

ORIGINAL RESEARCH PAPER

STUDY OF YIELD AND COMPOSITION OF CAMEL MILK IN ALGERIA

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Abstract: The aim of this study was to determine the yield and composition of raw camel milk throughout the lactation period. For this purpose seventeen multiparous she-camels, kept under grazing and supplement farming system in South East of Algeria were used in this study. A total of 153 milk samples were collected and analyzed through standard procedures to determine yield and physicochemical parameters of milk such as pH, acidity, density, fat, protein, lactose, ash and total solids. The results demonstrated that the overall means of daily milk yield and composition of pH, acidity, density, fat, protein, lactose, ash and total solids (TS) were $3.96 \pm 1.24 \text{ L} \cdot \text{day}^{-1}$, 6.55 ± 0.14 , $0.17 \pm 0.01 \%$, $1.032 \pm 0.002 \text{ g} \cdot \text{cm}^{-3}$, $3.72 \pm 0.14\%$, $3.37 \pm 0.18 \%$, $4.13 \pm 0.29 \%$, $0.96 \pm 0.22 \%$ and $9.99 \pm 1.82 \%$, respectively. Moreover, the milk yield was significantly ($p < 0.05$) higher during the mid stage of lactation than the early and the late one, while milk density, fat and total solids were the highest during the first stage of lactation. However, pH, protein and lactose contents content remained stable without significant change ($p > 0.05$). The results indicated that Algerian camel milk could provide a valuable nutritious food and energy source for population living in arid and semi arid zones and it was concluded that the stage of lactation had a significant effect ($p < 0.05$) on milk yield and most physicochemical parameters of raw camel milk.

Keywords: acidity, Algeria, ash, camel, density, fat, lactose, milk, pH value, protein

INTRODUCTION

In Algeria, camel breeding has been considerable momentum from 2000, rising from 234,220 head in 2000 to 315,849 head in 2010 [1]. Camel milk production in Algeria, estimated to about 5.6 L·day⁻¹ [2]. Moreover, camel meat and milk are the key foods in arid and semi-arid areas of Algeria. Camel milk does not only contain more nutrients compared to cow milk [3]. But, also it has therapeutic and antimicrobial agents [4].

According to Abdalla *et al.* [5], the mean values of different constituents of camel milk were: 3.01 %, 3.06 %, 0.69 %, 4.33 %, and 11.06 %, for protein, fat, ash, lactose and total solids respectively. On the other hand, Babiker and el Zoubair [6] reported that the milk yield of camel varies greatly depending on the husbandry systems, in addition to the other factors such as parity number, stage of lactation [5 – 8], calf mortality and calving season [5]. Similarly, wide variation in its components is attributed to some factors such as breed [9], geographical location, feeding regime [10], calving number and stage of lactation [5, 6, 11], seasons [5, 8], and management systems [6, 11, 12].

In Algeria, selling of milk is neither practiced nor accepted by camel herders in the traditional systems and there are no well-established camel dairy farms. However, currently a new trend towards commercialization of camel milk associated with the new farming system has started in the South East of Algeria. Few works were done on the Algerian camel, especially on milk yield [2, 13] and composition [2, 14]. However, mostly those obtained were based on surveys and not in measuring or monitoring.

Nevertheless, there is no published data on the composition fluctuations and yield of camel milk throughout the lactation period. Therefore, the objective of this study was to determine the yield and composition of Algerian camel milk and to evaluate its variability during the lactation period.

MATERIALS AND METHODS

Study area

The study was conducted at the locality of Bir Naam, South East of Algeria. This region has an arid climate, an average summer temperature of 42 °C and low monthly precipitation with 10.72 mm. The rainy period extends from November to January with a 23.8 mm maximum in January. The rest of the year, pastures in the region are considered arid. The vegetation commonly consists of steppe plants such as *Stipa tenacissima* and *Ampelodesmos tenax*.

Management of camels

This study was conducted from November 2014 to September 2015. Seventeen multiparous healthy lactating she camels kept under grazing and supplement farming system were randomly selected, where the animals graze in open areas surrounding the farm from the morning times until mid-day then they were kept inside the farm for milking and supplement feeding. These camels were supplemented with some barley concentrate and dry hay straw. The animals were watered regularly. The calving occurs mostly in winter season but starts as early as November.

Sampling procedure

A total of 153 raw milk samples were taken for estimating physicochemical compositions. The samples were collected during three different stages of lactation (early, mid and late respectively). Three samples were taken from each animal in each lactation stage. The samples were collected in the early morning into sterilized bottles after water washing and disinfection of the teats with alcohol (70 °C) and eliminating the first streams and immediately labeled. Furthermore, the samples were stored in ice box and transferred within 2 - 4 hours to the laboratory. Five hundred milliliters per milking were taken after thorough mixing for analyzing: pH, acidity, density, fat, protein, lactose, ash and total solids (TS).

Control of milk production

The animals were hand-milked twice daily at approximately 05:00 and 17:00 hours. The daily milk yield of each animal was the sum of morning and evening milking. The volume of milk was measured with a graduated cylinder.

Milk composition analysis

Physical analysis

The pH was measured using a pH-meter (Hanna HI 99161, Romania), while the titratable acidity was determined according to Association of Official Agricultural Chemists - AOAC [15] by titration of the fresh milk with 0.1 N NaOH in the presence of phenolphthalein indicator. The density at 20 °C was determined using a lactodensitometer to give a simple reading of the line corresponding to the point of touching the density of the test sample in which it floats.

Chemical analysis

Fat content of milk was analyzed by Gerber method according to AOAC [15]. Protein was determined through the quantification of the nitrogen content by the standard Micro-Kjeldahl method [15] and multiplying by a conversion factor of 6.38 to arrive at protein content. Lactose content was determined by Bertrand's method [16]. Ash content of milk was determined by the incinerations of dried sample in muffle furnace at 550 °C using method given in AOAC [15]. Total solids (TS) content was determined after drying in an oven at 100 °C for 3 hours [15]: $TS \% = W_1/W_2 \times 100$ (where: W_1 = weight of sample after drying; W_2 = weight of sample before drying).

Statistical analysis

Statistical evaluations were performed using SPSS software (Version 16). Firstly, the data were analyzed using the General Linear Models (GLM) procedure, and the means were separated using the Paired Sample T-Test or Wilcoxon Signed-rank test after evaluating normal distribution by the Shapiro-wilk and Kolmogorov-Smirnov test. Secondly, Pearson's correlation coefficients (r) were used to determine relationships between the various studied parameters. The results were considered significant if the associated P-value was < 0.05 .

RESULTS AND DISCUSSION

Milk yield

According to the study results, the overall mean of milk yield was $3.96 \pm 1.24 \text{ L}\cdot\text{day}^{-1}$ (Table 1). So, the length of lactation period was estimated as long as 9 months. The milk yield was significantly ($p < 0.05$) higher during the mid stage as compared to those obtained for the early and late stage of lactation, respectively (Table 1). The data showed that milk production does start at a low level during the first 2 months and then increased at the mid stage of lactation. Then it showed a slight gradual decline until the last stage of lactation (Table 1).

Table 1. Effect of lactation stage on yield and physical compositions of Algerian camel milk

Number of samples	Stage of lactation [months]	Milk yield [$\text{L}\cdot\text{day}^{-1}$]	pH	Acidity [%]	Density [$\text{g}\cdot\text{cm}^{-3}$]
51	0 - 2	3.58 ± 1.18^a	6.57 ± 0.12^a	0.17 ± 0.01^a	1.034 ± 0.003^a
51	3 - 5	4.78 ± 1.13^b	6.53 ± 0.10^a	0.17 ± 0.01^a	1.031 ± 0.001^b
51	6 - 9	3.52 ± 0.99^a	6.54 ± 0.19^a	0.18 ± 0.01^b	1.031 ± 0.002^b
153	overall mean	3.96 ± 1.24	6.55 ± 0.14	0.17 ± 0.01	1.032 ± 0.002
153	[p-value]	0.000	0.355	0.000	0.000

^{a,b} Means with different superscripts within a column are significantly different ($P < 0.05$)

In the present study, the overall mean of the observed daily milk yield was within the range reported by other researchers [2, 6, 13]. However, this finding was slightly higher than the range reported by Zeleke and Bekele [17] ($1.5 - 3 \text{ L}\cdot\text{day}^{-1}$) in eastern Ethiopia. Moreover, the length of lactation period was found to be higher than that reported by Babiker and El Zubeir [6] in Sudan, who mentioned that lactation length was 8 months for the same husbandry practice.

However, many previous researchers [2, 5, 13, 18 – 20] have reported a longer lactation length than that found in our study. This variation could be attributed to the breed/type and agro-ecological differences [19]. Similarly, Al-Haj and Al-Kanhal [21] mentioned that the factors affecting milk yields are the breed, feeding and management conditions, lactation number and stage of lactation, which are common to all dairy animals.

In addition, Babiker and El Zubeir [6] found that milk yield was significantly affected by husbandry system, stage of lactation and parity number. On the other hand, Bakheit *et al.* [22] reported that camels raised under semi-intensive system were able to produce significantly more milk than the other reared under traditional system.

Physical composition

The mean contents of physical parameters of milk at each stage of lactation (beginning, middle and end) are given in Table 1. The overall means of pH, acidity and density were 6.55 ± 0.14 , $0.17 \pm 0.01 \%$ and $1.032 \pm 0.002 \text{ g}\cdot\text{cm}^{-3}$, respectively. During lactation, a significant increase ($P < 0.05$) in acidity was observed at the late stage of lactation and in density for the first one. However, the pH value did not change significantly ($p > 0.05$) with advancing lactation.

The overall mean of *pH* observed in our study was comparable to the finding of Alwan *et al.* [12] in Libya for group of Farm-reared. This result was higher than that reported by Siboukeur [2] and Merzouk *et al.* [14]. However, other researchers [10, 23] reported higher *pH* values. The variation of *pH* value could be due to differences in hygiene of the milking practices and the total microbial count of milk [21]. According to Gorban and Izzeldin [24], the *pH* of camel milk can be affected by feed and availability of water.

Therefore, the overall mean of density was in agreement with the results of previous studies [6, 25]. However, this finding was higher than the results reported by Siboukeur [2]. This variation could be due to the water content in milk because the density is influenced directly by humidity of camel milk. On other hand, Laleye *et al.* [26] reported that camel milk was less viscous than bovine milk. For this reason herders living in arid zone use camel milk not only as nutritious food but especially as a substitute to almost deficient water as well [27].

The overall mean of acidity was within the range reported by other reports [6, 10, 12, 25]. However, it was lower than that declared in previous studies [2, 14]. According to Meiloud *et al.* [25], the milk is of good quality (acidity between 14 and 18°). This could be explained by the fact that the increased concentration of protein, including the casein fraction to a considerable degree, determines the acidity of milk. Moreover, variation in acidity may refer to differences in hygiene of the milking procedures and the total microbial count of milk [21].

Also, Alwan *et al.* [12] observed a gradual increase in the titratable acidity of the farmed reared camel milk than that of desert reared ones. Moreover, Shuiep *et al.* [28] reported highly significant differences in acidity of camel milk between summer and winter seasons which related to high temperature and acidification of bacteria in the hot season. However, the camel milk characterized by a greater buffering effect with respect to bovine milk [29], helps explain the lack of direct relationship between *pH* and acidity.

Chemical composition

The chemical parameters of milk at each stage of lactation are shown in Table 2. The study showed that the overall means of fat, protein, lactose, ash and TS were 3.72 ± 0.14 %, 3.37 ± 0.18 %, 4.13 ± 0.29 %, 0.96 ± 0.22 % and 9.99 ± 1.82 %, respectively. Fat content and TS were significantly ($p < 0.05$) higher during the first stage of lactation than second and third ones. On the other hand, the ash content was higher during the mid and the late stage of lactation. However, the protein and lactose contents remained stable without significant changes ($p > 0.05$) throughout the lactation period (Table 2).

In our study, the mean fat content was within the range reported by many reports [5, 6, 25, 30]. Conversely, other researchers reported lower fat content [2, 8, 23]. Although Merzouk *et al.* [14] stated higher fat finding for cold season. This diversity may be due to the nature of food taken by animals because it is known that total energy intake is directly related to fat content. In the same way, Khaskheli *et al.* [10] reported that variation in fat content is directly or indirectly related to the total solids content.

Table 2. Effect of lactation stage on chemical compositions of Algerian camel milk

Number of samples	Stage of lactation [Months]	Fat [%]	Protein [%]	Lactose [%]	Ash [%]	TS [%]
51	0 - 2	3.77 ± 0.15 ^a	3.38 ± 0.14 ^a	4.05 ± 0.25 ^a	0.88 ± 0.18 ^a	11.02 ± 1.56 ^a
51	3 - 5	3.70 ± 0.13 ^b	3.36 ± 0.19 ^a	4.18 ± 0.29 ^a	1.01 ± 0.20 ^b	9.28 ± 1.85 ^b
51	6 - 9	3.68 ± 0.14 ^b	3.36 ± 0.20 ^a	4.17 ± 0.31 ^a	1.01 ± 2.45 ^b	9.67 ± 1.60 ^b
153	Overall mean	3.72 ± 0.14	3.37 ± 0.18	4.13 ± 0.29	0.96 ± 0.22	9.99 ± 1.82
153	[p-value]	0.007	0.752	0.057	0.003	0.000

^{a,b} Means with different superscripts within a column are significantly different ($P < 0.05$), TS = Total Solids

Besides, Shuiep *et al.* [28] confirmed that the fat content of camel milk is significantly affected by management conditions and seasons. Also, Konuspayeva *et al.* [30] observed that there is a wide variation in camel milk fat in different parts of the world and showed that the milk composition from camels living in East Africa contains higher fat contents than the milk from camels living in Africa and Western Asia. Moreover, Abdalla *et al.* [5] reported that the low percentage of fat matter in camels probably reflects poor nutrition that is typical to the desert habitat conditions.

The total content of minerals (ash) was in agreement with the results of Khaskheli *et al.* [10] and Meiloud *et al.* [25]. However, many previous studies have reported lower ash content [2, 5, 8, 12, 14, 23]. The higher ash contents of camel milk that observed in this study might be correlated with the nature of the available vegetation in the study area and the nature of supplementary diet. Variations in ash content were attributed to breed differences, feeding [31], parity number and stage of lactation [5], season [28], management systems [11] and water intake [32].

In this study, the overall mean of total solids was in parallel with those of Khaskheli *et al.* [10] and Abbas *et al.* [23]. In some studies, higher content of TS were found [2, 12, 14]. The variation in TS content might be a consequence variation of negative effect of heat stress on feeding intake and thus protein, fat and lactose content [33]. Also, Abdalla *et al.* [5] reported that the stage of lactation, parity numbers affected significantly the content of total solids of camel milk in addition to other factors such as management conditions [12] and seasons [28]. Moreover, Alwan *et al.* [12] concluded that the total solids are significantly lowered as the amount of water in the camel's fresh milk is significantly increased when drinking water is restricted.

The obtained mean of protein content was within the range reported by previous studies [5, 6, 8, 12, 30]. However, other reports, demonstrated lower values of protein content [12, 14]. This difference may be due to the different management systems and variation of quality and quantity of feed available for such region, in addition to some individual factors including genetics. In the same way, Khaskheli *et al.* [10] reported that change in proteins content of milk could be attributed to difference in breeds and geographic areas, type of plants in the pasture, age, number of calves, lactation period and herd management.

The lactose content observed in this study was consistent with the results of other researchers [5, 6, 8, 25, 30]. However, Khaskheli *et al.* [10] found lower lactose content. Though, the given result was lower than that reported in previous studies [2, 12]. The wide variation of lactose content could be referred to the type of plants ingested in deserts [10]. Camels usually prefer halophilic plants such as *Atriplex*, *Salosa* and *Acacia*

to meet their physiological requirement so salts [34]. The physiological variations of the lactose concentration were less important than for protein and fat matter, as well as in Dromedary camel [35] than in Bactrian camel [36]. According to Haddadin *et al.* [32], lactose content was only found to change slightly for camel milk of some dromedary breeds in different part of the world.

Effect of lactation stage on yield and composition of milk

In the present study, the milk yield was significantly ($p < 0.05$) affected by stages of lactation. The highest milk yield was recorded at the mid stage of lactation, while at the late stage of lactation, the milk yield gradually decreased to similar levels to those recorded at the early stage of lactation. This finding was in agreement with the previous findings of Abdalla *et al.* [5], Al-Saiady *et al.* [7] and Mehari *et al.* [19]. However, these results were not consistent with Babiker and El Zubeir [6] and Zeleke [37], who reported that there was no significant decrease in milk, yield till the 9th month of lactation.

Increased milk yield during mid lactation due to increased growth and number of secretory cells in the udder or increased secretory activity of the mammary tissue or both [38]. On the other hand, many authors reported that milk yield was affected by stage of lactation and calving number [5 - 8], breeds [9], milking interval, diet type of camels [7], calving season [5, 8], calf mortality, lactation period [5] and management systems [6, 18, 22].

In current study, the most parameters of camel milk composition were significantly ($P < 0.05$) affected by stages of lactation, which was consistent with the results of other researchers [5 – 7, 11]. The results of the current study showed that the acidity of camel milk was higher at the late stage of lactation, while the density was higher during the first one. However, these findings disagreed with the results of Babiker and El Zubeir [6] who reported that the density and acidity of camel milk were not affected by stage of lactation. According to Siboukeur [2], the density of camel milk is directly dependent on the dry matter content which is strongly related to the frequency of watering.

In the present study, the fat and TS contents were higher during the first stage of lactation than the second and third one (Table 1). Similar results have also been observed by Zeleke [37], who found that the values of fat and total solids were the highest during the first 6 months of lactation and that was also reported by Al-Saiady *et al.* [7] and Haddadin *et al.* [32]. In addition, ash contents were lower during early stage of lactation, which was in agreement with the finding of El-Hatmi *et al.* [39] who reported that the ash content increased during lactation and reached peak (1 %) at the week 40 of lactation.

Furthermore, the current study demonstrated that the most camel milk constituents were lower during the second and third stage of lactation (Table 2). This finding may be due to the increase in the milk water content during the last stage of lactation [11]. These results support those of Zeleke [37], who demonstrated that total solids decreased from 11.7 % in the first stage of lactation to 10.1 % by the end and that fat content was gradually decreased. As well, Konuspayeva *et al.* [40] reported that fat content decreased all along the lactation period.

However, no significant ($p > 0.05$) effect of lactation stage on lactose content was observed in our study, This result agreed with Abdalla *et al.* [5] who stated that there

were no significant differences in lactose content between various stages of lactation. Also, Haddadin *et al.* [32] showed that the lactose matter was found to be the only milk component that remained over a season.

Also, no significant ($p > 0.05$) effect of lactation stage on the protein content was observed in this study. This result disagreed with the findings of other researchers [6, 11, 32, 37] who mentioned that the highest percentage of protein content of camel milk were at the first stage of lactation and then decreased along the lactation period. This may be due to the nature of food available and protein diet which resulted in production of milk rich in protein [41]. The variations in protein contents could be attributed to several factors such as breed [9, 40], geographical location [10], calving number [5, 6, 9, 11, 37, 42], season of calving [5, 8], management systems [6, 11, 12] and milking frequency [43].

Correlations between the different studied parameters

The correlations between the different studied parameters are presented in Table 3. The milk yield was negatively correlated with density, acidity, fat and protein but without significance ($p > 0.05$). However, a negative significant correlation ($P < 0.05$) between milk production and TS content was found in this study. On the other hand, correlations involving density with fat, fat with protein and ash, protein with lactose and ash, lactose with ash were positive ($p < 0.05$). However, a negative significant correlation ($P < 0.01$) was observed between TS content with lactose and ash.

Table 3. Matrix of correlation coefficient (*r*) between yield, physical and chemical parameters of Algerian camel milk (*n* = 153)

	<i>pH</i>	Acidity	Density	Fat	Protein	Lactose	Ash	TS
Milk yield	0.035	- 0.131	- 0.153	- 0.034	- 0.010	0.028	0.045	- 0.195*
<i>pH</i>		- 0.197*	0.085	0.086	0.015	- 0.022	- 0.005	0.011
Acidity			- 0.039	0.111	0.073	- 0.112	0.142	- 0.057
Density				0.221**	0.095	- 0.100	- 0.154	0.074
Fat					0.797**	0.136	0.243**	0.036
Protein						0.247**	0.336**	- 0.023
Lactose							0.633**	- 0.317**
Ash								- 0.439**

All Pearson correlation coefficients are significant at $P < 0.05$, * $P < 0.05$, ** $P < 0.01$; TS = Total Solids

In the present study, the most studied parameters showed negative correlations with the milk yield. These findings were in agreement with those of Musaad *et al.* [8] and Elobeid *et al.* [9], respectively. In the same way, Musaad *et al.* [8] attributed these negative correlations to the dilution effect.

However, positive correlation coefficient was found in our study between milk production and *pH*, lactose and ash contents, respectively. These results were in agreement with the findings of Elobeid *et al.* [9], who reported that the *pH* and ash contents were positively correlated with the milk yield. In contrast, Musaad *et al.* [8] found a significant ($p < 0.05$) negative correlation between milk yield and pervious parameters.

The relationship between most parameters included in this study (Table 3) agreed with the results of Musaad *et al.* [8] and Elobeid *et al.* [9], except for the negative correlation

between density and lactose, density and ash. In the present study, only the significant ($p < 0.05$) positive correlation between fat and protein was strong ($r = 0.797$). According to Konuspayeva *et al.* [44], the correlation between fat and protein is classical in the milk of all mammals.

CONCLUSIONS

In conclusion, the results of the current study may contribute to the overall knowledge about the compositions and production of camel milk in south east of Algeria and it confirmed that lactation stages have impact on milk yield and physicochemical compositions. The highest milk production was observed at the mid stage of lactation. However, the highest density values, fat and TS contents were noted at the first one, while ash was lowest. On the other hand, the protein, lactose contents and pH values did not change with advancing lactation. For future prospects, more research should be conducted to know the effect of breeds, season, milking frequency, calving number and to delineate management and feeding regime for the Algerian camel in order to make camel rearing an economical proposition.

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