

## Review Article

# Review on Productive and Reproductive Performances of One- Humped Camel

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## Summary

This seminar paper reviews reproduction and production performance of one-humped camels. Camels are strongly tolerant to punitive and more hostile climatical and environmental determinants unlike most other animals. They are defined to be ship of desert particularly *dromedarian* camel. There are three main species, even though there is some controversial, namely *C. bacterian*, *C. one-humped (dromedarian)* and *C. ferus*. They get full maturity at the age range of 3 to 5 years old. Rutting is a special sign for that the bull reached full maturity, it develops a very unique feature that is the dulla (a soft and balloon like tissue that develops in oral cavity during peak maturity). In case of female, it can give first birth at age of 5 years old usually with a single calf which means very rare twinning. Camel is mainly kept for milk production, which valuable for human food in the arid environment of camel keeping countries. Camel has the ability to produce milk of good composition and quantity for human consumption even when water is severely restricted. Milk is the main sources of nutrition for pastoralists, neonates calves and provides all essential nutrients for growth and development, e.g. proteins, minerals, carbohydrates, fatty acids, growth factors, immune modulators, etc

Camels have high milk yield and comparatively long milk service period for both their calves and human. Additionally, they highly prefer to consume halophilic plants such as *Atriplex* which is believed to qualify more the milk. Despite from milk, camels also provide meat as well as hides.

**Keywords:** One-humped camel; Reproduction; Production

**Abbreviations:** FAO: Food and Agriculture Organization; PMSG: Pregnant Mare Serum Gonadotropin; CL: Corpus Luteum; SD: Standard Deviation; Ph: Power of Hydrogen; ADH: Antidiuretic Hormone; SNF: Solid Non Fat; IgA/G: Immunoglobulin A and G; NAGase: N-Acetyl-Beta-D-Glucosaminidase; PGRP: Peptidoglycan Recognition Proteins.

## Introduction

At the outset, the word camel is said to have been derived from a Greek word "kremal" which means "throw away legs" and it makes sense since the camel seems to throw away its legs during movement [15].

Plainly, the word *Camelidae* encompasses both Old and New world camels including the Bactrian camel (*Camelus bactrianus*), the one-humped (*Camelus dromedarius*), Guanaco (*Lama guanicoe*), Llama (*Lama glama*), Viçuna (*Vicugna vicugna*), and Alpaca (*Vicugna pacos*) [40].

Almost 95% of the camelids in the Old World are one-humped (dromedaries), and the rest 5% are domestic Bactrian Camels (there are no more than a few thousand wild Bactrian Camels). In the New World, around 47% of camelids are Llamas, 41% Alpacas, 8% Guanacos, and 4% Viçunas. Because of their ability to thrive under tough conditions of extreme temperature and scarce food and water, domesticated *Camelids* have been extremely important to the development of human cultures in the steppes of Eurasia, the deserts of Africa, and the arid Andes of South America. Earliest *Camelids* were similar to modern guanaco but rabbit-sized (30 cm at shoulder). All *Camelids* are

diurnal and are adapted to harsh and dry climates and are all highly social [40]. Evolutionarily, there is hesitation about evolutionary relationship between *C. bactrianus*, *C. one-humped*, and *C. ferus*. However, DNA studies demonstrate wild Bactrian camel is not the ancestor of two domesticated species as previously thought and *C. ferus* is separate lineage and not direct progenitor of *C. bactrianus* [88], but previously, they were considered to be a sub-species, *C. bactrianusferus* [45].

Based on the distribution, the Food and Agriculture Organization [35] estimated the total population of camel in the world today to be 25.89 million, in which 89% are one-humped dromedary or Arabian camels and the remaining 11% are the two-humped (*Camelus bactrianus*) generally found in the cold deserts of central Asia. Hypothetically, over 80% of the world's camel population is found in Africa with the highest concentration in North East Africa which accounts for 63% of the world camel population. Camels contribute significantly to the livelihood of the pastoralists and agro-pastoralists living in the fragile environments [95].

The 25.89 million of world camel population spread across 47 countries; where Somalia has the highest population of 7 million (though it varies in different publications) followed by Sudan 4.25 million and Ethiopia 2.4 million grading it to be the third largest camel herd in the world After Somalia and Sudan [35]. Even though there are intense global warming and drought, recent studies show the world camel population is increasing regularly with a yearly growth of 3.4% since 1961 [35].

Therefore, the objectives of this seminar are to:-

- ☞ Review on productive and reproductive performances of one-humped camel.

### Reproduction Performance of One-Humped Camel

#### Reproductive Characters

**Puberty time:** Puberty was defined as the stage when the animal was able to produce viable sperms or ova. Controversially, the camels get sexually mature at 4 to 5 years of age [32], although a 3-year old camel can be used for reproduction [61]. In the male, full reproductive prowess is not developed until six years [74] or even seven years of age as shown in the table1 [48].

**Table 1:** Some of reproductive parameters of female and male camels.

Parameters	Female			Male		
	Mean	SD	Range	Mean	SD	Range
Age at puberty (Years)	3.84	0.71	2-6	4.8	0.9	3-7
Mountings/day	-	-	-	9	2	2-14
Male to female ratio				1:150	75	25-200
Age for castration				5	0.4	4-6
<b>Seasonality</b>	<b>Year round</b>					
Age at first calving (Years)	5	0.84	3-6			
Calving interval (months)	25.8	4.2	18-36			
Days to first service	12	3.2	9-18			
Days open	14	6	12-24			
Gestation length (months)	13	1.2	12-13			
Reproductive span (years)	17	2	12-24			

Source: Tefera and Gebreab, (2001) [92].

Aspects of sexual development and attainment of sexual and breeding maturity were studied in two groups of Najdi camels (Mojaheem and Wadah), maintained in stalls under good nutritional conditions. Assessments about body weight, testes diameter and degree of penile freedom were recorded weekly. Sexual maturity was assessed by the examination of semen collected by an artificial vagina. Mating, followed by strong jerks and ejaculation of mature sperms, was taken to indicate onset of breeding maturity. Mojaheem camels reached sexual maturity at a significantly younger age and heavier weight (164 weeks and 360 kg) than Wadah camels (182 weeks and 336.5 kg) [2].

When the camel bull is five years old, it is allowed to breed a few five-year old females [31]. The she-camel gets puberty at about 3 years of age, but breeding is usually not successful until 4 years [50]. This is perhaps because fecundity increases with age, even after sexual maturity but starts to decline with senility. The breeding age of the female camel as reported in the current study agrees with the findings of Ismail (1987) but that of the male camel was above the figure reported by Elmi (1989) which could be due to the reasons given by Mukasa-Mugerwa (1981). Uniquely, Copulation among camels may last 12 to 30 minutes in the kneeling position [20].

#### Breeding Season and Behavioral Changes

Anciently, evolutionist Aristotle reported that breeding time of camels is in November and December but depends on geographical location and its precipitation [61]. However, camels, both male and female are seasonal breeders, mating during the rainy season in which greening of the plants is abundant, or cold season [99]. Longer hours of daylight initiate the breeding season as means of camel are long daylight breeders [22]. The female camel can be in oestrus all year round [41].

Depending on the genetic and health condition of the sire, the geographical location and environmental parameters, management and nutritional factors, the duration of the breeding season ranges from 2 to 6 months. Out of the breeding season, usually, male camels lose their libido, do not copulate with females, and show testicular size and weight decrease and very low blood testosterone level [52].

An sturdy male is capable of mating at any time of the year but in truly speaking, the sexual activity depends on the food supply [11].

Rut is the time when males show keen interest in the female and fight it out stubbornly until a dominant male is found. At this mating time also males loose appetite and pass diarrhea there by making them to loss function in other activities that pattern to their functionality [73]. A unique feature for the one-humped bull is the *dulla*, an Arabic name for the inflatable and balloon-like pinkish-red mucous membrane that he expels from the side of his mouth during rut to make blathering sound. Bactrian camel does not have a *dulla* [10].

Rutting may occur throughout the year at the equator, because there are no marked seasonal differences in temperature and photoperiod [98]. Changes in weight of the testicles, corresponding to age and season, are described by several authors [3]. These variations are correlated with the number of spermatozoa in the epididymis and with the circulating testosterone levels in the blood which reach their maximum levels from late December to the end of March [99].

It was measured the fructose and citric acid levels in differ-

ent parts of the male genital organs. Fructose and citric acid levels reduce in castrated bull justifying that decreased activity of the glandular source as compared with intact bull [13].

### Oestrus Cycle and Ovulation

Usually, the female camels have multiple periods of estrus in the year (polyestrous), and the period of oestrus is easily recognizable by the animal's general restlessness, often aggressiveness in manner, and by swelling and discharge from the vulva [99]. The length of the oestrus cycle is normally 2–3 weeks [61], but in the Bactrian camel, the period can extend to 4 up to 5/6 weeks [19]. The actual heat lasts for 3–4 days, although 21 days as being the period of heat was considered by Yasin and Wahid (1957). Even if it is not a practical method because of the risk of the transmission of venereal and other diseases, induction of ovulation could be achieved in the camel by mating with an intact or vasectomised male [63]. Some researchers have obviously described the ovarian cycle activity and testified a 28-day cycles in which follicles mature in 6 days maintaining their size for 13 days, then regress in 8 days [85].

Usually, there is no spontaneous ovulation in the camel and hence, without mating there is no luteal phase. Ovulation occurs 30–48 hours following copulation [22]. Manual stimulation of the cervix for 15 minutes did not induce ovulation, although luteinization of the mature Graafian follicle occurred [72]. Formation of a corpus luteum and its size depends on the pregnancy and ovarian activity respectively [72].

Oestrus has been known able to re-occur a day after calving [16]. If the camel is well fed, oestrus can occur within one month post-partum [103]. Similarly, when She-camel stops milk service, then oestrus occurs within 28 days. This means that with good feeding conditions camels can be mated as soon as the young calves start grazing or weaned [32].

### Fertilization Rate and Infertility

The fertilization rate of camels is considered to be very low with 50% or even less of fertility as suggested by Novoa (1970). Repeated mating was often due to improper development of follicles [17]. Injections of artificially made Pregnant Mare Serum Gonadotropin (PMSG) with an interval of 48–72 hours led to 100 percent calving rate [104]. In fact, more things are still abstract but anatomical abnormalities of the females as well as fetal death are the main causes of infertility [84]. This was suspected when a single fetus was born, but more than one corpus luteum was found. Furthermore, failure of females to ovulate when mating and poor semen quality are also possible causes of infertility [49].

### Age at First Calving and Calving Interval

The mean age at first calving and calving interval are 5.17 and 2.82 years, respectively [52]. It has been found a reduction in the age at first calving due to use of veterinary services which shows the role health care plays in enhancing sexual maturity and subsequent productivity [64]. Nonetheless, inadequate body weight resulting from low plane of nutrition could be a possible cause of delayed age at first calving in camels [67].

Several factors can prolong the calving interval in the one-humped camel such as (i) the lengthy gestation period, (ii) the limited breeding season and (iii) late postpartum oestrus (frequently 1 year after parturition). It was shown that significantly prolonged calving intervals were recorded because mating is intentionally avoided by camel herders owing to its negative ef-

fect on milk yield, lactation length and calf survival rate [67]. In general, seasonal feed availability, long lactation, anoestrus and infectious diseases are among the factors that contribute to prolonged calving intervals in camels [64].

### Pregnancy and Natural Twinning

Naturally, the camel has many unusual reproductive characteristics that contribute to making it unique animal. One of those unusual features is that pregnancy is almost exclusively carried in the left horn of the uterus and the live birth twins is rarely reported [93]. Following the conception the average gestation length is commonly stated as 12 to 13 months or 390 but male calves may be carried 1 to 2 days longer [98]. Month of calving, sire and birth weight have significant effect on gestation length [87].

Differently, the Bactrian camel the gestation length averages 402.2+11.5 days [23]. Nonetheless, Yasin and Wahid, (1957) reported a gestation of 365 to 395 days whereas Evans and Powys (1979) record a gestation period of 373 to 393 days in Dromedary camel whereas it is 402 days in Bactrian camel [22].

Unlike to the other domestics, the incidence of natural twinning in camels is extremely low and when twin pregnancies progress past 40 days, abortion is more common than live birth [93].

Two or three CL was found in 15% of pregnant camels. However, the twinning rate was only 0.4% when both the ovaries ovulate at the same oestrus [71].

Embryos develop initially in both horns but, unfortunately the one in the right horn dies when it reaches a size of 2-3 cm. Multiple CL has been also observed in many other studies in camels [98]. Multiple ovulations and early death and resorption of embryos have been suggested as possible reasons for the occurrence of multiple CL in camels [65].

### Reproductive Longevity

The length of the camel's reproductive life varies, but some females continue to breed until 20 years old [67]. A female camel can be bred for about 22 years and about 10 calves can be produced within the 22 year period [31]. When well fed and managed, some camels live up to 40-50 years, and in spite of a calving interval approaching 2 years the camel is still capable of producing as many progeny as most pastoral cattle [67].

### Prenatal and Postnatal Mortality

Once a female camel conceives, abortion and prenatal mortality as well as stillbirth occur insignificantly but can happen due to poor nutritional level, diseases such as trypanosomiasis, brucellosis, pasteurellosis, and salmonellosis in addition to febrile conditions (camel pox, pneumonia etc.) during the gestation period [67]. Additionally, it was claimed that the considerable losses are vastly associated with strong inbreeding in the herds [98].

The mortality of newborn camel is very high owing to its extreme delicateness and probably larger body surface area with a rate of 30-50%. There are different and complex causes of the calf mortality. These include: overfeeding, underfeeding, too early weaning, tick intoxication, camel pox, calf diarrhoea (perhaps with a viral etiology), navel ill, septicemia, other endemic diseases as well as management malpractices [96].

## Productive Performances of One –Humped Camel

### Milk Production

The one- humped camel has an excellent capacity for milk production. The milk is a stable source of food for the desert nomads and has a good duration of lactation of about 240 to 540 days. The total milk yield is about 1300 to about 4200 liters. The total milk yield per day of a well feed camel can be 10 to 15 litres. The daily average yield is about 4 litres [103].

The high interest of camel milk by local population in arid lands rests on for at least 3 reasons:

(i) the main part of the production is self-consumed and thus, contributes to the food security of arid lands, (ii) there is a growing interest for camel milk from the urbanized population in those areas and then an increasing market opportunity, (iii) there is a trend to the development of dairy camel intensive system which could be profitable for settled producers [38]. Yet again, the milk is considered as having medicinal as well as mystical properties and it is a reason for many superstitions and beliefs have evolved around camel milk and milking [48].

In different data presentations, it was justified that the camel produces nutritious milk for human consumption. It is also evident that the taste and quality of milk is directly affected by the amount of water drunk, and the amount and quality of feed eaten. The fluctuations in fat, protein, fat and salt are determined by the amount of water drunk and by changes in pasture [99]. Grazing on *Atriplex halimus* gives a salty taste to the milk whereas *Schouwia purpurea* gives a cabbage smell to the milk [41].

It is reported that milking frequency in camels varies between 2 to 6 times daily depending on season, stage of lactation and milk yield [28].

### Composition of Camel Milk

Variations in the composition of camel milk may be attributed to several factors such as analytical measurement procedures, geographical area, nutritive conditions, breed, stage of lactation, age and number of calving [55].

Geographical origin and seasonal variations are the main factors that influence or dictate the change of camel milk composition, for instance camel milk from in East Africa has a larger amount of fat than those are from Western Asia [59]. Likewise, Seasonal variations play a significant role in the composition of camel milk, even with camels of the same breed and from the same region [14].

The first milk, the colostrum, is white and slightly diluted as compared with the colostrum of cow, and is generally opaque white [99]. Normally, it has a sweet and sharp taste, but sometimes it may be salty [80].

### pH

Fresh camel's milk has a high and almost neutral pH which lies between 6.5–6.7 as of that of sheep [85]. If the camel milk is left for a while to stand being sour, it's acidity promptly increases; lactic acid content increases from 0.03% after standing 2 hours to 0.14% after 6 hours [75].

### Water

The dominant component of the milk is water as a general, and in this context, the camel milk contains water which fluctu-

ates between 81.4–87% as elucidated in table 2 [18]. The level of water in the camel milk is very important for young camels, and especially the humans living in drought areas as means of fluid to maintain homeostasis and thermoneutrality [56]. There exist some factors that dictate the water content in the milk such as thirst or lack of drinking of water by the lactating camel as well as the water content of the fodder fed to [99]. Unlike the human being, most animals including camel do not sweat but since the mammary glands have the same embryonic origin as the sweat glands [91]. As ADH secretion is elevated in the dehydrated camel, loss of water into the milk occurs due to the action of this hormone [100] (Table 2).

The above table clearly shows that the amount of water in camel milk (81.4–87%) is similar to the amount of water in goat milk (84–88%).

### Fat

The camel milk fat is relatively different from that of other

**Table 2:** Percentage of water in the milk of various domestic species.

Species	Water in milk (%)	Source
Camel	81.4 - 87	Bhakat and Sahani (2006)
Cow	77 - 91	Bosnić (2003)
Sheep	75 - 87	Anifantakis (1985)
Goat	84 - 88	Gazibara (2007)
Mare	89	Tratnik (2008)
Donkey	90 - 92	Ivanković <i>et al.</i> , (2009)

**Table 3:** Fatty Acid composition of camel milk.

Fatty acids	Percentage (%)
Butyric acid	2.1
Caproic acid	0.9
Caprylic acid	0.6
Capric acid	1.4
Lauric acid	4.6
Myristic acid	7.3
Palmitic acid	29.3
Stearic acid	11.1
Oleic acid	38.9
Linoleic acid	3.8

Source: (Dhingra, 1934) [26].

**Table 4:** Milk constituents in different researches.

Fat%	SNF%	Protein%	Lactose %	Ash%	Density %	Water%	References
3.78	9.59	4.0	4.9	0.95	1.03-1.04	Not available	Ohri & Joshi 1961
3.08	9.92	3.8	5.4	0.7	1.04	NA	Khan & Appena, 1964
2.9	10.1	3.9	5.4	0.8	NA	87.6	Singh, 1962
4.1	NA	2.0	4.7	0.7	NA	88.5	Singh, 1962
2.3	NA	2.3	4.05	NA	NA	91.5	Raghvendearet., 2004

NA: Not available.

**Table 5:** Chemical composition of milk of different species.

species	Water %	Protein %	Fat %	Ash %	Lactose %
Camel	86-88	3.0-3.9	2.9-5.4	0.6-0.9	3.3
Cow	85-87	3.2-3.8	3.7-4.4	0.7-0.8	4.8-4.9
Buffalo	82-84	3.3-3.6	7.0-11.5	0.8-0.9	4.5-5.0
Sheep	79-82	5.6-6.7	6.9-8.6	0.9-0.1	4.3-4.8
Goat	87-88	2.9-3.7	4.0-4.5	0.8-0.9	3.6-4.2
Human	88-89	1.1-1.3	3.3-4.7	0.2-0.3	6.8-7.0

Source: (Kanhil and Hamad, 2010).

**Table 6:** Effect of age on some meat quality characteristics of dromedary camel.

Meat qualities	Age groups (Years)		
	1-3	3-5	5-8
Ultimate pH	5.91	5.84	5.71
shear force value	68.4	79.5	131.9
Expressed juice (cm <sup>2</sup> /g)	29.6	27.36	21.2
Color parameters			
<i>L*</i> (Lightness)	37.74	34.03	31.
<i>a*</i> (Redness)	13.37	13.82	16.18
<i>b*</i> (yellowness)	6.06	7.78	7.26

Source: (Kadim *et al.*, 2006) [51].

animals. When left standing, fat is distributed as small globules (1.2–4.2 microns in diameter) throughout the milk [99]. The amount of milk fat in camel milk ranges between 1.8g and 5.0g per 100g of milk with average being  $2.63 \pm 0.40$  g per 100g [55]. The ratio of fat to total solids averages 31.6% which is much lower than that of the buffalo which is 40.9% [85]. The fat of camel seems to be bound to the protein which makes it difficult to be extracted using churning of sour milk [80].

Milk fat from camel milk is composed of triacylglycerole, which represents about 96% of the total amount of lipides of various fat acid compositions [44].

Camel milk is also unique concerning its fatty acid profile. It contains 6 to 8 times less of the short chain ( $C_{14}$ - $C_{12}$ ) fatty acids compared to milk from cows, goats, sheep, and buffalo [21] but with same long-chained ( $C_{14}$ - $C_{22}$ ) fatty acids. The amount of saturated fatty acids is higher in cow milk (69.9%) than in camel milk (67.7%) [58].

Similarly, average values of unsaturated fatty acids (43 %) are higher in camel milk, especially essential fatty acids [47]. It has been claimed that the value of camel milk in somehow relates with the high concentrations of volatile fatty acids and, especially, linoleic acid and the polyunsaturated acids which are essential for human nutrition [78].

Camel milk fat has a low reichert value of 16.4. The fatty acid composition of camel milk fat was found to be as labeled below [26].

### Protein

Camel milk also has a higher keeping quality than cow milk due to superior protein it contains that makes it resistant to bacteria this makes fresh camel milk marketable commodity under basic hygienic conditions [102].

Milk proteins are a heterogeneous group of compounds that differ in composition and properties [43]. It contains two main groups (*casein* and *whey* proteins) and relatively higher amount immune proteins (*Peptidoglycan*, *Recognition Protein*, *Lactoferrin*, *Lysozyme* and *Lactoperoxidase*) and insulin [1].

Casein is the most important protein in milk, while the proportion of whey proteins is relatively low [46]. Even though different studies showed variable estimations, recently published studies accounted the total protein to be about 2.15 to 4.90% which is again 3.1% on average [58]. Milk protein is either Casein or albumin in that the casein content of dromedary and Bactrian milk as 2.7 and 0.89 percent respectively and that of albumin as 3.8 and 0.97 percent respectively [27]. Different breeds of camel may show variation in protein fractions level of milk [29].

Comparatively, camel milk casein and their fractions were obtained to have poor in crude protein as compared to that of cow milk [77]. Obviously, water has direct effect on milk composition, and hence dehydration tends to reduce the percentage of the milk protein [99].

Casein and whey proteins: Casein (CN) is the basic camel milk protein. The casein in the milk of one-humped camels is 1.63–2.76%, which represents about 52–87% of all proteins whereas whey protein found in camel milk are  $\alpha$ -lactalbumin, serum albumin, lysozyme, lactoferrin, lactoperoxidase, peptidoglycan recognition proteins, lactoperoxidase and immunoglobulins with total content of 20–25% out of all proteins. The amount of whey proteins in the milk of one-humped camels varies between 0.63 and 0.80% [55].

### Carbohydrate

The characteristic of sweetness of camel milk is the presence of lactose sugar in which its content in the milk remains often unchanged from the first months up to the end of the lactation. The concentrations in milk vary from 2.8 to 5.8 percent which is less when compared to cow milk (4.4–5.8%) (Grigor'yants, 1950). Unlike to some other milk constituents such as protein, dehydration or hydration does not affect the level of lactose in milk [99] but it is affected by the kind of the plants that are fed to the camel to satisfy their physiological needs for salt, for instance, halophilic plants such as *Atriplex*, *Salosa* and *locust* trees may give slight salty taste to milk [97].

### Milk ash

Milk is an important source of mineral substances, especially calcium, phosphorus, sodium, potassium, chloride, iodine, magnesium, and small amounts of iron. The main mineral compounds of milk are calcium and phosphorus, which are substantial for bone growth and the proper development of newborns. The high bioavailability of these minerals influences the unique nutritional value of milk. Camel milk is the richest in these minerals [9].

The mineral content of the camel milk is the total ash present in it and greatly varies from 0.60% to 0.90% but least percentage of the ash was gotten in the milk obtained from the dehydrated camel [88]. Average values of Na (29.70 mg%), K (50.74 mg%), Ca (94.06 mg%), P (41.68 mg%) and Mg (11.82 mg%) present in milk of early lactating camels. In late lactation period, the corresponding levels were  $35.49 \pm 0.89$  mg%,  $71.86 \pm 1.43$  mg%,  $97.32 \pm 0.51$  mg%,  $47.14 \pm 0.52$  mg% and  $13.58 \pm 0.31$  mg%, respectively [102].

Milk ash level depends on breed, analytical procedures, nutrition and water consumption [47]. In case of calcium, phosphate and magnesium, their concentrations decline in the milk of dehydrated camel [99]. Since camels usually prefer halophile plants as mentioned above, camel milk is a rich source of chloride [55]. However, these concentrations are still adequate to the sick, the elderly and the very young because of that it is not only healthy but also works especially well in the formation and strengthening of bone(s) [41]. Relatively, the values of trace minerals namely Fe, Zn, and Cu were significantly higher in camel milk than that of bovine [89].

### Vitamins

Camel milk is a significant source of both water-soluble and fat-soluble vitamins. Vitamin C, A, E, D and B group abundantly present in camel milk [47]. Among the vitamins, vitamin C

which is necessary in the body for the production of collagen, and additionally primates exclusively humans can't synthesize, is two to three folds higher in camel milk compared to cow milk, which in turn lowers the pH. As lactation steps forward, vitamin C level in the milk increases and it is accounted to be 5.7 up to 9.8 mg percent [90].

Relatively, the vitamin C levels are three to five times that of cow milk and one and half that of human milk. Vitamin C is an antioxidant that slows the rate of free-radical damage which causes skin dryness and wrinkles (Escott-Stump, 2008). Camel milk can be an alternative source of vitamin C under harsh environmental conditions in the arid and semiarid areas (Mal *et al.*, 2007). Moreover, camel milk contains more niacin (B3), folic acid, pantothenic acid, vitamin B12, but contains less vitamin A and riboflavin [90].

Another milk constituent vitamin fraction is Carotene having a concentrations that also declined from 0.46 mg/kg at 1.5 months lactation to 0.16 mg/kg at 4 months lactation and this lower amount of Carotene is a reason of whitish coloration of milk because carotene gives the milk yellowish color (Bestuzheva, 1964). The vitamin A content has been reported as being as little as 1.264 mg/l [10]. The vitamin A and carotene content in milk were found an average of 7.57 ug/ml and 9.4 ug/ml respectively [54].

Nonetheless, various camel milk constituents differ in amount and level in different researches as shown below (Table 4).

Furthermore, milk constituents differ in different species of animals as shown in the below Table 5.

#### Camel Milk Butter and Cheese

Although some nomad communities produced at least one type of cheese, the processing of camel milk into cheese is said to be difficult, even impossible [96]. A review about camel milk butter was indicated that in the Ahaggar region and the Sinai Peninsula only a few rare cheeses are manufactured by acidic separation and heating of milk proteins [97].

Research has confirmed that butter making from camel milk whey is feasible but more difficult than that of cow's milk whey because of its coagulation properties of the camel milk which are unsuitable for the production of cheese [36]. In other words, the coagulum is only poorly formed when camel's milk comes in contact with acid or pepsin. Another of difficulty of butter making is the weaker curd rigidity in camel milk owing to the small size of the fat globules, which are between 1.2 and 4.2 micrometers instead of the 1 to 10 micrometers in cow's milk [37].

Despite from that the fat is distributed as small micelle-like globules, it is apparently bound to protein and there is a great difference in fatty acid composition [41].

Whereas previous results have found small fat particles in camel milk, more recent work indicates that fat globule size distribution is similar to cow's milk, with an average of 2.9 micrometers [37]. The fat globule membrane appears to be thicker than in other types of milk and closely bound to the proteins expressly in the *casein* matrix. The creaming properties of camel milk fat globules are poor, resulting from a deficiency in agglutinin that causes a very slow creaming rate at all temperatures [81].

Furthermore, it has been recently stated that it is not pos-

sible to coagulate camel milk into cheese because *rennet* (a protease enzyme that curdles the casein in milk) was unable to coagulate the protein in the milk into curds. Fortunately, calcium Phosphate was discovered to be effective when added with vegetable rennet to form curds. The cheese so produced is better because it has low level of cholesterol and it is easy to digest and to eat even to those that are lactose intolerant. Camel cheese is on the contrary hard to get due to import restriction on the zone where they are produced [34].

#### Camel Meat

Meat is usually a by-product of a camel system and the demand for camel meat appears to be increasing among societies not herding camels that come mainly from old males and females that have served usefully in other functions in earlier life. Only a limited number of castrated males are raised especially for slaughter [53]. In fact, the one-humped camel is a good source of meat especially in areas where the climate adversely affects the performance of other meat animals. This is because of its unique physiological characteristics, including a great tolerance to high temperatures, solar radiation, water scarcity, rough topography and poor vegetation. In a survey on camel meat productivity and consumption conducted in Ethiopia particularly Jigjiga and Harar towns was indicated that, the dressing percentage of eastern Ethiopia camels was claimed to be  $54.03 \pm 5.13$  for male camels and  $50.65 \pm 3.70$  for female camels, meaning that since females are mainly used for dairy purpose, they are not slaughtered for meat purpose as male camels [60].

Camel meat is claimed by the Somali and Indian people to have a remedial effect for at least 13 different kinds of diseases, including hyperacidity, hypertension, pneumonia and respiratory diseases, and is also thought to be an aphrodisiac [60].

The meat of *one-humped* camel contains considerable amino acid, inorganic mineral content, less fat and remarkable moisture content [8]. Moreover, the cholesterol level in adipose tissue is comparatively lower than that of beef and mutton, which may figure out that camel meat is healthier than both mutton and beef. The nutrient content of camel meat can be affected by age, sex, carcass weight, fat-ness, packaging and storage conditions, and time (Dawood, 1995).

Practically, camel meat is tougher in texture than that of other consumable meat types. In fact, this does not mean that the camel meat is simply and naturally harder than others but the reason is that usually camels are slaughtered at older ages or when they aged because it is noted that the meat of young (<3 years) camels has same taste and texture to beef [30].

Meat from 6–8 years old camels was darker (lower L\*) and redder (higher a\*) than that of 1–3 years camels probably because of higher concentrations of myoglobin as shown in table 6. Other factors affecting meat color include muscle fiber type, ultimate pH and cooling rate [51].

#### Camel Hide

Despite from milk and meat, Camels generally provide hair, wool as well as hides. Hair production is mainly restricted to Bactrian camel which in some countries ranges annually between 1 to 3 Kg of hair that is used for making ropes, bags, mats, carpets and blankets. Camel hides are often used for making shoes and saddles. The hide of the dromedary is not of good quality and is mainly used for making whips and other products like a container for water and milk [53].

According to camel hides are important resource that could contribute a significant income to pastoralists if there is a reliable market and if they are properly cured [42]. It was observed that pastoralist use poor methods of curing camel hides leading to poor quality of hides as a result of this many tanneries have rejected camel hides. Camel hides have more fat than cow hides or goats skins and unless it is well removed, the hides rot (Foxwell, 1999).

For camel keepers to get maximum profit from camel hides proper curing methods, flaying and proper animal husbandry practices are paramount. In Kenya camel hides are used to make the roofs for traditional pastoral houses, for making ropes, guards, drums, seats, sandals, praying mats used by Muslims, and water and milk containers (Kagunyu and Matiri, 2012).

### Conclusion and Recommendation

Frankly, camels for their diverse uses are important livestock and strongly tolerant to environment that may be rightly termed as hostile in terms of extreme temperature, drought and lack of pasture unlike most other animals. They are defined to be ship of desert particularly *dromedarian* camel. There are three main species, even though there is some controversial, namely *C. bacterian*, *C. one-humped (dromedarian)* and *C. ferus*. They get full maturity at the age range of 3 to 5 years old. Rutting is a special sign for that the bull reached full maturity, it develops a very unique feature that is the *dulla* (a soft and balloon like tissue that develops in oral cavity during peak maturity). Intriguingly, though camels naturally breed during rainy seasons or flesh grazing period, they can breed throughout the year if fed well. In case of female, it can give first birth at age of 5 years old usually with a single calf which means very rare twinning reasonably for that the fetus in the right horn regresses or dies when it reaches 2 to 3 cm of size.

Abortion or stillbirth is considered to less significantly happen mainly due to diseases as well as malnutrition. Dissimilarly, postnatal deaths are not that much may be availability of veterinary services as well as management practices. Camels have high milk yield and comparatively long milk service period for both their calves and human. The superior value of camel milk rests on its lower fat and lactose but higher protein content as contrasted to that of cow. Additionally, halophilic plants such as *Atriplex* preferably consumed by camels are believed to qualify more on camel milk. Interestingly, butter can be made from camel milk but not as easy as that of cow, goat and the like because fat properties which are very fine globules bound by proteins. Moreover, *rennin* which is a coagulative enzyme in milk can't independently convert the milk proteins into curds. Despite from milk, *one-humped* camels also provide into some extent meat and hide.

Therefore, based on the above conclusive remarks, the following suggestions are straight!

☞ The knowledge about camels especially their reproductive capabilities and constraints on a successful and touchable reproduction should be promoted.

☞ Facts about camel milk as a clandestine treatment for detrimental diseases must be advanced.

☞ The mechanism of butter making from camel milk should be enhanced at least by boosting the activity of *rennet* or even developed an alternative procedure.

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