content

The crude fat in the product was determined according to the standard analytical method of [5]. Briefly, 5g of sample was mixed with 0.88 mL of ammonia solution and 10 mL of 95% ethanol and mixed well. 25 mL of diethyl ether was added to the mixture and shaken vigorously for 1 minute. This was then followed by addition of 25 mL of petroleum ether and shaken vigorously to mix well. The mixture was then left to stand for an hour to allow aqueous and organic phase to separate. The fat extract (organic phase) was collected and the solvent was removed by distillation. The fat in the flask was dried in the oven at 100℃ for 30 minutes and the solvent was removed completely. The flasks were then cooled in a desiccator and were weighed for their mass of fat. The percentage fat was calculated by the following formula.

$$\%\ \text{fat} = \frac{\text{weight of extracted fat (g)}}{\text{weight of sample used (g)}} \times 100$$

3.5.3 Determination of ash content

The ash content was determined according to [5]. Two grams of the samples were weighted in a crucible, and then placed in a muffle furnace (Carbolite, Sheffeild, England) at 550-600 ºC for 3 hours until ashes are carbon free. The crucible was then cooled in a desiccator and weight. The ash content is calculated using the flowing equation:

$$\text{Ash content}\ \% = \frac{\text{Weight of the ash(g)}}{\text{Weight of the sample(g)}} \times 100$$

3.5.4 Determination of total solid content

Total solid content (TS) content was determined according to [6]. A clean aluminum moisture dishes was dried at 105 ºC for 3 hrs. 5 grams of the sample was weighed in dry clean flat bottom aluminum dishes and heated on a steam bath for 15 minutes. The dishes were placed into a force draft oven at 100 ºC for 3 hrs. Then the samples were cooled in a desiccator and weighted quickly. Weighing was repeated until the differences between the two readings were ≤ 0.1 mg. The total solids (T.S) content was calculates as follows:

$$\text{T.S}\ \% = \frac{\text{weight of the dried residue(g)}}{\text{weight of the milk sample(g)}} \times 100$$

3.5.5 Determination of lactose

The lactose content was determined by Anthrone Method. One mL of milk was pipetted in a 500 mL volumetric flask and diluted to 500 mL with distilled water. Then mixed and 0.5 mL was transferred into boiling test tube (in duplicate) the sample are place in an ice bath, and shacks while adding 10 mL of ice cold anthrone reagent the tube contents was and then places in a boiling water bath for 6 min, then transfer back to the ice bath for 30 min. The optical density of the color solution was then read at 625 nm.

3.5.6 Determination of pH

The pH of the samples was measured by using a freshly calibrated pH meter model (HI 8521 microprocessor bench pH / MV / C° meter). The pH meter was calibrated with two standard buffers (6.8 and 4.0) just prior to use.

3.5.7 Determination of titratable acidity

The acidity of the samples was determined according to [37]. 10 mL of each sample were placed in a white porcelain dish and four drops of phenolphthalein indicator was added. Titration was carried out using 0.1N NaOH until a faint pink color appears.

3.5.8 Determination of boiling point

5 mL of milk sample was measured and placed in a heat-resistant container and a thermometer with the bulb submerged in the liquid, and milk sample was heated gradually while observing for the first signs of sustained bubbling, and the temperature at which this occurs was recorded as boiling point.

3.5.9. Determination of specific gravity

The specific gravity of different types of milk was determined by using lactometer device. The lactometer is a special type of hydrometer. It is constructs and graduate so that the lactometer reading is relates to the specific gravity of milk on the ratio of the milk to water weight of a unit volume at a specifying temperature.

3.5.10. Mineral content

A UV-VIS spectrophotometer was used for determination of phosphorus. The samples and standard solution were prepared and analyzed by UV-VIS Spectrophotometer. The element calcium, sodium and potassium was determined by photometer. Milk sample were diagested by Extraction with mineral acid was performed using modified methods. An amount of 2.5 g of the homogenized sample was boiled for 10 minutes with 10 mL of 6 M HCl with reflux. The solution was cooled to room temperature and transferred to a calibrated flask. After addition of 2 mL of 10% of lanthanum solution(which are standard reagent in mineral analysis) the sample was diluted to the final volume of 50 mL with distilled water, filtered, and the resulting solution was used for the analysis.

4. RESULTS AND DISCUSSION

4.1 Physicochemical composition of cow milk and camel Milk

Physicochemical analysis is important parameter to monitor the quality of milk and its products. In this study, temperature, specific gravity, pH, boiling point, titratable acidity, total solid ash, lactose, moisture, protein and fat were analyzed for all samples collected from the study areas. These properties of milk related to quality of milk, therefore, testing the safety of current milk produced in the study area is important. Three replicates of each cow's and camels milk sample were analyzed for each physicochemical property. Standard deviations and means of each triplicate were calculated using Microsoft Excel 2010 and the results were as indicated in Table 1 and Figures 2.

Table 1. Results of analysis of physical parameters of cows and camels milk samples

Physical parameters	Cow's milk	Camel milk
Temperature(^{o}C)	19.33 ± 0.57	18.33 ± 0.57
pH	5.82 ± 0.46	5.38 ± 0.32
Moisture (%)	85.13 ± 2.65	82.83 ± 1.22
Total solid (%)	14.82 ± 2.11	18.26 ± 0.50
Specific gravity	1.04 ± 0.11	1.09 ± 0.05
Boiling point (^{o}C)	92.66 ± 0.57	88.00 ± 1.00

Table 1 show the values obtained for the physicochemical properties of the triplicate raw cow's and camels milk samples. The mean values of physicochemical parameters such as temperature, specific gravity, pH, boiling point, and titratable acidity, contents of cow's milk samples were 19.3 ± 0.5, 1.04 ± 0.11 g/ml , 5.8 ± 0.46 , 92.6 ± 0.57 , respectively. On the other hand, the respective mean values total soild ,ash, lactose ,protein , and fat content were 18.26 ± 0.50 %, 0.63 ± 0.049 % , 4.57 ± 0.55 %, 3.85 ± 0.32 %, 3.85 ± 0.32 % respectively.

The mean values of physicochemical parameters such as temperature, specific gravity, pH, boiling point, and titratable acidity, contents of camels milk samples were 18.33 ± 0.57, 1.09 ± 0.05g/ml , 5.38 ± 0.32, 88.00 ± 1.00 , respectively. On the other hand, the respective mean values total soild ,ash, lactose ,protein , and fat content were 14.82 ± 2.11%, 0.84 ± 0.12 %, 4.57 ± 0.55% %, 3.32 ± 0.43%, 4.47 ± 0.62% respectively.

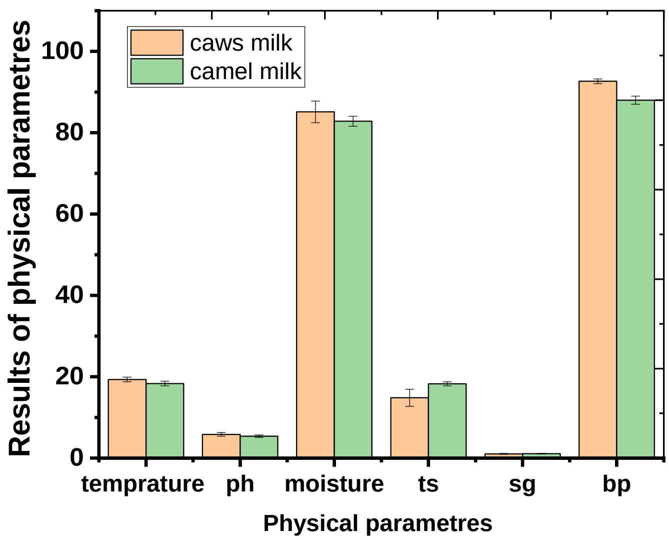

Figure 2: Level of physicochemical parameters in cows and camels milk

4.1.1 Discussion of physical characteristics

The physical characteristics such as specific gravity, moisture, pH, boiling point and TA are important parameters in studying the physicochemical compositions and nutritional aspects of milk. Table 1 and Figure 2 show the various physical parameters of the cows and camel milk samples.

4.1.1.1 Specific gravity

The density/specific gravity of milk among others usually used for quality test mainly to check for contamination of water to milk or removal of cream, addition of water to milk reduce milk density, while removal of cream increase it . From Table 1 and figure 2 , mean density values of raw cow's were 1.04 ± 0.11g/mL and camel were 1.09 ± 0.050 g/ml that influenced by the relation of its elements, such as fat, lactose, protein, casein, and salts. The density of milk decreases as the temperature is raised. Increased fat content decreases the specific gravity of milk. Generally, cow milk has a specific gravity between 1.027 and 1.035 with an average value of 1.032 at 25 ^{o}C and camel milk has specific gravity between 1.025 and 1.030 with an average value of 1.0275. As observed in the current study the values for both cow's and camel's milk were fallen outside of typical range 1.028 to 1.032 given for unadulterated milk.This may be due to: large standard deviations in the measurements,potential error in the methodology or sample handling.

4.1.1.2 Titrable acidity and pH

pH, a key indicator of acidity or alkalinity, is a crucial parameter in assessing milk quality**.** While international standards, such as those recommended by the WHO, suggest a pH of 6.6 for high-quality milk, this study (Table 1 and Figure 2) found the mean titratable acidity (TA) and pH values for both cow and camel milk to range from 0.2 ± 0.01% to 0.24 ± 0.030% and 5.38 ± 0.32 to 5.82 ± 0.46, respectively. Both milk types exhibited acidity, with TA values falling within the WHO permissible limit of 0.17% for fresh milk. However, the observed pH values were below the WHO recommended lower limit, indicating a more acidic nature. It is important to note that pH can increase up to 7.5 in cases of mastitis compared to normal mid-lactation milk.

4.1.1.3 Moisture

The results exhibited an average moisture content of 82.83 ± 1.22 % for camel milk and 85.13 ± 2.65% for cow's milk. However, the moisture contents in milk samples of cow are slightly greater when compared with milk samples collected from camel. This aligns with literature,as camel milk is known to have lower water content due to adaptation to arid environment [14]. and addition moisture in the storage material or adulteration and preservation processes.

4.1.2 Chemical Constituents

The chemical composition of the cow and camel milk samples, including total protein, ash, and fat content, was determined (Table 2). These analyses revealed significant variations in the chemical characteristics of the samples, with each sample exhibiting higher levels of at least one component compared to the others.

Table 2. Results of analysis of chemicals parameters of cows and camels milk samples

Chemical parameter	Cows millk	camel milk
Ash content (%/)	0.84 ± 0.12	0.63 ± 0.049
Lactose (%)	3.76 ± 0.50	4.57 ± 0.55
Fat (%)	4.47 ± 0.62	3.6 ± 0.48
Protein (%)	3.32 ± 0.43	3.85 ± 0.32

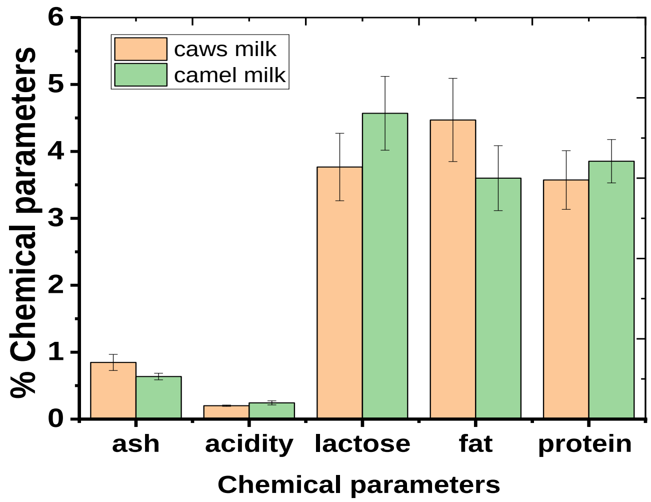

Figure 3 Level of chemical parameters in cows and camels milk

4.1.2.1 Total solid

From the Table 2 and figure 3, it can be seen that the total solids (ash) values are between 14.82 ± 2.11 % and 18.26 ± 0.50 % respectively for cows and camels milks. The result of this study also revealed that the total solid of cows and camel milk were within the quality standard values given by EU [36].

4.1.2.2 Total protein

The amount of total protein raw cow's and camel milk was found to be in the range of 3.32 ± 0.43 % for cow and 3.85 ± 0.32 % for camel from table 2 and figure 3. Total protein investigated was within the recommended values [36]. The results demonstrate that, cow's milk is a rich source of protein and casein whiles the content of total protein higher in the study area. According to my results the protein contents (3.32 ± 0.43 & 3.85 ± 0.32) are within acceptable range.

4.1.2.3 Total fat

Fat content in milk samples collected from cow and camel is given in Table 2 and figure 3. Results illustrated that fat content were 3.6 ± 0.48 and 4.47 ± 0.62 % for camels and cow's milk, respectively. From this result, the amount of fat in cow milk was slightly greater than camel milk. The study showed that the fat contents of the raw cow's and camels milk samples collected from sample area, which are good enough and above the minimum standard of WHO which is 3.5%.

4.1.2.4 Total ash

The white ash is mainly composed of oxides and chlorides of mineral elements, which include lime, mangnesia, soda ash, potash, phosphorus oxides, sulfur trioxide, ferric oxide, etc. The ash content values are found to be 0.63 ± 0.049 % for Camel and 0.84 ± 0.12 % for Cow's these values are slightly higher than that of the maximum permissible limit (0.65%). However, the ash contents in milk samples collected from camel are slightly lower when compared with milk samples collected from cow's milk [36].

4.2 Analysis of mineral contents of cows and camels milk

Table 3 and Figure 4 present the mean and standard deviations of mineral concentrations in composite samples of cow and camel milk. The highest mean concentration observed was **Ca** (17.07 ± 1.38 mg/L in cows and 22.44 ± 2.41 mg/L in camels), followed by **K** (11.97 ± 1.46 to 15.70 ± 2.59 mg/L), **Na** (2.51 ± 0.60 mg/L in cows and 3.63 ± 1.23 mg/L in camels), and **P** (2.43 ± 0.39 mg/L in cows and 2.63 ± 0.72 mg/L in camels), respectively,

In contrast to other studies [4] the mean of Ca in the current study (17.07 ± 1.38 mg/L) was lower, while the highest mean amount of Ca in camel's milk sample samples was 22.44 ± 2.41 mg/L. The mean K in the current study (11.97 ± 1.46 mg/l) for camel milk was much lower than cow's milk where it was 15.70 ± 2.59 mg/L according to the results of the study of [28]. In contrast, Na content in the present study (3.63 ± 1.23 mg/L) was the highest in cow's milk whereas it was the lowest (2.51 ± 0.60 mg/L) in camel's milk. In the current study, the findings of macro-mineral concentrations indicate that Ca and K had concentrations of more than Na which means that Na in cows and camels milks do not meet the requirements of the human body. Observed differences in mineral contents of cows and camels milks can be explained by several factors, including age, calf sex, feed composition, genetics, health status, parity, stage of lactation, milking practices, season, and geographica origin(due to the Aga wayu district was characterized by arid region that have less fertile soil and may have different mineral concentrations). Camel's milk contains different mineral contents in comparison to cow's milk since camels often eat arid, thorny plants that contain minerals.

Table 3 Results of mineral analysis of cow's and camels milk samples

Mineral analysis	Cow's milk (mg/L)	Camel milk (mg/L)
Phosphorus	2.43 ± 0.39	2.63 ± 0.72
Sodium	3.63 ± 1.23	2.51 ± 0.60
Calcium	22.44 ± 2.41	17.07 ± 1.38
Potassium	15.70 ± 2.59	11.97 ± 1.46

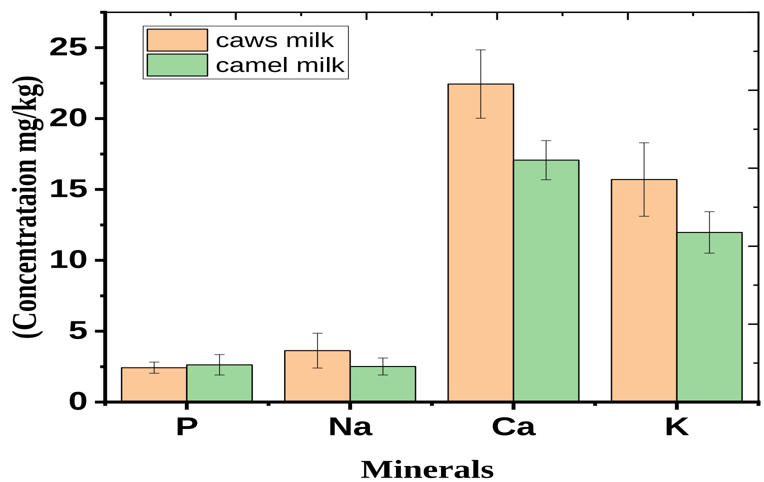

Figure 4 Concentration of minerals in cows and camels milk

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The physicochemical properties and mineral content of raw cow and camel milk samples collected from the study area were analyzed. Specifically, the concentrations of phosphorus (P), sodium (Na), calcium (Ca), and potassium (K) were determined. In cow milk, the mean mineral concentrations followed the order Ca > K > Na > P, while in camel milk, the order was Ca > K > P > Na. Physicochemical properties, including moisture content, pH, titratable acidity (TA), density, total solids (TS), ash, fat, and protein content, were also measured. The results indicated that the physicochemical composition of both milk types was generally consistent with FAO/WHO recommended values. The outcome of this study showed that, all the milk physicochemical compositions were significantly correlated with FAO/WHO recommended values. Cow's milk was found to have lower protein content than camel's , higher fat content than camel's milk, and camel's milk had a greater concentration of total solids. These findings highlight the distinct nutritional profiles of the two types of milk, which may have implications for their dietary applications

5.2 Recommendations

The study found that cow milk has higher fat and calcium,while Camel milk has more total solid and protein. The study also uncovered differences in minerals like sodium and potassium. It is recommended that these findings could be used to guide choices for consumers and policy makers. Additionally, further monitoring studies must be performed using more sensitive analytical instruments not only the studied one but also the other mineral in the future. Additional stuies should be conducted on all trace metals by using more sensitive instruments, taking time and increasing economy in the future. Therefore, it is recommended that introducing different dairy technologies should be supported with a continuous training on how to manage a dairy farm. Stronger milk quality control and quality base payment could help a lot to discourage adulteration.

Reference

1. Adolfsson, O.; Meydani, S. N.; Russell, R. M. Yogurt and Gut Function. Am. J. Clin.Nutr.2004, *80* (2), 245–256. (Accessed May 15, 2025, via SciRP).
2. Ahmida, N. H. S.; Shaboun, S.; Ahmida, M. H. S. Comparative Study on the Physiochemical and Nutritional Properties of Fresh Milk Samples Collected from Farms Animals in Benghazi City, Libya: Analysis of Physicochemical and Nutrition Properties of Raw Milk Samples. J. Pure Appl. Sci.2021, *20* (2), 49–53. DOI: 10.51984/jopas.v20i2.1086.
3. Al Haj, O. A.; Al Kanhal, H. A. Compositional, Technological and Nutritional Aspects of Dromedary Camel Milk. Int. Dairy J.2010, *20* (12), 811–821. DOI: 10.1016/j.idairyj.2010.04.003.
4. Al-Wabel, N. A. Mineral Composition of Camel Milk in Arid Regions: Implications for Nutritional Security. J. Arid Environ.2021, *188*, 104467. DOI: 10.1016/j.jaridenv.2021.104467.
5. AOAC. Official Methods of Analysis, 17th ed.; Association of Official Analytical Chemists: Washington, DC, 2000; Vol. II. (Accessed May 15, 2025, via SciRP).
6. AOAC International. Official Methods of Analysis, 22nd ed.; AOAC International: Rockville, MD, 2022.
7. Ayub, M.; Ahmad, Q.; Abbas, M.; Qazi, I. M.; Khattak, I. A. Modern Analytical Techniques for Milk Adulteration Detection: A Decade Review. Food Chem. Adv.2022, *1* (1), 100012. DOI: 10.1016/j.focha.2022.100012.
8. British Nutrition Foundation. (Accessed May 15, 2025, via SciSpace).
9. Burgess, K. [Review of] Milk and Dairy Products in Human Nutrition (2013), by E. Muehlhoff, A. Bennett and D. McMahon, Food and Agriculture Organisation of the United Nations (FAO), Rome. Int. J. Dairy Technol.2014, *67* (2), 303–304. DOI: 10.1111/1471-0307.12124.
10. Daniel, W. W. Biostatistics: A Foundation for Analysis in the Health Sciences, 9th ed.; John Wiley & Sons: New York, 2009. (Accessed May 15, 2025, via SciRP).
11. Dowelmadina, I. M. M.; El Zubeir, I. E. M.; Salim, A. D. A.; Arabi, O. H. M. H. Influence of Some Factors on Composition of Dromedary Camel Milk in Sudan. *Glob. J. Anim. Sci. Res.2014, *2* (2), 120–126. (Accessed via archives.gjasr.com).
12. FAOSTAT: FAO Statistical Databases; Food and Agriculture Organization of the United Nations: Rome, 2001. (Accessed May 13, 2025, via abebooks.com).

13. FAOSTAT; Food and Agriculture Organization of the United Nations: Rome, 2012. (Accessed May 15, 2025, via SciRP).

14. FAO. The State of Food and Agriculture 2023: Leveraging Livestock for Sustainable Development; Food and Agriculture Organization: Rome, 2013.

15. G, G.; M, A.; W, A.; K, H. Review on Goat Milk Composition and its Nutritive Value. J. Nutr. Health Sci.2016 , *3* (4), 401. DOI: 10.15744/2393-9060.3.401.

16. Hashim, I. B. Acceptance of Camel Milk Among Elementary School Students in Al Ain City, United Arab Emirates. J. Agric. Sci.2002, *14*, 54–59.

17. Haug, A.; Høstmark, A. T.; Harstad, O. M. Bovine Milk in Human Nutrition—A Review. Lipids Health Dis.2007, *6*, 25. DOI: 10.1186/1476-511X-6-25.

18. Hedayetullah, A. P.; Sohail, G. A. P.; Jamaat, A. P.; Hemat, K. Comparative Study on Nutritional Importance of Cow, Camel and Goat Milk of Nangarhar Province, Afghanistan. *IJRDO-J. Health Sci. Nurs.2019 , *4* (9), 01–06. DOI: 10.53555/hsn.v4i9.3204.

19. Hennessy, A. A.; Ross, R. P.; Stanton, C.; Devery, R.; Murphy, J. J. Development of Dairy Based Functional Foods Enriched in Conjugated Linoleic Acid with Special Reference to Rumenic Acid. In Functional Dairy Products, 2nd ed.; Saarela, M., Ed.; Woodhead Publishing: Cambridge, UK, 2007; Vol. 2, pp 443–495. DOI: 10.1533/9781845693107.3.443.

20. Hinrichs, J. Mediterranean Milk and Milk Products. Eur. J. Nutr.2004, *43* (Suppl. 1), i12–i17. DOI: 10.1007/s00394-004-1104-8.

21. Hodgkinson, S.; Godoy, L.; Beers, L. S.; Lewin, A. Improving Mental Health Access for Low-Income Children and Families in the Primary Care Setting. Pediatrics 2017 , *139* (1), e20151175. DOI: 10.1542/peds.2015-1175.

22. Imran, M.; Khan, H.; Hassan, S. S.; Khan, R. Physicochemical Characteristics of Various Milk Samples Available in Pakistan. *J. Zhejiang Univ., Sci., B 2008 , *9* (7), 546–551. DOI: 10.1631/jzus.B0820052.

23. Kamao, M.; Tsugawa, N.; Suhara, Y.; Wada, A.; Mori, T.; Murata, K.; Nishino, R.; Ukita, T.; Uenishi, K.; Tanaka, K.; Okano, T. Quantification of Fat-Soluble Vitamins in Human Breast Milk by Liquid Chromatography-Tandem Mass Spectrometry. *J. Chromatogr. B 2007 , *859* (2), 192–200. DOI: 10.1016/j.jchromb.2007.09.023.

24. Khan, I. T.; Nadeem, M.; Imran, M.; Ullah, R.; Ajmal, M.; Jaspal, M. H. Antioxidant Properties of Milk and Dairy Products: A Comprehensive Review of the Current Knowledge. Lipids Health Dis. 2019 , *18*, 41. DOI: 10.1186/s12944-019-0969-8.

25. Konuspayeva, G.; Faye, B.; Loiseau, G.; Levieux, D. Lactoferrin and Immunoglobulin Contents in Camel's Milk (Camelus bactrianus , Camelus dromedaries , and Hybrids) from Kazakhstan. J. Dairy Sci. 2007 , *90* (1), 38–46. DOI: 10.3168/jds.S0022-0302(07)72606-1.
26. Jayant, S. K.; Bano, Y.; Agrawal, N. D.; Kushwah, Y. K. Rheological Behavior and Comparative Analysis of Nutrient Composition of Milk from Three Different Breeds of Goats, Cows, and Buffalo. *Integr. Food Nutr. Metab. 2018 , *5* (2), 1–5. DOI: 10.15761/IFNM.1000208.
27. Lorenzen, P. C.; Wernery, R.; Johnson, B.; Jose, S.; Wernery, U. Evaluation of Indigenous Enzyme Activities in Raw and Pasteurised Camel Milk. Small Rumin. Res. 2011 , *97* (1–3), 79–82. DOI: 10.1016/j.smallrumres.2011.01.014.
28. Mostafidi, M.; Sanjabi, M. R.; Shirkhan, F.; Zahedi, M. T. A Review of Recent Trends in the Development of the Microbial Safety of Fruits and Vegetables. Trends Food Sci. Technol. 2020 , *103*, 321–332. DOI: 10.1016/j.tifs.2020.07.009.
29. Mossie, H. Review on Traditional Handling, Processing and Marketing of Milk and its Derivative in Ethiopia. Dairy Vet. Sci. J. 2019 , *13* (4), 555874. DOI: 10.19080/JDVS.2019.13.555874.
30. Musa, L. M. A.; Ahmed, M. K. A.; Peters, K. J.; Zumbach, B.; Gubartalla, K. E. A. The Reproductive and Milk Performance Merit of Butana Cattle in Sudan. Arch. Anim. Breed. 2005 , *48* (5), 445–459. DOI: 10.5194/aab-48-445-2005.
31. Omer, R. H.; Eltinay, A. H. Changes in Chemical Composition of Camel's Raw Milk During Storage. Pak. J. Nutr. 2009 , *8* (5), 607–610. DOI: 10.3923/pjn.2009.607.610.
32. Pereira, P. C. Milk Nutritional Composition and its Role in Human Health. Nutrition 2014 , *30* (6), 619–627. DOI: 10.1016/j.nut.2013.10.011.
33. Reincke, K.; Saha, A.; Wyrzykowski, Ł. The Global Dairy World 2017/18: Results of the IFCN Dairy Report 2018 ; IFCN Dairy Research Network: Kiel, Germany, 2018.
34. Reincke, K., Saha, A., & Wyrzykowski, Ł. (2018b). The Global Dairy World 2017/18 Results of the IFCN Dairy Report 2018.
35. Shapiro, B. I.; Gebru, G.; Desta, S.; Negassa, A.; Negussie, K.; Aboset, G.; Mechal, H. Ethiopia Livestock Sector Transformation: A 2030 Roadmap ; Ministry of Agriculture and ILRI: Addis Ababa, Ethiopia, 2023.
36. Tadesse, T.; Gure, A.; Kedir, K. Physicochemical Properties and Microbial Load Evaluation of Raw Cow Milks of Jimma Town, Ethiopia. Bull. Chem. Soc. Ethiop. 2023 , *37* (3), 553–563. DOI: 10.4314/bcse.v37i3.2.
37. FAO. The State of Food and Agriculture 2015: Social Protection and Agriculture—Breaking the Cycle of Rural Poverty ; Food and Agriculture Organization: Rome, 2015.

38. Shabo, Y.; Barzel, R.; Margoulis, M.; Yagil, R. Camel Milk for Food Allergies in Children. Isr. Med. Assoc. J. 2005 , *7* (12), 796–798. (Accessed May 15, 2025, via SciRP).