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Composition and Properties of Camel Milk In Comparison With Cow's and Buffaloes' Milks

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Abstract

Camel, cow's and buffaloe's milk samples were randomly collected from the animal breeding in Marsa-Matrouh, Res. Station. All samples were analysed for TS, fat, protein, lactose, Ca, P, acidity and pH value. Also, amino acids, fatty acids and protein fractionations were studied. Camel milk had a lower TS, protein, lactose, Ca, P, and acidity than cow's and buffaloes' milk. Also, camel milk contained lower CN/TN ratio, while it was higher in WP/TN and NPN/TN. Also, clear variations were detected in milk fat constants between the three different types of milk. The analysis of amino acids showed some variations between camel, cow, and buffaloe's milk. An obvious difference was observed in fatty acid contents between different species. Fractionation of proteins by electrophoresis showed a clear variation that the *β*-casein was high in camel milk and the *κ*-casein was very low, while *β*-lacto globulin was very low in camel milk. That it was similar with human milk in this property.

Key words: Camel, electrophoresis, fatty acids, amino acids

Introduction

Camels support the survival of millions of people in arid and semi-arid areas of the world. They possess remarkable abilities to exploit very limited resources because they are extremely well suited for life under harsh conditions of hot climates where water is frequently scarce. Also, they provide milk almost all year around in quantities much greater than other animals living under the same conditions (**El-Agamy, 2006**).

The camel is among the animals mentioned in the Holly Quran as a miracle of God. It is common practice to let camels to eat certain plants in order to use the milk for medicinal purpose (**Yagil, 1986**).

According to FAO statistics **GLIPHA, 2006** (**Global Livestock Production and Health Atlas)** the world population of camels is about 20 million animals, mainly in arid Zones, of which 15 million camels live in Africa and 5 million in Asia.

The camel 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 (**Khaskheli *et al*., 2005; Alwan** and **Igwebe, 2013**). Camel milk assesses vital role in human nutrition in the hot regions and arid countries. It contains all the essential nutrients found in the bovine milk (**El Agamy *et al*., 1998; Omer** and **Eltiney, 2009**). It has hyperchlostrolimic effect (**Elayan *et al.*, 2008**) and has been recommended to for by children who are allergic to bovine milk (**Al Agamy *et al*., 2009**). Camel milk containes a number of immunogoboulins that is compatible. Also, it has been used in different parts of the world in the treatment of a series of diseases such as dropsy, jaundice, tuberculosis, asthma, and leishmaniasis (**Abdel gadir, *et al*., 1998; Shabo** and **Yagil 2005**). Recently, camel milk was also reported to have other potential therapeutic properties such as anti-carcinogenic (**Magieed, 2005**), anti-diabetic (**Agrawal, *et al.*, 2007**), anti-hypertensive (**Quan *et al.*, 2008**) in the treatment of human viral related disease like: hepatitis C virus and immunity deficiencies (**El-Agamy 2000; El-Fakharany *et al.*, 2008; Sboui *et al.*, 2010; Salami *et al.*, 2011** and **JRAD Zeineb, *et al*., 2013**).

The wide variation observed of camel's milk composition have been attributed to many factors such as analytical techniques used, geographical location, feeding, size of samples analyzed and breeds, in addition to milking frequency, stage of lactation and parity (**FAO, 2001; Iqbal *et al*., 2001; Ayadi *et al.*, 2009, Konuspayeva *et al*., 2009: Al-Haj** and **Al-Kanhal, 2010; Hammadi *et al*., 2010; Aljumaah *et al*., 2011; Alwan *et al*., 2014**).

Although the composition of camel milk has been studied in various parts of the world. The, available information on camel milk composition are limited in Egypt, especially amino acids and fatty acids composition. Therefore, the present investigation was to study some principal chemical composition, nitrogen distribution, amino acids, fatty acids analysis, and milk fat constant of camel milk compared with cow's and buffaloe's milk.

Materials and Methods

Milk samples:

Camel milk: Bulk normal milk samples (*Camellus dromedaries*) were obtained from the Animal Breeding in Marsa-Matrouh, Research Station, Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture. Buffaloe's milk: Fresh morning milk was obtained from Buffaloe's Herd Kept at Sakha

(Kafre El Sheakh Governorate) of Animal Production Research Institute, Agriculture Research Centre, Ministry of Agriculture. Cow milk: Fresh morning milk was obtained from El-Gemmeza Animal Production Research Station herd (Gharbia Governorate), Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture, Egypt

Methods of Analysis:

The pH value of milk was determined using a glass electrode pH meter type (Digital HANNA instruments pH meter Hi 8014-Italy) according to **BSI (1989)**. The titratable acidity, total solids and ash content of the milk were determined according to the methods described by **AOAC (2010).** The conventional Gerber's method was followed for determination of milk fat content as described in **IDF (1996)**. Nitrogen distribution for milk was determined using the method of **IDF (2001)**. Lactose content was determined according to the method of **Lawrence (1968)**. Calcium content was determined by the method of **Francesco** and **Raffaello (1980)**; while, total phosphorous content of milk was measured according to **Olsen** and **Sommers (1982)**.

Amino acids were performed by analytical high performance liquid chromatograpghy (HPLC) method according to **Millipore co-operative (1987)**.

Fatty acids determination was carried out by extracting milk lipids. The milk lipids first were extracted four times from milk using the method of Rose-Gottlieb as reported by **Pearson (1976)**. Then Fatty acids were methylated by the procedure of **Christie (2003)** and directly injected into HP 6890 Series Gas Chromatograph System with an HP 5973 Mass Selective Detector.

Analysis of milk fat constants: Saponification, Rëichert – Mëssile, Polenske and Kirschner values of the milk fat were determined according to the methods of **FAO/WHO (2001)**. Iodine value of the milk fat was determined using the method described by **Murthy** and **Bhat (1976)**. The acid value of milk fat was performed according to **Peason (1970)**. The refractive index of the milk fat was determined at 40°C using a carlzeiss refractometer according to **AOAC (1980)**.

Gel electrophoresis analysis: Polyacrylamide gel electrophoresis was performed using the method of **Laemmli, (1970)**.

Statistical analysis: analysis of data was carried out using SAS procedure guide (**SAS, 2004**).

Results and Discussion

Chemical composition:

Chemical composition of camel milk compared with cow's and buffaloe's milk is shown in Table (1). The pH value of camel milk recorded an average value of 6.7±0.06 compared with 6.61±0.02 and 6.60±0.01 for cow's and buffaloe's milk, respectively. These result similar to that reported by **Field *et al*. (1997)** and **Khaskheli *et al*. (2005)**. However, it was slightly higher when compared to cow's milk and buffaloe's milk, while it was higher than those reported by **Sawaya *et al*., (1984)**; **Hassan *et al*. (1987)**; **Ahmed, (1990)**; **Farage** and **Kebary (1992).**

EL-Loly *et al.* (2009) found that the pH values of camel milk ranged from 6.55 to 6.87 with an average value of 6.6 which confirmed the obtained results.

Table 1. Gross chemical composition of camel, cow's and buffaloe's milks (Mean + SE).

Milk Type	pH	Acidity %	T. S %	Fat %	T. P %	Lactose %	Ash %	Ca mg/ 100g	P mg/ 100g
Camel	6.70 ±0.06^{b}	0.15 ±0.01^{a}	12.25 ±1.87^{a}	4.00 ±1.16^{a}	3.04 ±0.44^{a}	4.35 ±0.53^{a}	0.83 ±0.06^{b}	114.74 ±0.73^{a}	84.10 ±2.04^{a}
Cow's	6.61 ±0.02^{a}	0.16 ±0.00^{ab}	12.47 ±0.31^{a}	3.60 ±0.13^{a}	3.40 ±0.11^{a}	4.71 ±0.06^{a}	0.72 ±0.02^{a}	123.20 ±2.29^{b}	95.10 ±2.27^{b}
Buffalo's	6.60a ±0.01^{a}	0.17 ±0.00^{b}	16.94 ±0.52^{b}	6.70 ±0.34^{b}	4.77 ±0.24^{b}	4.69 ±0.09^{a}	0.76 ±0.01^{a}	193.50 ±0.03^{c}	113.80 ±2.28^{c}
LSD at 0.05	0.05	0.01	1.39	0.86	0.36	0.39	0.05	2.99	2.71

The values with the same superscript letter in the same column have no significant difference (P>0.05)

The acidity of camel milk recorded an average of 0.15±0.01% compared with 0.16±0.00% and 0.17±0.00% for cow's and buffaloe's milk, respectively. These results in the vicinity of that reported by **Al-Haj** and **Al-Kanhal (2010);** and **Rahli, *et al*. (2013)** who reported that the acidity of camel milk is lower than that of cow's milk.

The total solids content of camel milk recorded an average of 12.25±1.87% compared with 12.47±0.31% and 16.94±0.52% for cow's and buffaloe's milk in order. These results are higher than those of **Hassan *et al*. (1987)**, but lower than those of **El-Agamy, (1983); Zhang *et al*. (2005)** and **Kamal *et al*. (2007)**.

The fat content of camel milk recorded an average of 4±1.6% compared with 3.6±0.13% and 6.7±0.34% for cow's and buffaloe's milk. Similar data were recorded by **Farage** and **Kebary, (1992)** and **Kamal *et al*. (2007)**. These differences could reflect species differences and feeding conditions. Generally, fat percentages of camel milk vary with season, stage of lactation and pregnancy (**Knoess *et***

***al*., 1986, El-Amin 1979 and Rodriguez *et al*., 1985**).

With regard to the total protein content of camel milk it recorded an average 3.04±0.44 compared with 3.40±0.11% and 4.77±0.24% for cow's and buffaloe's milk, respectively. It could be stressed that protein content of the feed as well as water intake have directly affected the protein quality of milk (**FAO, 1982**). Similar data were observed by **Farag & Kebray**, **(1992)** and **El-Loly *et al*. (2009)** but lower than those of **El-Agamy, (1983)** and **Kamal *et al*. (2007)**. Also, slightly lower comparing to cow's milk (3.40%) and highly lower comparing to buffaloe's milk (4.77%).

The average of lactose content of the analysed milk samples was 4.35±0.53% 4.71±0.06% and 4.69±0.09% for camel, cow's and buffaloe's milks, in sequence. These results are in accordance with that reported by **Farage** and **Kebray, (1992)**; while it was higher than that of **Hassan *et al*. (1987); Haddadin *et al*. (2008),** and lower than those of **El-Agamy, (1983); Sawaya *et al*. (1984)** and **Kamal *et al*. (2007).** This wide variation could be attributed to the variable chemical composition of the individual milk (**Abu Lehia, 1990**). The change of lactose concentration would be due to the type of plants eaten in the desert by the camel. (**Farah, 1996; Khaskaheli *et al*., 2005** and **Alwan and Iqwegbe, 2013).**

Ash content of camel milk was 0.83±0.06%. This result was higher than those reported by **El-Agamy, (1983) and Kamal *et al*. (2007)** but was lower than those reported by **Knoess(1977)** and **EL-Loly (2009)** while the obtained results are in line with **Abu-Lehia (1987&1989); Rahli *et al.* (2013)** and **Alwan *et al*. (2014),** However, was higher when compared either with cow's (0.72±0.02%) or buffaloe's (0.76±0.01%) milks. The variations of ash content reflect the effects of genetic and environmental factors. **El-Amin, (1979)**.

It is well known that milk salts play an important role in the physical status and stabilization of milk proteins. From such salts calcium and phosphorus. The ratio between calcium (cation) and phosphorus (anion) is known as the salt balance which is affected by stage of lactation, feeding and health status of the animal udder. The concentration of calcium and phosphorus of camel milk recorded 114.7±2.73 and 84.1±2.04 mg/100gm compared with 123.2±2.29 and 95.1±2.27 for cow's milk and 193.5±2.23 and 113.8 ±2.28 mg/100gm for buffalo milk. These results are in accordance with that obtained by **El-Agamy (2006)**.

The wide variation of the milk composition may be attributed to many factors ***i.e.*** (breed, age, the number of calving, nutrition management, the stage of lactation and the sampling technique used). **Al-Haj** and **Al-Kanhal, 2010; Hammadi *et al*., 2010); Al-Jumaah *et al*., 2011; Benyagoub, *et al*., 2013;** and **Alwan *et al*., (2014).** In Addition, the fodder and water quality and quantity available to the animals also play an important role in this way. (**FAO, 2001**).

Nitrogen distribution: Nitrogen distribution of camel milk protein (mg/100g milk) compared with cow's and buffaloe's milk protein are presented in Table (2).

From these results, it was obvious that the total nitrogen content of camel milk recorded 501.69 ±69.72 compared with 560.88 ±18.9and 785.01±38.62 mg/100gm milk for cow's and buffalo's milk successively, while the protein nitrogen recorded 477.04±66.52, 533.54±20.11 and 747.91±36.62 mg/100gm milk for camel's, cow's and buffaloe's milk in the same order. The casein nitrogen was 355.20±46.86, 450.00 ±13.67 and 632.99 ±25.95mg/100 gm milk representing 70.80±1.14, 80.23±0.58 and 80.64±0.76 % from the total nitrogen for camel, cow's and buffalo's milk, in the same order. The casein content of cow's and buffaloe's milks is higher than that of camel milk. These results are in agreement with that of **Dyusembin and Rakhimberdiev (1975)** and are lower than the findings of **Shalash (1980**).

Whey protein nitrogen was in average 121.84±20.6, 83.54 ±5.11 and 114.92±11.73 mg/100 gm milk representing about 24.29±1.30, 14.90 ±0.58 and 14.64 ±0.80% from the total nitrogen for camel, cow's and buffaloe's milk, in sequence.

Table 2. Nitrogen distribution of camel, cow's and buffaloe's milks protein (mg/100g milk)

Milk Type	TN	TPN	CN	CN/T.N %	WPN	WPN/ TN %	NPN	NPN/ TN %
Camel	501.69 $\pm 69.72^{a}$	477.04 $\pm 66.52^{a}$	355.20 $\pm 46.86^{a}$	70.80 $\pm 1.14^{a}$	121.84 $\pm 20.6^{b}$	24.29 $\pm 1.30^{b}$	24.65 $\pm 3.75^{a}$	4.91 $\pm 0.42^{a}$
Cow's	560.88 $\pm 18.9^{b}$	533.54 $\pm 20.11^{a}$	450.00 $\pm 13.67^{b}$	80.23 $\pm 0.58^{b}$	83.54 $\pm 5.11^{a}$	14.90 $\pm 0.58^{a}$	27.34 $\pm 1.13^{a}$	4.88 $\pm 0.07^{a}$
Buffaloe's	785.01 $\pm 38.62^{c}$	747.91 $\pm 36.62^{b}$	632.99 $\pm 25.95^{c}$	80.64 $\pm 0.76^{b}$	114.92 $\pm 11.73^{b}$	14.64 $\pm 0.80^{a}$	37.10 $\pm 2.05^{b}$	4.73 $\pm 0.06^{a}$
LSD at 0.05	58.19	55.80	3.27	1.05	17.22	1.16	3.14	0.30

The values with the same superscript letter in the same column have no significant difference (P>0.05)

The results clear that the whey protein nitrogen for camel milk was higher than that ether of cow's or buffaloe's milk. These results are lower than the finding of **El-Bahgy (1962)** who found that whey protein nitrogen represents 27% of total nitrogen in case of camel milk. The average values of non-protein nitrogen were 24.65±3.75, 27.34±1.13 and 37.10 ±2.05mg/100 gm milk representing 4.91±0.42, 4.88±0.07 and 4.73±0.06% from total nitrogen for camel, cow's and buffaloe's milk in sequence.

The ratio of non-protein nitrogen to total nitrogen of camel milk was more or similar to that of cow's and buffalo's milk. These results are similar to the findings of **Abu-Lehia, *et al*., 1987; El-Agamy, 1983; Mehaia, *et al*., 1989, Mehaia, *et al*., 1995 and El-Agamy, 2006** who reported that the camel milks has higher content of whey proteins and slightly higher in their content of non-protein nitrogen than different animal milks.

Amino acids composition: Total amino acids composition of camel milk proteins (%) compared with cow's and buffalo's milk proteins are presented in Table (3).

From the obtained results it was clear that overall amino acids composition of camel milk protein appears to be generally similar to that of cow's and buffaloe's milk proteins. The highest level of amino acids recorded for glutamic acid (19.75± 0.75%) in case of camel milk followed by cow's (18.58± 0.42%) then buffaloe's milk (16.44± o.44%). While, the proline represented (10.42±0.23, 9.59± 0.10 and 10.0 ±0.30%) and both of those two amino acids are from non-essential amino acids. On the other hand, the leucin recorded (9.45±0.45, 9.25 ±0.35 and 9.88±0.22%) for camel, cows and buffaloe's milks, respectively. The lysine recorded 7.04±0.26, 8.11±0.08 and 7.98±0.2% in order and both two types are from essential amino acids. Also, the glutamic & praline represents the majority of non-essential amino acids. In the same way both of leucin and lysine represented the majority of essential amino acids.

Table 3. Total amino acids composition of camel. cow's and buffaloe's milk proteins (%)

Amino Acids	Camel	Cows	Buffaloe's	LSD at 0.05
Essential				
Arginine	4.01±0.09^{b}	3.46±0.01^{a}	3.32±0.08^{a}	0.18
Histidine	2.64±0.06^{a}	3.080.07^{b}	2.49±0.1^{a}	0.16
IsoLeucine	5.08±0.12^{a}	4.920.12^{a}	6.11±0.14^{b}	0.25
Leucine	9.45±0.45^{a}	9.25±0.35^{a}	9.88±0.22^{a}	0.70
Lysine	7.04±0.26^{a}	8.11±0.24^{b}	7.98±0.2^{b}	0.47
Methionine	3.03±0.12^{b}	2.34±0.08^{a}	2.32±0.08^{a}	0.19
phenylalanine	4.87±0.26^{b}	4.26±0.34^{a}	4.05±0.2^{a}	0.54
Threonine	5.70±0.40^{a}	6.00±0.45^{a}	8.23±0.22^{b}	0.74
Tryptophan	1.20±0.05^{a}	1.41±0.07^{b}	1.44±0.06^{b}	0.12
Valine	6.61±0.38^{a}	6.82±0.48^{a}	7.26±0.14^{a}	0.72
Total E.A.A	49.63±2.19^{a}	49.65±2.3^{a}	53.08±1.4^{a}	4.02
Non-essential				
Alanine	2.86±0.07^{a}	3.39±0.11^{b}	4.05±0.1^{c}	0.19
Aspartic	6.63±0.12^{b}	6.96±0.14^{c}	5.96±0.14^{a}	0.27
Cystine	1.02±0.02^{b}	0.81±0.04^{a}	2.13±0.07^{c}	0.10
Glycine	1.39±0.06^{a}	2.11±0.09^{b}	1.52±0.05^{a}	0.14
Glutamic	19.75±0.75^{c}	18.58±0.42^{b}	16.44±0.44^{a}	1.11
Proline	10.42±0.23^{b}	9.59±0.10^{a}	10.00±0.30^{ab}	0.45
Serine	5.13±0.27^{a}	5.66±0.04^{b}	4.76±0.24^{a}	0.42
Tyrosine	4.14±0.21^{b}	4.50±0.2^{c}	3.11±0.08^{a}	0.35
Total N.E.A.A	51.34±1.73^{b}	51.6±1.14^{b}	47.97±1.42^{a}	2.90
E.A.A / N.E.A.A	0.97±0.01^{a}	0.962±0.02^{a}	1.11±0.00^{b}	0.03

The values with the same superscript letter in the same column have no significant difference (P>0.05)

The lowest values of essential amino acids were recorded for tryptophan (1.20±0.05, 1.41±0.07 and 1.44±0.06%) and the lowest value of non- essential amino acids were recorded for cystine (1.02±0.02, 0.81±0.04 and 2.13±0.07%) for camel, cow's and buffaloe's milks, respectively. These results are in line with **Taha** and **Kielwein (1990), Ahmed (1990), Guo *et al*. (2006), El-Loly *et al*. (2009)** and **Salmen, *et al*. (2012).** The ratios of essential to non-essential amino acids were 0.97±0.01, 0.96±0.02 and 1.11±0.00 for camel, cow's and buffaloe's milk, successively. Similar results were obtained by (**El-Agamy** and **Nawar, 2000**).

The quite variations of the amino acid content of different animal milks are attributed to be accompanied by differences in total protein contents. Camel milk proteins have the satisfactory quality balance of essential amino acids equalling or exceeding the requirements of **FAO/WHO/UNU**

(1985) for each amino acid, therefore, it has the adequate nutritive values for human diets.

Fatty acids composition:

The lipids of milk play an important role in human nutrition, as an energy source, act as a solvent for fat-soluble vitamins and supply essential fatty acids. Fatty acids are the most important component of lipids, thus research dealing with milk fat has been focused mainly on fatty acids content of milk lipids.

Fatty acids composition of camel, cow's and buffaloe's milk fat are given in **Table (4).**

There are some variations in the fatty acids content of camel milk fat and the level of short-chain fatty acids (C_4-C_{12}) in a small amount. The predominant saturated fatty acids were for C_{16}, C_{18} and C_{14}, in a sequence for all types of milk. Also, it has higher proportions of unsaturated fatty acids compared with cow's and buffaloe's milk fat. There was a considerable level of poly unsaturated fatty acids (mainly C_{18}) is the most abundant in camel milk fat. Short chain fatty acids (C_4-C_{12}) of camel milk have been reported to be in the range of 0.27±0.03 (caprylic) to 0.69±0.09 gm/100 gm fat (lauric) which were considerably lower than that of cow's 1.21±0.09 (caprylic) to 3.05±0.15 (butyric) and buffaloe's milk fat 0.84±0.09 (caprylic) to 4.05±0.2(butyric). The fatty acids C_{16}, C_{18} and C_{14} recorded the majority of saturated fatty acids for all milk types and recorded 28.88±1.12, 12.99±0.77 and 11.04±0.7% camel, cow's and buffaloe's milk, respectively. These results are similar to those of **(Haddadin *et al*., 2008); Kamal and Salama, 2008; El-loly *et al*., 2009; Azza** and **Omar 2009** and **Kanuspayeva *et al.*, 2014.**

Table 4. Fatty Acids composition (gm/100gm fat) of camel, cow's and buffaloe's milk fat.

Fatty Acids	Camel	Cow's	Buffaloe's	LSD at 0.05
Saturated fatty acids				
$C_{4:0}$ Butyric	0.59±0.07[a]	3.050.15[b]	4.05±0.2[c]	0.30
$C_{6:0}$ caproic	0.39±0.06[a]	1.70±0.10[c]	1.41±0.09[b]	0.17
$C_{8:0}$ Caprylic	0.27±0.03[a]	1.21±0.09[c]	0.84±0.09[b]	0.15
$C_{10:0}$ Capric	0.40±0.07[a]	2.56±0.14[c]	1.42±0.23[b]	0.32
$C_{12:0}$ Lauric	0.69±0.09[a]	2.60±0.15[c]	1.90±0.25[b]	0.35
$C_{14:0}$ Myristic	11.04±0.70[a]	10.71±1.28[a]	10.05±1.00[a]	2.04
$C_{15:0}$ Pentadecanic	0.68±0.09[a]	1.45±0.15[b]	0.78±0.12[a]	0.24
$C_{16:0}$ Palmitic	28.88±1.12[a]	30.68±1.42[a]	30.41±1.5[a]	2.71
$C_{17:0}$ Margaric	0.70±0.09[c]	0.16±0.01[a]	0.36±0.13[b]	0.18
$C_{18:0}$ Stearic	12.99±0.77[b]	10.05±0.45[a]	14.20±0.8[b]	1.38
$C_{20:0}$ Arachidic	0.66±0.08[b]	0±0[a]	1.05±0.1[c]	0.15
Total Saturated Fatty acids(TSFA)	**57.29±3.17[a]**	**64.17[ab]**	**66.47±4.51[b]**	**7.82**
Unsaturated Fatty Acids				
$C_{10:1}$ Caproleic	0±0[a]	0.10±0.01[b]	0.20±0.03[c]	0.04
$C_{12:0}$ Lauroleic	0±0[a]	0.58±0.12[b]	0.09±0.02[a]	0.14
$C_{14:1}$ Myristoleic	1.38±0.12[a]	2.03±0.17[b]	1.12±0.12[a]	0.28
$C_{16:1}$ Palmitoleic	10.29±1.00[b]	2.59±0.21[a]	2.13±0.17[a]	1.19
$C_{17:1}$ Margaroleic	0.64±0.09[c]	0.22±0.01[b]	0±0[a]	0.10
$C_{18:1}$ Oleic (Omega7)	25.39±1.61[a]	27.00±1.25[a]	26.75±1.00[a]	2.62
$C_{20:1}$ Eicosenoic	0.35±0.05[b]	0±0[a]	0±0[a]	0.06
$C_{22:1}$ Erucic (omega9)	0.07±0.09[a]	0±0[a]	0±0[a]	0.10
$C_{16:2}$ Hexadecdienoic	0±0[a]	0±0[a]	0.50±0.1[b]	0.12
$C_{18:2}$ Linoleic	3.63±0.3[c]	2.54±0.16[b]	1.90±0.3[a]	0.52
$C_{18:3}$ Linolenic	2.00±0.10[a]	0.70±0.15[a]	0.79±0.20[a]	0.31
$C_{20:4}$ Arachidonic	0±0[a]	0±0[a]	0.09±0.01[b]	0.01
Total unsaturated Fatty Acids(TUSFA)	**42.696±3.35[b]**	**35.76±2.08[a]**	**33.57±1.95[a]**	**5.07**
TUSFA/TSFA	0.745±0.02[c]	0.553±0[b]	0.505±0.01[a]	0.02

The values with the same superscript letter in the same column have no significant difference (P>0.05)

Camel milk fat also has higher proportions of mono unsaturated fatty acids $C_{16:1}$ present in greater portions in camel milk (10.29g/100g) than cow's (2.59 g/100g) and buffaloe's milk (2.13 g/100g). On the other hand, poly unsaturated fatty acids ($C_{18:2}$ and C_{18-3}) are relatively high in camel milk (3.63 and 2.00 g/100g) compared with cow (2.54 and 0.70 g/100g) and buffaloe's milk (1.90 and 0.79 g/100g), respectively. The most abundant unsaturated fatty acids are present at higher amount in camel milk fat (**El-Agamy 2006** and **El-Loly *et al.*,, 2009**) but lower amount than that recorded by **Abu-Lehia 1989** for cow. According to **Gnan** and **Sheriha (1986)** who mentioned camel milk fat contained relatively high levels of poly unsaturated fatty acids, which essential for human nutrition especially linolenic ($C_{18:3}$) and linoleic ($C_{18:2}$) acids.

Moreover, SAFAs represented 57.29% of the total fatty acids. Similar results are give by **Farag** and **Kebary (1992**) and was higher than those of **Gobran and Izzeldin (1999)** (52%), but lower than that reported by **Czech *et al*., (2005)**. Thus, these differences can partially explained by different factors that affect on the fatty acid composition of camel milk include breed, feeding, composition of dietary fat, dietary protein, seasonality and region and stage of lactation (**Palmquist *et al*., 1993; Gobran** and **Izzeldin 2001**).

Milk fat constants:

Milk fat constants of camel, cow's and buffaloe's milk are presented in Table (5). Physical and chemical constants have been derived for the characterization of the types of fatty acid components present in milk fats. They also enable the detection of fat adulteration qualitatively and quantitatively. Highly significant variations among the three types of milk are found especially between camel milk and that of cow's and buffaloe's. Camel milk fat is higher in refractive index, iodine value and acid value which recorded about 1.4756±0.001, 47.85±1.15 and 0.49±.02, respectively compared with 1.4535±0.001, 32.00±0.79 and 0.25±0.01 for cow's and 1.4594±0.001, 31.68±0.74 and 0.29±0.01 for buffaloe's milk in the same order. low saponification, Rėichert Mėissl, Polenske and Kirschner values were recorded, since it has 190.05±3.20, 16.43±1.44, 0.86 ±0.15and 10.41±0.64, respectively for camel milk compared with 228.65±3.32, 26.57±2.34, 1.81±0.29 and 25.5±1.46 for cow's and 230.47±3.51, 32.17±2.19, 1.59±0.21 and 31.60±1.4 for buffaloe's milk fat, in the same order. This reflects its higher content of long-chain fatty acids (C_{14}-C_{18}) and lower content of short-chain fatty acids (C_4-C_{12}). These results are in agreement with that reported by **El-Agamy (2006)**.

Electrophoresis of protein fractions:

Milk proteins can be separated and identified by molecular mass (Mol. Weight in Kilo Daltons). One method of separating proteins is by poly acrylamide gel electrophoresis. This method essentially separates the proteins by molecular mass, with the largest proteins migrating more slowly in the gel and remaining near the top and the smaller proteins migrating more rapidly toward the bottom of the gel.

Table 5. Milk fat constants of camel milk, compared to Cow's and Buffaloe's milk (Mean + SE).

Parameter	Milk type			LSD at 0.05
	Camel	Cow	Buffalo	
Refractive index (40°C)	**1.4756± 0.0001[b]**	**1.4535± 0.0001[a]**	**1.4594± 0.0001[c]**	**0.0002**
Iodine Value gm Iodine/100 gm fat	**47.85± 1.15[b]**	**32.00± 0.79[a]**	**31.68± 0.74[a]**	**1.82**
Saponification Value mg KoH/gm fat	**190.05± 3.20[a]**	**228.65± 3.32[b]**	**230.47± 3.51[b]**	**6.68**
Reichert - Messile Value	**16.43± 1.44[a]**	**26.57± 2.34[b]**	**32.17± 2.19[c]**	**4.05**
Polenske Value	**0.86± 0.15[a]**	**1.81± 0.29[b]**	**1.59± 0.21[b]**	**0.45**
Kirschner Value	**10.41± 0.64[a]**	**25.50± 1.46[b]**	**31.6± 1.40[c]**	**2.45**
Acid Value	**0.49± 0.02[c]**	**0.25± 0.01[a]**	**0.29± 0.01[b]**	**0.03**

The values with the same superscript letter in the same raw have no significant difference (P>0.05)

The relative size of the caseins (~25-35 KDa) vs the major whey proteins β-lactoglobulines (~18 kDa) and Lactalbumin (~14 KDa). Others include primary lactoferrin (~80 KDa) and serum albumin(~ 66 KDa). To assess the relative molecular weight of a protein on a gel, protein molecular weight marker is run in the outer lanes of the gel for comparison. The different proteins appear as distinct blue- stained bounds on the finished stained gel. From the positions and intensities of these bands, we can determine the size and relative abundance of the the proteins based on available reference. In this study, it is important to identify the proteins in camel milk compared with cow's and buffalo's milk. **Fig (1)** shows the electrophoretic patterns of whole milk protein of camel, cow's and buffaloe's.

Results showed that the relative migration of casein bands were not identical. In camel caseins, the relative migration of α-$_{s,}$ β- and K- Casein was slower than those of cow and buffalo casein. The same trend was observed by **Metwalli and Al-Saleh (2010)** and **El-Agamy *et al*. (2009)** and **Salah *et al*. (2012).** This indicates the differences in molecular weight of camel, cow's and buffaloe's caseins.

Differences in electrophoretic patterns of whey proteins (WPs) of the three types of milk are clear. It is obvious that the major WP bands in cow's and buffaloe's milk belong to serum albumin (SA), *β*-lactoglobulin (*β*-lg) and α-lactalbumin (*α*-la), where as in camel milk WPs pattern, β-lg was minor band.The very low or absence of β-lg in camel milk makes it compatible with human milk and it is suitable to children who are allergic to bovine milk. However, the bands of SA and α-la (as well as another unknown fraction) were found in high intensities. Similar results were obtained by **Farah (1986)** and **El-Agamy (2000).**

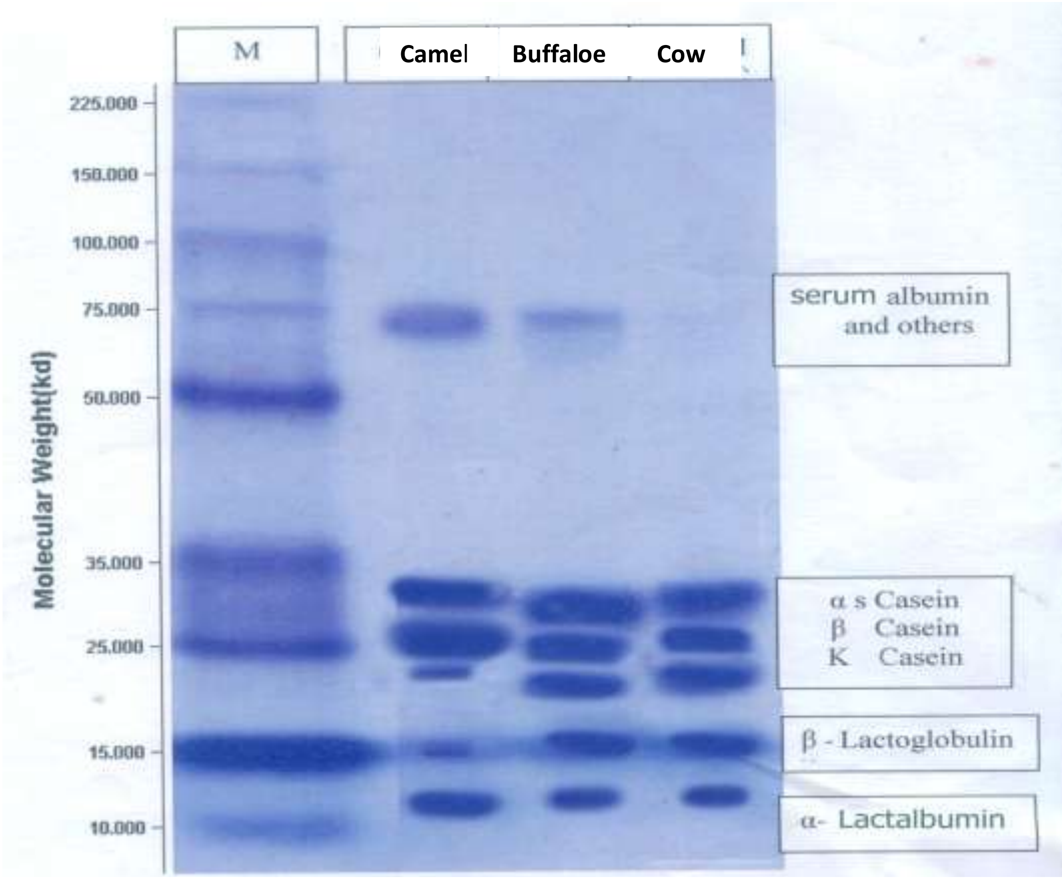

Fig. 1. Polyaccrylamide gel electrophoresis of proteins for Camel milk (lane 1), buffaloe's milk (lane 2), and cow's milk (lane 3) compared with marker (M).

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التركيب الكيميائى للبن الإبل ومقارنته باللبن البقرى والجاموسى

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جمعت عينات لبن الإبل من محطة تربية الحيوان التابعة لمعهد بحوث الإنتاج الحيوانى بمرسى مطروح، تم التحليل الكيميائى للعينات وتم مقارنتها بعينات من اللبن البقرى والجاموسى حللت العينات جميعها للجوامد الكلية والدهن والبروتين واللاكتوز والرماد والكالسيوم و الفسفور وكذلك الحموضة والـ pH. أيضا تم تحليل الأحماض الأمينيه – الأحماض الدهنيه–ثوابت الدهن وكذا البروتين بالتفريد الكهربي.

أوضحت النتائج أن لبن الجمال يحتوى على نسبة أقل من اللبن البقرى والجاموسى فى محتواه في كل من الجوامد الكلية والبروتين واللاكتوز والكالسيوم والفسفوروكذلك الحموضة.

بينما احتوى لبن الجمال على نسبة من CN/TN أقل من نسبة NPN/TN, WP/TN كانت أعلى منها فى اللبن البقرى والجاموسى وبتقدير الأحماض الأمينية فى اللبن وجدت اختلافات بين لبن الجمال والبقرى والجاموسى فى نسب الأحماض الأمينية وأيضا عند تحليل الأحماض الدهنية وجدت اختلافات كبيرة بين لبن الجمال والبقرى والجاموسى مما أدى إلى إختلافات كذلك فى ثوابت الدهن لهذه الألبان. أدى تحليل البروتين بالتفريد الكهربى إلى إيجاد فروق كثيرة بين لبن الجمال والبقرى والجاموسى وأهمها هو نسبة البيتاكازين فى لبن الجمال فهى أعلى منها فى البقرى والجاموسى وكذلك اختلاف فى نسبة الكاباكازين فهى قليلة فى لبن الجمال، كما أنه لايوجد بيتالاكتوجلوبيولين فى لبن الجمال وكانت قليل جدا فهو فى ذلك يشابه لبن الأم.