Effect of Different Stages of the Lactation Period on Physicochemical Properties of Camel, Goat and Cow Milk
أثر مراحل فترة الإدرار المختلفة في الخواص الفيزيوكيميائية للبن الإبل والماعز والأبقار

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وَإِنْ لَكُمْ فِي الأَنْعَامِ لَعْبَرَةٌ ۖ بِذَٰلِكَ نُسْقِيُّكُمْ مِّمَّا فِي بُطُونِهِ

(سورة النحل (الآية 66))
DEDICATION

To my father, mother, brothers and
Sisters
To all my friends
To all people who supported me during this study
With great respect

Amaal
AKNOWLEDGEMENTS

First and foremost, thanks and praise to Allah, who gave me the power and health to accomplish this study.

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ABSTRACT

This research was conducted to study the effect of different stages of the lactation period on physicochemical properties of three species, dromedary camel, saanen goat and cow milk during different lactation stages. The lactation period of each species was divided into three stages after calving, early, mid and late stages. Milk samples for each species were collected at different intervals during each stage and thus covering the whole lactation period. The samples were then subjected to laboratory analysis, which include compositional properties (Fat, Protein, Moisture, Lactose, Ash, Total solids and Solids not fat, calcium, phosphorus, iron) and physical properties (pH, titratable acidity, electrical conductivity, specific gravity and freezing point). The obtained results indicated the following:

The mean fat % of camel, goat and cow milk obtained in early stage of lactation period was 3.807±0.098, 2.933±0.126 and 4.407±0.263 respectively. The statistical analysis revealed a high significant difference (P ≤0.01) between the averages of the fat content of the different animals. In mid stage, means of 3.367±0.073, 5.020±0.149 and 3.787±0.356 for camel, goat and cow milk were detected and were also highly significant difference (P ≤0.01). For late stage of lactation, average fat % of 2.300±0.072, 3.580±0.047 and 4.367±0.352 was found in camel, goat and cow milk respectively. Similarly, high significant difference was noticed hereby (P ≤0.01).

The protein content (%) of milk in early stage for camel, goat and cow was 3.087±0.092, 3.633 ±0.039 and 3.400±0.072 respectively. Values obtained were highly significant difference (P ≤0.01). In mid stage were 3.333±0.055, 3.267±0.089 and 3.540±0.065 for camel, goat and
cow milk respectively. A significant difference (P ≤0.05) was noticed in this case. Average values detected in late stage were 3.393±0.055, 3.513±0.045 and 3.280±0.034 for camel, goat and cow milk respectively, and showed a significant difference (P ≤0.05).

The average moisture content (%) of camel, goat and cow milk in early stage was 88.159±0.171, 87.974±0.175 and 87.957±0.159 respectively, and no significant (P ≥0.05) was revealed between the averages. In mid stage mean values of 88.254±0.155, 87.714±0.133 and 87.802±0.045 were obtained for camel, goat and cow milk respectively and there were highly significant difference (P ≤0.01). In late stage mean values of 88.817±0.34, 87.569±0.106 and 87.802±0.045 were obtained for moisture content of camel, goat and cow respectively, with a high significant difference between the means (P ≤0.01).

Average total solids (TS) % for camel, goat and cow milk obtained in early stage was 11.841±0.171, 12.026±0.175 and 12.043±0.159 respectively. No significant difference was found herby (P ≥0.05). In mid stage was 11.746±0.155, 12.286±0.132 and 12.671±0.132 were obtained and also highly significant differences were obtained (P ≤0.01). In late stage mean values of 11.183±0.034, 12.431±0.106 and 12.198±0.045 were reached and a high significant difference (P ≤0.01) was noticed.

The average lactose % of camel, goat and cow milk found in early stage was 4.093±0.113, 4.651±0.071 and 3.491±0.071; in mid stage 4.271±0.074, 3.356±0.088 and 4.603±0.097 and in late stage 4.673±0.041, 4.557±0.097 and 3.807±0.097 respectively. A high significant difference (P ≤0.01) was noticed between the average percentages of lactose for the three stages of the lactation period.
Mean values of ash % found in early stage was 0.745±0.008, 0.755±0.007 and 0.740±0.007 in camel, goat and cow respectively, with significant difference (P ≤0.05). In mid stage mean value of 0.743±0.008, 0.756±0.005 and 0.747±0.007, in late stage was 0.745±0.008, 0.755±0.007 and 0.740±0.007 for ash % were reached for camel, goat and cow milk respectively. No significant difference (P ≥0.05) was detected between the average ash % in both mid and late stages of the lactation period. However, the calcium content (mg/100g) of camel, goat and cow milk was highly significant difference (P ≤0.01) in early, mid and late stages of the lactation period. Same was applicable for the phosphorus and iron contents.

Mean values of the solid non fat (SNF) in early stage in camel milk 8.035±0.174, in goat milk 9.092±0.080 and in cow milk 7.656±0.115. In mid stage was 8.379±0.104, 7.266±0.156 and 8.891±0.092, in late stage were 8.889±0.071, 8.851±0.093 and 7.831±0.104 for camel, goat and cow milk were recorded, a high significant difference (P ≤0.01) was recorded between the means of the SNF throughout the three stages of the lactation period.

Concerning physical properties; average pH values of camel, goat and cow milk in early stage obtained were: 6.584±0.019, 6.727±0.018 and 6.440±0.042 respectively. A high significant difference (P ≤0.01) was detected. In mid stage was 6.477±0.024, 6.573±0.042 and 6.600±0.041, in late stage were 6.486±0.042, 6.591±0.027 and 6.583±0.009 for camel, goat and cow milk respectively. The statistical analysis revealed a significant difference (P ≤0.05) between the means of pH in both mid and late lactation stages.
Average titratable acidity (as lactic acid) % obtained in early stage, was 0.161±0.003, 0.140±0.002 and 0.141±0.002 for camel, goat and cow milk respectively, and showed a high significant difference (P ≤0.01). For mid stage were 0.166±0.004, 0.154±0.004 and 0.169±0.003 respectively, indicating a significant difference (p ≤0.05). In late stage were 0.150±0.005, 0.175±0.002 and 0.156±0.005 for camel, goat and cow milk respectively, with a high significant difference (P ≤0.01).

Mean values of electrical conductivity (mS) in early stage, 6.553±0.124, 5.767±0.147 and 4.487±0.034, in mid stage was 7.989±0.135, 5.798±0.073 and 5.453±0.091, and for late stage was 7.965±0.086, 6.234±0.122 and 5.427±0.109 for camel, goat and cow milk respectively. The statistical analysis showed a high significant difference (P ≤0.01) between the means values during the three stages of lactation period.

The specific gravity showed means of 1.0324±0.0003, 1.0322±0.0003 and 1.0327±0.0003 for early stage; for mid stage, 1.0318±0.0005, 1.0324±0.0005 and 1.0325±0.0004 and late stage, 1.0326±0.0004, 1.0318±0.0004 and 1.0320±0.0004 for camel, goat and cow milk respectively, and no significant difference (P ≥0.05) was noticed throughout the three stages of the lactation period.

Freezing point (°C) showed an average of -0.543± 0.002, -0.472±0.073 and -0.549±0.001 in early stage, in mid stage was -0.546±0.002, -0.545±0.002 and -0.546±0.002. In late stage was -0.576±0.002, -0.576±0.002 and -0.576±0.002, with no significant difference (P ≥0.05) throughout the three stages of the lactation period.
المستخلص

هُدِفتْ هذه الدراسة لمعرفة تأثير مراحل الإفريقيا الفيزيوكيميائية لأربعة أنواع من الحيوانات، وهما: اللبلب العربي، نخال الحليب، الإبل، وجبين أبقار الأسود، في تأثيرهم على خصائص الفيزيائية للثلثة مراحل الإدرار بعد الولادة، منتصف ونهاية مرحلة الإدرار.

تم جمع عينات من اللبن لكل نوع خلال مراحل الإدرار المختلفة، ثم اختصت العينات للتحليل المعملي وقد شملت الخصائص الكيميائية التي تم تحليلها: (الدهن، البروتين، سكر ال荔枝، الرطوبة، الرماد، الجوامد الصلبة، الجوامد الصلبة اللاهدئية، البوتاسيوم، الفسفور، الحديد).

في بداية مرحلة الإدرار كان متوسط الدهن 3.807±0.098%، وفي منتصف مرحلة الإدرار كان متوسط الدهن 3.367±0.126%. وتُظهر النتائج التحليل الإحصائي وجود تفاوتات معنوية عالية (P≤0.01) في متوسط الدهن بين الإبل، نخال الحليب، الإبل، والأبقار.

وُجدَت التفاوتات المعنوية ذاتية (P≤0.01) بين متوسط نسبة الدهن في بداية مرحلة الإدرار 3.400±0.072%، وفي منتصف مرحلة الإدرار 3.393±0.045%.

وُجدَت التفاوتات المعنوية ذاتية (P≤0.01) بين متوسط نسبة البروتين في بداية مرحلة الإدرار 3.633±0.039%، وفي منتصف مرحلة الإدرار 3.580±0.047%.

وُجدَت التفاوتات المعنوية ذاتية (P≤0.01) بين متوسط نسبة العضلات في نهاية مرحلة الإدرار 3.540±0.065%.
أما متوسط نسبة الرطوبة للبن لإبل والماعز والأبقار في بداية مرحلة الإدرار فكانت

المعنوية بين المتوسطات الثلاث.

( P ≤ 0.05)

الألباق: 87.329±0.132 88.254±0.155 87.714±0.133

المتوسطات في نهاية مرحلة الإدرار: 87.569±0.106 88.817±0.034 87.714±0.133

أظهرت النتائج وجود فروق ذات معنوية عالية ( P ≤ 0.01). 

متوسط نسبة الجوامد الصلبية في بداية مرحلة الإدرار كانت 12.043±0.159 12.026±0.175

المعنوية بين الأنواع الثلاث. (P ≥ 0.05)

11.746±0.132 12.286±0.132 12.671±0.132

веденية عالية ( P ≤ 0.05). 

و في نهاية مرحلة الإدرار أيضا سجلت وجود معنوية عالية 11.183±0.045 12.431±0.106

12.198±0.045. 

( P ≤ 0.01)

أظهرت النتائج وجود فروق ذات معنوية عالية ( P ≤ 0.01). 

( P ≤ 0.01)

0.754±0.006 0.755±0.007

0.745±0.007

0.756±0.005

0.747±0.007

0.755±0.007

0.754±0.005

0.745±0.007

0.755±0.007

0.754±0.005

( P ≥ 0.05) 

0.762±0.003

0.754±0.006

0.743±0.008

0.743±0.008

0.754±0.006

0.743±0.008

0.754±0.006

0.743±0.008

0.754±0.006

وقيمة المتوسطات في منتصف مرحلة الإدرار كانت 0.743±0.008 0.754±0.006 0.743±0.008

وفي نهاية مرحلة الإدرار كانت 0.743±0.008 0.754±0.006 0.743±0.008

كل من لبن الإبل والماعز والأبقار على التوالي حيث

( P ≤ 0.05) 

0.762±0.003

0.754±0.006

0.743±0.008
محتوى الكالسيوم (\(100\)) كان عاليا خلال مراحل الإدرار المختلفة وهذا ينطبق أيضاً على كل من محتوى الفسفر وال الحديد.

دهنية في بداية مرحلة الإدرار كانت 8.035±0.174
8.379±0.104  7.656±0.115  9.092±0.080
أما في نهاية مرحلة الإدرار 8.889±0.071
8.891±0.092  7.266±0.156  8.851±0.093

دهنية خلال مراحل الإدرار الثلاث.

فيما يتعلق بالخصائص الفيزيائية كان متوسط قيم الأس الهيدروجيني في بداية مرحلة 6.727±0.018  6.584±0.019
(\(P\leq0.01\) على التوالي حيث أشارت النتائج الي وجود معنوية عالية (\(P\leq0.01\) في نهاية 6.573±0.042  6.477±0.024
6.583±0.009  6.591±0.027  6.486±0.042
وقد أظهرت نتائج التحليل الإحصائي الي وجود معنوية (\(P\leq0.05\).

أظهرت النتائج لقيم الأس الهيدروجيني لمنتصف ونهاية مراحل الأدرار.

كثيك) في بداية مرحلة الإدرار 0.161±0.002
0.141±0.000  0.140±0.002
(\(P\leq0.01\) في نهاية مرحلة الإدرار 0.169±0.003  0.154±0.004  0.166±0.004
معنوية (\(P\leq0.05\).

أظهرت النتائج في نهاية مرحلة الإدرار معنوية عالية (\(P\leq0.01\).

البقر على التوالي حيث أظهرت النتائج وجود معنوية عالية (\(P\leq0.01\).

التمسط التوصيل الكهربائي (سيمنز) في بداية مرحلة الإدرار 6.553±0.124
7.989±0.135  4.487±0.034  5.767±0.147
وفي نهاية مرحلة الإدرار 5.453±0.091  5.798±0.073
7.965±0.086  5.427±0.109  6.234±0.122
أظهرت نتائج التحليل الإحصائي وجود معنوية عالية (\(P\leq0.01\) بين المتوسطات خلال

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قد أشارت نتائج التحليل الإحصائي معنية (P ≤ 0.05) بين متوسطات الوزن النوعي في بداية 1.0322 ± 0.0003 و 1.0324 ± 0.0005 و 1.0325 ± 0.0004 و 1.0326 ± 0.0004.

كما أشارت النتائج أيضاً إلى عدم وجود معنية (P ≥ 0.05) بين متوسطات نقطة درجة منوية في بداية -0.543 ± 0.001 و -0.547 ± 0.002 و -0.549 ± 0.002 و -0.576 ± 0.002 و -0.575 ± 0.002 و -0.576 ± 0.002 و -0.576 ± 0.002 و -0.576 ± 0.002 و -0.576 ± 0.002 و -0.576 ± 0.002 و -0.576 ± 0.002 و -0.576 ± 0.002.
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CHAPTER ONE
INTRODUCTION

Milk is a fluid secreted by the female of all mammals and important for the function of meeting the complete nutritional requirement of the neonate of the species. It must supply energy, amino acids, vitamins, and minerals. Hence, milk is an ideal food for both infants and adults (Tamime 2006). Moreover, many physiological functions are performed by milk constituents; it contains several bio-protective molecules that ensure health security to humans including antimicrobial substances: immunoglobulins, lacto peroxidase, and lacto transferring enzymes and enzyme inhibitors and vitamin-binding carrier proteins (Fox et al. 2000).

The utilization of milk from different species depends on geographical conditions. There are more than 4,000 species are present in the world, only four species including cow, sheep, goat and buffalo produce milk for human consumption (Fox et al. 2000). The cow has long been the principal dairying species in many regions of the world. Buffaloes contribute significantly to milk production in the Indian subcontinent and Egypt. Sheep and goat are important in the Mediterranean regions, parts of the Middle East and some regions in Africa. The camel is an important source of milk in desert regions of North and East Africa, and the Middle East (Tamime 2006).

The composition of milk from milk producing species differs from each other. In addition to the species, geographical location and requirement for the neonates affect the milk composition. Also, genetic constitution of the individual species, age of the species, stage of lactation, number and time of milking, and certain disease conditions and seasons, influence the composition of milk (Üçüncü 2005).
Camel milk is one of the most valuable food resources for nomads in arid regions and can contribute to a better income for pastoralists (Farah 2004 and Chaibou 2005). Camel milk is mainly consumed in its raw state (boiling of the milk is not common as it is known to remove its"goodness") (Radwan et al. 1992) and (Semereab and Molla 2001). Many products can be transformed from Camel milk e.g. Al-Gariss and cheese but the ability of coagulation is much lower in camel milk than in the milk of cows, ewes, or goats (Gast et al. 1969) and (Ottogalli and Resmini 1976) and butter but unaccepted results in consistency and taste (Gast et al. 1969; Farah et al. 1989 and Abu-Lehia 1997).

Goat milk resembles cow milk on the basis of nutrient composition. However, it differs in several characteristics. All the beta-carotene is converted to vitamin A in goat milk, so it is white. The fat globules are smaller and therefore remain suspended, but the fat content is about the same with cow milk (Üçüncü 2005).

A close relationship is noticed between the different stages of the lactation period of a certain animal and milk composition. This is dependent on many factors of which the manage-mental conditions of the farm is of vital importance. Economically, an optimum benefit of milk is reached, when possible effects of the different stages of the lactation period (early, mid or late) on the physicochemical properties of the produced milk are put in consideration. The current study deals with such aspects.

Objectives:
1/ To determine and compare the physicochemical properties of camel, goat and cow milk during different lactation stages (early, mid and late).
2/ To study the effect of the lactation stages on milk physicochemical properties of the above mentioned three species.
CHAPTER TWO

LITERATURE REVIEW

2.1 Lactation Length

2.1.1 Lactation Length of Dromedary Camel:

Lactation length in the female camel varies from one region to another (from 8 to 24 months) (Tibari and Anouassi 2000). The duration of the lactation periods depends on race, parturition, climate and food conditions (Farah 2004). Although the lactation period may last up to 2 years, the camel calf is generally weaned much earlier, at any time between 3 and 18 months under traditional pastoral systems, the average beginning 12 months (Mukasa-Mugerwa 1981).

Lactation length of she-camel depends upon various factors and varies from 9 to 18 months (Qureshi 1986). The mainly available food item for the pastoralists is the milk of she-camel; therefore, they do not dry the animal, which results in the lengthy lactation period, even higher than 18 months. However, according to some researchers, the milk yield and lactation length of Pakistani camel averaged 1894.93 liters and 445.58 days (15months), respectively (Baloch 2001). In another Pakistan study lactation length varies between 270 to 525 days (9-18) months with the total milk yield ranging in between (1.250 to 3.650) liters with an average of 1800 liters per lactation as reported by (Jasra and Aujla 1998). The average lactation period in Indian camels lasts from 14 to 16 months, depending upon the time the calf is weaned. Milk yield averages 3-4 kg/day, with a peak yield of about 6 kg/day during the 5th and 6th month (Raghvendas 2004). Lactation period for Sudanese camels was found to extend between 10 to 20 months, and average milk production
during the lactation period varied from (1200 to 2600 kg), excluding the consumption of the young offspring (Wardeh 1989). In Saudi Arabia, Almutairi et al. (2010) reported, 1816.5 kg for the total milk yield at 305 days and a daily mean yield of 6.11 kg, with the persistency of 87.3%. Richard and Gerard (1989) reported average milk yield in Ethiopia 1123 kg with 97.1 % persistency from day (100 to 200) of lactation and 74.2 % from (200 to 300) days of lactation and the peak yield being reached at 56.5 days with the mean of 4.4 liters and 12.25 months for lactation length.

Razig (2004) has observed that the causes for different length of lactation probably are due to the breeders' control, fluctuations in vegetation, long prevailed drought in the last decade (1996-2002) and poor manage-mental practices of different areas.

2.1.2 Lactation Length of Saanen Goat:

Gol (1996) found that the length of lactation in Saanen goats was 256.4 day. Gamal and El-Khidir (1993) and El-Naim (1979) mentioned that the lactation length in Sudanese Nubian goat was 135±28 and 147 days respectively. Saanen goats in Switzerland had lactation length of 246 days in the first lactation and mature goats of the same breed had 273 days (French 1970). Kalafalla and Soliman (1990) reported, the lactation length of the Saanen and Nubian goats under Sudan condition was 253±56 and 121±46 days.

2.1.3 Lactation Length of Cow:

Lactation length is a period from calving to drying up of cow and is important factor influencing the milk yield. The standard length of lactation has been taken as (305) days which corresponds to the
reproductive cycle of cows. Both short and long lactation periods are not desirable since both increase loss of profit (Bath et al. 1985).

The length of first lactation was 244±6.9 and 295±8.28 days for Friesian cows in India as reported by Kulkarni et al. (2001). He pointed out the effect of season on lactation length was significant in Holstein Friesian breed. Rahmatalla (2002) found that the average lactation length in Belgravia, Khartoum University Farm and Judiciary Farm crossbred cows were 366.69±107.51, 371.46±122.90 and 344.15±188.11. Bhatt et al. (2004) working on Indian–born Holstein Friesian reported an average lactation length of 295±8.28 days. Ishag (2000) claimed, mean lactation length in Kenana Sugar Company Farm (crossbred cows) as 322.57±5.88 and 291.34±2.12 days in the first and overall lactation respectively. In North-East Tanzania, Masnga et al. (2000) studied lactation length of crossbred animals in small holder and reported that the least squire mean for first lactation was 33±77 days. Bulal (2000) observed that the overall mean of lactation length for crossbred cows in small holder farm was 363.5 days at Bilalo and 383.7 days at Lemmu. In Bangladesh, Islam et al. (2002) estimated that the lactation length of Friesian cross, Sahiwal cross, Sindhi cross and indigenous dairy cows were 253±24.73, 256.31±24.31, 255.86±27.58 and 230.62±30.68 days respectively. Rahman and Haque (2001) found that the lactation length of native cows in Bangladesh ranged from 230.58±69.51 to 266.96±78.91 days. In Vietnam, Dokim (2001) studied the lactation performance of dairy cattle breed and reported lactation length of 281.8 days.

Cows normally have a lactation curve that loses 8 to 10 % per month after the peak, but those rare animals whose production declines by only 4% or so may make a longer calving interval (Esslemont 2003). In most modern dairy farms, a lactation length of 305 days is commonly
accepted as a standard. However, such a standard lactation length might not work for smallholder dairy cows in which the lactation length is extended considerably in most cases (Teodor and Madalena 2003; Masama et al. 2003 and Msangi et al. 2005).

However, Borman et al. (2004) demonstrated that extended lactation are suitable for some dairy enterprises and that the suitability depends particularly on cow milk potential, the ability to grow pasture of feed supplements economically, management expertise, environmental constraints, herd size and labour availability. Moreover, Osterman and Bertilsson (2003) suggested that by combining a longer calving interval with increased milking frequency, daily milk production from one calving to another could be increased, making an increased calving interval an interesting option for dairy farmers. In addition, an economic advantage in extending lactations (by 60 days) was found even in the case of high-yielding cow. This advantage was greater for primiparous cows because of the high persistency of their milk production and the increase in the fat and protein contents of their milk as lactation progresses (Arbel et al. 2001). Thus, it is of interest to properly evaluate the economic benefits and subsequently optimize both the lactation length and calving interval under the given production level and prevailing management condition.

2.2 Compositional Properties

2.2.1 Chemical Composition of Dromedary Camel Milk:

Camel milk composition was found to be less stable than other species such as bovine milk. These variations in camel milk composition could be affected by several factors such as analytical measurement procedure, geographical location, feeding conditions and samples being taken from different breeds, in addition to other factors including stage of
lactation, age and calving number (Khaskheli et al. 2005 and Al-Haj and Al-Kanhal 2010). According to Konuspayeva et al. (2009) geographical origin and seasonal variations were found to be the most effective factors in camel milk composition. Studying the effect of geographical origin on camel milk composition they found that the milk composition from camels living in East Africa has higher fat content than the milk from camels living in Western Asia. Alwan et al. (2014) reported that the important factors that affect the composition of camel milk is the amount of water available to the she-camels; hence they found the moisture content of milk from she-camel reared in desert was higher than those reared on farm. Mehaia et al. (1995) demonstrated that many variations in camel milk composition were observed for camel from the same species (Dromedary) but bred in different parts of the world. Haddadin et al. (2008) and Shuiep et al. (2008) showed that camel milk composition was also affected by seasonal variation even for camels from the same species (Dromedary) and region. Also Haddadin et al. (2008) found a contrary relationship between total solids in camel milk and water intake by camel; they studied all components, except lactose, reached their maxima in winter and were lowest in summer. For example, total solids were 13.9% in December and January, and 10.2 in August due to availability of drinking water. In another study, the fat content of camel milk was reported to decrease from (4.3 to 1.1) percent due to the increase in water content of milk produced by thirsty camels (Yagil and Etzion 1980).

2.2.1.1 Fat Content:

According to Grounda (1996) the concentration of fat in dromedary camel milk ranges between (2.6 - 5.5%) and (1.9 to 5.6 %) according to (Bayomi 1990). The variation in the fat content is associated with the type of breed, stage of lactation and feeding condition as described by
(Webb et al. 1980). Basmaeil and Bakkar (1987) noticed the fat content in camel milk is less than in cow milk. Cream layer formation of camel fat globules is very poor due to deficiency in agglutinin that causes very slow creaming rate at all temperatures as observed by (Farah and Ruegg 1991).

2.2.1.2 Protein Content:

Konuspayeva et al. (2009) reported that dromedary Camel milk protein content in range of (2.15 to 4.90) percent. Camel milk from same breeds has similar protein content (whey protein and caseins) and different for other breeds (Sawaya et al. 1984; El-Amin and Wilcox 1992 and Mehaia et al. 1995). With the change in season, protein content of same strain varied. It is found to be low in summer 2.408 percent and high in winter 2.9 percent (Mehaia et al. 1995).

2.2.1.3 Water (Moisture) content:

Water considered as the important component of camel milk. Al-Ani (2004) and Omer (2001) reported the water content of dromedary camel milk was 87% and 88.31% respectively. Ahmed (1988) mentioned, the camel milk composition is so similar to cow milk composition and the water content is 87.3% for milk of both animals.

In thirsty she-camel the water content increases from 87% to 91% as noticed by (Soliman et al. 2006). In case of water sufficiency and shortage, the content in the milk was found as 86.6% and 91% respectively (Abdel-Aziz 2001). Yagil and Etzion (1980) reported, when examining only the affects of the lack of drinking water on camel milk the diet remains only unchanged throughout the year, but great changes in water content of the milk, and it would appear that lactating camel loses water in the milk at time of drought, which could be natural adaptation in
order to provide not only nutrients, but necessary fluid to the dehydrated calf.

2.2.1.4 Total Solids Content:

Sawaya et al. (1984) found the total solids content of camel milk were 11.7%. However Khanna (1986) reported that the total solids were 12.39 to 14.30% . Abu-Lehia (1987) analyzed milk samples of Najdi camels for a period of 3 months during winter/spring season and stated that total solids 11.29±0.57. Mal et al. (2006b, 2007) reported that total solids content in range of (9.85-11.45) percent.

2.2.1.5 Lactose Content:

The concentration of Lactose in dromedary camel milk found to range 2.4-5.3% as given by (El-Amin and Wilcox 1992 and Wilson 1984).

A remarkable variation between the averages of lactose % in different areas was noticed, e.g. 5.8% in Pakistan, 4.9% in India and 4.4% in Saudi Arabia (Abdel-Rahaman 1996). The lactose content of camel milk remained unchanged from the first months up to the end of lactation (Haddadin et al. 2008); this indicated that the values did not change (Indra and Evdeneboatr 1994). The lactose content of camel milk in case of plentiful – drinking water was 4.6% and in scarce-drinking water 2.9% as noticed by (Yagil and Etizon 1980.)

2.2.1.6 Ash Content:

The total content of minerals is usually expressed as total ash. This amount was found to range from 0.60 to 0.90% in dromedary camel milk (Konuspayeva et al. 2009). According to Gaber and Naiem (2006) the ash content was 0.7% while Gihad (1995) gave a range of (0.26-0.64 %).
In thirsty camels the ash content decreases to 0.35% (Abdel-Aziz 2006), but compared with cow milk it was low. Gendil (2003) gave an ash content of 0.79% for camel milk and 0.67% for cow milk.

**2.2.1.7 Minerals:**

The minerals content of dromedary camel milk chemical analysis studies revealed that the ash is a complicated mixture which contains potassium, sodium, calcium, magnesium, chlorine, phosphorus and sulfur in relatively large amounts, small amounts of iron, copper, zinc, aluminum, cobalt and iodine and traces of silicon boron are present in camel milk (Clarence *et al.* 1982). The differences in mineral content were affected by several factors such as feeding, breed, analytical procedures (Mehaia *et al.* 1995) and water intake (Haddadin *et al.* 2008). Al-Haj and Al-Kanhal (2010) reviewed that the mean values of dromedary milk minerals are as follows: calcium, 114 mg/100g, potassium, 156 mg/100g, sodium, 59/100g, iron, 0.29/100g, magnesium, 10.5/100g, manganese, 0.05/100g and zinc, 0.53/100g. Camel milk is a rich source of chloride (Khaskheli *et al.* 2005). Camels usually prefer halophilic plants such as Atriplex, Salosa and Acacia to meet their physiological requirements of salts (Yagil 1982). Moreover, the decrease in major milk components and increase in chloride content of milk from dehydrated camels might be another cause for the salty taste in camel milk (Yagil and Etzion 1980).

The minerals Na, K, Fe, Cu and Mn in dromedary camel milk were considerably higher than those reported for bovine milk (Sawaya *et al.* 1984 and Mehaia *et al.* 1995). Several minerals play important roles in different biological activities such as Fe which is found to play an essential role in a number of biological systems, including oxygen transport and storage as well as DNA synthesis. Al-Attas (2008), stated that Mn plays a key role in cellular metabolism, where the presence of
this element is important for the function of a number of enzymes. Furthermore, the content of Ca, P and Mg of dromedary camel milk are close to bovine milk (Sawaya et al. 1984).

2.2.2 Chemical Composition of Saanen Goat Milk:

Goat's milk is made up of fat, protein, lactose and water, and it has a pure white appearance when fresh (Steel 1996). Differences occur between breeds and between individuals within breeds as well, due to stage of lactation, and environmental factors such as nutrition (Devendra and Burns 1982). Goats milk composition varies appreciably according to the breed, the locality, the stage of lactation, the season of the year, the feeding and management, the incidence of estrus and the state of health of the nanny, consequently and perhaps even more so than with cows, also there can be a significant variation between individuals (Frensh 1970).

2.2.2.1 Fat Content:

The average fat content is 3.7±0.66% in Saanen goat's milk under Sudan condition (Gol and Abdullah 1997). Ibrahim (2000) estimated that the fat % was 4.05±0.76, 3.64±0.42 and 3.4±0.54 in Nubian goat's milk, crossbred 0.75 Nubian x 0.25 Saanen and 0.50 Nubian x 0.50 Saanen respectively. The fat % of milk of cross Saanen goats in Brazil is 3.83±1.04% and the correlation is positive r =0.7715 among fat and total solids in milk content (Chornobai et al. 1999). Similarly, Prata et al. (1998) estimated that the percentage milk fat averaged 3.74 in Saanen goat in the south eastern region of Brazil. Sung et al. (1999) reported that the percentages of fat milk of three goat, breeds in Taiwan, Alpine, Nubian Saanen and Toggenburg was 3.54±1.01, 4.48±0.66 and 3.54±0.96 respectively. More mover, in Alpine, Saanen and their crossbred the milk yield average 588.628 and 566 kg respectively, the fat concentration was
32.7, 30.9 and 31.8 gram/kg respectively in France milk goats (Montigny 1990). Sigwald (1993) reported that the fat yields were 22.9, 22.7 and 20.4 kg in Alpine, Saanen and their crossbred, while milk yield was found to be 66.5, 709 and 623 kg per lactation period respectively. El-Naim (1979) and Koudouda (1985) stated that the fat % of Nubian goat's milk was 3.61% and 3.39% respectively in Sudan. Anglo-Nubian goat's yield was 681 kg and its milk fat content was 31.7 kg in temperate region (Sommerfield 1993).

2.2.2.2 Protein Content:

Gol and Abdullah (1997) stated that the protein content was 3.43±0.37 in Saanen breeds under Sudan condition. El-Naim (1997) and Koudouda (1985) estimated that the protein content of Sudanese Nubian goats milk was 3.42 and 3.46% respectively. The protein yield is 25 kg from 681 kg as milk yield in Anglo-Nubian goats milk (Sommerfield 1993) in Taiwan. The protein for Alpine, Nubian, Saanen and Toggenburg revealed 3.08±0.57, 4.23±1.02, 3.25±0.57 and 3.21±0.59 respectively, (Sung et al. 1999). In United States livestock dairy goats have protein content ranging from 3.69 % for Nubian breed to 2.98% for Toggenburg (Haenlein 1996). Moreover, in cross Saanen goats protein was 3.34±0.73% as given be (Chornobai et al. 1999).

2.2.2.3 Water (Moisture) Content:

The amount of water in milk reflects the nutritional balance of milk which makes milk as a whole of greater nutritional value than the value of its individual nutrients. The water content of goat milk ranged from 88-90 % (Bencini and Pulina 1997). The water content of Nubian goat milk was found to be 88.05%, which was lower than that of Saanen goat milk which was found to be 88.44 % (Gol and Abdullah 1997). While
Michel (1991) found that the average value of water content of cow milk was 88% whereas the water content of ewe milk was found to be 79.64% (Mackenzie 1980).

2.2.2.4 Total Solids Content:

Gol and Abdullah (1997) found the total solids content of Saanen goats milk under Sudan condition to be 12.18±0.88%. In Nubian goats milk total solids are 12.55% (El-Naim 1979). However, Kudouda (1985) reported that the total solids were 11.98% in Sudan, while, the percentages for total solids in Taiwan were 11.55±1.35 for Alpine breed, 13.56±1.73 for Nubian, 11.06±1.16 for Saanen and 11.61±1.34 for Toggenburg breed (Sung et al. 1999). Chornobai et al. (1999) stated that the total solids content of raw milk samples collected from crossbred Saanen goats was 12.25±1.94 gram/100 grams in Brazil, and also reported a positive correlation for fat/total solids 0.7715 and protein/total solids 0.6228. Similarly, mean value for total solids was 12.24±0.92 in samples of Brazilian goat milk and total solids are affected by breeds, climate and lactation D'-Alessandro et al. (1995), and also found that Anglo-Nubian goats produced more concentrated milk than Brown and Saanen goats. The percentage of water of Saanen goat milk in the southeastern region of Brazil is 88.49 from total components of milk (Prata et al. 1998). Queiroga et al. (1998) reported that the total dry extract ranged from 12.75 to 13.9 gram/100 grams of milk for morning and Afternoon milking of crossbred goats, Anglo-Nubian, Parda Alpine and Saanen crossed with native breeds in Brazil.

2.2.2.5 Lactose Content:

The lactose content is 4.41±0.56% in Saanen breeds milk under Sudan condition (Gol and Abdullah 1997). However, for Nubian goats
milk in the Sudan, Kudouda (1985) and El-Naim (1979) found that lactose content was 4.31% and 4.67% respectively. In evaluation of lactose contents of milk in Alpine, Nubian, Saanen and Toggenburg breeds in Taiwan 4.37±0.34%, 4.16±0.63% 4.56±0.19% and 4.16±0.46% were found respectively by (Sung et al. 1999). The lactose % of Saanen goat's milk in the south eastern region of Brazil averages 4.35% (Prata et al. 1998). For morning and afternoon milking of crossbred goats (Anglo-Nubian, Parda Alpine and Saanen crossed with native breeds in Brejo Paraibano, Brazil during 195 days lactation, the mean value is 4.11 to 4.26 gram/ 100ml for lactose content (Queiroga et al.1998).

2.2.2.6 Ash Content:

The average ash content is 0.65± 0.06 of milk in Saanen goats breed in Sudan (Gol and Abdullah 1997). While the Nubian goat in Sudan, revealed ash content of 0.82% and 0.84% according to El-Naim (1979) and Kudouda (1985) respectively. In Southeastern region of Brazil, Parta et al. (1998) reported that the mean value of ash was 0.682 to 0.744 gram/ 100 for Anglo-Nubian, Parda Alpine and Saanen crossed with native breeds in Brazil.

2.2.2.7 Minerals:

Goat milk has the highest minerals contents compared to that of cow milk. Jenness (1980), Desjeux (1993) and Belewu et al. (2002) reported that, goat’s milk provides a great amount of calcium and phosphorus.

Calcium content of goat milk was found to be 0.13% Kon (1972), Warner (1978) and Meschy (2002). It was very close to that of cow milk (the value of cow milk Calcium was found to be 0.12%). The mean concentration of Calcium in milk of Nubian goats was found to be 0.14%
while the average value of Calcium in milk of Saanen goats was found to be 0.10%, which is lower than Nubian goat milk (Csapo et al. 1986). Sheep milk was found to have calcium content of 0.2% (William 1990), which was higher than that of goat milk.

The true absorption coefficient (TAC) of phosphorus is higher in goat milk than in milk of other ruminant species. The average value of phosphorus in goat milk was found to be in the range between 0.065 to 0.088 percent (Sawaya et al. 1984), while cow milks phosphorus has lower value than goat milk, which was found to be 0.023% (Dronen 1990). The average value of phosphorus content of Nubian goat milk was found to be 0.086%, which was higher than phosphorus content 0.080% of Saanen goat milk (Csapo et al. 1986).

2.2.3 Chemical Composition of Cow Milk:

Cow milk is mainly composed of water, with approximately 4.8% lactose, 3.2% protein, 3.7% fat, 0.195% non protein nitrogen and 0.7% ash (Smit 2005).

According to Osman (2006) the milk components can be divided into originary and non originary components, whereby the originary components include water, protein, fats, lactose, minerals, vitamins and enzymes, while microorganisms, chemicals, cells and others represents the non-originary components.

2.2.3.1 Fat Content:

Fat is the complex of lipids and exists in microscopic globules as oil in water emulsion in milk. The majority of milk lipids are triglycerides or esters of fatty acids, combined with glycerol (97-98%), and the minority are phospholipids (0.2-2 %) free sterols (0.2-0.4 %) and traces
of free fatty acids and about 62% of milk fat is saturated and 4% of minor types of fatty acids (Miller et al. 2000).

According to Darwish (1990) milk fat is composed of triglycerides containing saturated fatty acids of 4-20 carbon and some of unsaturated fatty acids. Altakriti and Alkhal (1986) estimated the fat content of cow milk to be 4%.

According to Zaid and Mohamed (1994) fat content of cow milk from a mixture herd is 3.7% and it is important component to determine milk price. Al-Barbary (2000) mentioned that fat content of cow milk is 3.6%, while Ben (1976) gave a 3.7% fat content.

A wide variation between the fat content of different species is recorded, e.g. Friesian 3.42%, Jersey 5.87%, Guernsey 5.03% and Semental 3.89% (Said Ahmed and Adel 2000).

The fat content of different species of cows was as follow: Ayrshire 4.1%, Brown Swiss 4.0%, Guernsey 5.0%, Friesian 3.35%, Jersey 5.5% and Zebu 4.9% (Taha et al. 1989).

Al-Shabibi et al. (1990) noticed that fat is the most component which changes and ranges from 3.5-3.7%. The fat content influenced by several factors, such as species, genetics, physiological state, environment and management of stock, nutrition and lactation period (Al-Higrawy 1987).

Abdullah (2002) noticed that fat content of tropical breeds was found to be 5.3%, while of the European breeds 3.9%. The fat of cow milk is digestible and contains high percent of short chained free fatty acids 10% and 30% long chained fatty acids 4% essential fatty acids and vitamins soluble in fat A, D, E and K (Al-Nimer 2007).
2.2.3.2 Protein Content:

The basic components of protein are amino acids; the protein of milk is influenced significantly by the feeding and varies between 3.0-3.6%, and total protein of cow milk is 3.4% (Ben 1976).

Smit (2005) mentioned that milk contains two types of proteins, a protein in water soluble at pH 4.6 called casein and represent 78% of the total nitrogen's in bovine milk and the soluble protein called whey or serum protein , which consists of two types globulin and albumins, but now known as B-lacto- globulin and ø–lacto-albumin.

Hana and Ata-Allah (1995) mentioned that proteins of cow milk can be grouped as follow: B-lacto globulin, casein and lacto-albumin, they make about (90-95%) of the total protein in cow milk. The average percentages of the three types of cow milk proteins according to Al-Higrawy (1987), casein 3.1% lacto-albumin 0.5% and lacto-globulin 0.5%.

Casein as the principal protein in cow milk has been extracted commercially at the 20th century and the casein content of whole milk varies according to the breed of cow, stage of lactation and time of milking, but is generally in the range of 24-29 gm/liter as reported by Janness and Putton (1959), Also Taha et al. (1989) mentioned, cow milk protein consists of 2.5% casein and 0.6% whey protein. The protein content of mixture milk of some cows was found as 3.5% by (Zaid and Mohamed 1994).

Al-Barbary (2000) reported, the protein content of cow milk is (3.32%) of the total components. Said Ahmed and Adel (2000) gave the protein of various species of cows as follows: Friesian (3.25%), Jersey (4.08%), Semental (3.32%), Gurency (3.93%).
2.2.3.3 Moisture (Water) Content:

Al-Nimer (2007) stated, water constitutes about (85-90 %) of mammalian milk and some milk component are soluble in water, e.g. vitamins, enzymes and lactose. Furthermore, he added that water is found in milk in two forms water free (96%) of the total milk and bound water (4%) and combined with proteins, phospholipids and fat globules.

According to Al-Barbary (2000) cow milk contains 83.3% water, while Said Ahmed and Adel (2000) mentioned that the water content differs from cow to another due to breed, and the water content in the milk of some types of species was as follow: Friesian 87.82%, Jersey 84.60%, Semental 87.27%, Gurency 85.20%.

Abdel-Alhameed (1996) indicated that cow milk contains 87% water of total composition of milk. Spreer and Mixa (1995) explained that water is the major component of milk; it is used principally as solvent for the ingredients in the dairy products, e.g. milk powder, cheese and butter.

According to Gendil (2003) water is a basic component in milk and it is 87.3% in cow milk. Eltakriti and Alkhal (1986) gave a 86.2% for water content of cow milk and the same for camel milk. Abdullah (2002) recorded that milk contains about (79-89%) water according to animal type and other factors e.g. nutrition.

Water is the fluid fraction of cow milk; it is about 87% of the total composition of milk (Al-Safar and Al-Hamadani 1982).

The cow milk contains about 86-87% water, and is found in two types, free and combined (Al-Higrawy et al. 1974).
2.2.3.4 Total Solids Content:

Khalifa and Bayoumi (1966) reported that the total solids (TS) content of cow’s milk in a dairy herd varied slightly from one season of the year to another ranging from 13.72 to 14.83%. Idris et al. (1975) reported comparable values of total solids TS to those reported by (Khalifa and Bayoumi 1966). On the other hand, Khalid and Joseph (1976) reported higher values of total solids (TS) content of cow’s milk varying from 12.13 to 15.39%.

2.2.3.5 Lactose Content:

Lactose is the characteristic carbohydrate of milk, the average of lactose content in cow milk is 4.8% (Ben 1976). Abu-Dawoud et al. (2003) stated that lactose is an essential carbohydrate in milk, composed of glucose and galactose, less soluble in water, sweet than sucrose, fermented with bacteria to give lactic acid and is about 4.91% in cow milk.

Lactose is a disaccharide which is found only in milk and the content of cow milk is 4.9% as given by (El takriti and Alkhal 1986). The lactose of various breeds is different, e.g. Ayrshire 4.57%, Friesian 4.46%, Guernsey 4.57%, short horn 4.51% as given by (Abdel-Alhameed 1996). Lactose is the principal carbohydrate in milk, it is a disaccharide formed from galactose and glucose and forms about 54% of the total non-fat milk solid, and provides 30% of the energy of milk (Smit 2005).

Zaid and Mohamed (1994) calculated 4.9% lactose content in mixed milk of different milk cows also Said Ahmed and Adel (2000) found a variation between species of cows in the lactose content as follows: Friesian 4.9%, Jersy 4.7%, Semental 4.8%, Guernsey 5.1%.
2.2.3.6 Ash Content:

The ash content in cow milk is 0.7% as given by (Gaber and Naiem 2006). Also Sharesha (1990) compared the basic milk components of some animals and human, he found the ash content in cow milk 0.7%, camel milk 0.6 - 0.8% and human 0.2-0.3%, also, Abdel-Alhameed (1996) mentioned, ash content in 0.76% Holstein, 0.77% in Jersey and 0.73% in Short horn.

The percentage of ash in the composition of milk is about 0.7%. Khalid and Joseph (1976) reported that the ash content varies from 0.5-0.72 percent. Pearson (1976) reported that the ash figure below 0.75 % may be due to the presence of added water.

2.2.3.7 Minerals:

Cow milk contains seven minerals as major components and may vary widely (Harber and Hall 1981).

As stated by Abuzeid (1999) milk contains minerals such as Zn, Mg, Fe, Cu, Mn, which are activator and important in enzymes function, while Mo and Co are essential part of vitamin (B_{12}) and Fe for blood hemoglobin. Also, Eckles and Macy (2004) reported that the ash of milk contains potassium, sodium, calcium, magnesium, chlorine, phosphorus, and sulfur in relatively large amounts .Beside other small amount of iron, copper, Zink, aluminum, manganese, cobalt and iodine and traces of silicon, boron, titanium, vanadium, rubidium, lithium strontium.

The average percentages of the main minerals from total composition were as follow: calcium 0.120%, phosphorus 0.10%, potassium 0.15%, chlorine 0.11%, manganese 0.01% and sodium 0.05% as given by Hanna and (Ata-Allah 1995). They added that minerals in
cow milk was estimated between (0.6-0.8) percent of total composition of milk, and are changed to ash in analysis of milk.

2.3 Physical Properties

2.3.1 Physical Properties of Dromedary Camel Milk:

Camel milk is usually opaque-white in color and has acceptable taste (Yagil and Etzoin 1980) and (Alwan and Igwegbe 2013). The milk normally has a sweet and sharp taste, but sometimes can also have a salty taste due to the type of plants eaten in the desert by the camels (Rao et al. 1970; Khaskheli et al. 2005 and Alwan and Igwegbe 2013). The changes in taste are mainly caused by the type of fodder and availability of drinking water (Farah 1996). Camel milk is frothy when shaken slightly (Shalash 1979).

2.3.1.1 pH Value:

The average pH-value of dromedary camel milk was 6.65-6.7 as given by (Al-Ani 2004).

According Sawaya et al. (1984) the pH ranges from 6.2 to 6.5 which agreed with that reported by (Ohri and Joshi 1961). Moreover, Alwan et al. (2014) found that the pH of camel milk was ranged from 6.3 for she-camel reared under normal desert conditions and 6.57 for she-camel reared under good farm conditions. Shalash (1979) mentioned, the pH of camel ranged between 6.5 - 6.7 which is similar to the pH of sheep milk, but slightly lower than bovine milk (Sawaya et al.1984).

2.3.1.2 Titratable Acidity:

Al-Inpiadairy (2010) stated the acidity of fresh camel milk and milk diluted with water (1:1) and stored at room temperature was 0.12±0.03%, also Sawaya et al. (1984) noticed an acidity of 0.13% in camel milk. Since camel milk contains antimicrobial and protective
effects compounds of protein-nature, the growth of bacteria in milk can be inhibited and as a result of the developed acidity, this allows camel milk to be kept for longer periods compared with other milks (Wernery 2007; Elias 1995).

Dukwal et al. (2007) pointed out camel milk remains quite stable at room temperature and takes a comparatively longer time to become sour. The rate of developed acidity is lowered, especially at pH 5.2, while the natural acidity of camel milk is maintained for 13 days, when the milk is kept at 10°C (Zaid et al. 1991).

2.3.1.3 Electrical Conductivity:

The electrical conductivity was not considered adequate method for mastitis diagnosis in camels by Younan et al. (2001) and Bhatt et al. (2004) as no significant change can be proved in case of mastitis. Electrical conductivity is defined as the resistance of a material to electric current. It is widely used as a simple and effective tool for mastitis diagnosis in cows. In case of mastitis, the cell membranes of the udder parenchyma are damaged. This increases the permeability of the barrier between blood and milk. The content of chloride (Cl-) and sodium (Na+) increases and the content of lactose and potassium (K+) decreases leading to a higher electrical conductivity of the milk (Schulz and Sydom 1957). Electrical conductivity had a negative correlation with fat, lactose, ash, protein and density (Abdel-Gadir et al. 2013).

2.3.1.4 Specific Gravity:

A wide range was observed in the specific gravity of camel milk. Khan (2014) estimated that the density of camel milk to range between 1.014-1.017 at 20°C. According to Takele (2014) the specific gravity of camel milk ranged 1.020-1.022 at 20°C. Khanna and Rai (1993) observed that the specific gravity of Indian camel milk was 1.030. EL-Erian (1979)
reported that the milk of camels grazing near Riyadh (Saudi Arabia) had specific gravity between (1.028 - 1.038). Igbal (1999) found it to be 1.030 in camel milk. The specific gravity of camel milk is lower than that of cow sheep or buffalo (Shalash 1979). The average density of camel milk is 1.029 g/cm³ Farah (1996), and has been reported to be less viscous than bovine milk (Laleye et al. 2008). The specific gravity of camel milk was significantly lower than that of cow milk. This is due to the increased content of longer chain fatty acids Abu-Lehia (1989); also Igbal et al. (2001) found that specific gravity of camel milk ranged between 1.028 - 1.033 which is lower than that of cow, buffalo and sheep milk. The density of camel milk was found to be highly associated with protein, lactose, and ash.

2.3.1.5 Freezing Point:

The freezing point of camel milk ranges -0.57 and -0.61 C according to (Wangoh 1997). Salash (1982) explained, camel milk has grater freezing point depression -0.576 C and this might be related to the comparatively high chloride content in camel milk.

2.3.2 Physical Properties of Saanen Goat Milk

2.3.2.1 pH Value:

pH values of milk were in the range 6.48-6.64 in goat milk and 6.55-6.68 in sheep milk, (Asif and Sumaira 2010). Zahraddeen et al. (2007) reported that pH of milk was not significantly influenced by breed, highest in Red Sokoto 6.32±0.08 followed by West African Dwarf 6.21±0.10 and lowest in Sahel 6.21±0.09. Fandialan and Davide (2001) reported that the lactation period influenced the titratable acidity in goat's milk. pH value of goat milk ranges from 6.5 to 6.9 as against 6.6 and 6.8 in case of cow milk (Syed and Henna 2010).
2.3.2.2 Titratable Acidity:

The Titratable acidity expressed as lactic acid ranges from 0.10 to 0.26 percent in goat's milk, but most samples fall in the range of 0.11 to 0.18 percent (Parkash and Jenness 1968). The acidity of milk samples of cross Saanen goats average 12.96±3.64 D in Brazil (Chornobai et al. 1999). Moreover, they reported that there was positive acidity/ density correlation (r=0.2115). However, the acidity of Saanen goats milk in the southeastern region of Brazil was found to be 16.11 D (Prata el. al.1998).

2.3.2.3 Electrical Conductivity:

Range of all milk samples for electrical conductivity was from 6.55±1.56 mS to 11.0±2.10 mS (Riel 1985). In animal milk, minimum conductivity was recorded for the buffalo milk 6.55±1.56 mS, followed by the cow milk 9.20±1.95 mS and the highest was measured for the goat milk 10.8±2.07 mS. Among the liquid-peak milk, the lowest conductivity was found for Dairy Queen Milk 8.20±1.75 mS and highest was for the Haleeb milk 11.0±2.10 mS (Varnum and Sutherland 1994). The conductivity of the milk is mainly due to the presence of various electrolytes. The variation in conductivity may be due to the different levels of the electrolytes present in the milk samples (Singh et al. 1997)

2.3.2.4 Specific Gravity:

Specific gravity was found in range of 1.030-1.035 in buffalo milk, 1.027 - 1.031 in cow milk, 1.028 - 1.032 in goat milk and 1.032 -1.037 in sheep milk (Asif and Sumaira 2010). Bhosale et al. (2009) found that specific gravity of goat milk was lowest in first (1.025) lactation and significantly increased in second (1.027), third (1.028) and fourth (1.029) lactations. Agruello et al. (1998) reported that the lactation period
influenced the specific gravity of goat milk. The specific gravity of cow and goat milk is similar and was from 1.023 to 1.030 (Syed and Henna 2010). Nina et al. (2009) found that the density content of milk slightly increases in stage three, with the progress of lactation (1.025.9±0.52, 1.025.7±0.62 and 1.029.8±0.71).

2.3.2.5 Freezing Point:

Harding (1999) stated that the freezing point of goats milk was slightly lower than cow's milk, but buffalo's milk had a freezing point similar to cow's milk. Also, Parkash and Jenness (1968) stated that the freezing point of goat's milk is about -0.580 °C, which is lower than that of cows milk. Dharmarajan et al. (1954) reported a range of -0.545 to -0.625 °C for 69 samples from individual goats. They also found that 92% of them falling in the range of -0.565 to -0.600 °C. The freezing point of Saanen goat milk in the South- eastern region of Brazil is -0.575 °C (Prata et al.1998).

2.3.3 Physical Properties of Cow Milk

2.3.3.1 pH Value:

Murphy (1982) documented that wide spread and longtime usage of pH has caused it to be considered mathematically equivalent to other biological variables. Robert et al. (1974) reported that pH of cow’s milk is commonly stated as falling between 6.5 and 6.7 average with of 6.6 the most usual value. Eckles and Macy (2004) found that pH, or hydrogen-ion concentration of fresh milk was 6.5 to 6.6. Mohamed (2004) evaluated the quality of milk sold in Khartoum State and found a pH value of 6.50.
2.3.3.2 Titratable Acidity:

Idris *et al.* (1975) found that the mean titratable acidity for Sudanese cattle milk range was 0.16-0.22 percent with mean of 0.19% lactic acid. Higher values indicate developed acidity due to the action of bacteria on milk sugar. The large proportion of this acidity is due to the lactic acid formed by action of bacteria on the lactose. Eckles and Macy (2004) reported that the milk from animals suffering from mastitis is frequently much lower in acidity than that produced by animals having mammary glands free of the disease. Titratable acidity plays a fundamental role and represents average high important parameter for technical evaluation of the quality of milk (Harris and Bachman 1988). Titratable acidity is valuable as a guide manufacturing operation and for measuring the quality of dairy products (Smit 2005).

2.3.3.3 Electrical Conductivity (EC):

The average conductivity of cow milk ranges between 4 and 5.8 mS and depends on lactation stage, age, milking interval and race of the individual animal (Nielen *et al.* 1992; Walzel 1997; Billon *et al.* 2001). The electrical conductivity (EC) of milk is used to screen cows for possible sub clinical mastitis, for which a number of portable instruments are commercially available (Fascar *et al.*1992; Hillerton *et al.*1991 and Lansbergen *et al.*1994). EC is based on the concentrations of sodium and chlorides in the milk. The EC of milk can vary due to a number of factors such as nutrition, age, breed, estrous cycle, stage of lactation and climatic conditions (Brentrup *et al.*1994; Nowak *et al.*1990 and Tongel *et al.*1994).

A few studies have been carried out regarding the use of EC for detecting cows in estrus. Varying results have been reported regarding the relationship between blood progesterone values and the EC of milk.
during the course of estrous cycle (Anderson et al.1983; Molla 2001; Mol et al.1998).

2.3.3.4 Specific Gravity:

The specific gravity value at 15.5 °C for fresh whole mixed herd milk, seldom lies outside the range of 1.030 to 1.035 and 1.032 is often quoted as an average value (Robert et al. 1974). Siegentholer and Chulthess (1977) highlighted that milk specific gravity is determined by its three major components: water, solid-non-fat and butterfat. Increased butterfat content decreases the specific gravity of milk while increased solids-non-fat increases milk specific gravity. Eckles and Macy (2004) found that the specific gravity ranged from 1.027-1.035 and influenced by the relation of its constituents, such as fat, lactose, protein, casein, and salts.

2.3.3.5 Freezing Point:

This is the most constant physical property of milk and is determined by the number of solute particles present. Milk freezes at lower temperature than normal water with its freezing point lying between -0.525 C and -0.565 C. The presence of soluble water lowers the freezing point (Bundelkhand 2011).

2.4 Effect of Lactation Stages on Milk

2.4.1 Effect of Lactation Stages on Dromedary Camel Milk:

Several studies indicated that dromedary camel milk can reach its peak in different stages of lactation. According to Basmaeil and Bakkar (1987) the peak yield of camel milk was attained at 14 weeks which persisted for 12 weeks thereafter.

Abdel-Raziq et al. (2011) demonstrated that fat and ash content of camel milk was higher in (7th month) of lactation than in the initial stage
of lactation (2nd month), while protein and lactose content of camel milk was higher in (2nd month) of lactation than in the late stage of lactation (7th month). Acidity, solids not fat, protein and lactose were gradually decreased by subsequent stage of lactation (Ahamed et al. 2012). Also pH was affected by lactation stage and declined in 2nd lactation stage than in 1st (Riyadh et al. 2012). Also Wafa and El Zubeir (2014) recorded that the camel milk during the early stage of lactation (1-3) month, highest content of solids not fat, fat, protein and lactose were found.

Khan and Iqbal (2001) observed that milk yield reached the peak yield during the second to the third month of lactation. Ahmed et al. (2012) found that the highest camel milk yield at early stage of lactation was at (1-6) months while Wafa and EL Zubeir (2014) stated that it was at (1-3) months.

In India, Sahani et al. (1998) reported that pH 6.38, fat 3.1%, solids not fat % (SNF) 8.22% and total solids % 11.32 were significantly higher during the late phase of lactation than during the early stage of lactation. However, protein 3.87% and casein 3.01% contents were also high in late phase of lactation but differences were not significant. Gaili et al. (2000) and Zelake (2007) demonstrated that total solids of camel milk decreased from 11.7% in the first stage of lactation to 10.1% by the end stage of lactation. Al-Shaikh and Salah (1994); Haddadin et al. (2008) and Zelake, (2007) found that the values of fat, protein and total solids were highest during the first 6 month of lactation. In the opposite, Zeleke (2007) reported that percentage composition of fat and protein of camels in Eastern Ethiopia was the highest during the first 3 months of lactation period, whereas percentage of lactose remained unaffected by all factors considered. Moreover, the mean fat, protein, lactose and solids not fat values were significantly the highest during the first stage of lactation.
Protein, lactose and solids not fat values were gradually decreased by the subsequent parity. Settled system and Shoal breed had the significant high content of fat compared to their counterparts. Fat content was significantly high at the first stage of lactation in comparison with the second and third ones. Semi nomadic system and in Mightier breed significantly increased the Ca\(^{++}\) and K\(^{+}\) values compared to their counterparts. The Na: K ratio was also affected by production system. The results indicated that variations in camel milk composition were mainly attributed to factors such as production system, breed, parity and stage of lactation. Therefore, those factors should be taken into account when nutritional and technological aspects of camel milk need to be evaluated (Riyadh et al. 2012).

2.5.2 Effect of Lactation Stages on Saanen Goat Milk:

Within species, within breed, the stage of lactation was found to influence the chemical composition of milk (Voutsinas et al. 1990).

Fat content in goat milk was found to change from 2.7% in mid lactation to 4.6% during the last week of lactation, and also protein content was found to increase from 3 to 4.2% (Voutsinas et al. 1990).

Many components in ewe or goat milk as in cow milk, especially fat and protein are high in colostrums in early lactation, much lower thereafter, until they rise again at the end of lactation (Anifantakis and Kandarakis 1980). Ahmed and Siham (2000) concluded that, the calcium levels were lowest in first lactation compared to mid lactation. Chlepkos (2003) found that, daily milk yield decreased with advancing lactation in goat, milk fat and milk protein varied in a negative correlation with milk yield. Bhosale et al. (2009) observed that the pH content of local goat milk decreased from first (6.5 to 6.3) to fourth lactation. It was observed
that the pH content of local goat milk was significantly affected due to lactation.

2.5.3 Effect of Lactation Stages on Cow Milk:

Stage of lactation affects milk production considerably. The advancement of lactation increased the fat percentage of the milk of the herd of the Khartoum University farm during July – December (Khalifa 1964). These findings were similar to those obtained by Spike and Freeman (1967) who reported that milk fat and solids not fat percentages decreased with lactation reaching a minimum at the second or third month and then increased gradually throughout the remainder of lactation with a sharp increase in the last two months. The author attributed the increase in fat percentages to gestation. Studying the 305 day yield of Jersey and Guernsey cows, Davis and Woodward (1971) found that fat content of the milk increased to final values of 5.39 and 5.56% for the two breeds respectively. Protein and solids not fat showed a trend similar to that of fat but the increase in Guernsey did not commence until after day 122 postpartum. In Czechoslovakia, Suchannek and Kuapilik (1975) reported that milk total solids, fat, protein and ash percentages of Zechpied or Ayrshire x Zechpied cows were lowest in the second and third months of lactation and highest in the tenth month. The authors claimed that all constituents were more variable in the first and last two months of lactation than in mid lactation. In Egypt El-Hamidi et al. (1981) reported that fat, solids not fat and total solids contents of Friesian cow's milk were minimum 7 weeks after calving being 3.82, 7.99 and 11.41% respectively, and however the protein percentage was minimum 9 weeks postpartum. All constituents showed an increase till the end of lactation. Likewise, Abdel-Raziq et al. (1982) found that milk constituents of Holstein – Friesian cows in Egypt were lower during early lactation and tended to increase as lactation advanced. Further, NG-Kwai-
Hang et al. (1983) reported that in Canada the milk protein content of Holstein Friesian cows were highest (3.8%) during the first 10 days of lactation and dropped sharply to a minimum of 3.08% at the second month of lactation, this was followed by a gradual increase during the later part of lactation. Moreover, studying the kuradi cows in Iraq, El-Barbary et al. (1983) found that average fat percentage was 4.75% at the beginning of lactation, decreased gradually up to the 10th week, and then increased reaching a maximum of 5.3% at the end of lactation. Total solids content was ranging between 12.91% and 14.78% with the minimum value being obtained 28 weeks postpartum. Pavic et al. (2002) stated that in the middle and at the end of the lactation period the contents of total solids, fat, protein and pH value were higher (P<0.01) than at the beginning.

In Sudan, Hussein (1985) reported that milk total solids % age of graded dairy cows was high 12.80% ± 1.50 at the beginning of lactation and decreased to a minimum value of 12.20%±1.10 at the third month of lactation before it increased to a value of 12.80%±1.30 at the fifth month of lactation. Solids-not-fat was highest 9.10%±1.40 at the start and decreased gradually with advancing lactation. Fat showed an opposite trend, total solids and solids not fat being low 3.70%±0.70 at the first month of lactation and increased to a maximum of 5.30%±0.20 at the end of lactation. Protein followed a trend similar to that of the total solids. It started at a high level 3.70%±0.60, decreased to a minimum value of 2.70% ±0.40 at the 6th month postpartum and increased again at the end of lactation. Robinson (1997) found that milk protein in Holsteins cow declined from 4% in the first week of lactation to about 2.7% by the fifth week Of lactation, then showed a slow increase to as high as 3.8% by the end of the lactation. Ash was almost constant and varied from 0.68% ±0.10 at the start, peaked at the value of 0.78%±0.10 at the 3rd month.
The overall lactation yield of ash was 0.72% ± 0.03. Abdullah (1987) found a significant effect (p<0.01) of the stage of lactation on milk fat, protein and total solids percentages. The value for fat during early, mid and late lactation were 4.40, 4.70 and 5.20% respectively, whereas those for protein were 3.40, 3.60, and 3.80% and those of total solids were 13.30, 13.60, and 14.30% respectively. The findings of El-Abid (1992) were in complete agreement with those of Hussein (1985) and Abdullah (1987). Sharma et al. (1990) reported that milk fat, total solids, solids not fat and protein percentages of Holstein and Jersey cows in the U.S.A declined slightly at the beginning of lactation and rose after 2.5 to 3.5 months. In Jersey cows, a steady increase in fat and total solids was noticed from the start of lactation whereas in Holstein cows, fat and total solids decreased initially and increased after 4.5 month in Holstein and Jersey, solids not fat showed a trend similar to that of protein with the increase being after 4.5 month in the Holstein and 2.4 month in the Jersey cow.
CHAPTE THREE

MATERIAL AND METHODS

3.1 Area of the Study:
The study was conducted using three types of animal, camel (Camelus Dromedaries) from Camel Research Center University of Khartoum (Shambat), Saanen Goat and Friesian Cows from different farms in Umdurman and Khartoum North, the experimental period from November 2014 to August 2015.

3.2 Experimental Animal:
Forty five experimental animals of different species (Cow, Goat and she Camel), were selected then were divided as followed: 15 cows, 15 goats and 15 she -camels for the whole stages of the lactation periods. The camels were in ages from 9-13 years and 2nd to 4th parities on other hand the goats were in ages from 1st to 3rd years and 1st to 3rd parities and cows were in ages from 4th to 12 years and 1st to 4th parities.

3.3 Experimental Design:
Samples of milk were collected at intervals according to each lactation stage of the animal species. The lactation stages were grouped after calving as follows:

Camel: 1st (1-3), the 2nd (4-6) and the 3rd (7-9) months for early, mid and late stages of lactation respectively.

Goat: 1st (1-1.5), the 2nd (1.5-3) and the 3rd (3-4.5) months for early, mid and late stages of lactation respectively.

Cow: 1st (1-2), the 2nd (3-4) and the 3rd (5-6) months for early, mid and late stages of lactation respectively.
3.4 Sampling and Milk Collection:

The collected samples were 15 per each stage and each species of animal in total of 45 for the stage, 135 for the three stages. The experimental animals were milked by hand twice a day (morning and evening). Milk samples were collected at the morning; put in sterile bottles and then kept in ice box and then brought to the laboratory of the Department of Food Technology at the University of Sudan, where the physicochemical analysis were done, and Food Research Center (Shambat) where the Minerals analysis were done.

3.5 Analysis of Milk Component

3.5.1 Determination of Fat:

The fat content was determined using Gerber Method, (Marshal 1993). 10 ml of sulfuric acid (specific gravity 1.815 at 15.5 C) was measured into clean dry Gerber butyrometer tube, and then 11 ml of sample were added carefully. Then one ml of amyl alcohol (specific gravity 0.814 at 15.5 C) was added. The content of the tube were thoroughly mixed till no white particles were seen (until the curd was completely digested). The tubes were then centrifuged at 1100 revolution per minutes (rpm) for five minutes. The tube was transferred to a water bath at 65 C for three minutes. Direct reading of fat content was recorded from measures on the tubes.

3.5.2 Determination of Protein:

The protein content of milk was determined according to AOAC (1995); 10 ml milk is poured in to a50 ml volumetric flask. Then added 0.4 ml saturated potassium oxalate solution and added 3 drops phenolphthalein indicator. Set aside for 2 minutes. Neutralized the milk by titrated. Added 2ml of 40% formaldehyde solution disappear of pink color; also Titrated with 0.1 N NaOH to the same end point (pink color).
Run a blank by titrated 2 ml of 40% formaldehyde solution plus 10 ml distilled water with 0.1N NaOH (three drops of phenolphthalein). Thereafter, protein determined by the following:

\[ \text{Protein (\%)} = (V_a - V_b) \times 1.74 \]

Where:

- \( V_a \) = Volume of 0.1N NaOH used to Titrate Blank.
- \( V_a - V_b \) = Formaldehyde Value.

### 3.5.3 Determination of Moisture:

The moisture content of milk was determined according to the standard method of (AOAC 1990).

**Principle:** The moisture content in a weight sample is removed by heating the sample in an oven (under atmospheric pressure) at 105°C. Then, the difference in weight before and after drying is calculated as a percentage from the initial weight.

**Procedure:** A sample of 5 gm was weight 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°C until a constant weight was obtained. After drying, the covered sample was transferred to a desicador and cooled to room temperature before reweighing. Triplicate results were obtained for each sample and the mean value was reported to two decimal points according to the following formula:

**Calculation:**

\[ \text{Moisture Content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \]

Where:

- \( W_1 \) = Weight of Empty Dish
- \( W_2 \) = Weight of Dish+ Sample
- \( W_3 \) = Weight of Dish+ Dried Samples
3.5.4 Determination of Total Solids:

The total solids content was determination according to the modified method of (AOAC 1990).

In a clean flat bottomed aluminum dish three grams of milk were placed. The weight of the sample and the dish were recorded. The dish was heated in a steam bath for 10-15 minutes, and then transferred to an air-oven for 3 hours at 105°C. The dish was then placed in desiccaters to cool and then weight. The difference between weights was less than 0.1 gm.

Calculation:

\[
\text{Total Solids (\%)} = \frac{W_1}{W_2} \times 100
\]

Where:

\( W_1 \) = Weight of Sample after Drying
\( W_2 \) = Weight of Sample before Drying

3.5.5 Determination of Lactose:

The lactose content was determined according to modified method of (AOAC 1990).

10 ml milk is poured in volumetric flask and then 40 ml distilled water, 10 ml sulfuric acid and 5 ml NaOH% 10 were added. To complete the volume of mixture to 100 ml distilled water is added. The mixture is left for (5-16) minutes in another flask and the volume completed to 100 ml with distilled water. In glass cup 25 ml Benedict solution and 5g sodium carbonate contents were placed on heater unit boiling. The contents of cup with mixture in burette are titrated until the color changes to white and of blue color of residual disappeared.
Calculation of Lactose Content:

\[
\text{Lactose (\%)} = \frac{0.067}{R} \times 10 \times 1
\]

R = amount of residual to reach to final point.

25 ml of Benedict solution equivalent 0.067 g lactose.

3.5.6 Determination of Ash:

The ash content was determined by the gravimetric method AOAC (2000). Five grams of the sample were weighed in a crucibles, then placed in muffle furnace at 550-600°c for 3 hours until ash was carbon free. The crucibles were then cooled in desiccators and weighed. The ash content was calculated using the following equation:

\[
\text{Ash (\%)} = \frac{\text{Wt. of Ash}}{\text{Wt. of Sample}} \times 100
\]

3.5.7 Determination of Solids Non Fat:

Solids non fat (SNF) content was determined by difference as reported by Harding (1995), using the following formula:

\[
\text{SNF Content (\%)} = \text{TS (\%)} – \text{Fat (\%).}
\]

3.6 Determination of Minerals

3.6.1 Determination of Calcium:

Calcium was determined by an atomic absorption spectrophotometer method, according to (Chapman and Pratt 1961).

One gm of milk was ashed, and then 10 ml HCL 28% were added. Thereafter, the mixture was placed in a sand-bath for one hour, then it was filtrated in 100 ml flask and completed to 100 ml with de-ionized water. Thereafter, 15 ml of the mixture were transferred to a 25 ml volumetric flask then 10 ml of \( \text{LaCl}_3 \) 10% solution were added to the flasks for the preparation of the standard curve 2, 4, 6, 8, and 10 ml of Ca standard solution were placed in series of 25 ml volumetric flasks, then
10 ml of LaCl₃ 10% were added to each flask, and all the flasks were completed to 25 ml with de-ionized water. The results were obtained by using atomic absorption spectrophotometer at 420 n. A stand X-axis and the absorbance on the Y-axis). thereafter the sample concentration was read from the graph.

Ca= content was calculated as follows:

\[
Ca \ (mg/g) = \frac{\text{Sample Concentration Dilution Factor}}{\text{Sample Weight}}
\]

3.6.2 Determination of Phosphorus:

Phosphorus was determined by atomic absorption spectrometer method, according to (Chapman and Pratt 1961).

One gm of milk was a shed, then 10 ml of HCL (28%) were added, the mixture was placed in a sand bath for one hour, then it was filtrated in 100 ml flasks and completed to 100 ml with de ionized water. After that, 15 ml of the mixture were transferred to a 25 ml volumetric flask, and then 10 ml of ammonium molybdate were added to the flask. For the preparation of the standard curve 2,4,6,8 and 10 ml of phosphorus standard solution (50 mg p/m) were placed in a series of 25 ml volumetric flask, then 10 ml of ammonium molybdate were added to each one of the flasks, then they were completed to 25 ml with de-ionized water. The blank solution was prepared by diluting 10 ml of ammonium molybdate to 25 ml with de-ionized water. The results were obtained by using atomic absorption spectrometer at 440 nm by which the standard curve was prepared (phosphorus concentration on the X-axis and the absorbance on Y-axis). Then the samples concentration was read from the graph.

Phosphorus (p) was calculated as follows:

\[
P \ (mg/g) = \frac{\text{Sample Concentration} \times \text{Dilution Factor}}{\text{Sample Weight}}
\]
3.6.3 Determination of Iron:

Iron was determined by atomic absorption spectrometer method, according to (Jones 2001).

One gm of sample was weight in a crucible and ignited at 550°C in a muffle furnace till a light grey ash was formed then 5 ml of HCL was added to the ashed sample, it was then put in a sand bath for 10 minutes, then filtered into a 50 ml volumetric flask. The filter paper was washed with H2O. Washings were collected in the same flask, and then diluted to volume with H2O. Five ml of the ash extract was transferred into 50 ml volumetric flask, 10 ml ammonium molybdate vanadate reagent (22.5g NH4Mo7 O.H2O in 400 ml H2O +1.25g ammonium meta vanadate in 300 ml boiling distilled water) and 250ml conc. HNO3 was added, mixed and completed to one liter H2O, then mixed again after 30 minutes. The density of color was read at 470 nm wavelength UV.

3.7 Physical Properties Analysis

3.7.1 pH Value:

The pH of milk was measured with digital pH meter (model 5a520). 4 and 7 pH buffers were used for the calibration of pH meter. After calibration, 20 ml of milk was taken in a beaker and then electrode was immersed in the milk until constant reading attained (Ong et al. 2007).

3.7.2 Specific Gravity:

Specific gravity was determined according to (AOAC 2000). Mix the milk sample gently and pour it gently into a measuring cylinder (300-500). Let the Lactometer (float) slowly into the milk. Read and record the last Lactometer reading just above the surface of the milk. If the temperature of the milk is different from the calibration temperature (calibration temperature may be=20°C) of the lactometer, calculate the
temperature correction. For each °C above the calibration temperature adds 0.5 °C for each °C below calibration temperature subtract 0.5 °C from the recorded lactometer reading.

\[ \text{SPG} = \frac{\text{C.L.R}}{1000} \pm 1 \]

Where:

SPG = Specific Gravity.

C.L.R = Correct Lactometer Reading

3.7.3 Titratable Acidity:

Acidity of milk was determined by titration method given in (AOAC 2000). Acidity was determined by taking 10 mL of milk in 100 mL Erlenmeyer flask and after adding 2-3 drops of phenolphthalein, it was titrated against 0.1N NaOH until development of pink color. The percent acidity was calculated by following formula:

\[ \text{Acidity (\%)} = \frac{0.009 \times \text{Vol of NaOH used (ml)}}{\text{Wt of Sample}} \times 100 \]

3.7.4 Freezing Point:

Freezing point was measured by means of a thermistor Cryoscope, FISKE (U.S.A). Two ml sample of milk was held in a sample tube and immersed in a bath at 7 °C. The temperature of the sample was measured using a thermistor, centered in the body of the sample, which stirred, by a vibrating stirrer wire. Initially the sample was super-cooled to about 3 °C, a pulse of energy causing the stirrer wire to strike the walls of the tube giving a freeze pulse formed ice crystals. Latent heat of fusion was released as the super-cooled milk changes to ice and the freezing point was measured (Harding 1999).
3.7.5. **Electrical Conductivity:**

EC Ds/m/at 25°C determined by portable EC meter model 410 micromho.

3.8 **Statistical Analysis:**

The obtained data was analyzed statistically by using Analysis of Variance ANOVA SPSS program (Version 16). The Least Significant Difference (LSD) was used for mean separation between the different species.
CHAPTER FOUR

RESULTS

4.1 Compositional Properties

4.1.1 Compositional Properties of Dromedary Camel Milk:

The composition of camel milk (fat, protein, moisture (water), total solids, lactose, ash and solids not fat) are shown in Table (1).

The data in Table 1 indicated that the means of fat content of camel milk samples were significantly (P ≤0.01), higher during the early lactation stage (3.80%±0.098) compared to mid lactation stage (3.367%±0.073) and late lactation stage (2.300%±0.072).

The average protein content of camel milk was low during the early lactation stage (3.087%±0.02) and significantly (P ≤0.01) increased during mid (3.333%±0.055) and late (3.393%±0.055) lactation stages.

The obtained average water content of dromedary camel milk samples at early, mid and late lactation stages was (88.159%±0.171), (88.254%±0.155) and (88.817%±0.045) respectively. The statistical analysis indicated a high significant difference (P ≤0.01) between averages of water content.

The average total solids content from dromedary camel milk were significantly (P ≤0.01) higher during the early (11.841%±0.171) and mid (11.746%±0.155) stages of lactation period. It decreased in late (11.183%±0.034) stage of lactation period.

The average of lactose content of dromedary camel milk was significantly higher (P ≤0.01) during the late stage of lactation period
(4.673%±0.041); it decreased at early (4.093%±0.113) and mid (4.271%±0.074) lactation period stages.

The average level of ash of milk of dromedary camel milk was regular during the early (0.754%±0.006), mid (0.743%±0.008) and late (0.745%±0.008) lactation period stages, with no significant (P ≥0.05) variation.

The average of solids non fat (SNF) content of camel milk camel was significantly higher (P ≤0.01) during the late stage of lactation period (8.889% ± 0.71); it decreased at early (8.035%±0.174) and mid (8.379%±0.71) lactation period stages.
Table (1): Compositional Properties of Dromedary Camel Milk at Different Lactation Stages.

<table>
<thead>
<tr>
<th>Lactation Stages</th>
<th>Compositional Properties</th>
<th>Mean ± (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fat %</td>
<td>3.807±0.098</td>
</tr>
<tr>
<td></td>
<td>Protein %</td>
<td>3.078±0.02</td>
</tr>
<tr>
<td></td>
<td>Moisture %</td>
<td>88.159±0.171</td>
</tr>
<tr>
<td>Early Stage</td>
<td>Total solids %</td>
<td>11.841±0.171</td>
</tr>
<tr>
<td></td>
<td>Lactose %</td>
<td>0.754±0.006</td>
</tr>
<tr>
<td></td>
<td>Ash %</td>
<td>8.035±0.174</td>
</tr>
<tr>
<td></td>
<td>Solids not Fat %</td>
<td>8.379±0.104</td>
</tr>
<tr>
<td></td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Mid Stage</td>
<td>Fat %</td>
<td>3.678±0.073</td>
</tr>
<tr>
<td></td>
<td>Protein %</td>
<td>3.333±0.055</td>
</tr>
<tr>
<td></td>
<td>Moisture %</td>
<td>87.254±0.155</td>
</tr>
<tr>
<td></td>
<td>Total solids %</td>
<td>11.746±0.155</td>
</tr>
<tr>
<td></td>
<td>Lactose %</td>
<td>0.743±0.008</td>
</tr>
<tr>
<td></td>
<td>Ash %</td>
<td>8.379±0.104</td>
</tr>
<tr>
<td></td>
<td>Solids not Fat %</td>
<td>8.379±0.104</td>
</tr>
<tr>
<td></td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Late Stage</td>
<td>Fat %</td>
<td>2.300±0.072</td>
</tr>
<tr>
<td></td>
<td>Protein %</td>
<td>3.393±0.055</td>
</tr>
<tr>
<td></td>
<td>Moisture %</td>
<td>88.817±0.045</td>
</tr>
<tr>
<td></td>
<td>Total solids %</td>
<td>11.183±0.034</td>
</tr>
<tr>
<td></td>
<td>Lactose %</td>
<td>0.745±0.008</td>
</tr>
<tr>
<td></td>
<td>Ash %</td>
<td>8.889±0.71</td>
</tr>
<tr>
<td></td>
<td>Solids not Fat %</td>
<td>8.889±0.71</td>
</tr>
<tr>
<td></td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

NS: Not Significant.

*: Significant (P ≤0.05).

**: High significant (P ≤0.01).

- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05).
4.1.2 Compositional Properties of Saanen Goat Milk:

The composition of goat milk fat, protein, moisture (water), total solids, lactose, ash and solids not fat are shown in Table (2).

The average fat content was the lowest in early stage of lactation (2.933%±0.126) and significantly increased at mid (5.020%±0.149) lactation period stage. Then it decreased at late stage of lactation period (3.580%±0.047). The statistical analysis indicated a high significant difference (P ≤0.01) between averages of fat contents.

Protein content of Saanen goat milk was significantly (P ≤0.01) affected due to lactation period stages. The highest protein was recorded at early lactation period stage (3.633%±0.039) and late stage of lactation period (3.513%±0.045) than mid lactation period stage (3.267%±0.089).

The moisture (water) of Saanen goat milk during early (87.974%±0.175), mid (87.714%±0.133) and late (87.569%±0.106) lactation stages were not significantly different (P ≥0.05).

The total solids content of Saanen goat milk during early (12.026%±0.175), mid (12.286%±0.132) and late (12.431%±0.106) lactation period stages was not significantly different (P ≥0.05).

The lactose content was higher during the early stage of lactation period (3.633%±0.39) and late stage of lactation period (4.557%±0.097), then decreased slowly at mid stage of lactation period (3.356%±0.088). A high significant difference was recorded in this case (P ≤0.01).

The level of ash of Saanen goat milk was regular during the early (0.762%±0.003), mid (0.756%±0.005) and late (0.755%±0.007) lactation period stages. Also no significant difference (P ≥0.05) was detected.
The average values for solids non fat (SNF) content of milk of Saanen goat were (9.092%±0.080), (7.266%±0.156) and (8.851%±0.093) during early, mid and late lactation period stages respectively. It was higher during early lactation period stage and decreased in mid lactation period stages, and then showed slight regular increase during the late stage of lactation period. A high significant variation (P ≤0.01) was recorded between the averages.
Table (2): Compositional Properties of Saanen Goat Milk at Different Lactation Stages.

<table>
<thead>
<tr>
<th>Lactation Stages</th>
<th>Compositional Properties Mean ± (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fat %</td>
</tr>
<tr>
<td>Early Stage</td>
<td>2.933 ± 0.126</td>
</tr>
<tr>
<td>Mid Stage</td>
<td>5.020 ± 0.149</td>
</tr>
<tr>
<td>Late Stage</td>
<td>3.580 ± 0.047</td>
</tr>
<tr>
<td>Significant</td>
<td>**</td>
</tr>
</tbody>
</table>

**NS**: Not Significant.

* : Significant (P ≤ 0.05).

**:**: High significant (P ≤ 0.01).

- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤ 0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥ 0.05).
4.1.3 Compositional Properties of Cows Milk:

The compositional properties of cow milk: fat, protein, moisture (water), total solids, lactose, ash and solids not fat are shown in Table (3).

The mean of cow milk fat was significantly different (P ≤0.01) during the three stages of lactation period. It was higher during early (4.407%±0.068) and mid stages (4.367%±0.091), compared to late (3.787%±0.092) stage of lactation period.

The average protein content was higher in mid stage (3.540%±0.065) of lactation period. In early and late stages of lactation period the protein content was (3.400%±0.072) and (3.280%±0.034) respectively. Statistically a significant difference (P ≤0.05) was detected between the averages of the protein content of cow milk.

The average of water content of milk from cow was significantly (P ≤0.01) higher values were found during the early (87.957%±0.159) and late (87.802%±0.045) stages of lactation period, compared to mid (87.329% ±0.132) lactation period stage.

The values obtained for total solids in early, mid and late lactation period stages were (12.043%±0.159), (12.671%±0.132) and (12.198%±0.045) respectively. Total solids were higher at mid stage of lactation than early and late stages of lactation. A significant variation (P ≤0.01) was revealed in this case.

The average lactose content was the lowest in early stage of lactation period (3.491%±0.071) and significantly increased at mid (4.603%±0.097) lactation period stage. Then it decreased at late (3.807%±0.097) stage of lactation period. Statistical analysis indicated a significant difference (P ≤0.01) between averages of lactose content.
The average ash content of cow milk during early, mid and late lactation period stages was (0.745%±0.007), (0.74%±0.007) and (0.740%±0.007) respectively. Statistically no significant difference (P ≥0.05) was found between the averages of the ash at the different stages of lactation period.

The average of solids non fat of cow milk during early, mid and late lactation stages was (7.656%±0.115), (8.891%±0.092) and (7.831%±0.104) respectively. Higher values were found during the mid stage of lactation period compared to early and late lactation period stages. A high significant variation was detected hereby.
Table (3): Compositional Properties of Cow Milk at Different Lactation Stages.

<table>
<thead>
<tr>
<th>Lactation Stages</th>
<th>Compositional Properties Mean ± (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fat %</td>
</tr>
<tr>
<td>Early Stage</td>
<td>4.407 ± 0.068</td>
</tr>
<tr>
<td>Mid Stage</td>
<td>4.367 ± 0.091</td>
</tr>
<tr>
<td>Late Stage</td>
<td>3.787 ± 0.092</td>
</tr>
</tbody>
</table>

NS: Not Significant.

*: Significant (P ≤ 0.05).

**: High significant (P ≤ 0.01).

- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤ 0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥ 0.05).
4.1.4 Variation in Compositional Properties of Dromedary Camel, Saanen Goat and Cow Milk:

4.1.4.1 Fat Content:

Table 4, figure 1 (see appendix). The fat content of camel, goat and cow milk was found at early stage of lactation, (3.807%±0.098), (2.933%±0.126) and (4.407%±0.263) respectively. Fat content of cow milk was higher compared to that of other species and high significantly different (P ≤ 0.01). Also camel milk fat was higher compared to that of goat milk and a high significant variation was detected in this case (P ≤0.01).

In mid stage of lactation period, the average fat content was (3.367±0.073), (5.020%±0.149) and (3.787%±0.356) for camel, goat and cow milk respectively. The fat content of goat milk was higher compared to camel and cow milk. The statistical analysis indicated a high significant difference (P ≤0.01) between the averages of the fat content of the animals during the mid stage of the lactation period.

For late stage of lactation (2.300%±0.072), (3.580%±0.047) and (4.367%±0.352) fat content was obtained in camel, goat and cow respectively. A high significant difference (P ≤0.01) was found between the averages of the fat content of the different animals at this stage of lactation period, in favor of cow’s milk.
Table (4): Variation in Fat Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Period Stages.

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th>Early Lactation</th>
<th>Mid Lactation</th>
<th>Late Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
</tr>
<tr>
<td>Camel</td>
<td></td>
<td>3.807&lt;sup&gt;b&lt;/sup&gt; ± 0.098</td>
<td>3.367&lt;sup&gt;c&lt;/sup&gt; ± 0.073</td>
<td>2.300&lt;sup&gt;c&lt;/sup&gt; ± 0.072</td>
</tr>
<tr>
<td>Goat</td>
<td></td>
<td>2.933&lt;sup&gt;c&lt;/sup&gt; ± 0.126</td>
<td>5.020&lt;sup&gt;a&lt;/sup&gt; ± 0.149</td>
<td>3.580&lt;sup&gt;b&lt;/sup&gt; ± 0.047</td>
</tr>
<tr>
<td>Cow</td>
<td></td>
<td>4.407&lt;sup&gt;a&lt;/sup&gt; ± 0.263</td>
<td>3.787&lt;sup&gt;b&lt;/sup&gt; ± 0.356</td>
<td>4.367&lt;sup&gt;a&lt;/sup&gt; ± 0.352</td>
</tr>
<tr>
<td>Significant</td>
<td></td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant (P ≤ 0.05).
**: High significant (P ≤ 0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤ 0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥ 0.05).

4.1.4.2 Protein Content:

Table 5, figure 2 (see appendix). Result obtained showed that the protein content of camel, goat and cow milk during the early stage was (3.087% ± 0.092), (3.633%±0.039) and (3.400%±0.072) respectively. Protein content in goat milk was higher compared to other species and high significant (P ≤0.01). Protein content of cow milk was also higher than that of camel milk and high significantly different (P ≤0.01).

At mid stage the protein content of cow milk was the highest (3.540%±0.065) followed by camel milk (3.333%±0.055) and goat milk (3.267%±0.0.089). The statistical analysis indicated a significant difference (P ≤0.05) between the averages.

The protein content in late stage obtained (3.393%±0.055), (3.513%±0.045) and (3.280% ± 0.034) for camel, goat and cow milk.
respectively. A significant difference ($P \leq 0.05$) was found between the averages of the protein content of the three species, in favor of goat milk.

**Table (5): Variation in Protein Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Period Stages.**

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th>Early Lactation</th>
<th>Mid Lactation</th>
<th>Late Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
</tr>
<tr>
<td>Camel</td>
<td></td>
<td>3.087&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.333&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.393&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.092</td>
<td>±0.055</td>
<td>±0.055</td>
</tr>
<tr>
<td>Goat</td>
<td></td>
<td>3.633&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.267&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.513&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.039</td>
<td>±0.089</td>
<td>±0.045</td>
</tr>
<tr>
<td>Cow</td>
<td></td>
<td>3.400&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.540&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.280&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.072</td>
<td>±0.065</td>
<td>±0.034</td>
</tr>
</tbody>
</table>

*NS: Not Significant.*  
*Significant ($P \leq 0.05$).*  
**High significant ($P \leq 0.01$).**

- Means ± SE values having different superscript letters in the same raw are significantly different ($P \leq 0.05$).
- Means ± SE values having same superscript letters raw are not significantly different ($P \geq 0.05$).

**4.1.4.3 Moisture Content:**

Water content in milk collected from camel, goat and cow is given in Table 6 figure 3 (**see appendix**).

Water content at early lactation stage was (88.159%±0.171) in camel milk, (87.974%±0.175) in goat milk and (87.957%±0.157) in cow milk. There was no significant ($P \geq 0.05$) difference between the averages of water content in camel, goat and cow milk.

In mid lactation the water content of camel milk (88.254%±0.155) milk was higher compared with goat milk (87.714%±0.133) and cow milk (87.329%±132) and a high significant difference ($P \leq 0.01$) was found.
In late lactation water content of camel milk (88.817%±0.034) was higher than that in goat (87.569%±0.106) and cow milk (87.802%±0.045). Statistical analysis indicated a high significant difference (P ≤0.01) for the averages of water content, in favor of camel milk.

Table (6): Variation in Moisture Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Period Stages.

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th>Early Lactation</th>
<th>Mid Lactation</th>
<th>Late Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td></td>
</tr>
<tr>
<td>Camel</td>
<td>88.159±1</td>
<td>88.254±1</td>
<td>88.817±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.171</td>
<td>±0.155</td>
<td>±0.034</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>87.974±1</td>
<td>87.714±1</td>
<td>87.569±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.175</td>
<td>±0.133</td>
<td>±0.106</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>87.957±1</td>
<td>87.329±1</td>
<td>87.802±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.159</td>
<td>±0.132</td>
<td>±0.045</td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>NS</td>
<td>**</td>
<td>**</td>
<td></td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05).

4.1.4.4 Total Solids Content:

The concentration of total solids in milk samples collected from camel, goat and cow is given in Table 7 figure 4 (see appendix).

These results illustrated that the concentration of total solids at early lactation stage was (11.841%±0.171) in camel milk, (12.026%±0.175) in goat milk and (12.043%±0.159) in cow milk. There was no significant difference between (P ≥0.05) the concentration of total solids in camel, goat and cow milk.
The concentration of total solids at mid lactation of camel milk (11.746%±0.155) and lower than that of goat (12.286%0.132) and cow milk (12.671%±0.132). A high significant difference was recorded (P ≤0.01).

The concentration of total solids at late lactation of goat milk (12.431%±0.106) was higher than that in the milk of other species and highly significant (P ≤0.01). The concentration of total solids in cow milk (12.198%±0.045) was higher than camel milk (11.183%±0.034) and also highly significant (P ≤0.01), in favor of goat milk.

Table (7): Variation in Total Solids Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Period Stages.

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th>Early Lactation Mean ± SE</th>
<th>Mid Lactation Mean ± SE</th>
<th>Late Lactation Mean ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camel</td>
<td></td>
<td>11.841a±0.171</td>
<td>11.746b±0.155</td>
<td>11.183c±0.034</td>
</tr>
<tr>
<td>Goat</td>
<td></td>
<td>12.026a±0.175</td>
<td>12.286a±0.132</td>
<td>12.431a±0.106</td>
</tr>
<tr>
<td>Cow</td>
<td></td>
<td>12.043a±0.159</td>
<td>12.671a±0.132</td>
<td>12.198b±0.045</td>
</tr>
</tbody>
</table>

Significant NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05)
4.1.4.5 Lactose Content:

Lactose content in milk collected from camel, goat and cow is given in Table 8, figure 5 (see appendix).

Results illustrated that the lactose content at early stage of lactation period was found to be (4.093%±0.113) in camel milk, (4.651%±0.076) in goat milk and (3.491%±0.071) in cow milk. The amount of lactose content in goat milk was higher than that in cow and camel milk. A high significant difference was also detected hereby (P ≤0.01).

The amount of lactose content at mid lactation stage in cow milk (4.603%±0.97%) was higher than that in goat milk (3.356%±0.088) and camel milk (4.271%±0.74), but lactose of camel milk was higher compared with that of goat milk. A high significant difference was also detected hereby (P ≤0.01).

At late stage of lactation lactose content was lower in cow milk (3.807%±0.097) and higher in goat milk (4.557%±0.097) and camel milk (4.673%±0.041). The statistical analysis indicated a high significant difference (P ≤0.01) between the average concentrations of the lactose during all stages of the lactation period.
Table (8): Variation in Lactose Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Period Stages.

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early Lactation</td>
<td>Mid Lactation</td>
<td>Late Lactation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td></td>
</tr>
<tr>
<td>Camel</td>
<td>4.093b ±0.113</td>
<td>4.271b ±0.074</td>
<td>4.673a ±0.041</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>4.651a ±0.076</td>
<td>3.356c ±0.088</td>
<td>4.557a ±0.097</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>3.491c ±0.071</td>
<td>4.603a ±0.097</td>
<td>3.807b ±0.097</td>
<td></td>
</tr>
</tbody>
</table>

Significant: **

NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05).

4.1.4.6 Ash Content:

Ash content in milk collected from camel, goat and cow is given in Table 9, figure 6 (see appendix).

The results of this study revealed that the ash content at early lactation stage was (0.754%±0.006) in camel milk, (0.762%±0.003) in goat milk and (0.745%±0.007) in cow milk. Ash content was higher in goat milk. Statistically, ash content in goat milk and camel milk was similar, also camel and cow milk was similar. A significant difference (P ≤0.05) was found between the averages of the ash content.

The ash content at mid lactation stage was (0.743%±0.008) in camel milk, (0.756%±0.005) in goat milk and (0.747%±0.007) in cow milk. There was no significant difference (P ≥0.05) was detected in this case.
The ash content at late lactation stage was (0.745%±0.008) in camel milk, (0.755%±0.007) in goat milk and (0.740%±0.007) in cow milk. Also no significant difference (P ≥0.05) was found hereby.

### Table (9): Variation in Ash Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Period Stages.

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th>Early Lactation</th>
<th>Mid Lactation</th>
<th>Late Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td></td>
</tr>
<tr>
<td>Camel</td>
<td>0.754a±0.006</td>
<td>0.743a±0.008</td>
<td>0.745a±0.008</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>0.762a±0.003</td>
<td>0.756a±0.005</td>
<td>0.755a±0.007</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>0.745b±0.007</td>
<td>0.747a±0.007</td>
<td>0.740a±0.007</td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05).

4.1.4.7 Solids Non Fat Content:

Solids non fat content in milk collected from camel, goat and cow is given in Table 10, figure 7 (see appendix). The solids not fat content at early lactation stage was higher in goat milk (9.092%±0.080) compared with camel milk (8.035%±0.174) and cow milk (7.656%±0.115) and highly significant (P ≤0.01).

The solids non fat content at mid lactation was higher in cow milk (8.891%±0.092) compared with that of camel milk (8.379%±0.104) and goat milk (7.266%±0.156) and highly significant (P ≤0.01).

The Solids non fat content at late lactation stage was (8.889%±0.071) in camel milk, (8.851%±0.093) in goat milk and
(7.831%±0.104) in cow milk. Cow milk solids not fat were lower compared with camel and goat milk. A high significant difference (P ≤0.01) was recorded between the averages of the solids not fat in milk of all species.

Table (10): Variation in Solids Non Fat Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Period Stages.

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th>Mean ± SE</th>
<th>Mean ± SE</th>
<th>Mean ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camel</td>
<td>Early Lactation</td>
<td>8.035b±0.174</td>
<td>8.379b±0.104</td>
<td>8.889a±0.071</td>
</tr>
<tr>
<td></td>
<td>Mid Lactation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>Early Lactation</td>
<td>9.092a±0.080</td>
<td>7.266c±0.156</td>
<td>8.851a±0.093</td>
</tr>
<tr>
<td></td>
<td>Mid Lactation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>Early Lactation</td>
<td>7.656c±0.115</td>
<td>8.891a±0.092</td>
<td>7.831b±0.104</td>
</tr>
<tr>
<td></td>
<td>Mid Lactation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Significant: **: Significant (P ≤0.05).
          : High significant (P ≤0.01).

Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).

Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05)

4.1.4.8 Minerals

4.1.4.8.1 Minerals of Dromedary Camel Milk:

The minerals content are shown in Table 11, calcium (Ca++) , phosphorus (P++) and Iron (Fe++).

Camel milk minerals content was significantly affected (P ≤0.01) by the stage of lactation periods with highest content of Ca++ (120.93±1.993) mg/100g being recorded during the late stage of lactation and the lowest value (112.93±1.677) mg/100g during the early stage of lactation period. A high significant difference (P ≤0.01) was recorded in this case.
The phosphorus content of camel milk during early, mid and late lactation stages was (75.67±1.745)mg/100g, (78.00±1.721) mg/100g and (79.87±2.004) mg/100g respectively. However, there was no significant difference between the values of phosphorus content during the three stages of lactation period.

The Iron content of camel milk was also significantly affected by the stage of lactation period (P ≤0.01), with the highest content of Iron during late (0.149±0.005) mg/100g stage of lactation period and the lowest during early (0.129±0.004) mg/100g and mid (0.119±0.003) mg/100g stage of lactation periods.

Table (11): Minerals of Dromedary Camel Milk at Different Stages of Lactation Period.

<table>
<thead>
<tr>
<th>Lactation Stages</th>
<th>Minerals Mean ±( SE)</th>
<th>Calcium</th>
<th>Phosphor</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Stage</td>
<td></td>
<td>112.93b</td>
<td>75.67a</td>
<td>0.119b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.677</td>
<td>±1.745</td>
<td>±0.003</td>
</tr>
<tr>
<td>Mid Stage</td>
<td></td>
<td>115.60b</td>
<td>78.00a</td>
<td>0.129b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.386</td>
<td>±1.721</td>
<td>±0.004</td>
</tr>
<tr>
<td>Late Stage</td>
<td></td>
<td>120.93a</td>
<td>79.87a</td>
<td>0.149a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.993</td>
<td>±2.004</td>
<td>±0.005</td>
</tr>
<tr>
<td>Significant</td>
<td>**</td>
<td>NS</td>
<td>**</td>
<td></td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05).
4.1.4.8.2 Minerals of Saanen Goat Milk:

The minerals content are shown in Table 12, calcium (Ca$^{++}$), phosphor (P$^{++}$) and Iron (Fe$^{++}$).

Saanen goat milk minerals content was significantly ($P \leq 0.01$) affected by the stage of lactation periods with highest content of Ca$^{++}$ (147.40±0.289) mg/100g during early stage compared with mid (143.87 ±0.524) mg/100g and late (143.87±0.456) mg/100g stage of lactation period.

The phosphorus content of Saanen goat milk at early, mid and late lactation was (101.73±0.258) mg/100g, (102.73±0.492) mg/100g and (102.27±0.431) mg/100g respectively. However, there was no significant difference ($P \geq 0.05$) between the values during the three stages of lactation period.

The Iron content of Saanen goat milk at early, mid and late lactation was (0.237±0.003) mg/100g, (0.228±0.005) mg/100g and (0.229±0.003) mg/100g respectively. Also, there was no significant difference ($P \geq 0.05$) between stages of lactation period.
Table (12): Minerals of Saanen Goat Milk at Different Stages of Lactation Period.

<table>
<thead>
<tr>
<th>Lactation Stages</th>
<th>Minerals Mean ± (SE)</th>
<th>Calcium</th>
<th>Phosphor</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Stage</td>
<td></td>
<td>147.40a±0.289</td>
<td>101.73a±0.258</td>
<td>0.237a±0.003</td>
</tr>
<tr>
<td>Mid Stage</td>
<td></td>
<td>143.87b±0.524</td>
<td>102.73a±0.492</td>
<td>0.228a±0.005</td>
</tr>
<tr>
<td>Late Stage</td>
<td></td>
<td>143.87b±0.456</td>
<td>102.27a±0.431</td>
<td>0.229a±0.003</td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript 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).

4.1.4.8.3 Minerals of Cow Milk:

The minerals content are shown in Table 13, calcium (Ca++) , phosphorus (P++) and iron (Fe++).

Cow milk minerals content was significantly (P ≤0.01) affected by the stages of lactation period with highest content of Ca++ (138.73±1.071) mg/100g at late stage compared to early (135.13±0.661) mg/100g and mid (134.3±0.960) mg/100g stage of lactation period.

The phosphorus (P++) content of cow milk during early, mid and late lactation was (93.00±0.811) mg/100g, (92.27±1.084) mg/100g and (95.60±1.004) mg/100g respectively. It was higher at late stage of lactation. Statistically, phosphorus (P++) content in early and late were similar (P ≥0.05) also early and mid stages (P ≥0.05). But a significant difference was found between the values of late and mid stage (P ≤0.05).
The iron (Fe^{++}) content of cow milk during early, mid and late lactation was (0.183±0.009) mg/100g, (0.175±0.005) mg/100g and (0.200±0.009) mg/100g respectively. It was higher at late stage of lactation. Statistically, Iron (Fe^{++}) content during early and late stages showed no significant difference (P ≥0.05), also early and mid stages were similar (p ≥0.05). A significant difference (P ≤0.05) was noticed between the averages of late and mid stages of lactation period for Iron.

Table (13): Minerals of Cow Milk at Different Stages of Lactation Period.

<table>
<thead>
<tr>
<th>Lactation Stages</th>
<th>Minerals Mean ± (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Calcium</td>
</tr>
<tr>
<td>Early Stage</td>
<td>135.13b ±0.661</td>
</tr>
<tr>
<td>Mid Stage</td>
<td>134.53b ±0.960</td>
</tr>
<tr>
<td>Late Stage</td>
<td>138.73a ±1.071</td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05)

4.1.4.8.4 Variation in Minerals Content of Camel, Goat and Cow Milk:

**Calcium Content:**

Calcium content in milk collected from camel, goat and cow milk is given in Table 14, figure 8 (see appendix). The calcium content during early stage of lactation period was (112.93±1.677) mg/100g in camel milk, (147.40±0.289) mg/100g in goat milk and (135.13±0.661) mg/100g
in cow milk. The cow milk calcium content was the highest followed by goat milk and the lowest found in camel milk. The calcium of cow milk was significantly ($P \leq 0.01$) higher than that of the goat milk as well as camel milk.

The average of $Ca^{++}$ during the mid stage of lactation period of camel, goat and cow milk was ($115.60 \pm 1.386$) mg/100g, ($143.87 \pm 0.524$) mg/100g and ($134.53 \pm 0.960$) mg/100g respectively. The $Ca^{++}$ of camel, goat and cow milk revealed a high significant difference between their averages ($P \leq 0.01$), in favor of goat milk.

The average of calcium during late stage of lactation period was ($120.93 \pm 1.993$) mg/100g in camel milk, ($143.87 \pm 0.456$) mg/100g in goat milk and ($138.73 \pm 1.071$) mg/100g in cow milk. The $Ca^{++}$ of cow milk was higher than that of the camel and goat milk calcium. Also A high significant difference was recorded hereby ($P \leq 0.01$).

Table (14): Variation in Calcium Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages (mg/100g).

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Early Lactation</th>
<th>Mid Lactation</th>
<th>Late Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean $\pm$ SE</td>
<td>Mean $\pm$ SE</td>
<td>Mean $\pm$ SE</td>
</tr>
<tr>
<td>Camel</td>
<td>$112.93^c$ $\pm 1.677$</td>
<td>$115.60^c$ $\pm 1.386$</td>
<td>$120.93^c$ $\pm 1.993$</td>
</tr>
<tr>
<td>Goat</td>
<td>$147.40^b$ $\pm 0.289$</td>
<td>$143.87^a$ $\pm 0.524$</td>
<td>$143.87^b$ $\pm 0.456$</td>
</tr>
<tr>
<td>Cow</td>
<td>$135.13^a$ $\pm 0.661$</td>
<td>$134.53^b$ $\pm 0.960$</td>
<td>$138.73^a$ $\pm 1.071$</td>
</tr>
</tbody>
</table>

Significant: **

NS: Not Significant.
*: Significant ($P \leq 0.05$).
**: High significant ($P \leq 0.01$).
- Means $\pm$ SE values having different superscript letters in the same raw are significantly different ($P \leq 0.05$).
- Means $\pm$ SE values having same superscript letters raw are not significantly different ($P \geq 0.05$).
**Phosphorus content:**

Phosphorus content in milk collected from camel, goat and cow milk is given in Table 15, figure 9 (see appendix). The average of phosphorus during early stage of lactation was (75.67±1.745) mg/100g in camel milk, (101.73±0.358) mg/100g in goat milk and (93.00±0.811) mg/100g in cow milk. The phosphorus average contents also showed a high significant difference between them (P ≤0.01), in favor in goat milk.

The phosphorus during mid stage of lactation period was (78.00±1.721) mg/100g in camel milk, (102.73±0.492) mg/100g in goat milk and (92.27±1.084) mg/100g in cow milk. All values of the phosphorus contents were highly significant (P ≤0.01), in favor in goat milk.

The phosphorus during late stage of lactation period was (79.87±2.004) mg/100g in camel milk, (102.27±0.431) mg/100g in goat milk and (95.60±1.004) mg/100g, and also a high significant difference between the averages was noticed (P ≤0.01), in favor in goat milk.
Table (15): Variation in Phosphorus Content of Camel, Goat and Cow milk during Early, Mid and Late Lactation Stages (mg/100g).

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th>Early Lactation</th>
<th>Mid Lactation</th>
<th>Late Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
</tr>
<tr>
<td>Camel</td>
<td></td>
<td>75.67(^c) ± 1.745</td>
<td>78.00(^c) ± 1.721</td>
<td>79.87(^c) ± 2.004</td>
</tr>
<tr>
<td>Goat</td>
<td></td>
<td>101.73(^a) ± 0.358</td>
<td>102.73(^a) ± 0.492</td>
<td>102.27(^a) ± 0.431</td>
</tr>
<tr>
<td>Cow</td>
<td></td>
<td>93.00(^b) ± 0.811</td>
<td>92.27(^b) ± 1.084</td>
<td>95.60(^b) ± 1.004</td>
</tr>
<tr>
<td>Significant</td>
<td></td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript 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).

**Iron content:**

Iron content in milk collected from camel, goat and cow milk is given in Table 16, figure 10 (see appendix). The average of Fe\(^{++}\) during early lactation period of camel, goat and cow milk was (0.129±0.004) mg/100g, (0.237±0.003) mg/100g and (0.183±0.009) mg/100g respectively, and a high significant difference was also detected (P ≤0.01), in favor of goat milk.

The average of Iron content during mid stage of lactation period of camel, goat and cow milk was (0.149±0.005) mg/100g, (0.228±0.005) mg/100g and (0.175±0.005) mg/100g respectively, and a high significant difference was revealed in this case (P ≤0.01), in favor of goat milk.

The average of Iron content during late stage of lactation period of camel, goat and cow milk was (0.119±0.003) mg/100g, (0.229±0.004) mg/100g and (0.200±0.009) mg/100g respectively. The statistical analysis
indicated a high significant difference ($P \leq 0.01$) between the averages, in favor of goat milk.

**Table (16): Variation in Iron Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages (mg/100g).**

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th>Early Lactation</th>
<th>Mid Lactation</th>
<th>Late Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td></td>
</tr>
<tr>
<td>Camel</td>
<td>0.119$^c$</td>
<td>0.129$^c$</td>
<td>0.149$^c$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.003</td>
<td>±0.004</td>
<td>±0.005</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>0.237$^a$</td>
<td>0.228$^a$</td>
<td>0.229$^a$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.003</td>
<td>±0.005</td>
<td>±0.004</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>0.183$^b$</td>
<td>0.175$^b$</td>
<td>0.200$^b$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.009</td>
<td>±0.005</td>
<td>±0.009</td>
<td></td>
</tr>
</tbody>
</table>

**Significant**

- NS: Not Significant.
- *: Significant ($P \leq 0.05$).
- **: High significant ($P \leq 0.01$).
- Means ± SE values having different superscript letters in the same raw are significantly different ($P \leq 0.05$).
- Means ± SE values having same superscript letters raw are not significantly different ($P \geq 0.05$).

### 4.2 Physical Properties

#### 4.2.1 Physical Properties of Dromedary Camel Milk:

The average values of pH, acidity, electrical conductivity, specific gravity and freezing point of dromedary camel milk at each stage of lactation (early, mid and late lactation) are given in **Table 17**.

The pH values of dromedary camel milk was significantly ($P \leq 0.05$) affected by the stage of lactation with value decreasing with the progress of lactation period, hence the highest pH value was (6.584±0.019) at early lactation and reached (6.477±0.024) and (6.486±0.042) at mid and late stages of lactation.

The acidity was higher during mid stage (0.166%±0.004). Statistically, early (0.161%±0.003) and mid stage of lactation
(0.166%±0.004) are similar (P ≥0.05). On the other hand early (0.161%±0.003) and late (0.150%±0.005) lactation stages are also similar (P ≥0.05). However mid milk of lactation was higher in acidity than late stage of lactation period.

Electrical conductivity of camel milk during early, mid and late lactation was (6.553±0.124) mS, (7.989±0.135) mS and (7.965±0.086) mS respectively. These values were reduced during the early stage and increased at the mid and late stages of lactation period. A high significant difference was noticed between the averages (P ≤0.01).

The specific gravity of camel milk during early (1.0324±0.001), mid (1.0318±0.001) and late (1.0326±0.000) lactation stages showed no significant difference (P ≥0.05).

The freezing point of camel milk during early (-0.573±0.002), mid (-0.576±0.002) and late (-0.576±0.002) lactation stages indicated also no significant difference (P ≥0.05).
<table>
<thead>
<tr>
<th>Lactation Stages</th>
<th>pH Value Mean ± (SE)</th>
<th>Acidity % Mean ± (SE)</th>
<th>Electrical Conductivity mS Mean ± (SE)</th>
<th>Specific Gravity Mean ± (SE)</th>
<th>Freezing Point °C Mean ± (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Stage</td>
<td>6.584\textsuperscript{a} ± 0.019</td>
<td>0.161\textsuperscript{ab} ± 0.003</td>
<td>6.553\textsuperscript{b} ± 0.124</td>
<td>1.0324\textsuperscript{a} ± 0.001</td>
<td>-0.573\textsuperscript{a} ± 0.002</td>
</tr>
<tr>
<td>Mid Stage</td>
<td>6.477\textsuperscript{b} ± 0.024</td>
<td>0.166\textsuperscript{a} ± 0.004</td>
<td>7.989\textsuperscript{a} ± 0.135</td>
<td>1.0318\textsuperscript{a} ± 0.001</td>
<td>-0.576\textsuperscript{a} ± 0.002</td>
</tr>
<tr>
<td>Late Stage</td>
<td>6.486\textsuperscript{b} ± 0.042</td>
<td>0.150\textsuperscript{b} ± 0.005</td>
<td>7.965\textsuperscript{a} ± 0.086</td>
<td>1.0326\textsuperscript{a} ± 0.000</td>
<td>-0.576\textsuperscript{a} ± 0.002</td>
</tr>
</tbody>
</table>

NS: Not Significant.  
*: Significant (P ≤ 0.05).  
**: High significant (P ≤ 0.01).  
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤ 0.05).  
- Means ± SE values having same superscript letters raw are not significantly different (P ≥ 0.05).  

4.2.2 Physical Properties of Saanen Goat Milk:  

The average values of pH, Acidity, electrical conductivity, specific gravity and freezing point of Saanen goat milk at each stage of lactation (early, mid and late) are given in Table 18.  

The pH value of Saanen goat milk was significantly (P ≤ 0.01) affected by the stages of lactation period. The highest value was (6.727±0.018) at early stage of lactation period, it decreased at mid (6.573±0.041) and late (6.591±0.027) lactation period stages.  

The titratable acidity as lactic acid % of Saanen goat milk was (0.140%±0.002), (0.154%±0.004) and (0.175%±0.002) for early, mid and late stages of the lactation period respectively. A high significant difference (P ≤ 0.01) was found hereby.
The electrical conductivity of Saanen goat milk was found as (5.767±0.147) mS, (5.798±0.073) mS and (6.234±0.122) mS for early, mid and late stages of lactation period respectively. However, the milk showed the highest electrical conductivity in the late stage of the lactation period. A significant different was detected (P ≤ 0.05) between the values of the electrical conductivity.

Result obtained for the specific gravity of Saanen goat milk was (1.032±0.000), (1.032±0.000) and (1.031±0.000) for early, mid and late stages of respectively. No significant difference was found in this case (P ≥ 0.05).

The freezing point of Saanen goat milk was obtained (-0.472±0.073), (-0.545%±0.001) and (-0.546±0.001) in early, mid and late stages of the lactation period respectively. Statistical analysis revealed no significant variation hereby.

Table (18): Physical Properties of Saanen Goat milk at different Stages of Lactation Period.

<table>
<thead>
<tr>
<th>Stage of Lactation</th>
<th>Physical Properties Mean ± (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH Value</td>
</tr>
<tr>
<td>Early Stage</td>
<td>6.727a ±0.018</td>
</tr>
<tr>
<td>Mid Stage</td>
<td>6.573b ±0.041</td>
</tr>
<tr>
<td>Late Stage</td>
<td>6.591b ±0.027</td>
</tr>
<tr>
<td>Significant</td>
<td>**</td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant (P ≤ 0.05).
**: High significant (P ≤ 0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤ 0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥ 0.05).
4.2.3 Physical Properties of Cow Milk:

The average values of pH, acidity, electrical conductivity, specific gravity and freezing point of cow milk at each stage of lactation (early, mid and late) are given in Table 19.

pH value of cow milk was significantly (P ≤0.01) affected by the stages of lactation period with lowest pH value (6.440±0.042) at early stage compared with mid (6.600±0.041) and late (6.583±0.009) stages of lactation period.

Values obtained for the titratable acidity % in early, mid and late lactation stages were (0.141%±0.002), (0.169%±0.003) and (0.156%±0.002) respectively. High and lowest acidity were obtained during mid and early stages. A high significant variation (P ≤0.01) was recorded between the averages of the acidity.

The electrical conductivity of cow milk was significantly (P ≤0.05) affected by the stages of lactation with lowest electrical conductivity (4.487±0.034) mS in early stage compared with mid (5.453±0.091) mS and late (5.427±0.109) mS stages of lactation period.

The specific gravity of cow milk was regular during the early (1.0327±0.000), mid (1.0325±0.000) and late (1.0320±0.000) stages of lactation period, and no significant variations (P ≥0.05) was recorded between the averages of the specific gravity.

Results obtained showed that the Freezing point of cow milk was (-0.549±0.001), (-0.546±0.002) and (-0.546±0.002) at early, mid and late stages of lactation period. No significant difference during the three stages of the lactation period (P ≥0.05) was revealed.
Table (19): Physical Properties of Cow milk at different Stages of Lactation Period.

<table>
<thead>
<tr>
<th>Stage of Lactation</th>
<th>Physical Properties Mean ± (SE)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH Value</td>
<td>Acidity %</td>
</tr>
<tr>
<td>Early stage</td>
<td>6.440±0.042</td>
<td>0.141±0.002</td>
</tr>
<tr>
<td>Mid Stage</td>
<td>6.600±0.041</td>
<td>0.169±0.003</td>
</tr>
<tr>
<td>Late Stage</td>
<td>6.583±0.009</td>
<td>0.156±0.005</td>
</tr>
<tr>
<td>Significant</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05).

4.2.4 Variation in Physical Properties of Camel, Goat and Cow Milk

4.2.4.1 pH Value:

The data obtained for pH of all three types of milk along with their statistical analysis is presented in Table 20, figure 11 (see appendix).

The means of pH during the early stage of lactation period for camel, goat and cow milk was (6.584±0.019), (6.727±0.018) and (6.440±0.042) respectively. A significant variation was revealed between the means of the pH (P ≤0.01), in favor of goat milk.

The pH values during the mid stage of lactation period were (6.477±0.024) in camel milk, (6.573±0.042) in goat milk and (6.600±0.041) in cow milk. No significant difference (p ≥0.05) was
recorded between goat and cow milk in terms of the pH, but a significant difference was found between goat and cow milk and that of camel milk ($P \leq 0.05$).

The values of the pH during late stage of the lactation period were ($6.486\pm 0.042$), ($6.591\pm 0.027$) and ($6.583\pm 0.009$) for camel, goat and cow milk. No significant variation between goat and cow milk. But significant difference ($P \leq 0.05$) between goat, cow milk and that of camel milk was recorded.

**Table (20): Variation in pH Values of Camel, Goat and Cow Milk during Early, Mid and Late Stages of Lactation Period.**

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early Stage</td>
<td>Mid Stage</td>
<td>Late Stage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td></td>
</tr>
<tr>
<td>Camel</td>
<td>6.584$^b$ ± 0.019</td>
<td>6.477$^b$ ± 0.024</td>
<td>6.486$^b$ ± 0.042</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>6.727$^a$ ± 0.018</td>
<td>6.573$^{ab}$ ± 0.042</td>
<td>6.591$^a$ ± 0.027</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>6.440$^c$ ± 0.042</td>
<td>6.600$^a$ ± 0.041</td>
<td>6.583$^a$ ± 0.009</td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>**</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant ($P \leq 0.05$).
**: High significant ($P \leq 0.01$).
- Means ± SE values having different superscript letters in the same raw are significantly different ($P \leq 0.05$).
- Means ± SE values having same superscript letters raw are not significantly different ($P \geq 0.05$).

**4.2.4.2 Titratable Acidity:**

The average of titratable acidity of milk samples collected from camel, cow and goat milk is given in Table 21figure 12 (see appendix).

It was observed that the values of titratable acidity during the early stage of lactation period was ($0.161\%\pm 0.003$) in camel milk, ($0.140\%\pm 0.002$) in cow milk and ($0.141\%\pm 0.002$) in goat milk. A high
significant difference (P ≤0.01) was noticed between there averages, in favor of camel milk.

The values of titratable acidity during the mid stage of lactation period of camel (0.166%±0.004) and cow (0.169%±0.003) milk were higher than that of goat milk (0.154%±0.004). A significant difference was found for titratable acidity in this case (P ≤0.05).

The values of titratable acidity during the late stage of lactation period of goat milk (0.175%±0.002) were higher than that of camel (0.150%±0.005) and cow milk (0.156%±0.005). A high significant difference (P ≤0.01) was recorded between the averages of titratable acidity of the three milks, in favor of goat milk.

Table (21): Variation in Titratable Acidity of Camel, Goat and Cow Milk during Early, Mid and Late Stages of Lactation Period.

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early Lactation</td>
<td>Mid Lactation</td>
<td>Late Lactation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td></td>
</tr>
<tr>
<td>Camel</td>
<td>0.161&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.166&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.150&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.003</td>
<td>±0.004</td>
<td>±0.005</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>0.140&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.154&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.175&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.002</td>
<td>±0.004</td>
<td>±0.002</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>0.141&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.169&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.156&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.002</td>
<td>±0.003</td>
<td>±0.005</td>
<td></td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05).

4.2.4.3 Electrical Conductivity:

The data obtained for electrical conductivity of all three types of milk is shown in Table 22, figure 13 (see appendix).
The average of electrical conductivity during the early stage of lactation period was (6.553±0.124) mS in camel milk, (5.767±0.124) mS in goat milk and (4.487±0.034) mS in cow milk. A high significant difference (P ≤0.01) was noticed hereby, in favor of camel milk.

The electrical conductivity during mid stage of lactation period was (7.989±0.135) mS in camel milk, (5.798±0.073) mS in goat milk and (5.453±0.091) mS in cow milk. A high significant difference (P ≤0.01) was also detected in this case, in favor of camel milk.

The electrical conductivity during late stage of lactation period was (7.965±0.086) mS in camel milk, (6.234±0.122) mS in goat milk and (5.427±0.109) mS in cow milk. The camel milk showed the highest electrical conductivity, followed by goat milk and the lowest electrical conductivity found in cow milk. The electrical conductivity of camel milk was significantly (P ≤0.01) higher than that of the cow milk as well as goat milk.

Table (22): Variation in Electrical Conductivity of Camel, Goat and Cow Milk during Early, Mid and Late Stages of Lactation Period.

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th>Mean ± SE</th>
<th>Mean ± SE</th>
<th>Mean ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early Lactation</td>
<td>Mid Lactation</td>
<td>Late Lactation</td>
<td></td>
</tr>
<tr>
<td>Camel</td>
<td>6.553±0.124</td>
<td>7.989±0.135</td>
<td>7.965±0.086</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>5.767±0.147</td>
<td>5.798±0.073</td>
<td>6.234±0.122</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>4.487±0.034</td>
<td>5.453±0.091</td>
<td>5.427±0.109</td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td></td>
</tr>
</tbody>
</table>

NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05).
4.2.4.4 Specific Gravity:

The data obtained for specific gravity is presented in Table 23 figure 14 (see appendix).

The mean specific gravity during early stage of lactation period of camel, goat and cow milk was (1.0324±0.0003), (1.0322±0.0003) and (1.0327±0.0003) respectively. No significant variation was found (P ≥0.05).

The specific gravity during the mid lactation stage was (1.0318±0.0005) in camel milk, (1.0324±0.0005) in goat milk and (1.0325±0.0004) in cow milk. Also no significant variation was recorded (P ≥0.05).

The specific gravity during the late stage of lactation period was (1.0326±0.0004) in camel milk, (1.0318±0.0004) in goat milk and (1.0320±0.0004) in cow milk. The statistical analysis revealed no significant variation (P ≥0.05) between the averages of the specific gravity for the three stages of lactation period of the three breeds.
Table (23): Variation in Specific Gravity of Camel, Goat and Cow Milk during Early, Mid and Stages of Lactation Period.

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th>Mean ± SE</th>
<th>Mean ± SE</th>
<th>Mean ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early Lactation</td>
<td>Mid Lactation</td>
<td>Late Lactation</td>
<td></td>
</tr>
<tr>
<td>Camel</td>
<td>1.0324(^a) ±0.0003</td>
<td>1.0318(^a) ±0.0005</td>
<td>1.0326(^a) ±0.0004</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>1.0322(^a) ±0.0003</td>
<td>1.0324(^a) ±0.0005</td>
<td>1.0318(^a) ±0.0004</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>1.0327(^a) ±0.0003</td>
<td>1.0325(^a) ±0.0004</td>
<td>1.0320(^a) ±0.0004</td>
<td></td>
</tr>
</tbody>
</table>

Significant: NS

NS: Not Significant.
*: Significant (P ≤0.05).
**: High significant (P ≤0.01).
- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥0.05).

4.2.4.5 Freezing Point:

The data obtained for freezing point of all 3 types of milk is presented in table 24, figure 15 (see appendix).

The average freezing point during early stage of lactation period of camel, goat and cow milk was (-0.543±0.002), (-0.472±0.073) and (-0.549±0.001) respectively, with no significant difference.

The freezing point during the mid stage of lactation period was (-0.546±0.002) in camel milk, (-0.545±0.002) in goat milk and (-0.546±0.002) in cow milk. The statistical analysis revealed no significant variation (P ≥0.05).

The freezing point during the late stage of lactation period was (-0.576±0.002) in camel milk, (-0.576±0.002) in goat milk and (-0.576±0.002) in cow milk. No significant difference (P ≥0.05) between
the averages of the freezing point for the three stages of lactation period of the three breeds.

Table (24): Variation in Freezing Point of Camel, Goat and Cow Milk during Early, Mid and Late Stages of Lactation Period.

<table>
<thead>
<tr>
<th>Source of Milk</th>
<th>Lactation Stages</th>
<th>Early Lactation</th>
<th>Mid Lactation</th>
<th>Late Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td>Mean ± SE</td>
<td></td>
</tr>
<tr>
<td>Camel</td>
<td>-0.543&lt;sup&gt;a&lt;/sup&gt; ±0.002</td>
<td>-0.546&lt;sup&gt;a&lt;/sup&gt; ±0.002</td>
<td>-0.576&lt;sup&gt;a&lt;/sup&gt; ±0.002</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>-0.472&lt;sup&gt;a&lt;/sup&gt; ±0.073</td>
<td>-0.545&lt;sup&gt;a&lt;/sup&gt; ±0.002</td>
<td>-0.576&lt;sup&gt;a&lt;/sup&gt; ±0.002</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>-0.549&lt;sup&gt;a&lt;/sup&gt; ±0.001</td>
<td>-0.546&lt;sup&gt;a&lt;/sup&gt; ±0.002</td>
<td>-0.576&lt;sup&gt;a&lt;/sup&gt; ±0.002</td>
<td></td>
</tr>
</tbody>
</table>

Significant: NS

NS: Not Significant.

*: Significant (P ≤ 0.05).

**: High significant (P ≤ 0.01).

- Means ± SE values having different superscript letters in the same raw are significantly different (P ≤ 0.05).
- Means ± SE values having same superscript letters raw are not significantly different (P ≥ 0.05).
CHAPTER FIVE
DISCUSSION

5.1 Compositional Properties:

As for compositional properties variations the obtained results in (Table 1) for fat content in camel milk followed the same trend reported by Alshaikh and Salah (1994) and Haddadin et al. (2008) who found the values of fat were highest during the first 6 month of lactation. Camel milk constituents were gradually decreased during the second and third stage of lactation. Fat was significantly decreased during second and third stage of lactation. These results are in conformity with those of Gaili et al. (2000) and Zeleke (2007) who demonstrated, the fat content of camel milk was gradually decreased with the progress of stage of lactation. Also, Konuspayeva et al. (2009) reported that the fat content decreased all along the lactation period and the fat content varied between 4.34% - 7.81%.

The obtained results for fat in saanen goat milk in (Table 2) agreed with those of Chornobai et al. (1999) who reported that the lactation period influenced the fat content of goat milk and with Palmquist et al. (1993) who mentioned that the variation in fat content was related to lactation stages in addition to other various factors, such as temperature, quantity of milk produced, breed and feed type and also agreed with those obtained by Zahraddeen et al. (2007) who mentioned, the fat content showed a decrease with advance in stage of lactation period.

The results in (Table 3) for fat in cow milk were in line with Stoop et al. (2009). But disagreed with that reported by Bohmanova et al.
(2009) who found, fat content of the milk was lower especially in late stage of lactation. This may be due to differences in breed and other confounding factors between the two studies.

Results in (Table 4) for fat in camel, goat and cow milk indicated that the fat content in cow milk was higher than that obtained by Eckles and Macy (2004) and Lingathurai et al. (2009). The amount of fat content found in goat milk in current study was similar to that given by Bhosale et al. (2009). On the other hand fat content of goat and camel milk found in this study were almost in full agreement with those reported by Mepham (1983) and Mehaia et al. (1995).

Concerning the protein content of the results given in (Table 1), for protein in camel milk agreed with those by Sahani et al. (1998) who observed that protein content was 3.0% in camel milk in India, the protein content was significantly higher during the late phase of lactation than during the early stage of lactation. The mean content of protein in this study showed lower results compared to those reported by Zeleke (2007), El-Amin et al. (2006) and Riydh et al. (2012) who mentioned the highest percentage of protein of camel milk was at the first lactation and then decreased along the lactation period. Ahmed et al. (2012) observed that protein was gradually decreased by subsequent stage of lactation. But disagreed with that reported by Wafa and El Zubeir (2014) who found, the highest content of protein was recorded in camel milk during the early stage of lactation (1-3) month. The variations of this result from those obtained by Wafa and El Zubeir (2014) could be because they examined the milk from different animals, while this study followed the same animals.

Results given in (Table 2) for protein in saanen goat milk agreed with that obtained by Keskin et al. (2004) who found that the protein
content showed a downward trend until mid-lactation before it significantly increased towards the end of lactation, also agreed with Mestawet et al. (2012) who demonstrated that protein content in goat milk was significantly higher in the early and late stages of lactation than in the middle one. But the result obtained disagreed with Ahamefule et al. (2003) who gave protein values of 4.26, 4.23 and 4.34% for West African Dwarf goat in early, mid and late lactation stages. The increase in protein content could be due to the decline milk yield (Mioc et al. 2008). During earlier and mid stages of lactation, the milk yield was higher; however, during late lactation when milk yield was low, protein content was higher (Mahmoud et al. 2014).

Results in (Table 3) for protein in cow milk agreed with that reported by Abdel-Raziq et al. (1982) who stated that milk constituents of Holstein – Friesian cows in Egypt were lower during early stage of lactation periods and tended to increase as lactation advanced, also these agreed with Sharma et al. (1990) who found that protein percentage of Holstein and Jersey cows in the U.S.A declined slightly at the beginning of lactation periods and rose after 2.5 to 3.5 months.

For the results obtained in (Table 5) for protein in camel, goat and cow milk, the protein content in this study found in cow milk was in line with the findings of (Imran et al. 2008; Enb et al. 2009; Mahboba and Zubeir 2007 and Samia et al. 2009). Protein content found in goat milk during this investigation was similar to the finding of Haenlein (1996) and the protein content found in camel milk during this research work was similar to the findings of Konuspayeva et al. (2009), who reported that protein content of dromedary Camel milk ranged between 2.15 to 4.90.

For the moisture content the results obtained in (Table 1) for moisture in camel milk agreed with that reported by El-Erain (1979)
who pointed out the water content of camel grazing near Riyadh (Saudi Arabia) ranged 85.60-89.64, and with Gaili et al. (2000) who stated that the water content in camel milk increased during lactation and with parities. Also these results agreed with Zia-ur-Rehman et al. (1998) who found the composition of camel milk studied at different phases of production viz. I (1 to 3 months), II (4 to 7 months) and III (8 to 12 months), the water content showed an increasing trend towards the end of lactation.

The water content of Saanen goat milk was not significantly affected throughout the lactation stages (Table 2). These results were in disagreement with Bencini and Pulina (1997) who gave water content of Saanen goat milk ranged from 88 to 90%

Results in (Table 3) for water in cow milk were in line with the finding of Al-Nimer (2007) who stated that water content of cow milk ranged from 85-90% and also Said Ahmed and Adel (2000) who mentioned that the water content of Friesian cow milk was 87.82%, and disagreed with Talukder et al. (2013) who stated that water content of early stage of lactation was significantly higher than that of late stage of lactation.

Table (6) showed that moisture content for camel, goat and cow milk, water in camel milk obtained was higher than those of El-Amin and Wilcox (1992), but slightly lower than that of (El- Hag et al. 2003). Johanson (1980), Bencini and Pulina (1997) who found a moisture content of 87.2% and 89% for cow and goat milk respectively.

The results of total solids (Table 1) in camel milk were in conformity with those of Gaili et al. (2000) and Zelake (2007), who demonstrated that total solids of camel milk decreased from 11.7% in first stage of lactation to 10.1% by the end stage of lactation, also agreed with Zia-ur-Rehman et al. (1998) who observed that total solids showed a
decreasing trend towards the end of lactation. AL-shaikh and Salah (1994); Haddadin et al. (2008) and Zelake (2007) found that the total solids were highest during the first 6 month of lactation and in contrast with the finding reported by Sahani et al. (1998) who stated that total solids content was 11.32% in camel milk in India. However, the total solids content was significantly higher during the late phase of lactation than during the early stage of lactation,

The variation of total solids content in milk from Saanen goat (Table 2) was similar to the finding of Zahraddeen et al (2007) who observed that no significant difference in total solids content of milk from Nigerian goat during the stage of lactation.

Similar results for total solids content of cow milk (Table 3) was obtained by Sharma et al. (1990) who noticed that milk total solids of Holstein and Jersey cows in the U.S.A declined slightly at the beginning of lactation and rose after 2.5 to 3.5 months, also agreed with the finding reported by El-Hamidi et al. (1981) in Egypt for the total solids contents of Friesian cow's milk which were at minimum 7 weeks after calving. The present result disagreed with Hussein (1985) who reported, milk total solids % of Sudan graded dairy cows was high 12.80% ± 1.50 at the beginning of lactation and decreased to a minimum value of 12.20%±1.10 at the third month of lactation before it increased to a value of 12.80%±1.30 at the fifth month of lactation.

Table (7) showed that total solids content for camel, goat and cow milk, the concentration of total solids found in goat milk was similar to that given by (Kanawal et al. 2004) and (Imran et al. 2008).The concentration of total solids found in cow milk during the current research was in line with the finding of (Imran et al. 2008). The concentration of total solids found in camel milk was similar to the finding of (Sawaya et al. 1984). Singh et al. (1979) who stated that milk
composition is affected by several factors environmental and physiological factors.

As for the lactose content, the average lactose was reduced during the early and mid lactation stages and increased at late stage of lactation in camel milk (Table 1), lower mean values of the lactose content were found during the present study compared to those reported by Zeleke (2007) and Riaydh et al.(2012), who reported that the highest lactose content was recorded in the first lactation and then deceased significantly at the end of lactation periods and Ahmed et al. (2012) who stated, the lactose content was gradually decreased by subsequent stage of lactation. But disagreed with El-Amin et al. (2006) found no significant differences in lactose content between different stages of lactation period. Lactose content was only found to change slightly for camel milk of some Dromedary breeds in different parts of the world (Haddadin et al. 2008).

Similar results for lactose content in saanen goat milk (Table 2) was obtained by Bhosale et al. (2009) and Antunac et al. (2001), who found the higher content of lactose was observed at the beginning of lactation period in comparison with middle of lactation stages. However higher values were found for lactose content during the early stage of lactation than the values reported by (Keskin et al.2004). Moreover, the result disagreed with Wuschko and Seifert, (1992) and Brendehaug and Abrahamsen (1986) who observed that lactose value decreased slowly from the beginning until the 9th week of lactation.

Result in (Table 3) for lactose content of cow milk was in contrast with the finding reported by Boros (1986) who observed that lactose was fairly constant over the lactation period showing no substantial changes.

Result in (Table 8) for lactose content of camel, goat and cow milk, lactose content found in cow milk during this research work period was
similar to the finding of Aquasha and Al-Jiboory (2002) and Iglesia et al. (1994) who reported higher lactose content in goat and camel milk i.e. 4.65% and 4.67% respectively. Lactose content in cow milk was lower than those reported by Ben, (1976) and Abu-Dawoud et al. (2003) who recorded 4.8% and 4.91% respectively.

The result of ash content of camel milk obtained in (Table 1) disagreed with those of Abdel-Raziq et al. (2011) who demonstrated ash content of camel milk was higher in (7th month) of lactation than in the initial stage of lactation (2nd month).

The average ash content in (Table 2) for saanen goat milk supported those given by (Salem et al. 2000) and (Keskin et al. 2004). Moreover, the result disagreed with Aganga, (2002) who studied that the milk composition of Tahwana goat and Ewes milk, and also studied the effect of lactation on composition of goat milk and reported that minerals fluctuated in both goats and ewes milk throughout the lactation period.

Ash content of cow milk was not significantly affected throughout the lactation stage (Table 3). These results disagreed with the finding reported by Suchaech and Kvapilik (1975) who found that ash percentage of Zechpied or Ayrshire x Zechpied in Czechoslovakia cows was lowest in the second and third months of lactation and highest in the tenth month, also Robinson (1997) found that ash was almost constant and varied from 0.68% ±0.10 at the start, peaked at a value of 0.78%±0.10 at the 3rd month.

Table (9) showed that there was no significant (P ≥0.05) difference between averages of ash content of camel, goat and cow milk during the stages of lactation period.

Results given in (Table 1) for SNF in camel milk was in agreement with that of Sahani et al. (1998) who reported that in India the milk solids not fat % 8.22 and significantly higher during the late phase of lactation.
than during the early stage of lactation and lower values were found by Zelake (2007) and Wafa and El Zubeir (2014) who reported the highest content of solids not fat was recorded in camel milk during the early stage of lactation (1-3) month.

**Solids non fat content** obtained for saanen goat milk (Table 2) was similar to the finding of (Zamfirescu 2009). The increase in concentration of protein and fat in subsequent stages of lactation had a direct effect on the content of total solids and solids not fat (Strzalkowska et al. 2009).

**Solids-non-fat content of cow** milk in (Table 3), was similar to that obtained by Sharma et al. (1990) who stated that the solids not fat was highest 9.10%±1.40 at the start and decreased gradually with advancing lactation in full agreement with Hussein (1985) who reported that in Sudan the milk solids not fat content was highest 9.10%±1.40 at the start and decreased gradually with advancing lactation but dissimilar with that reported by Harris and Bachman (2008) who suggested that within any given lactation, SNF content is relatively high in the first month, drops to a low in the second, than rises as lactation advances. Such variation might be due to the milk composition was influenced by feed types of substrates for synthesis of various milk components.

Results in Table (10) for **solids not fat in camel, goat and cow** milk, showed that SNF found in camel milk was similar to that cited by (Kan et al. 2001 and Kanna 1986). Solids not fat content found in goat milk during stages of lactation was similar to the finding of (Strzalkowska et al. 2009). Solids not fat content in cow milk of the current study was similar to the findings of (Sharma et al. 1990).
5.2 Minerals:

Calcium, phosphorus and iron content of dromedary camel, saanen goat and cow milk were given in Tables (11-16).

The results in Table (11) for calcium, phosphorus and iron content in camel milk, the values of calcium content of camel milk was in agreement with that reported by Sawaya et al. (1984) and Ayadi et al. (2009) but not with the finding reported by Zhang et al. (2005) who studied the physiological variations of main minerals in the first 90 days of lactation and observed quite similar trends with a parallel change of calcium and phosphorus, a slight increase at the first week of lactation and a progressive decrease up to the third months and also with Mal et al. (2007) who observed higher values at the end of lactation.

The observed values in iron concentration of the current study appeared lower on average than those reported by (Sawaya et al.1984).

It seems that a change in mineral content of camel milk depends on productions system, breed variations, parity and stages of lactation. This agreed with Farah (1996) who pointed out that minerals composition of camel's milk was affected by factors such as stage of lactation and udder health status. However, few data are available on minerals composition of camel's milk (Dell’orto et al.2000).

Results in Table (12) for calcium, phosphorus and iron content in saanen goat milk, results indicated that lower level of Calcium in saanen goat milk was observed at the mid and late stage of lactation in comparison to the beginning of lactation. The changes in phosphorus and iron values of goat milk during lactation were not found statistically significant (P ≥0.05). Those results are in conformity with Mestawet et al. (2012), who reported that the Calcium concentration in goat milk was significant higher in the first and last stage of lactation. Some researchers
have mentioned that phosphorus and calcium increase during lactation (Boros et al. 1988). Antunac et al. (2001) also reported that significantly higher content of calcium and phosphorus were determined at the beginning of lactation in comparison with middle lactation. Whereas in other studies, it was reported that phosphorus concentration was higher at the beginning of lactation Mba et al. (1979) and according to Boros et al. (1988) phosphorus content was low at the beginning and increased 3.4% during lactation.

The variations in milk mineral content at different stages of lactation reported in this study are in line with that reported by (Mestawet et al. 2012) and (Grayling et al. 2004).

Results in Table (13) for calcium, phosphorus and iron content in cow milk, stage of lactation had an effect on milk minerals concentration. The results obtained for mineral content of cow milk were dissimilar to those of Gaucheron (2005). Toffanin et al. (2015b) mentioned that calcium and phosphorus contents are high at the beginning of lactation, decrease rapidly until 6-8 weeks and increased thereafter. However, some studies found different results (Haug et al. 2007; Van Hulzen et al. 2009; Zamberlin et al. 2012). Iron was affected by stage of lactation, the Iron content given in the current study for the stages of lactation are comparable with those of Rodriguez et al. (2001), Soliman (2005) and Ceballos et al. (2009), but higher than those of (Sola-Larranga and Navarro-Belasco 2009) and (Khan 2006).

The Results in Tables (14,15,16) obtained for calcium, phosphorus and iron content of camel, goat and cow milk, indicated the value of calcium content of goat milk was found to be 0.13% and in agreement with Kon (1972); Warner (1978) and Meschy (2002). It was very close to that of cow milk (the value of cow milk Calcium was found to be 0.12%). Dronen (1990) reported that phosphorus is higher in goat
milk than in milk of other ruminant species. The average value of phosphorus in goat milk was found to be in the range 0.065% to 0.088% Sawaya et al. (1984), while cow milk phosphorus has lower value than goat milk, which was found to be 0.023% (Dronen 1990). The minerals Na, K, Fe, Cu and Mn in dromedary camel milk were considerably higher than those reported for bovine milk (Sawaya et al. 1984) and (Mehaia et al. 1995). Al-Haj and Al Kanhal (2010) reviewed that the mean values of dromedary milk minerals are as follows: calcium, 114 mg/100g, potassium, 156 /100g, sodium, 59/100g, iron, 0.29/100g, magnesium, 10.5/100g, manganese, 0.05/100g and zinc,0.53/100g.

5.3 Physical Properties:

As for physical properties variations the results in (Table 17) for the pH value of camel milk agreed with that obtained by Riyadh, (2012) who stated that pH was affected by stages of lactation and declined in 2\textsuperscript{nd} lactation stages by then in 1\textsuperscript{st} and lower stages. Sahani et al. (1998) demonstrated that in India the milk pH values 6.38 were significantly higher during the late phase of lactation than during the early stage of lactation.

Similar results for Saanen goats were observed by (Table 18) Bhosale et al. (2009), that the pH content of local goat milk decreased from first (6.5 to 6.3) in fourth lactation. It was observed that the pH content of local goat milk was significantly affected due to lactation. The result disagreed with Zahraddeen et al. (2007) who reported the pH value rose consistently during lactation. Tsioupas et al. (2007) reported that the pH value of goat milk was significantly affected by the lactation period.

The pH value of cow milk (Table 19) was similar to the study of Pavic et al. (2002) who stated that in the mid and at the end of the
lactation period the pH value was higher than at the beginning of lactation period.

Results in (Table 20) for pH value of camel, goat and cow milk, the results showed that pH values found in camel milk were accordance with the findings of (Alwan et al. 2014) and (Shalash, 1979). PH values found in goat milk were similar to that reported by Fandialan and Davide (2001), pH values found in cow milk were in agreement with the finding of (Eckles and Macy 2004) and (Mohamed, 2004).

The results given in (Table 17) for titratable acidity in camel milk was in line with Ahmed (2012) who found that acidity was gradually decreased by subsequent stage of lactation, and in contrast with the finding reported by Raghvendar et al. (2004) who stated that higher acidity was recorded in the late lactation, followed by the early and middle stage of lactation.

The results obtained in the present study for titratable acidity in goat milk (Table 18) are in agreement with the finding reported by Fandialan and Divide (2001) who studied the relation between pH and titratable acidity in goat's milk. Zahraddeen et al. (2007) found that titratable acidity was decreased during lactation in parallel to the changes in pH values.

Results in (Table 19) obtained for titratable acidity of cow milk disagreed with that of Talukder et al. (2013) who reported that the titratable acidity during early lactation was significantly higher than middle and late lactation stages.

Results in (Table 21) obtained for titratable acidity of camel, goat and cow milk. Showed that titratable acidity of camel milk was in agreement with those reported by Raghvendar et al. (2004) reported (0.154%) lactic acid in Indian camel milk. Similar, by the data obtained for titratable acidity for cow milk agreed in general with those reported
by Park et al. (2007) (0.15-0.18) lactic acid in cow milk. The titratable acidity of goat milk was similar to the finding of Idris et al. (1975) who found that the mean titratable acidity for Sudanese cattle milk ranged between 0.16-0.22 percent with mean of 0.19% lactic acid.

For the electrical conductivity the camel milk (Table 17) had a negative correlation with fat, lactose, ash, protein and density (Abdel-Gadir et al. 2013).

No information about electrical conductivity of Saanen goats milk (Table 18) were available to the author, Results in the current study are according to our own finding.

The electrical conductivity of cow milk (Table 19) was significantly (p ≤0.05) affected by the stage of lactation with lowest values during early stage compared to mid and late stages of lactation. The Electrical Conductivity increases with the increase in temperature. Brentrup. (1994); Nowak et al. (1990) and Tongel et al. (1994) stated that the EC of milk can vary due to a number of factors such as nutrition, age, breed, oestrous cycle, stage of lactation and climatic conditions.

Electrical conductivity affected by concentration of irons presents in the milk for camel, goat and cow (Table 22). In milk about 60 to 80% of the current carried by Na+, K+ and Cl− (Schulz and Sydom 1957). Khaskheli et al. (2005) observed the range between 0.20 to 0.28g per 100gm camel milk. Therefore, high electrical conductivity may be due to high chloride content, also Park et al. (2007) reported 0.0040-0.0050 ( -1cm-1) electrical conductivity of cow milk, also Nielen et al. (1992); Walzel, (1997) and Billon et al. (2001) stated that the average conductivity of cow milk ranges between 4 and 5.8 mS in cow milk. Riel (1985); Varnum and Sutherland (1994) and Singh et al (1997) reported 10.8±2.07 electrical conductivity of goat milk. The variation in
conductivity may be due to the different levels of the electrolytes present in the milk samples.

The results (Table 17) showed that the specific gravity in camel milk according to the stage of lactation remains not at a significant variation (P ≥ 0.05). The range of specific gravity of milk in the stages of lactation period was 1.031 to 1032. Milk normally varies in specific gravity and it ranges between 1.028 - 1.034.

The results (Table 18) showed that the specific gravity content in Saanen goat milk according to the stage of lactation remains not significant (P ≥ 0.05). These observations are in partial disagreement with other studies by Bhosale et al. (2009) who found that specific gravity of goat milk was lowest in first (1.025) lactation and significantly increased in second (1.027), third (1.028) and fourth (1.029) lactations, Agruello et al. (1998) reported that the lactation period influenced the specific gravity of goat milk.

The results showed that the specific gravity content in cow milk according to the stage of lactation (Table 19) was not significant (P ≥ 0.05). The range of specific gravity of milk at the stage of lactation was 1.032-1.032. Milk normally varies in specific gravity between 1.028 to 1.034 Anantakrishnan et al. (1993) reported that generally the specific gravity of cow's milk ranges from 1.028 to 1.032.

Table (23) showed that there was no significant (P ≥ 0.05) difference between the specific gravity of camel, goat and cow milk during stages of lactation periods. The data obtained in present study for mean specific gravity of cow and goat milk was in agreement with Syed and Henna (2010) who found that specific gravity from 1.023 to 1.030 and disagreed with the finding reported by Abu-Lehia (1989) who stated that the specific gravity of camel milk was significantly lower than that of cow milk.
For the freezing point, results of camel milk did not vary significantly throughout the lactation period (Table 17). Wangoh (1997) reported that the freezing point of camel milk ranges \(-0.57\) and \(-0.61\) C.

Table (18) showed, freezing point of saanen goat was not significantly affected throughout the stages of lactation. These results contradicted with Antunac et al. (2001) who indicated that maximum freezing point values at the beginning of lactation period. Jenness (1980) found that the average values of freezing point increased at the end of lactation, approaching those revealed in the beginning of lactation. The lower SNF content in milk at the beginning of the monitored period corresponded to the increased freezing point.

Freezing point content of cow milk was not significantly affected by the stage of lactation periods (Table 19). Bundel khand (2011) found that the freezing point of cow milk ranged between \(-5.25\) C to \(-5.65\) C.

The results in (Table 24) showed that the freezing point content in camel, saanen goat and cow milk according to the stage of lactation periods (Table 24), remained not significant \((P \geq 0.05)\). The value obtained in the current study for average freezing point of camel milk was similar to those reported in the literature for camel milk. However, the freezing point of cow and goat milk disagreed with Harding (1999) and Parkash and Jenness (1968) who stated that the freezing point of goat's milk was slightly lower than cow's milk.
CHAPTER SIX

CONCLUSIONS & RECOMMENDATIONS

6.1 Conclusion:

It can be concluded that the physicochemical properties of dromedary camel, Saanen goat and cow milk showed significant difference throughout the different stages of lactation periods, which in turn vary in length. In the progress of the lactation period, these differences were clearly observed, dependant on the length of each stage and thus the overall lactation period.

6.2 Recommendation:

1. The differences in milk composition of the different animal species at different stages of lactation could be utilized by the industry to process products of different qualities and components that with consumer health and preference.
2. More research studies should be conducted on relationship between lactation stage and milk composition and properties.
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Figure (1): Variation in Fat Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages.
Figure (2): Variation in Protein Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages.
Figure (3): Variation in Water (Moisture) Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages.
Figure (4): Variation in Total Solids Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages.
Figure (5): Variation in Lactose Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages.
Figure (6): Variation in Ash Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages.
Figure (7): Variation in Solids Non Fat Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Period Stages.
Figure (8): Variation in Calcium Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages (mg/100g).
Figure (9): Variation in Phosphorus Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages (mg/100g).
Figure (10): Variation in Iron Content of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages (mg/100g).
Figure (11): Variation in pH Values of Camel, Goat and Cow Milk during Early, Mid and Late Stages of Lactation Period.
Figure (12): Variation in Titratable Acidity of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages.
Figure (13): Variation in Electrical Conductivity of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages.
Figure (14): Variation in Specific Gravity of Camel, Goat and Cow Milk in Early, Mid and Late Lactation Stages.
Figure (15): Variation in Freezing Point of Camel, Goat and Cow Milk during Early, Mid and Late Lactation Stages.