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(Original Article)

Chemical Composition and Microbiological Quality of Camel Milk

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Abstract

So far, there has been little available literature regarding the quality and safety of consumed raw camel milk. Therefore, the present study aimed at examining some chemical composition and microbiological quality of camel milk. To achieve this aim, three batches of samples of camel milk were collected from various regions (Aswan; Qena; New Valley) undergoing chemical composition analyses and microbiological quality. The results showed that, the average values of acidity, density, moisture, total solids, total nitrogen, soluble nitrogen, total protein and fat were; 0.19%, 1.025 g/cm^3, 87%, 13%, 0.417%, 0.080, 2.66 and 2.34 and 0.19%, 1.028 g/cm^3, 85.5%, 14.5%, 0.458%, 0.082%, 2.92% and 3% and 0.17%, 1.033 g/cm^3, 81%, 19%, 0.430%, 0.117%, 2.74% and 4.1% in the samples collected from Aswan, Qena and New Valley; respectively. Moreover, microbiological analysis revealed that, the average counts (Log cfu/ml) of total bacterial counts were 3.92, 3.20 and 3.70, While the average counts (Log cfu/ml) of lactic acid bacteria were 3.53, 3.37 and 3.64 in the samples collected from Aswan, Qena and New Valley; respectively. Furthermore, the coliform bacteria, Yeasts and Moulds counts, and clostridium count were not detected in all investigated samples.

Keywords: *Camel milk, Chemical composition, Microbiological quality.*

Introduction

Camels (*Camelus dromedarius*) are the most productive and surviving animal species under difficult environmental conditions, and the single-humped camel plays a social and economic role in the arid and semi-arid regions of Asia and Africa (Gwida *et al*., 2011). Since thousands of years, camels have been integrated into the daily life of nomads and reared under harsh conditions. Currently, camel a highly valued animal for its meat, milk, wool, skin, and folk medicine. It also serves as a mean of transportation, sport as well as a source of pride and wealth (Abbas *et al*., 2013). The population of the Arabian one-humped camel is approximately 25 million, of which, 159 thousand raised in Egypt (FAO, 2014). In Egypt, the majority of people consume cow's milk regularly than camel milk, due to the fact that cows and buffalos give much more milk and require less maintenance and labor. Unfortunately, people are unaware about the nutritional facts and healthy benefits of camel's milk, their composition

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is different from that of ruminants (Al-Haj and Al-Kanhal, 2010). Camel milk is the most valuable product and it is known as 'white gold of the desert' (Wernery, 2006 and Davati *et al*. 2015). The period life of raw Camel milk is 8-9 h (Singh *et al.,* 2017). In 2016, Camel milk contributed to the non-bovine milk production with a total amount of 2.7 million tons (FAO, 2018). Camel milk has proved to be suitable for producing various derived products with significant nutritional value (Khalesi *et al*., 2017). It is mainly valued for its better digestive in the gastrointestinal system due to contain it the smallest fat globules and its hypoallergenic properties (Meena *et al*., 2013). They do not naturally aggregate due to the absence of agglutinin (Khalesi *et al*, 2017). Camel milk do not contain β-lactoglobulins as in human milk, therefore, α-lactalbumin is the main whey protein in camel milk (Alhaj *et al*. 2013). Consequently, Camel milk can easily be digested and safely consumed by people with weak immune systems or lactose intolerance (Jirimutu *et al.,* 2010 and Shori, 2015). It is one of the mainor contributors to saturated fatty acid (SFA) and unsaturated fatty acid (USFA) intake (Wang and Hu, 2017). Indeed, camel milk has recently been recognized for several therapeutic properties such as being anticancer, antidiabetic and recommended for children allergic to bovine milk (Faye, 2013 and Khalesi *et al*., 2017). So, the objective of this study was to evaluate the chemical and microbiological quality of the camel milk.

Materials and Methods

Camel milk samples

18 samples of Camel milk were collected from different 3 various governorate in Egypt (Aswan, Qena and New Valley), all the samples were immediately kept under aseptic conditions and cooled until analyzed.

Chemical analysis

Determination of titratable acidity, total solids (TS), density, total nitrogen (TN) and soluble nitrogen (SN) contents were determined according to the methods described by A.O.A.C. (2000).

Total protein (TP) contents were determined using the following equations: Total protein = TN × 6.38

Fat content was determined by using Gerber method as described by Ling (1963).

Microbiological analysis

One ml of well stirred Camel milk was transferred under aseptic condition, to 9 ml sterilized saline (0.85% NaCl) in making the serial dilution were prepared for counting the following groups of bacteria:

- Total bacterial count (T.B.C.) were determined by using the standard plate count technique as described by Marshall (2004).
- Lactic acid bacterial count was determined using MRS agar medium according to the methods described in the International Standard (FIL/IDF 117A, 1988).

- Coliform bacteria detection was determined by using MacConkey broth according to Bradley *et al.* (1992).
- Yeasts and Moulds counts were determined according to the methods described in FIL/IDF (1985).
- *Clostridium spp*. were determined according to the methods described by Mirhosseini *et al*. (2010).

Results and Discussion

Chemical composition of Camel milk

Data presented in Table 1 represented the chemical composition of Camel milk collected from different two areas located in Aswan governorate (A1 and A2). It could be observed that, the mean values of acidity determined as lactic acid was 0.18% in samples collected from A1, while the mean values of acidity in the samples collected from A2 was 0.19%. In addition, the mean values of density were 1.028 and 1.021 g/cm^3 in A1 and A2, respectively.

Table 1. Chemical composition of Camel milk collected from Aswan governorate

Areas	Chemical properties							
	Acidity (%)	**Density (g/cm^3)**	**Moisture (%)**	**TS (%)**	**TN (%)**	**SN (%)**	**TP (%)**	**Fat (%)**
A1	0.18	1.028	84	16	0.422	0.084	2.69	2.6
	0.18	1.028	84	16	0.422	0.084	2.69	2.6
	0.19	1.028	84	16	0.422	0.086	2.69	3.0
Mean	**0.18**	**1.028**	**84**	**16**	**0.422**	**0.085**	**2.69**	**2.7**
A2	0.19	1.021	90	10	0.412	0.075	2.63	2.0
	0.19	1.022	90	10	0.412	0.075	2.63	2.0
	0.18	1.021	90	10	0.413	0.075	2.63	2.0
Mean	**0.19**	**1.021**	**90**	**10**	**0.412**	**0.075**	**2.63**	**2.0**
General average	**0.19**	**1.025**	**87**	**13**	**0.417**	**0.080**	**2.66**	**2.4**

A1: Darao area; A2: Edfu area; TS: total solids; TN: total nitrogen; SN: soluble nitrogen; TP: total protein

Moreover, the mean values of moisture and TS percentages were 84 and 90% and 16 and 10% for A1 and A2; respectively. Regarding to the protein characteristic, it could also notice that the TN as well as TP in both areas were closed to each other, while in the case of SN the mean values of the A1 was higher than that of A2. Finally, the mean value of fat content in A1 was higher than that of A2. These results are in harmony with those of Ibrahim *et al.* (2018).

Data presented in Table 2 represented the chemical composition of Camel milk collected from different two areas located in Qena governorate (A1 and A2). It could be observed that, the mean values of acidity determined as lactic acid was 0.17% in samples collected from A1, while the mean values of acidity in the samples collected from A2 was 0.20%. In addition, the mean values of density were 1.028 and 1.027 g/cm^3 in A1 and A2, respectively. Moreover, the mean values of moisture and TS percentages were 83 and 88% and 17 and 12% for A1 and A2, respectively.

Table 2. Chemical composition of Camel milk collected from Qena governorate

Areas	Chemical properties							
	Acidity (%)	Density (g/cm^3)	Moisture (%)	TS (%)	TN (%)	SN (%)	TP (%)	Fat (%)
A1	0.17	1.028	83	17	0.476	0.075	3.04	3.0
	0.17	1.028	83	17	0.475	0.075	3.03	3.0
	0.18	1.028	83	17	0.470	0.084	2.99	3.0
Mean	**0.17**	**1.028**	**83**	**17**	**0.474**	**0.078**	**3.02**	**3.0**
A2	0.20	1.027	88	12	0.411	0.084	2.62	2.9
	0.20	1.027	88	12	0.462	0.085	2.95	3.0
	0.20	1.027	88	12	0.454	0.085	2.90	3.0
Mean	**0.20**	**1.027**	**88**	**12**	**0.442**	**0.085**	**2.82**	**3.0**
General average	**0.19**	**1.028**	**85.5**	**14.5**	**0.458**	**0.082**	**2.92**	**3.0**

A1: Naqada area; A2: Mahrousa area; TS: total solids; TN: total nitrogen; SN: soluble nitrogen; TP: total protein

Regarding to the protein characteristic, it could also notice that the TN as well as TP in both areas were closed to each other, while in the case of SN the mean values of the A1 was lower than that of A2. Finally, the mean value of fat content in both areas were similar. These results are in harmony with those of Bouhaddaoui *et al*. (2019).

Data presented in Table 3 represented the chemical composition of Camel milk collected from different two areas located in New Valley governorate (A1 and A2).

Table 3. Chemical composition of Camel milk collected from New Valley governorate

Areas	Chemical properties							
	Acidity (%)	Density (g/cm^3)	Moisture (%)	TS (%)	TN (%)	SN (%)	TP (%)	Fat (%)
A1	0.16	1.031	81	19	0.420	0.140	2.68	2.7
	0.15	1.031	80	20	0.420	0.140	2.68	2.7
	0.16	1.031	81	19	0.392	0.168	2.50	2.7
Mean	**0.16**	**1.031**	**81**	**19**	**0.411**	**0.149**	**2.62**	**2.7**
A2	0.18	1.035	81	19	0.448	0.084	2.86	5.4
	0.18	1.035	81	19	0.448	0.084	2.86	5.4
	0.18	1.035	81	19	0.448	0.084	2.86	5.4
Mean	**0.18**	**1.035**	**81**	**19**	**0.448**	**0.084**	**2.86**	**5.4**
General average	**0.17**	**1.033**	**81**	**19**	**0.430**	**0.117**	**2.74**	**4.1**

A1: Gharb El-Maohob area; A2: Dahos area; TS: total solids; TN: total nitrogen; SN: soluble nitrogen; TP: total protein

It could be observed that, the mean values of acidity determined as lactic acid was 0.16% in samples collected from A1, while the mean values of acidity in the samples collected from A2 was 0.18%. In addition, the mean values of density were 1.031 and 1.035 g/cm^3 in A1 and A2, respectively. Moreover, the mean values of moisture and TS percentages in both areas were similar.

Regarding to the protein characteristic, it could also notice that the TN as well as TP in A1 lower than that of A2, while in the case of SN the mean values of the A1 was higher than that of A2. Finally, the mean value of fat content in A1

lower than that of A2. These results are in harmony with those of El-Sheikh *et al*., 2016 and Ibrahim *et al*., 2018.

Microbiological quality of Camel milk

Data presented in Table 4 represented the microbiological quality of Camel milk collected from different two areas located (A1 and A2) in Aswan governorate, the values are estimated as logarithms.

Table 4. Microbiological quality of Camel milk collected from Aswan governorate

Areas	Microbiological quality				
	TBC	**LAB**	**Coliform**	**Yeasts and Moulds**	***Clostridium* spp.**
A1	4.26	4.10	ND*	ND	ND
	4.02	3.89	ND	ND	ND
	3.83	3.02	ND	ND	ND
Mean	**4.04**	**3.67**	**ND**	**ND**	**ND**
A2	4.34	3.70	ND	ND	ND
	3.40	3.28	ND	ND	ND
	3.67	3.18	ND	ND	ND
Mean	**3.80**	**3.39**	**ND**	**ND**	**ND**
General average	**3.92**	**3.53**	**ND**	**ND**	**ND**

A1: Darao area; A2: Edfu area; TBC: total bacterial count; LAB: lactic acid bacteria; ND: Not detected

From this data, it could be observed that the mean counts (Log cfu/ml) of TBC was 4.04 in samples collected from A1, while the mean counts of TBC in the samples collected from A2 was 3.80. In addition, the mean counts (Log cfu/ml) of LAB were 3.67 and 3.39 in A1 and A2; respectively. Moreover, the coliform bacteria, Yeasts and Moulds and Clostridium counts were not detected in all investigated samples. These results are in agreement with those reported by Elsheikh *et al*., 2016 and Ibrahim *et al.*, 2018).

Data presented in Table 5 represented the microbiological quality of Camel milk collected from different two areas located (A1 and A2) in Qena governorate, the values are estimated as logarithms.

Table 5. Microbiological quality of Camel milk collected from Qena governorate

Areas	Microbiological quality				
	TBC	**LAB**	**Coliform**	**Yeasts and Moulds**	***Clostridium* spp.**
A1	4.13	4.16	ND	ND	ND
	4.19	3.11	ND	ND	ND
	4.16	4.10	ND	ND	ND
Mean	**4.16**	**3.79**	**ND**	**ND**	**ND**
A2	2.36	3.10	ND	ND	ND
	2.33	2.88	ND	ND	ND
	2.02	2.83	ND	ND	ND
Mean	**2.24**	**2.94**	**ND**	**ND**	**ND**
General average	**3.20**	**3.37**	**ND**	**ND**	**ND**

A1: Naqada area; A2: Mahrousa area; TBC: total bacterial count; LAB: lactic acid bacteria; ND: Not detected

From this data, it could be observed that the mean counts (Log cfu/ml) of TBC was 4.16 in samples collected from A1, while the mean counts of TBC in the samples collected from A2 was 2.24. In addition, the mean counts of LAB were 3.79 and 2.94 in A1 and A2; respectively. Moreover, the coliform bacteria, Yeasts and Moulds and clostridium counts were not detected in all investigated samples. These results are in agreement with those reported by Abdoul-Latif *et al*. (2017).

Data presented in Table 6 represented the microbiological quality of Camel milk collected from different two areas located (A1 and A2) in New Valley governorate, the values are estimated as logarithms.

From this data, it could be observed that the mean counts (Log cfu/ml) of TBC was 4.05 in samples collected from A1, while the mean counts of TBC in the samples collected from A2 was 3.35.

Table 6. Microbiological quality of Camel milk collected from New Valley governorate

Areas	Microbiological quality				
	TBC	**LAB**	**Coliform**	**Yeasts and Moulds**	***Clostridium* spp.**
A1	4.19	4.18	ND	ND	ND
	5.13	4.13	ND	ND	ND
	2.83	2.84	ND	ND	ND
Mean	**4.05**	**3.72**	**ND**	**ND**	**ND**
A2	3.33	3.02	ND	ND	ND
	3.36	3.84	ND	ND	ND
	3.37	3.83	ND	ND	ND
Mean	**3.35**	**3.56**	**ND**	**ND**	**ND**
General average	**3.70**	**3.64**	**ND**	**ND**	**ND**

A1: Gharb El-Maohob area; A2: Dahos area; TBC: total bacterial count; LAB: lactic acid bacteria; ND: Not detected

In addition, the mean counts (Log cfu/ml) of LAB were 3.72 and 3.56 in A1 and A2; respectively. Moreover, the coliform bacteria, Yeasts and Moulds and clostridium counts were not detected in all investigated samples. These results are in agreement with those reported by Abdoul-Latif *et al*. (2017).

Comparison between general averages of Camel milk samples being collected from some governorate in Egypt (Aswan, Qena and New Valley)

Chemical composition

As shown in Table 7 represent the general average chemical composition of the Camel milk samples being collected from some governorate in Egypt (Aswan; Qena and New Valley).

From this Table, it could be observed that the average of acidity percentages determined as lactic acid were 0.19, 0.19 and 0.17%, whilst the average of density values was 1.025, 1.023 and 1.033 g/cm^3 in the samples collected from Aswan, Qena and New Valley, respectively. The highest density

was in collected samples from New Valley. These results are in harmony with those of Bouhaddaoui *et al.* (2019).

Table 7. Average chemical composition of Camel milk collected from some governorate in Egypt.

Governorate	Chemical properties							
	Acidity (%)	Density (g/cm^3)	Moisture (%)	TS (%)	TN (%)	SN (%)	TP (%)	Fat (%)
Aswan	0.19	1.025	87	13	0.417	0.080	2.66	2.4
Qena	0.19	1.023	85.5	14.5	0.458	0.082	2.92	3.0
New Valley	0.17	1.033	81	19	0.430	0.117	2.74	4.1

TS: total solids; TN: total nitrogen; SN: soluble nitrogen; TP: total protein

Regarding TS and moisture content, the results showed that, the TS percentages are ranged from 13% (Aswan) to 19% (New Valley) with mean value 16%. While moisture percentages are ranged from 81% (New valley) to 87% (Aswan) with mean value 84%. These results are in agreement with those reported by Elsheikh *et al*., 2016 and Ibrahim *et al.* 2018.

Regarding to the protein characteristic, it could also notice that the TN percentages are ranged from 0.417% (Aswan) to 0.458% (Qena) with mean value 0.438%. While SN percentages are ranged from 0.080% (Aswan) to 0.117% (New Valley) with mean value 0.099%. Whereas TP are ranged from 2.66% (Aswan) to 2.92% (Qena) with mean value 2.79%. However, all values of the investigated samples lie round the value of the ranges obtained by Yoganandi *et al*. (2014).

Finally, the mean value of fat content was ranged from 2.4% (Aswan) to 4.1% (New Valley) with mean value 3.3%. These results are in harmony with those of Mourad *et al*., 2014 and Ibrahim *et al*., 2018.

Microbiological quality

As shown in Table 8 represent the general average microbiological quality of the Camel milk samples being collected from some governorate in Egypt (Aswan; Qena and New Valley).

From this Table, it could be observed that the average counts (Log cfu/ml) of TBC were 3.92, 3.20 and 3.70 in the samples collected from Aswan, Qena and New Valley; respectively. These results are in agreement with those reported by El-Hosseny *et al*. (2018).

Table 8. Average microbiological quality (Log cfu/ml) of Camel milk collected from some governorate in Egypt.

Governorate	Microbiological quality				
	TBC	LAB	Coliform	Yeasts and Moulds	*Clostridium* spp.
Aswan	3.92	3.53	ND	ND	ND
Qena	3.20	3.37	ND	ND	ND
New Valley	3.70	3.64	ND	ND	ND

TBC: total bacterial count; LAB: lactic acid bacteria; ND: Not detected

Moreover, the average counts (Log cfu/ml) of LAB were 3.53, 3.37 and 3.64. These results are in harmony with those of Bouhaddaoui *et al.* (2019).

Furthermore, the coliform bacteria, Yeasts and Moulds counts, and clostridium count were not detected in all investigated samples. These results were in agreement with those obtained by Abdoul-latif *et al* (2017).

Conclusions

It could be concluded that, the different samples of Camel milk produced in different governorate in Egypt were safe for consumption. However, more attention must be paid to improve the quality of raw Camel milk and the equipment used in its manufacturing. Samples contains the recommended level of total solids, fats and total protein. Also, the coliform bacteria, Yeasts and Moulds have not detected in the investigated samples, make it a suitable for human diet.

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التركيب الكيماوي والجودة الميكروبيولوجية للبن الإبل

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الملخص

حتى الآن ، لا يتوفر سوى القليل من الابحاث المتعلقة بجودة وسلامة لبن الإبل الخام المستهلك في مصر لذلك هدفت الدراسة الحالية إلى فحص بعض الخواص الكيميائية والجودة الميكروبيولوجية للبن الإبل ، ولتحقيق هذا الهدف تم جمع ثلاث دفعات من عينات لبن الإبل من مناطق مختلفة (أسوان ، قنا ، الوادي الجديد) خضعوا لتحليل التركيب الكيميائي والجودة الميكروبيولوجية، وقد ظهرت النتائج أن متوسط قيم الحموضة ، الكثافة ، الرطوبة ، المواد الصلبة الكلية ، النيتروجين الكلي ، النيتروجين الذائب ، البروتين الكلي والدهون كانت 0.19% ، 1.025 جم/سم^3 ، 87% ، 13% ، 0.417% ، 0.080% ، 2.66% ، 2.4% في العينات المجمعة من محافظة أسوان ، 0.19% ، 1.028 جم/سم^3 ، 85.5% ، 14.5% ، 0.458% ، 0.082% ، 2.92% ، 3% في العينات المجمعة من محافظة قنا ، 0.17% ، 1.033 جم/سم^3 ، 81% ، 19% ، 0.430% ، 0.117% ، 2.74% ، 4.1% في العينات المجمعة من محافظة الوادي الجديد على التوالي ، وقد أظهر التحليل الميكروبيولوجي أن متوسط العدد البكتيري الكلي (لوغاريتم وحدة خلية ميكروبية/مل لبن) كان 3.92 و 3.20 و 3.70 ، بينما كان متوسط العدد (لوغاريتم وحدة خلية ميكروبية/مل لبن) لبكتيريا حمض اللاكتيك 3.53 و 3.37 و 3.64 في العينات المأخوذة من محافظة أسوان وقنا والوادي الجديد على التوالي ، علاوة على ذلك ، لم يتم الكشف عن بكتيريا القولون والخمائر والفطريات وبكتريا الـ *Clostridium spp*. في جميع العينات التي تم فحصها.