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EFFECTS OF DIET SUPPLEMENTATION ON CAMEL MILK DURING THE WHOLE LACTATION UNDER TUNISIAN ARID RANGE CONDITIONS

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ABSTRACT

The quantity and the quality of milk produced by two groups of ten multiparous camels (*Camelus dromedarius*) grazed in arid pasture in the region of Medenine were evaluated. Group I received 1 kg of concentrate feed/day/head while Group II received 4 kg of concentrate feed/day/head. Milk yield was estimated from the total milking of two quarters at the morning. The milk content of the two other quarters were fed by the offspring. Calves and their mothers were separated during seventeen hours from night till morning. Milk was analysed every two weeks throughout almost one complete lactation period. The evolution of physico-chemical quality of milk consisted in the determination of the levels of total dry extract, protein, casein, lactose, mineral salt, fat, calcium, potassium, magnesium, sodium, phosphorus. The Group II produced more daily milk than Group I, with a maximum average of 3105.4 ± 1027.8 ml/day and 1854 ± 386.9 ml/day, respectively. Total dry matter and fat content were higher for Group I (148.5 g/l, 55.6 g/l) because the quantity of milk production was lower. The Group II had a higher level of mineral salt than Group I. The milk was more concentrated with the different components at the onset of lactation than the cessation. However, the milk production was lower at the start of lactation than the end. There were significant ($p<0.01$) differences between the two camel groups, the Group II produced more quantity of milk than Group I, but with less concentration of the various components.

Key words : Arid Tunisia, camel milk, quality, quantity, stage of lactation

There are some 95,000 camels (*Camelus dromedarius*) in Tunisia of which more than 95% graze the arid and desert lands where pasture productivity is marginal and forage yields are highly variable by season and year (Hammadi *et al*, 2002). The physiological adaptations of this domestic animal were extensively investigated (Cauvet, 1925; Schmidt-Nielson, 1964; Yagil and Etzion, 1980 and Khorchani, 1996). However, data about camel milk are still scarce. The camel milk contains all essential nutrients as cow milk (Elagamy *et al*, 1998) and has also a high biological value due to the higher contents of antimicrobial factors such as lysozyme, lactoferrin, and immunoglobulins than the milk of other animals (Elagamy *et al*, 1992). Camel milk is a very important nutrient resource for humans in several arid and semiarid zones of subtropical and tropical regions where it represents often the only protein source. In hostile environment, where the availability of water is scarce and ambient temperature is very high, dairy camels can provide milk almost all the year, in quantities higher than those of other domestic animals (Farah, 1996).

Up to now the lactation characteristics of camels milk were not studied in Tunisia. Therefore, the objective of the present study were to obtain data on the composition of camel milk using milk from one herd, collected throughout almost one complete lactation period.

Materials and Methods

Experimental animals

The research started in February and ended in December 2000 in the Arid Lands Institute. Experimental Station is situated in the southern Tunisia (33°30′N, 10°40′E). This region is characterised by an arid climate with an annual rainfall of about 180 mm. Twenty multiparous lactating camels (*Camelus dromedarius*) Maghrebi breed, belonging to a 60-head herd, were used. The herd was kept in the pen during the night and moved to graze in the range during the day for 7 to 8 hours. Camels had access to water in the morning before leaving to the range. The pasture covered some 500 ha dominated by salty native species (*Arthrocnemum indicum*, *Tamarix gallica*, *Limoniastrum gynianum*, *Nitraria retusa*, *Suaeda*

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mollis, *Atriplex halimus*, *Salsola tetrandra*…). The experimental animals were alotted, in equal number, to two supplemented groups (Group I and Group II) based on the body weight (Group I: 418 ± 20 kg; Group II: 429 ± 34 kg), age of the female (Group I: 10.0 ± 2.8 years; Group II: 10.1 ± 3.4 years) and body condition score (Group I:5.1 ± 1.0; Group II:5.3 ± 1.0). The concentrate was formulated /quatified for Group II to supply 60% of total daily requirement energy during the 2 pre-and 3 post-partum months for a 420 kg females producing 4 litre of milk/day during the first 3 months of lactation (INRA, 1978; Guerouali *et al*, 1995). Body weight/ body condition score were controlled every month.

Group I has received 1 kg of concentrate feed/day / head; Group II has received 4 kg of concentrate feed / day / head. This concentrate feed was composed of 60% of barley, 17.5% of wheat bran, 17.5% of olive grignon and 5% of mineral and vitamin supplement. The animals were hand milked. Milk was collected and analysed every two weeks throughout almost one complete lactation period of 42 weeks. From August 2000 a supplement of 2 kg of concentrate feed to Group I was needed instead of 1 kg. The milk yield was estimated from the total milking of two quarters, and calves are allowed to suckle two teats and multiplying the record yield by two.

Milk samples

Immediately after milking, 0.02% (wt/vol) $NaNO_3$ was added to each sample as a preservative. The milk samples were transported to the laboratory and stored at -20°C until analyses. Samples of milk were analysed for fat content by the Gerber method (Elagamy *et al*, 1998). For total protein, total solids (TS), ash and lactose according to the AFNOR method (1993).

The pH was determined with a pH-meter (Radiometer A/S, Copenhagen, Denmark), the titrable acidity by the Dornic Method, expressed in Dornic degree (1°D = 0.1 g lactic acid/litre of milk), was determined by titration of 10 ml of sample with M/9 sodium hydroxide to a pink end point using phenolphthalein as indicator (AFNOR, 1993). Calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) were measured using a Hitachi Z-6100 model atomic absorption spectrometer (Hitachi Instruments Engineering, Ibaraki, Japan) in the presence of lanthanum oxide (1%) (Sigma, St. Louis, MO, USA) to overcome phosphate interference for Ca and Mg, and in the presence of the cesium chloride (CsCl) for K and Na. Hydrochloric acid (20%) was used to dissolve ash. The concentration of phosphorus (P) was determined by a colorimetric method with ammonium molybdate (Pien, 1969).

Statistical analysis

The data (production, total solid, ash, fat, protein, lactose) were subjected to statistical analysis using SAS computer software (SAS Institute, 1998), to test the effects of camel feeding on the milk production and on the content of main milk constituents.

Results and Discussion

The evolution of average daily concentration of the main constituents of camel milk at different lactation stages (2 weeks intervals during a period of 41 weeks) are given in Fig 2; for the Group I and II. This figure show the variations of these values, based on all samples taken for Groups I and II. Lactation curves were configured by grouping monthly data into 2-weeks interval, according to lactation stage.

The TS content of milk decreased in parallel to its minimum after 19 to 27 weeks which was the summer season for Groups I and II (Fig 2). The fat content of milk decreased from the beginning of lactation to reach a minimum value of 19.4 g/l at week 21 for Group I and 17.2 g/l at week 23 for Group II. The Group I had a level of fat higher than the Group II, which increased slightly and then decreased again at the end of lactation (Fig 2).

The protein content of milk decreased progressively with advancing lactation. In average, the Group I had a level of proteins higher than that

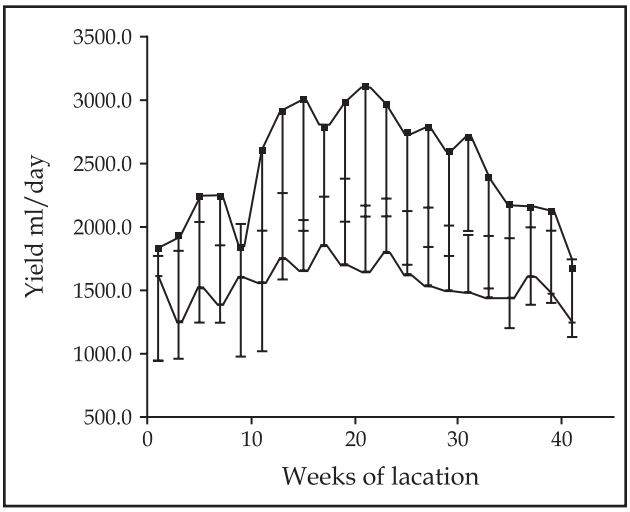
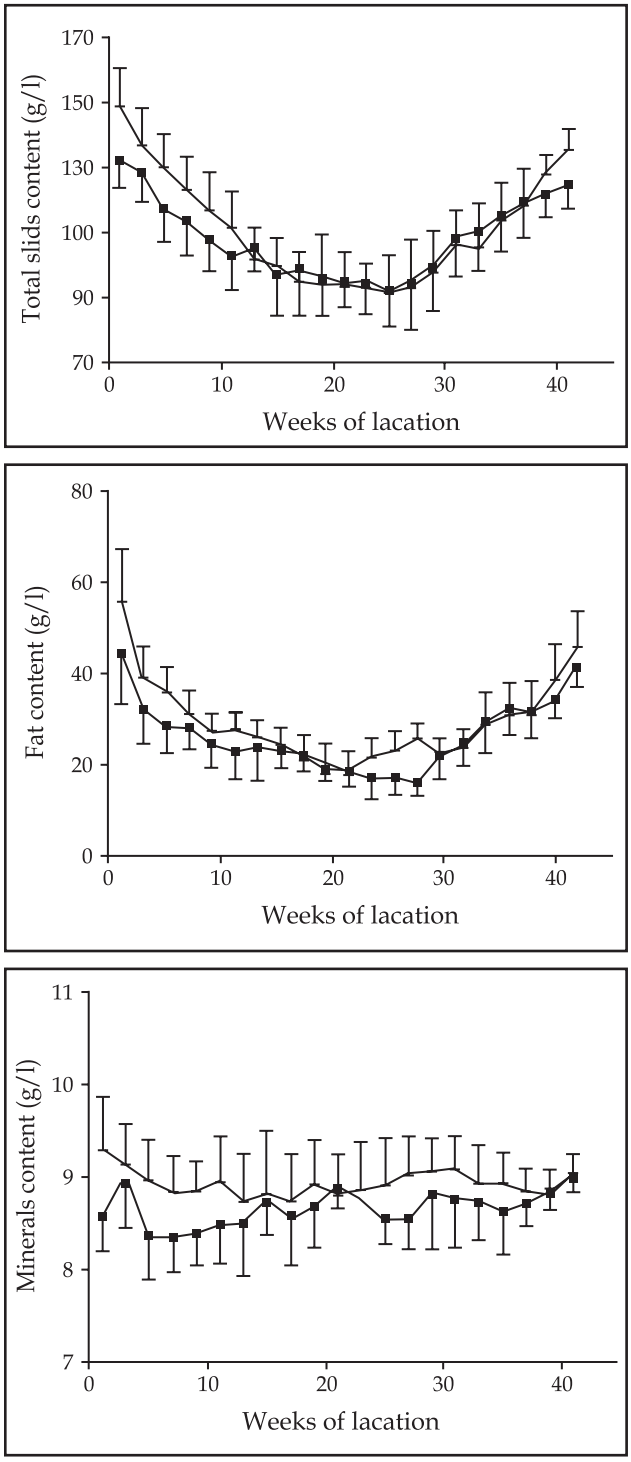


Fig 1. Milk yield per milking during lactation (mean values ± SD): Group I (—), Group II (■). SD: Standard deviation, error bars represent SD (only positive or negative values are presented for clarity).



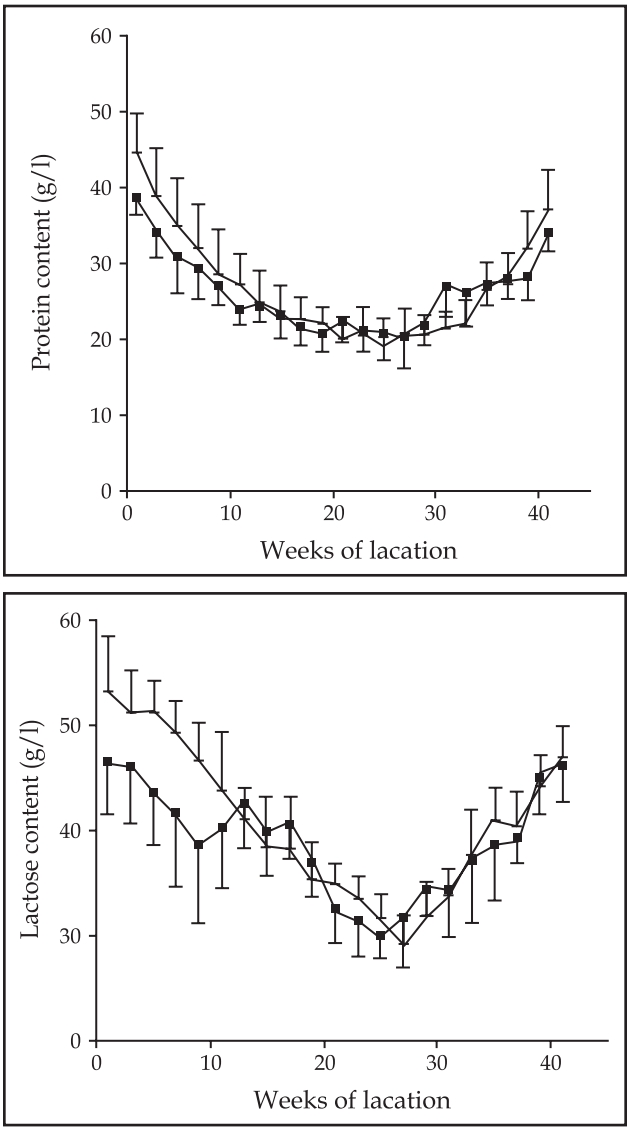
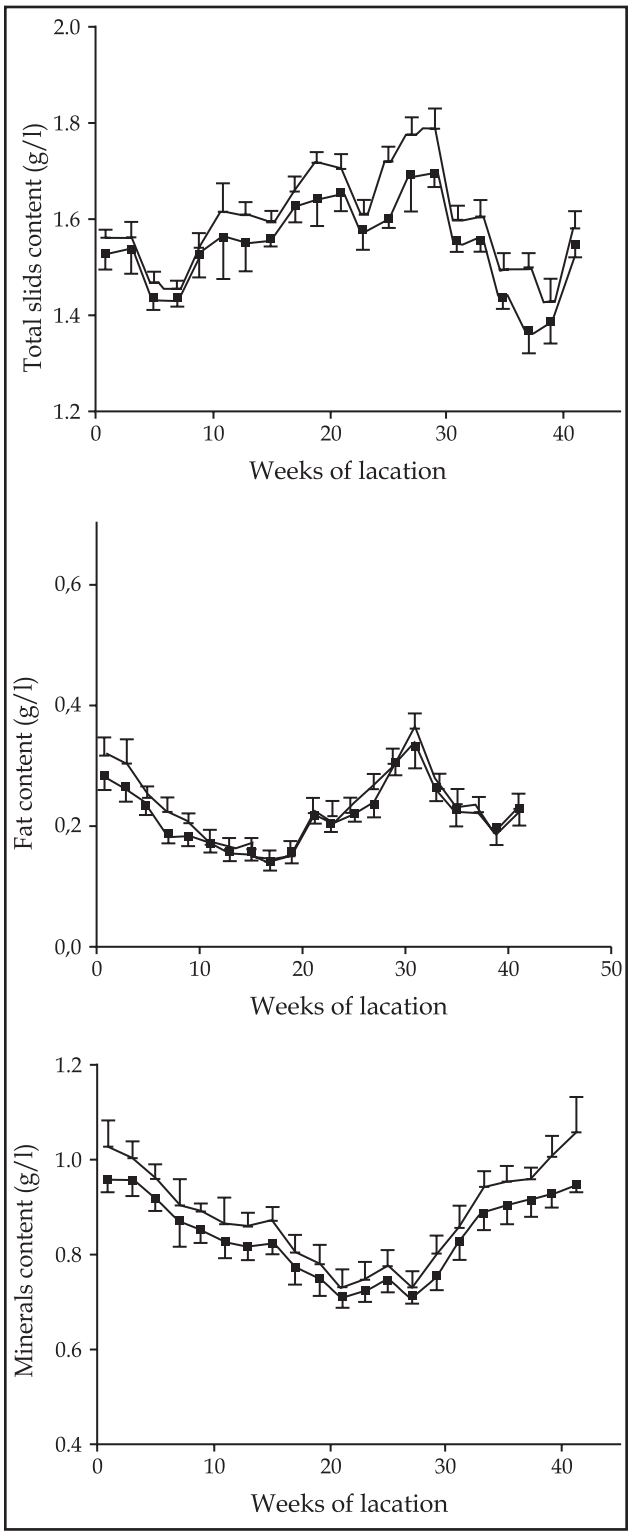


Fig 2. Camel's milk contents (mean ± SD) during lactation: Group I (—), Group II (■). SD: Standard deviation, error bars represent SD (only positive or negative values are presented for clarity.)

of Group II (Fig 2). The lactose content of milk of the Groups I and II decreased slowly until weeks 22 to 27 of lactation which corresponded to dry season of June-July (Fig 2). The lactose content average of camel milk range from 29.2 to 53.2 g/l, there were no significant difference in lactose level of milk between the two groups throughout lactation $p<0.05$. Ash content (Fig 1) was high (9.3 g/l in weeks 1). Milk produced by the Group I were frequently more concentrated in minerals than milk produced by the Group II. The highest concentration was observed at the stage week 1 of lactation (9.3 g/l) for the Group I and at the stage week 3 of lactation (8.9 g/l) for the Group II. In our study there weren't a great difference in level of pH and acidity for Groups I and II. The titrable acidity fluctuate between 15 and 23°D, and pH from 6.5 to 6.7.

The values for composition and characte-ristics of camel's milk were frequently based on analyses of milk from single camel or from a small number of camels, and rarely of milk from a herd. The most complete data are those reported by Abu-Lehia



(1989) for Saudi camels. Usually the results were for short period of lactation, whereas the composition of camel's milk is known to depend on such factors as breed, stage of lactation, feeding and individual animal differences (Hassan *et al*, 1987; El-Amin and Wilcox, 1992; Farah, 1993 and Mehaia, 1996).

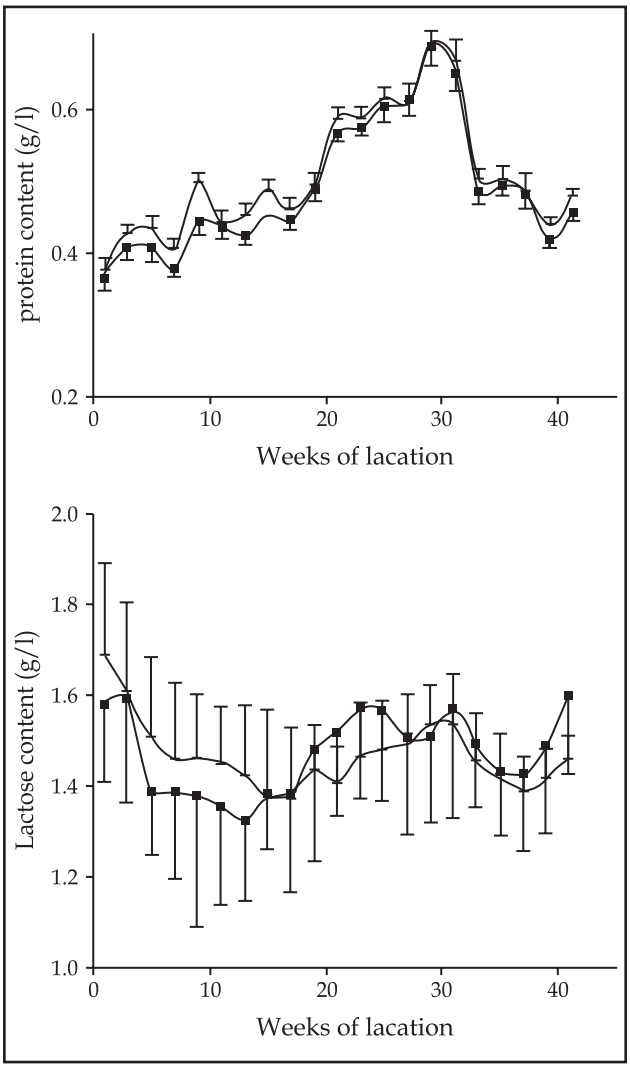


Fig 2. Camel's milk contents (mean ± SD) during lactation: Group I (—), Group II (■). SD: Standard deviation, error bars represent SD (only positive or negative values are presented for clarity.)

Milk yield

The results presented in this study were comparable with those of other authors in similar environmental condition (Bachmann and Schulthers, 1987; Hassan *et al*, 1987 and El-Amin and Wilcox, 1992). Dell'Orto *et al* (2000) reported that camel can produce 1.8 to 4.5 k/day of milk in Kenya. Milk yield was the highest at the third month after parturition, showing an irregular pattern in the following months. According to the literature, the daily milk yields mostly depend on area, breed, feeding, milking system. The highest average lactation yields were reported from Pakistan, India, Libya and ex-USSR (Yagil, 1982 and Knoess *et al*, 1986). The milk yield of a particular herd is influenced not only by the fodder quality and availability of water, but also by the frequency of milking (Knoess, 1976). The system of

separating the camel calves in the evening, recording milk yield in the morning and multiplying the record yield by a factor two led to a quantity which was smaller than the true daily production. In this study there was a constant variation between the production of milk of Groups I and II. Yagil (1982) has reported an daily average of 5 kg in Somalia and in Egypt, while Burgemeister (1974) has reported an average daily milk production of 4 kg in Tunisia with a lactation length of 12 months. In the present study a maximum average of 3.2 l/day was obtained for the Group II (Fig 1) which was supplemented with 4 kg/day/head for a lactation duration of 10 months. The milk yields reported vary from 3.5 kg for animals under desert conditions up to 18 kg for animals in irrigated land. In the beginning of lactation (weeks 2 to 4), the camel weight average of the two groups were similar. The higher supple-mentation of food of the Group II than the Group I had then a clear effect on the weight of camels. The weight of camels of Groups I and II decreased with the stage of lactation. Camels in Tunisia are specially known characterised by their meat production, this is why the supplementation of food has not a great effect on the production of milk.

Milk composition

Several studies have reported results on the composition of camel milk, but the data sometimes differ because of differences in breed, length of lactation at the sampling time, sampling procedures, and management.

The total solids content of milk for the two groups decreased in parallel to a minimum at weeks 15 to 29 which corresponded at the summer season (Fig 2). The fat content of milk decreased from the beginning of lactation to a minimum (weeks 15 to 29) for Groups I and II. The Group I had a higher level of fat than the Group II. It increased slightly and then decreased again at the end of lactation (Fig 2). Generally, The fat content of camel milk vary according to the season (Knoess *et al*, 1986), the stage of lactation (El-Amin, 1979) and the pregnancy (Rodriguez *et al*, 1985). Fat contents in camel's milk are similar to those in cows' milk (Gorban and Izzedin, 1997 and Farah, 1996). Milk fat varies between 2.8 and 3.7 % which was similar to the averages that we found. Protein concentration decreased during the first four months of lactation, and then increased until the end of lactation. The level of protein content of the two groups are lower in summer during the fourth and fifth month. Protein contents in camels' milk are similar to those in cows' milk (Gorban and Izzedin, 1997 and Farah, 1996). Milk protein ranges from 2.8 to 4.0 % for our study it ranges between 20.2 to 44.6 g/l. The lactose content in milk of the Groups I and II decreased slowly until 21 to 27 weeks of lactation which corresponded to the dry season of June to July (Fig 2). The average lactose content of camel milk ranges from 20.2 to 44.6 g/l. There was not a great difference in level of lactose in milk between the two groups throughout lactation. Sawaya *et al* (1984) have shown that the mean content of lactose of Nadji camel milk in Saudi Arabia (4.4 %) was slightly lower than that of cow milk (4.9 %) but higher than that reported by Shalash (1979) and Knoess (1976) for arid Egyptian and Ethiopian camel milk, respectively.

Ash content (Fig 1) was high, suggesting that, depending on yields, camel milk could provide a high level of minerals for consumers. The camel milk contained higher mineral concentration than the milk of others animals (Gorban and Izzedin, 1997). The mineral content of camel milk was expressed as the ash relative proportion, which was comprised between 0.6 to 0.8 %. El-Amin and Wilcox (1992) have found lower mineral content than that determined in the present study, whereas Attia *et al* (2001) have reported mineral content for camel and cow milk higher than that of the present study. The sodium content for the two groups was higher (0.69 g/l) than the previously reported by El-Amin and Wilcox (1992). Again the level of sodium (potassium) can be affected by seasonal heat and water intake (Yagil and Etzein, 1980). Potassium, calcium and magnesium levels were higher than those previously reported for Saudi (Sawaya *et al*, 1984 and El-Amin and Wilcox, 1992) and Ethiopian (Knoess, 1977) camel milks.

There were no difference in level of pH and acidity between the Groups I and II. The pH was highly dependent on the stage of lactation, although the average pH found was similar to that reported by other workers (Sawaya *et al*, 1984 and Mehaia *et al*, 1995). The titrable acidity decreased gradually to reach a minimum value between weeks 20 to 22 and then increased to the end of lactation. The titrable acidity was not affected by the stage of lactation. The average acidity found was higher than that found for camels and cows in Saudi Arabia (Sawaya *et al*, 1984).

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