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A study on the effect of thermal treatments on composition and some properties of camel milk

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The present study was carried out to investigate the effect of different thermal treatments on the composition and chemical properties of camel milk. The rennet clotting time of camel milk was also investigated. Camel milk samples were thermal treated at 63, 80 and 90°C for 30 min and 72°C for 15 s, whereas raw milk sample was served as a control. We found that the fat content was not affected by the applied treatments ($3.2\pm 0.189\%$), but the protein contents average \pm SD values were found to be 3.2 ± 0.148 , 3.4 ± 0.136 , 3.4 ± 0.149 , 3.3 ± 0.049 and $3.1\pm 0.157\%$, respectively. The ash contents were also affected by the thermal treatments and their average \pm SD values were 0.70 ± 0.065 , 0.71 ± 0.056 , 0.73 ± 0.052 , 0.71 ± 0.088 and $0.68\pm 0.096\%$, respectively. The thermal treatments affected also the total solids in the samples; 10.0 ± 1.168 , 10.10 ± 1.057 , 10.16 ± 1.089 , 10.05 ± 1.055 and $9.9\pm 1.189\%$, respectively. The non protein nitrogen (NPN), non casein nitrogen (NCN) and whey protein nitrogen (WPN) gradually decreased as thermal treatments were increased but casein number and the percentage of denaturation were increased. Rennet clotting time in the presence of different concentrations of CaCl_2 (0 to 20 mg /100 ml) was found to be increasing by raising the temperature. However, increasing the amount of calcium chloride was found to be decreasing the rennet clotting time at all thermal treatment. Incubation of milk with yoghurt culture at 40°C for 12 h revealed a significant increase to the acidity level and a substantial decrease in the pH level at all the applied thermal treatments.

Key words: Camel milk, heat treatments, chemical composition, some properties.

INTRODUCTION

Camel milk represents one of the basic ingredients of human food in many parts of the world, especially in the arid and semi-arid zones. Camels, even under extreme hostile conditions of high temperatures, drought, lack of pastures and lack of water, can survive and produce good quality milk.

Despite the low percentage of camel milk in the total milk production in Egypt, camel milk has attracted the attention of researchers over the past few decades. The composition, chemical properties and suitability of processing camel milk were studied by a number of researchers (Bayoumi, 1990; Farag and Kebary, 1992; El-gammal and Moussa, 2007; Hassan et al. 2009). The chemical composition, properties processing and products were studied recently by Mal and Pathak

(2010). A good review about the production and composition of camel milk is given by Khan and Iqbal (2001).

A number of researchers reported the health benefits of camel milk. It was found that camel milk contains good qualities of lactoferrin, lactoperoxidase, lysozyme and other antibacterial and antiviral protective proteins, which made it more superior over cow milk in terms of nutrients (El-Agamy et al., 1992; Abd El-Gawad et al., 1996; El-Agamy, 2000; Mal and Pathak, 2010).

As known, milk is a heat labile material and the thermal treatments of milk are to improve quality. Therefore, it is very important to understand the changes happening in the technological, biological and functional properties of milk during the applied thermal treatments. Such changes were noted in sheep and goat milk. To the best of our knowledge, very limited studies have been carried out on camel milk (Farah, 1986; Farah and Atkins, 1992; Hassan et al., 2009).

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Table 1. Effect of different thermal treatments on gross chemical composition of camel milk*.

Constituent (%)	Raw milk	Thermal treatment			
		63°C for 30 min	80°C for 30 min	90°C for 30 min	72°C for 15 s
Fat	3.2±0.189 ^a	3.2±0.189 ^a	3.2±0.189 ^a	3.2±0.189 ^a	3.2±0.189 ^a
Protein	3.1±0.157 ^c	3.2±0.148 ^b	3.4±0.136 ^a	3.4±0.149 ^a	3.3±0.127 ^b
Ash	0.68±0.096 ^c	0.70±0.065 ^b	0.71±0.056 ^b	0.73±0.052 ^a	0.71±0.088 ^b
Total solids	9.9±1.189 ^c	10.0±1.168 ^c	10.10±1.057 ^b	10.16±1.089 ^a	10.05±1.055 ^b

*Averages ± Standard deviation (SD) of three replicates. *Values (a, betc.) within the same row with different superscripts differed significantly (P<0.05).

The objective of the current research was to study the impact of a number of thermal treatments on the gross chemical composition of camel milk. Activity of rennet and yoghurt culture in raw and thermal treated milk was also taken into consideration.

MATERIALS AND METHODS

Milk samples

Milk samples were collected from the herd of Animal Production Research Institute, Animal Production Research Station, located at Marsa Matrouh and kept under cooling temperatures ($4 \pm 1^\circ\text{C}$) until analysis.

Experimental procedure

Milk samples were divided into 5 equal portions. One of them was kept without thermal treatment and served as a control sample, while 3 other parts were thermally treated at 63, 80 and 90°C for 30 min. and one was thermally treated at 72°C for 15 s (using stopwatch). This was done by filling up a round bottomed flask, of a long neck fitted with a stopper, with three liters of milk for each treatment of each sample. The flask was then placed in thermostatically-controlled water bath and was gently stirred during heating, then cooled immediately after the specified time using a running tap water.

Method of analysis

All milk samples were tested for fat, ash, total solids (TS), acidity and pH as given in AOAC (2007).

Total nitrogen (TN), non - casein nitrogen (NCN) and non - protein nitrogen (NPN) were determined using the semi- micro kjeldahl method according to Ling (1963) and used for the following calculations:

$$\text{Total protein} = \text{TN} \times 6.38$$

$$\text{Whey protein nitrogen (WPN)} = \text{NCN} - \text{NPN}$$

$$\text{Casein No.} = [(\text{TN} - \text{NCN}) / \text{TN}] \times 100$$

$$\text{Denaturation \%} = \frac{\text{WPN}_{\text{raw}} - \text{WPN}_{\text{heated}}}{\text{WPN}_{\text{raw}}} \times 100 \text{ (Manji and Kakuda, 1987).}$$

Rennet clotting time (RCT) was measured according to Berridge (1952) using calf rennet powder (Hansen's Lab., Copenhagen, Denmark), whereas the changes in acidity and pH were followed during 12 h incubation at 40°C in the presence of yoghurt culture (YC-X11) obtained from Hansen's Laboratory (Denmark). The

starter consisted of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus* and was added in adequate amount recommended for making good quality yoghurt from cow's milk (2% starter).

Statistical analysis

Statistical analysis for the attained data was done using SPSS computer program (SPSS, 1999). Analysis of variance and Duncan's test were carried out in this respect.

RESULTS AND DISCUSSION

Table 1 shows the chemical composition of camel milk samples subjected to different thermal treatments. The fat content was not affected by the applied treatments when the average ± SD value of fat remained constant being 3.2±0.189%. The highest average ± SD value of protein (3.4±0.136%) was found in thermal milk at 80°C for 30 min and 90°C for 30 min compared with raw milk (3.1±0.157%). The differences in this respect were significant. The highest ash content average ± SD value (0.73±0.052%) was achieved in the thermal treated milk at 90°C for 30 min followed by the average ± SD value of (0.71±0.056%) in milk treated by heating at 80°C for 30 min or 72°C for 15 s. The control (raw) milk had the lowest average ± SD value (0.68±0.096%) of ash content. The TS contents average ± SD values were 9.9±1.189, 10.0±1.168, 10.10±1.057, 10.16±1.089 and 10.05±1.055% in the control milk and milk treated with different thermal treatments of 63, 80, 90°C for 30 min and 72°C for 15 s, respectively. The values of TS contents reflect clearly the effect of thermally treated milk samples. The results given by Farah (1996) indicated that the thermal treatment of at 63°C for 30 min did not affect the chemical composition of camel milk. On the other hand, the gross chemical composition of camel milk agrees with the composition range reviewed by Khan and Iqbal (2001). In the local studies carried out by El-gammal and Moussa (2007) and by Hassan et al. (2009), camel milk samples contained 3.9 and 3.1% fat, 2.9 and 2.81% protein, 0.74 and 0.90% ash, whereas TS contents were 11.93 and 11.94%, respectively.

Distributions of nitrogen fractions in raw milk (control)

Table 2. Effect of different thermal treatments on the nitrogen distribution in camel milk*.

Property	Raw milk	Thermal treatment			
		63°C for 30 min	80°C for 30 min	90°C for 30 min	72°C for 15 s
% TN	0.612±0.238 ^a	0.612±0.238 ^a	0.612±0.238 ^a	0.612±0.238 ^a	0.612±0.238 ^a
% NPN	0.040±0.176 ^a	0.038±0.165 ^b	0.037±0.152 ^c	0.037±0.152 ^c	0.038±0.154 ^b
% NPN/TN	6.536±1.026 ^a	6.206±1.019 ^b	6.046±1.016 ^c	6.046±1.017 ^c	6.209±1.024 ^b
% NCN	0.168±0.196 ^a	0.154±0.165 ^b	0.129±0.145 ^d	0.112±0.138 ^e	0.136±0.158 ^c
% NCN/TN	27.385±1.265 ^a	25.196±1.247 ^b	21.029±1.149 ^c	18.317±1.056 ^d	22.222±1.136 ^c
% WPN	0.124±0.159 ^a	0.118±0.138 ^b	0.093±0.108 ^c	0.079±0.129 ^d	0.099±0.116 ^c
% WPN/TN	20.261± 1.139 ^a	19.066±1.148 ^a	15.226±1.158 ^b	12.923±1.178 ^c	16.305±1.156 ^b
Casein No.	72.622±1.338 ^d	74.814±1.392 ^c	78.971±1.448 ^b	88.792±1.565 ^a	77.783±1.463 ^b
% Denaturation	-	5.894±0.656 ^d	24.482±1.258 ^b	36.213±1.368 ^a	19.521±1.178 ^c

*Averages ± Standard deviation (SD) of three replicates. *Values (a, betc.) within the same row with different superscripts differed significantly (P<0.05).

as well as in thermal treated milk samples are present in Table 2. Different thermal treatments showed no effect on the total nitrogen (TN) content when the same average ± SD value of 0.612±0.238% was recorded in all samples. Non protein nitrogen (NPN) and %NPN/TN were affected significantly by the different thermal treatments. The highest values were recorded for the control (raw milk) samples (0.040±0.176 and 6.536±1.026), whereas the lowest average ± SD values of 0.037±0.152 and 6.046±1.016% were found for NPN and NPN/TN of milk samples treated with the thermal treatments of 80°C for 30 min and 90°C for 30 min, respectively. Hassan et al. (2009) found the same value of 0.029 and 0.025% for NPN of raw and thermal (85°C for 5 min) camel milk.

On the other hand, the average ± SD values of non casein nitrogen (NCN) and NCN/TN% were affected by the different thermal treatments following the same trend of NPN results. The highest values were recorded for the control samples whereas the minimum values were observed for the milk subjected to the thermal treatments (80°C for 30 min and 90°C for 30min). This agrees with the results found by Hassan et al. (2009) who gave values of 0.147 and 0.104% for NCN of raw and thermal (85°C for 5 min) camel milk.

The whey protein nitrogen (WPN) and WPN/TN% contents were also studied under the different thermal treatments. They were found to be significantly decreased as affected by the different thermal treatments in comparison with the raw milk sample. On the contrary, the casein number (Casein No. = [(TN - NCN) / TN] × 100) showed increasing trend under the applied of thermal treated milk samples. This agrees with the results obtained by Hefnawy and Mehanna (1988) who reported that increasing the severity of thermal treatments, of goat's milk resulted in increasing in the values of casein nitrogen (CN) and decreasing in the values of WPN. They attributed such impact to denaturation of whey proteins that co-precipitated with the caseins. The same results were also obtained by Qi et al. (1995). On the other hand,

the results of WPN and CN came also in agreement with the results achieved by Hassan et al. (2009) for raw and thermally treated (85°C for 5 min) samples of camel milk. The corresponding values were 0.102 and 0.059% for WPN and 0.348 and 0.391% for CN, respectively.

The denaturation of whey proteins was also measured and the results are given in Table 2. It can be seen that highest denaturation (36.213±1.368%) occurred at the highest thermal treatment (90°C for 30 min), and the lowest denaturation (5.894±0.656%) was obtained at the lowest thermal treatment (63°C for 30 min). The denaturation rate increased to 24.482±1.258 and 19.521±1.178% by applying the thermal treatments of (80°C for 30 min) and (72°C for 15 s), respectively. However, it was reported in the literature that moderate thermal treatment (60 to 70°C) induced structural unfolding of the milk proteins, whereas at higher temperature, protein aggregation occurred (Schmidt et al., 1984).

Stephen and Ganguli (1974) noticed considerable changes occurred to nitrogen distribution in milk in response to thermal treatments, especially to those performed at temperatures higher than 65°C. Farah and Atkins (1992) found that camel milk showed more stability in response to thermal treatments than buffalo and cow milk that was attributed to the deficiency of k-casein and β-lactoglobulin in camel milk.

The behavior and activity of rennet and yoghurt culture in raw and thermal treated camel milk were also studied here as knowing coagulation and fermentation are important principles in making cheese and yoghurt.

Table 3 shows rennet clotting time (RCT) of raw and thermal treated milk in the presence of different calcium chloride concentrations. The control milk had the lowest RCT whereas it gradually increased in the thermal treated milk at 63, 80, 90°C for 30 min and 72°C for 15 s. The effect of increasing the amounts of calcium chloride on decreasing RCT was quite significant in all thermal treated samples. Whatever the concentration of calcium

Table 3. Rennet clotting time (RCT) of camel milk in the presence of different concentrations of calcium chloride as affected by different thermal treatments*.

Amount of CaCl ₂ (mg/ 100 ml)	Raw milk	Thermal treatment			
		63°C for 30 min	80°C for 30 min	90°C for 30 min	72°C for 15 s
0	17±1.186 ^{dA}	20±1.275 ^{cA}	26±1.256 ^{aA}	28±1.248 ^{aA}	23±1.169 ^{bA}
5	14±1.167 ^{dB}	17±1.192 ^{cB}	24±1.254 ^{aB}	25±1.268 ^{aB}	20±1.285 ^{bB}
10	12±1.154 ^{eC}	14±1.189 ^{dC}	21±1.246 ^{bC}	23±1.257 ^{aC}	18±1.157 ^{cC}
20	9±1.078 ^{dD}	12±1.128 ^{cD}	18±1.148 ^{aD}	20±1.252 ^{aD}	15±1.139 ^{bD}

*Averages ± Standard deviation (SD) of three replicates. *Values (a, betc. and A, B.....etc) within the same row and column in order with different superscripts differed significantly (P<0.05).

Table 4. Changes in acidity (%) and pH values (in parenthesis) of milk inoculated with yoghurt culture during incubation at 40°C for 12 h*.

Incubation time (h)	Raw milk	Thermal treatment			
		63°C for 30 min	80°C for 30 min	90°C for 30 min	72°C for 15 s
0	0.16±0.149 ^b (6.6±0.153 ^a)	0.15±0.158 ^c (6.5±0.172 ^a)	0.17±0.148 ^a (6.4±0.136 ^b)	0.18±0.164 ^a (6.3±0.145 ^b)	0.16±0.139 ^b (6.6±0.158 ^a)
1	0.16±0.155 ^b (6.6±0.149 ^a)	0.15±0.169 ^c (6.5±0.165 ^a)	0.17±0.156 ^a (6.4±0.148 ^b)	0.18±0.159 ^a (6.3±0.136 ^b)	0.16±0.145 ^b (6.6±0.157 ^a)
2	0.18±0.159 ^b (6.3±0.149 ^b)	0.15±0.158 ^c (6.5±0.164 ^a)	0.19±0.176 ^a (6.1±0.155 ^c)	0.20±0.198 ^a (5.9±0.167 ^c)	0.18±0.164 ^b (6.3±0.152 ^b)
4	0.18±0.175 ^c (6.3±0.153 ^b)	0.15±0.147 ^d (6.5±0.149 ^a)	0.22±0.198 ^a (5.8±0.184 ^c)	0.22±0.174 ^a (5.7±0.145 ^d)	0.20±0.166 ^b (5.9±0.176 ^c)
6	0.20±0.155 ^c (5.9±0.154 ^b)	0.17±0.153 ^d (6.4±0.164 ^a)	0.24±0.175 ^a (5.6±0.175 ^c)	0.25±0.188 ^a (5.5±0.196 ^d)	0.22±0.169 ^b (5.7±0.182 ^c)
8	0.22±0.174 ^b (5.7±0.143 ^b)	0.17±0.156 ^c (6.4±0.154 ^a)	0.26±0.196 ^a (5.4±0.123 ^c)	0.27±0.186 ^a (5.3±0.145 ^c)	
10	0.26±0.184 ^c (5.4±0.125 ^c)	0.19±0.165 ^e (6.2±0.152 ^a)	0.28±0.188 ^b (5.4±0.135 ^b)	0.30±0.179 ^a (5.1±0.174 ^d)	
12	0.30±0.196 ^b (5.1±0.126 ^c)	0.22±0.154 ^d (5.7±0.135 ^a)	0.30±0.185 ^b (5.4±0.149 ^b)	0.32±0.179 ^a (4.9±0.158 ^d)	

*Averages ± Standard deviation (SD) of three replicates. *Values (a, betc.) within the same row with different superscripts differed significantly (P<0.05).

chloride was different trends of results were recorded in the literature about the rennet behavior in camel milk. Bayoumi (1990) reported that the raw camel milk characterized with poor rennet ability even with the addition of calcium chloride. The RCT values given by Farag and Kebary (1992) ranged between 13.5 and 76 min (36.3 min in average) after the analysis of 40 camel milk samples. Recently, Hassan et al. (2009) demonstrated that no time could be recorded for RCT of both raw and thermal treated (85°C for 5 min) camel milk.

Camel milk was also incubated with a yoghurt culture for 12 h at 40°C and the changes in acidity and pH, as indicators to the activity of yoghurt culture in camel milk, were monitored as shown in Table 4. As the incubation period advanced, the acidity in raw and thermal treated milk samples increased gradually with a very slow rate. The acidity average values ± SD were 0.16±0.149, 0.15±0.158, 0.17±0.148, 0.18±0.164 and 0.16±0.139% after one hour incubation of raw and thermal treated milk at 63, 80, 90°C for 30 min and 72°C for 15 s, respectively and increased to

be 0.30±0.196, 0.22±0.154, 0.30±0.185, 0.32±0.179 and 0.26±0.152% in order at the end of incubation period. The differences in acidity in response to the applied thermal treatments were almost significant and could be due to the phase change of calcium phosphate from the soluble phase to the colloidal one. The phase change is thought to be resulted from the liberation of hydrogen ion. This agrees with the findings of Hassan et al. (2009) for camel milk.

The opposite trend was recorded concerning pH values which decreased gradually as the

incubation period advanced reaching minimum average \pm SD values of 5.1 ± 0.126 , 5.7 ± 0.135 , 5.4 ± 0.149 , 4.9 ± 0.158 and 5.4 ± 0.132 respectively at the end of incubation period for raw and thermal treated milk samples at 63, 80, 90°C for 30 min and 72°C for 15 s, respectively. The slow development of acidity, despite of addition of sufficient amounts of active yoghurt starter may be ascribed to the presence of antibacterial substances in camel milk which inhibited the activity of yoghurt culture and the effect of thermal treated on camel milk proteins by antimicrobial factors (El-Agamy et al., 1992) and El-Agamy (2000). However, El-gammal and Moussa (2007) gave acidity value of 0.58% and pH of 5.5 for the fresh yoghurt made from camel milk which needed also longer incubation time for complete coagulation.

Conclusions

Results of this study showed that the thermal treated of camel milk had significant impact on milk composition and distribution of nitrogen. Rennet clotting time in the present of different CaCl_2 was found increasing by raising the thermal treated camel milk. However, increasing the amount of calcium chloride decreased the rennet clotting time in all thermal treated. Yoghurt culture at 40°C for 12 h significant increase the acidity level and decrease the pH level at all applied thermal treated camel milk.

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