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Research Article

Effect of Heat Treatments on Physico-chemical properties of Milk Samples

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Abstract

This study assessed the effect of different heat treatments (Low pasteurized at 68°C, Flash pasteurized at 72°C, Boiled at 100°C and Sterilized at 121°C) on the quality of on four types of milk (cow, camel, sheep and goat). Raw milk samples were heated by difference types of heat treatments and physico-chemical characteristics were determined in all samples before and after heating. The results showed significant differences ($p \leq 0.05$) between raw milks on density, fat, protein, SNF, moisture content except pH, acidity and lactose content. The results showed that the raw cow milk recorded higher lactose content (4.585%), sheep milk recorded higher acidity (0.156%), density (1.039 g/cm^3), fat (8.790%), protein (5.750%) and SNF (12.40%), goat milk recorded higher pH (6.9), and moisture (88.60%). The results also showed that heat treatment affected milk properties significantly ($p \leq 0.05$); increasing heat decreased pH, protein and lactose content. Acidity was highly increased due to heat treatment but SNF, fat, density were stable.

Keywords: Heat treatments, milk quality, physico-chemical characteristics, milk properties, lactose.

Introduction

Milk as a raw material has a relatively short shelf life but it can be prolonged by heat treatment, which is an essential step adopted by the dairy industry (Raikos, 2010). In the dairy industry, every product is heated at least once; thus, heat treatment is by far the main unit operation. Thermal treatments are carried out to ensure food microbiological quality and confer various functional properties to milk products, like thermal stability, gelation, viscosity, foaming, and emulsifying ability. Milk plays an important role in the dietary intake as it helps to improve bone and dental health and possibly protect against hypertension and colon cancer. For these benefits, human being consumes milk from different animal species such as cow, goat and camel. The main objective of milk heat treatment is to eliminate pathogenic microorganisms or reduce them to a level safe for human consumption and to increase the shelf-life by inactivating spoilage microorganisms without affecting the nutritive value of milk. In modern dairy industry, milk heat treatment is the major method for milk preservation and extending the shelf-life. Heat treatment methods include thermization, low temperature long time, high temperature short time, sterilization and ultra-high temperature (Gedam *et al.,* 2007). However, in many rural areas traditional methods such as boiling are the methods of choice.

Recently, many methods other than heat treatment were used to improve the quality of fresh milk including ultraviolet treatment and microwave (Reinemann *et al.,* 2006). Most liquid foods are processed by pasteurization (HTST) and UHT processing, and pasteurization is the practice of choice in many countries around the world since it removes 95-99% of bacteria present in milk significantly extending the shelf-life (Pereira *et al.,* 2006). The quality of most dairy products is closely related to the microbial status of raw milk from which they are manufactured. Depending on the temperature, conditions and length of milk storage, various groups of microorganisms can undergo a period of intensive growth producing high concentrations of enzymes, particularly lipases and proteinases (Mani and Hubert, 1997). Although the microorganisms are destroyed by sterilization, the enzymes produced may remain active in sterilized products. The heat stability of milk is reduced when it is first homogenized and then heated, but not when homogenization follows heating (Walstra *et al*., 2006). The reason for this seems to be that heat-induced interactions of serum protein with fat surface-adsorbed casein promote heat coagulation. Extension of shelf-life from hours to months has been a prime objective of the dairy industry for many years to meet the demands for increasing distribution times and distances.

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Fluid milk processors would like to achieve 60-90 d of refrigerated shelf-life for high temperature short time (HTST) pasteurized milk to allow more efficient marketing and distribution of product (Champan and Boor, 2001). Considering the above points in mind, the objectives of this study are to evaluate the effect of milk type and heat treatments on physiochemical properties and microbial content of cow milk.

Materials and methods

Milk samples: Four types of raw milk samples (cow, camel, goat and sheep) were obtained from different farms in Khartoum state in Sudan. They were collected in sterilized bottles and transported to the laboratories during morning time in ice boxes.

Heat treatment of milk samples: A half liter (500 mL) from all the four different samples of milk was put in four different sterilized glass bottles and heated: Raw milk (treatment A), Low pasteurized at 68°C for 30 minutes (treatment B), Flash pasteurized at 72°C for 15 seconds (treatment C), and boiled at 100°C for 1 minute (treatment D) in thermostatically controlled oil bath followed by rapid cooling in ice-bath to 5°C. In another experiment the different four samples of milk were heated to 60°C (to avoid milk browning) and then sterilized at 121°C for 1 minute (treatment E) by autoclave, followed by rapid cooling (Grant *et al.,* 1996).

Chemical and physical analysis: The chemical and physical analyses for different milk samples were determined as follows: The pH of samples was determined using electronic pH meter (3510 pH meter). The titrable acidity of the samples was determined according to the method described in AOAC (1990). Fat content was determined by Gerber method according to AOAC (1990). Solid not fat (SNF%) was determined according to AOAC (1990). The milk density and other constituents (Protein and lactose) were determined by using milkoscan FT2 FOSS Analytical A/S.69, Slangeruggade, and DK3400 Hillerod Denmark, and also the other constituents were confirmed by the same device.

Sensory evaluation test: Sensory evaluation test was determined according to 7 point hedonic scale, a 7-point hedonic scale designed was employed to elucidate panelists' acceptance of color, taste, odor, texture and overall acceptability.

Statistical analysis: All data were subjected to statistical analysis using Statistical Analysis System (SAS). Significant differences between Means were determined by Duncan's Multiple Range Test (DMRT) at $p<0.05$ as reported (Montgomery, 2001).

Results and discussion

pH value: As shown in Table 1, the results showed that the pH value of raw milk samples were 6.90, 6.86, 6.66 and 6.61 from goat, sheep, cow and camel mike samples respectively. The results showed that there were no significant difference ($P\leq 0.05$) between raw milk samples of goat and sheep but there was a significant difference ($P\leq 0.05$) between these cow and camel milk samples. For cow milk; heat treatment in general decreased pH value, but pH value was not significantly ($P\leq0.05$) increased by treatment B (6.71) and decreased by treatment D (6.65). However pH value of cow milk was significantly ($P\leq0.05$) decreased by treatment E (6.51) and pH value was not affected by heat treatment C (6.66). For camel milk; pH values were increased but not significantly ($P\leq0.05$) by heat treatments. pH value was decreased significantly ($P\leq0.05$) by heat treatment E (6.51). For sheep milk; heat treatments decreased the pH values significantly ($P\leq0.05$) by all methods of heat, the pH values were 6.75, 6.71, 6.74 and 6.73 as recorded by A, B, C and D respectively. For goat milk heat treatments decreased pH values but not significantly ($P\leq0.05$) by all heat treatment methods, the recorded pH values were 6.87, 6.89, 6.87 and 6.85 by treatment A, B, C and D respectively. Ammara *et al.* (2009) mentioned that the pH value was 6.20-6.75 after pasteurization of milk. Sabahelkhier *et al.* (2012) reported the pH value for animal milk was 6.5 in camel, 6.6 in Cow. Hassan *et al.* (2009) mentioned that the pH values in milk heated by UHT (Ultra High Temperature), HP (High Pasteurized), LP (Low Pasteurized) were found to be (6.64-6.69), (6.21-6.69) and (5.83-6.57) respectively. The decrease in pH value in raw milk may be attributed to animal species, age, environment and feeding. The variation of pH value in milk after heating could be due to variation of heating methods and laboratory conditions.

Titratable acidity (%): As in Table 2, the results showed that the titratable acidities (%) of raw milk were 0.156, 0.152, 0.144 and 0.135 in sheep, camel, cow and goat respectively. The results showed that there were no significant differences ($P\leq0.05$) between all samples of raw milk. Generally titratable acidity (%) was increased and decreased but not significantly ($P\leq0.05$) by heat treatments compared to raw milk samples. Only titratable acidity (%) value of goat milk heated by treatment D (0.229) was significantly different ($P\leq 0.05$) from raw samples and other heat treated milk samples. Sabahelkhier *et al.* (2012) reported the titratable acidities (%) in animal milk as 0.14, 0.15, 0.12 and 0.18 for goat, camel, cow and sheep respectively. Hassan *et al.* (2009) reported that the titratable acidity in milk heated by UHT, HP, LP were found to be 0.15-0.18, 0.16-0.20 and 0.17-0.23 respectively.

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Table 1. Effect of various heat treatments on pH value of milk samples.

Treatment	Source of milk				Overall treatment (mean)
	Cow	Camel	Sheep	Goat	
(A) Raw milk	6.66[cde] ±0.01	6.61[e] ±0.9	6.86[a] ±0.02	6.90[a] ±0.02	6.76[A]
(B) Low pasteurized at 68°C	6.71[bcd] ±0.50	6.62[e] ±0.08	6.75[b] ±0.05	6.87[a] ±0.03	6.74[AB]
(C) Flash pasteurized at 72°C	6.66[cde] ±0.03	6.62[e] ±0.03	6.71[bcd] ±0.01	6.89[a] ±0.02	6.72[B]
(D) Boiled at 100°C	6.65[de] ±0.07	6.63[e] ±0.05	6.74[b] ±0.02	6.87[a] ±0.00	6.72[B]
(E) Sterilized at 121°C	6.51[f] ±0.02	6.51[f] ±0.04	6.73[bc] ±0.03	6.85[a] ±0.01	6.65[C]
Overall source of milk (mean)	6.64[C]	6.60[D]	6.76[B]	6.88[A]	
$Lsd_{0.05}$	0.06596*				
SE±	0.02236				

Values are mean ±SD. Mean(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT.

Table 2. Effect of various heat treatments on titrable acidity of milk samples.

Treatment	Source of milk				Overall treatment (mean)
	Cow	Camel	Sheep	Goat	
(A) Raw milk	0.144[b] ±0.01	0.152[b] ±0.01	0.156[b] ±0.00	0.135[b] ±0.00	0.1468[A]
(B) Low pasteurized at 68°C	0.144[b] ±0.01	0.159[b] ±0.03	0.156[b] ±0.01	0.135[b] ±0.01	0.1488[A]
(C) Flash pasteurized at 72°C	0.157[b] ±0.03	0.152[b] ±0.02	0.149[b] ±0.02	0.139[b] ±0.02	0.1495[A]
(D) Boiled at 100°C	0.157[b] ±0.03	0.1500[b] ±0.02	0.155[b] ±0.03	0.229[a] ±0.01	0.1730[A]
(E) Sterilized at 121°C	0.148[b] ±0.02	0.157[b] ±0.01	0.154[b] ±0.02	0.139[b] ±0.02	0.1496[A]
Overall source of milk (mean)	0.1500[A]	0.1542[A]	0.1542[A]	0.1557[A]	
$Lsd_{0.05}$	0.06596*				
SE±	0.02236				

Ammara *et al.* (2009) mentioned that the titratable acidity was 0.11-0.15 after pasteurization of milk. The variation of titratable acidity (%) in raw milk may be attributed to sample cleaning, animal species, age, environment and feeding, the variation of titratable acidity (%) in milk after heating could be due to variation of heated methods and laboratory conditions. Also titratable acidity (%) was affected by pH value.

Density: As shown in Table 3, the density of raw milk was found to be 1.039, 1.032, 1.029 and 1.028 in sheep, camel, cow and goat respectively. The results showed that there was a significant difference (P≤0.05) between all samples of raw milk sources. For cow milk, results showed there were no significant difference (P≤0.05) between all milk samples heated by different methods and raw milk sample. Camel milk heat treatments also have no significant (P≤0.05) effect on the density. Density was increased significantly (P≤0.05) in sheep milk heated by treatment D (1.040), but decreased significantly (P≤0.05) by treatment E (1.034). In goat milk, heat treatment decreased density but not significantly (P≤0.05) from 1.028 for raw sample to 1.027 by all heat treatment methods. Sabahelkhier *et al.* (2012) explained the density in animal milk was 1.029 in goat and camel milks it was 1.032 and 1.033 in sheep. The variation of density in raw milk may be attributed to animal species. The increase of density in milk after heating could be due to evaporation of some water that increases the concentration of milk ingredients.

Fat (%): As shown in Table 4, the fat content (%) of raw milk was found to be 8.790, 3.795, 3.120 and 2.705 in sheep, cow, goat and camel milk samples respectively. The results showed that there were significant differences (P≤0.05) between different raw milks.

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Table 3. Effect of various heat treatments on density of milk samples.

Treatment	Source of milk				Overall treatment (mean)
	Cow	Camel	Sheep	Goat	
(A) Raw milk	1.029^{g} ±0.01	1.032^{de} ±0.01	1.039^{b} ±0.02	1.028^{h} ±0.02	1.032^{B}
(B) Low pasteurized at 68°C	1.029^{g} ±0.01	1.032^{ef} ±0.01	1.039^{ab} ±0.02	1.027^{h} ±0.01	1.032^{B}
(C) Flash pasteurized at 72°C	1.029^{g} ±0.01	1.031^{f} ±0.02	1.039^{b} ±0.02	1.027^{h} ±0.01	1.032^{B}
(D) Boiled at 100°C	1.030^{g} ±0.02	1.033^{d} ±0.01	1.040^{a} ±0.01	1.027^{h} ±0.01	1.032^{A}
(E) Sterilized at 121°C	1.030^{g} ±0.01	1.032^{de} ±0.01	1.034^{c} ±0.02	1.027^{h} ±0.02	1.031^{C}
Overall source of milk (mean)	1.030^{C}	1.032^{B}	1.038^{A}	1.027^{D}	
$Lsd_{0.05}$	0.06596*				
SE±	0.02236				

Table 4. Effect of various heat treatments on fat% of milk samples.

Treatment	Source of milk				Overall treatment (mean)
	Cow	Camel	Sheep	Goat	
(A) Raw milk	3.795b ±0.05	2.705de ±0.02	8.790a ±0.05	3.120c ±0.04	4.602A
(B) Low pasteurized at 68°C	3.780b ±0.06	2.555d ±0.00	8.700a ±0.02	3.150c ±0.02	4.596A
(C) Flash pasteurized at 72°C	3.810b ±0.04	2.695de ±0.01	8.685a ±0.04	3.100c ±0.05	4.572A
(D) Boiled at 100°C	3.800b ±0.02	2.750d ±0.03	8.715a ±0.01	3.110c ±0.04	4.594A
(E) Sterilized at 121°C	3.725b ±0.06	2.620e ±0.02	8.700a ±0.04	3.160c ±0.01	4.551A
Overall source of milk (mean)	3.782D	2.705D	8.718A	3.128C	
$Lsd_{0.05}$	0.1143*				
SE±	0.03873				

Heat treatments has not significantly ($P \leq 0.05$) affected fat percentage in cow, sheep and goat milks. In camel milk, heat treatment E significantly ($P \leq 0.05$) decreased fat (%), but the other heat treatments did not significantly ($P \leq 0.05$) affect the fat percentage. Ammara *et al.* (2009) mentioned that the fat was 3.50– 3.80 after pasteurization of milk. Sabahelkhier *et al.* (2012) explained that the fat content (%) in animal milk was 3.90, 3.60, 3.75 and 6.90 for goat, camel, cow and sheep respectively. The variation of fat% in raw milk may be attributed to animal species; the increase of fat content in milk after heating could be due to loss of evaporated water during heating.

Protein (%): As shown in Table 5, the protein content (%) of raw milks were found to be 5.750, 3.235, 2.680 and 2.610 in sheep, cow, goat and camel milk samples respectively. The results showed that there were significant differences ($P \leq 0.05$) between raw milk samples. Heat treatments decreased protein content (%) significantly ($P \leq 0.05$) in cow and camel milks.

In sheep milk, the protein content (%) was not affected by treatments B, C and D but it was decreased significantly ($P \leq 0.05$) by heat treatment E. Protein content in goat milk was decreased but not significantly ($P \leq 0.05$) by heat treatment B (2.620) and but was decreased significantly ($P \leq 0.05$) by treatment D (2.580), treatment C (2.575) and treatment E (2.400). The results showed that there were no significant differences ($P \leq 0.05$) between heat treatment B, C and D, but there was a significant difference ($P \leq 0.05$) between heat treatment E and other treatments used in goat milk. Sabahelkhier *et al.* (2012) reported that the protein content in animal milk was 3.30, 2.95, 3.40 and 6.35 for goat, camel, cow and sheep respectively. Ammara *et al.* (2009) mentioned that the protein content was 3.40–3.70 after pasteurization of milk. Siddig (2002) showed that the protein content of sheep's milk is higher than in women, cow, camel and goat's milk and also found that fat content in sheep's milk is high between the other four milks. The increase of protein content in milk after heating could be due to coagulation and some other unknown reactions.

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Table 5. Effect of various heat treatments on protein % of milk samples.

Treatment	Source of milk				Overall treatment (mean)
	Cow	Camel	Sheep	Goat	
(A) Raw milk	3.235[c] ±0.02	2.610[f] ±0.02	5.750[ab] ±0.02	2.680[e] ±0.03	3.569[A]
(B) Low pasteurized at 68°C	3.080[d] ±0.04	2.510[g] ±0.01	5.800[a] ±0.01	2.620[ef] ±0.02	3.503[B]
(C) Flash pasteurized at 72°C	3.095[d] ±0.05	2.440[h] ±0.02	5.760[ab] ±0.02	2.575[fg] ±0.01	3.467[C]
(D) Boiled at 100°C	3.070[d] ±0.02	2.510[g] ±0.03	5.740[ab] ±0.01	2.580[f] ±0.02	3.475[C]
(E) Sterilized at 121°C	3.040[d] ±0.01	2.410[h] ±0.01	5.720[b] ±0.01	2.400[h] ±0.01	3.392[D]
Overall source of milk (mean)	3.104[B]	2.496[D]	5.574[A]	2.571[C]	
$Lsd_{0.05}$	0.06596*				
SE±	0.02236				

Table 6. Effect of various heat treatments on lactose % of milk samples.

Treatment	Source of milk				Overall treatment (mean)
	Cow	Camel	Sheep	Goat	
(A) Raw milk	4.585[a] ±0.06	4.365[abcd] ±0.02	4.180[cdef] ±0.04	4.320[bcde] ±0.00	4.363[A]
(B) Low pasteurized at 68°C	4.565[a] ±0.03	4.310[bcde] ±0.01	4.120[defg] ±0.03	3.910[ghi] ±0.01	4.226[BC]
(C) Flash pasteurized at 72°C	4.570[a] ±0.01	4.320[bcde] ±0.05	4.010[fghi] ±0.01	3.995[fghi] ±0.02	4.224[BC]
(D) Boiled at 100°C	4.590[a] ±0.02	4.400[abc] ±0.02	3.970[fghi] ±0.04	4.110[efgh] ±0.04	4.267[B]
(E) Sterilized at 121°C	4.550[ab] ±0.01	4.285[cde] ±0.00	3.840[i] ±0.01	3.870[hi] ±0.01	4.136[C]
Overall source of milk (mean)	4.572[A]	4.336[B]	4.024[C]	4.041[C]	
$Lsd_{0.05}$	0.2188*				
SE±	0.07416				

Lactose (%): The results in Table 6, showed that the Lactose content (%) of raw milks was found to be 4.585, 4.365, 4.320 and 4.180 in cow, camel, goat and sheep respectively. The results showed that there were no significant differences (P≤0.05) between raw milk samples of cow and camel, no significant difference (P≤0.05) between raw milk samples of camel, sheep and goat, but there was a significant difference (P≤0.05) between raw milk samples of cow, sheep and goat. Heat treatments decreased and increased Lactose content (%) but not significantly (P≤0.05) in cow and camel milks. Lactose content (%) was decreased significantly (P≤0.05) in goat milk by heat treatments: B (3.91), C (3.995) and E (3.870). Sabahelkhier *et al.* (2012) explained that the Lactose (%) in animal milk was 4.40, 4.30, 4.80 and 5.00 for goat, camel, cow and sheep respectively. The lactose content of human milk is higher than that in goat's milk as reported (Clarence *et al.*, 2004), but the lactose content of camel and cow's milk is 4.5 and 4,9% respectively as stated by Siddig (2002). Decrease of Lactose content by heating was attributed to some unknown reaction.

Non-Soluble Fat (NSF%): As shown in Table 7, the NSF content (%) of raw milk was found to be 12.40, 9.34, 8.88 and 8.28 in sheep, camel, cow and goat milk samples respectively. The results showed that there was a significant difference (P≤0.05) between raw milk samples. Heat treatment C did not affected NSF%, but heat treatments B, D and E increased SNF % but not significantly (P≤0.05) in cow milk. Heat treatment did not significantly (P≤0.05) increased NSF% by treatment E (9.35) and treatment D (9.50) and but decreased by treatment B (9.25), but significantly (P≤0.05) decreased NSF% by treatment C (9.11). In sheep milk, NSF% was decreased significantly (P≤0.05) by heat treatment E (11.13). In goat milk, NSF% was not affected by all methods of heat treatments compared to raw sample.

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Table 7. Effect of various heat treatments on SNF% of milk samples.

Treatment	Source of milk				Overall treatment (mean)
	Cow	Camel	Sheep	Goat	
(A) Raw milk	8.88^{g} ±0.11	9.34^{cd} ±0.15	12.40^{a} ±0.13	8.28^{h} ±0.16	9.73^{B}
(B) Low pasteurized at 68°C	8.90^{fg} ±0.12	9.25^{de} ±0.11	12.42^{a} ±0.14	8.27^{h} ±0.13	9.71^{B}
(C) Flash pasteurized at 72°C	8.88^{g} ±0.15	9.11^{ef} ±0.13	12.38^{a} ±0.15	8.25^{h} ±0.11	9.66^{B}
(D) Boiled at 100°C	8.98^{fg} ±0.17	9.50^{c} ±0.08	12.59^{a} ±0.10	8.23^{h} ±0.00	9.820^{A}
(E) Sterilized at 121°C	9.04^{fg} ±0.22	9.35^{cd} ±0.07	11.13^{e} ±0.10	8.28^{h} ±0.05	9.449^{C}
Overall source of milk (mean)	8.94^{C}	9.31^{B}	12.19^{A}	8.26^{D}	
$Lsd_{0.05}$	0.1979**				
SE±	0.06708				

Table 8. Effect of various heat treatments on SNF% of milk samples.

Treatment	Source of milk				Overall treatment (mean)
	Cow	Camel	Sheep	Goat	
(A) Raw milk	87.32^{d} ±0.25	87.95^{bc} ±0.16	78.81^{f} ±0.12	88.60^{a} ±0.16	85.67^{BC}
(B) Low pasteurized at 68°C	87.32^{d} ±0.24	87.99^{bc} ±0.18	78.88^{f} ±0.15	88.57^{a} ±0.1	85.69^{B}
(C) Flash pasteurized at 72°C	87.31^{d} ±0.23	88.19^{b} ±0.20	78.93^{f} ±0.19	88.65^{a} ±0.19	85.77^{B}
(D) Boiled at 100°C	87.22^{d} ±0.21	87.75^{c} ±0.13	78.70^{f} ±0.15	88.66^{a} ±0.20	85.58^{C}
(E) Sterilized at 121°C	87.24^{d} ±0.19	88.03^{b} ±0.12	80.17^{e} ±0.16	88.56^{a} ±0.22	86.00^{A}
Overall source of milk (mean)	87.28^{C}	87.98^{B}	79.10^{D}	88.61^{A}	
$Lsd_{0.05}$	0.2468**				
SE±	0.2468				

Ammara *et al.* (2009) mentioned that the NSF% was 8.55-8.60 after pasteurization of milk. Sabahelkhier *et al.* (2012) explained that the NSF% in animal milk was 12.0, 11.7, 12.8 and 19.3 for goat, camel, cow and sheep respectively. The total solid in sheep milk is higher than in goat, cow and camel as reported (Siddig, 2002; Clarence *et al.*, 2004). Increases of SNF % in milk after heating may be attributed to relation between moisture content and SNF%; the decrease of moisture by heating should increase the SNF%. The variation of SNF% in raw milk may attribute to animal species and feeding.

Moisture content (%): As shown in Table 8, the moisture content (%) of raw milk was found to be 88.60, 87.95, 87.32 and 78.81 in goat, camel, cow and sheep milk samples respectively. The results showed that there were significant differences (P≤0.05) between raw milk samples. Heat treatments did not significantly (P≤0.05) affect the moisture content (%) in cow, goat and camel milks.

There was a significant difference (P≤0.05) in moisture content% between heat treatment C and other heat treatments in camel milk, but there was no significant difference between heat treatments in cow and goat milks. Only heat treatment E decreased moisture content (%) significantly (P≤0.05) in sheep milk compared to raw milk and other heat treatments. Decreased moisture content (%) in milk samples after heating may be due to evaporation of water from milk samples. The variation of moisture content (%) in raw milk may be attributed to animal species and feeding.

Conclusion

Effect of different heat treatments (Low pasteurized at 68°C, Flash pasteurized at 72°C, Boiled at 100°C and Sterilized at 121°C) on physic-chemical properties of milk samples (cow, camel, sheep and goat) showed varied results depending on heat treatment and milk type.

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