Slovak J. Anim. Sci., 44, 2011 (3): 97-102

ISSN 1337-9984

A STUDY ON THE EFFECT OF THERMAL TREATMENT ON COMPOSITION AND SOME PROPERTIES OF CAMEL MILK

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ABSTRACT

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

Despite the low percentage of camel's milk in the total milk production in Egypt, camel's 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 on the production and composition of camel milk was given by Khan and Iqbal (2001).

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

As it is known, milk is a heat labile material and the thermal treatments for milk to improve quality. Therefore, it is very important to understand the changes happened in the technological, biological and functional properties of milk during the applied thermal treatments. Such changes were extent for sheep's milk and goat's milk. To the best of our knowledge, very limited studies were carried out on camel's milk (Farah, 1986; Farah and

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Received: March 30, 2011
Accepted: July 11, 2011

Atkins, 1992; Hassan *et al*., 2009).

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

MATERIAL AND METHODS

Milk samples

Milk samples were collected from the herd of Animal Production Research Institute, Animal Production Research Station and located at Marsa Matrouh and kept under cooling temperatures (4 ± 1°C) until analysis.

Experimental procedure

Milk samples were divided into 5 equal portions. One of them was kept without thermally treated 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 / 15 sec. (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 bath of water 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 the 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:

Total protein = TN × 6.38
Whey protein nitrogen (WPN) = NCN - NPN
Casein No = [(TN - NCN) / TN] × 100
Denaturation % = WPN_{raw} - WPN_{heated} / WPN_{raw} × 100
(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 Lab. (Denmark). The starter consisted of *Streptococcus thermophilus* and *Lactobacillus delbruckii subsp. Bulgaricus* and was added in adequate amount recommended for making good quality yoghurt from cow's milk (2% starter).

Statistical Analysis for the attained data was done using SPSS computer programme (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 value of fat remained constant being 3.2±0.189%. The highest average 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

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

Constituent (%)	Raw milk	Thermal treatments			
		63°C /30 min.	80°C /30 min.	90°C /30 min.	72°C /15 sec.
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 Deviations (SD) of three replications
*Values within the same row with different superscripts differ significantly (P<0.05)

were significant. The highest ash content (0.73±0.052%) was achieved in the thermally treated milk at 90°C for 30 min. followed by the average value of 0.71±0.056% in milk treated by heating at 80°C for 30 min. or 72°C / 15 sec. The control (raw) milk had the lowest average value (0.68±0.096%) for ash content. The TS contents 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°C, 80°C, 90°C /30 min. and 72°C /15 sec., 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 is in agreement 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) as well as in thermally treated milk samples are presented in Table 2. Different thermal treatments showed no effect on the total nitrogen (TN) content when the same 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 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 /30 min. and 90°C /30 min., respectively. Hassan *et al.* (2009) found the same value of 0.029 and 0.025% for NPN of raw and thermally treated (85°C / 5 min) camel milk.

On the other hand, the average 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

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

Property	Raw milk	Thermal treatments			
		63°C /30 min.	80°C /30 min.	90°C /30 min.	72°C /15 sec.
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 Deviations (SD) of three replications

*Values within the same row with different superscripts differ significantly (P<0.05)

(80°C /30 min. and 90°C /30 min.). This agrees with the results of Hassan et al. (2009) who gave values of 0.147 and 0.104% for NCN of raw and thermally treated (85°C / 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 significantly decrease as affected by the different thermal treatments in comparison to the raw milk sample. On the contrary, the casein number [Casein No. = {(TN - NCN) / TN} × 100] showed increasing trend with the thermal treatment of 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 increase in the values of CN and decrease 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 /5 min.) samples of camel's 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 /30 min.), and the lowest denaturation (5.894±0.656 %) was obtained at the lowest thermal treatment (63°C /30 min). The denaturation rate increased to 24.482±1.258 and 19.521±1.178 % by applying the thermal treatments of (80°C / 30 min.) and (72°C / 15 sec.), respectively. However, it was reported in the literature that moderate thermal treatment (60-70°C) induced structural unfolding of the milk proteins, whereas at higher temperature protein aggregaration occurred (Schmidt *et al.*, 1984).

Stephen and Ganguli (1974) noticed considerable changes 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's milk showed more stability in response to thermal treatments than buffalo's and cow's milk that was attributed to the deficiency of k-casein and β-lactoglobulin in camel's milk.

The behavior and activity of rennet and yoghurt culture in raw and thermally treated camel's milk were also studied here considering the fact that coagulation and fermentation are important principles in manufacture of cheese and yoghurt. Table 3 shows rennet clotting time (RCT) of raw and thermally treated milk in the presence of different calcium chloride concentrations. The control milk had the lowest RCT whereas it gradually increased in the thermally treated milk at 63, 80, 90°C for 30 min. and 72°C / 15 sec. The effect of increasing the amounts of calcium chloride on decreasing RCT was quite significant in all thermally treated samples.

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

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/100ml)	Raw milk	Thermal treatments			
		63°C /30 min.	80°C /30 min.	90°C /30 min.	72°C /15 sec.
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 Deviations (SD) of three replications

*Values within the same row and column in order with different superscripts differ significantly (P<0.05)

Camel's milk was also incubated with a yoghurt culture for 12 hours at 40°C and the changes in acidity and pH, as indicators to the activity of yoghurt culture in camel's milk, were monitored as shown in Table 4. As the incubation period advanced the acidity in raw and thermally treated milk samples increased gradually with a very slow rate. The acidity values 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 of incubation of raw and thermally treated milk at 63, 80, 90°C for 30 min. and 72°C / 15 sec., respectively and increased to 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 result from the liberation of hydrogen ion. This agrees with the findings of Hassan *et al.* (2009) for camel's milk. An opposite trend was recorded concerning pH values which decreased gradually as the incubation period advanced reaching minimum 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 thermally treated milk samples at 63, 80, 90°C for 30 min. and 72°C / 15 sec., respectively.

The slow development of acidity, despite addition of sufficient amounts of active yoghurt starter may be ascribed to the presence of antibacterial substances in camel's milk which inhibited the activity of yoghurt culture and the effect of thermal treatment on camel milk proteins by antimicrobial factors (El-Agamy *et al*., 1992; 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's milk which also needed longer incubation time for complete coagulation.

CONCLUSIONS

Results of this study showed that the thermal treatment of camel's milk had significant impact on milk composition and distribution of nitrogen. Rennet clotting time in the presence of different amounts of $CaCl_2$ was found to increase by raising the thermal treatment camel's milk. However, increasing the amount of calcium chloride decreased the rennet clotting time in all thermally treated milk samples. Yoghurt culture at 40°C

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

Incubation time (h)	Raw milk	Thermal treatments			
		63°C /30 min.	80°C /30 min.	90°C /30 min.	72°C /15 sec.
Zero	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})	0.22±0.165 ^{b} (5.7 ±0.162 ^{b})
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})	0.24±0.168 ^{d} (5.6 ±0.135 ^{b})
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})	0.26±0.152 ^{c} (5.4 ±0.132 ^{b})

*Averages ± Standard Deviations (SD) of three replications

*Values within the same row with different superscripts differ significantly ($P<0.05$)

for 12 hours significantly increased the acidity level and decreased the pH level at all applied thermal treatments in camel‘s milk.

ACKNOWLEDGMENTS

The authors would like to thank the Animal Production Research Institute, Animal Production Research Station and Animal Production Research laboratory for financial support.

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