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Effect of some processing treatments on shelf life of camel milk in comparison to cow milk

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Camel milk production is gradually increasing due to an increased interest of consumers in recent years. Camel has proved as a potential milch animal which is such an obvious solution for improving human nutrition in the arid zones of the world, where hunger is endemic. Camel milk has an important role in human nutrition as it contains all the essential nutrients (El-Agamy *et al.* 2009, Yoganandi *et al*. 2014, Kaskous 2016, Kumar *et al.* 2016, Rahmeh *et al.* 2019, Al Nohair 2021) found in bovine milk. Fresh and fermented camel milk is used as a treatment for a series of diseases such as dropsy, jaundice, tuberculosis, asthma, etc. Recently camel milk was also reported to have other potential therapeutic properties such as anti-carcinogenic (Magjeed 2005), antidiabetic (Agrawal *et al.* 2007, Rahmeh *et al.* 2019, Al Nohair 2021) and anti-hypertensive (Quan *et al.* 2008) and has been recommended for children who are allergic to bovine milk (El-Agamy *et al.* 2009).

A definite idea about the shelf life of any milk is pre-requisite for making its optimum use. In general, shelf life of milk is considered to be poor because of its high water content (De 2019, McSweeney *et al.* 2020) and hence should be consumed soon after milking. Most of the research conducted on camels in the past has focused on their anatomical and physiological features. Although, the problem of malnutrition has been overcome to a certain extent by the camel milk production in hot and arid zones, camel milk has not been given as much attention in the research as compared with bovine milk, and problem of preserving the quality of camel milk under such ambient (25°C) conditions still remains a challenge. Hence, systematic study has been carried out on shelf–life of camel milk and the effect of various processing treatments on it, as compared to cow milk so as to check its suitability and superiority in comparison to cow milk.

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In order to study the shelf-life of raw and pasteurized camel milk in comparison to cow milk, pooled camel milk samples were collected from the camel flocks of surrounding areas of Udaipur, Southern Rajasthan and brought to the laboratory under refrigerated (7°C) conditions. Similarly, pooled cow milk samples were collected from the Livestock Farm of Rajasthan, College of Agriculture, MPUAT, Udaipur in 2017. Camel and cow milk samples were divided into raw and pasteurized, followed by storage at ambient (25°C) as well as refrigerated (7°C) conditions.

Each sample was analyzed for acidity (% lactic acid), free fatty acids content (FFA) as meq/L, alcohol test and clot on boiling (COB) test.

Clot on boiling: COB test of the camel as well as cow milk samples was determined using standard methods (IS 1479 Part I 1960) method. In each sample, tests were carried out at ambient (25°C) temperature at an interval of 2 h until the sample showed positive COB test. At refrigeration temperature, tests were carried out for initial 12 h of refrigeration, with an interval of 2 h, then for next 69 h, observations were taken at every 12 h interval and finally samples were analyzed at every 24 h till COB test was found to be positive.

Acidity: Acidity of the camel as well as cow milk samples was determined using standard (IS 1479 Part I 2016) method.

Free fatty acids: The free fatty acids content of the camel as well as cow milk samples was determined by using Thomas *et al.* (1954) method.

Alcohol test: Ethanol stability of of the camel as well as cow milk samples was determined by using standard (IS 1479 Part I 2016) method.

Statistical analysis: The statistical analysis of analytical data was carried out according to Snedecor and Cochran (1994).

In the present investigation, an attempt was made to study the shelf life of raw and pasteurized camel milk in comparison to cow milk by taking into account the time required for milk samples to clot on boiling, i.e. clot on boiling time (COB). The changes in terms of acidity, free

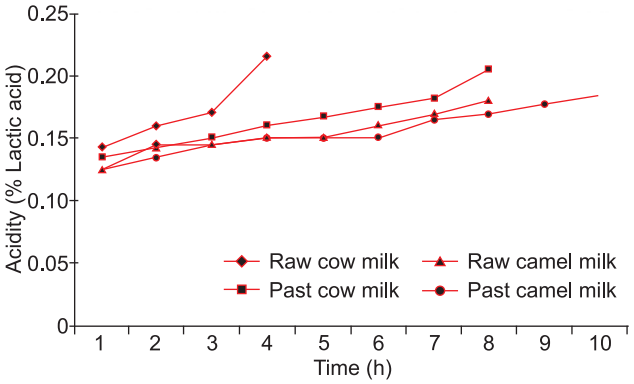

Fig. 1. Acidity of raw and pasteurized camel and cow milk under ambient conditions.

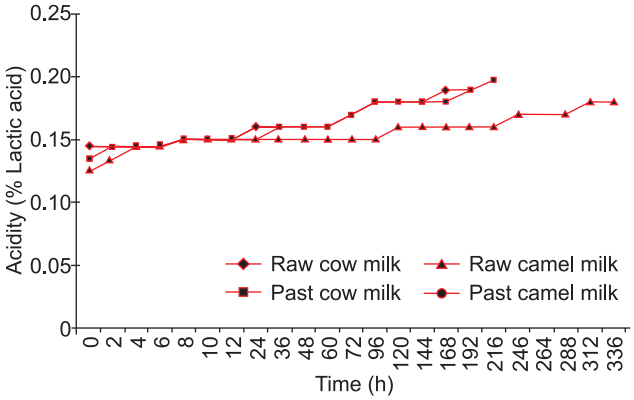

Fig. 2. Acidity of raw and pasteurized camel and cow milk under refrigerated conditions.

fatty acids content and stability towards ethanol, in milk samples were also assessed. The results obtained in the present study are presented in Table 1 and Figs 1 to 4.

Acidity: Trends in the development of acidity of raw and pasteurized camel and cow milk at ambient (25°C) and refrigerated (7°C) temperatures has been illustrated in Fig.1 and Table 1. Raw and pasteurized camel milk were found to be less acidic throughout the study. Raw cow milk clotted on boiling just after 6 h, whereas, the camel milk took 14 h for clotting. The camel milk acidity increased steadily from 0.127% to 0.153% LA till 6 h, thereafter, it remained almost constant for 6–8 h, and started rising up until it showed positive COB test after 14 h at an acidity of 0.171% LA. In case of cow milk, though it clotted on boiling just after 6 h, but it tolerated the boiling temperature till its acidity increased up to 0.21% LA. No substantial increase in the shelf life of camel milk was observed when it was pasteurized, whereas, the shelf life of cow milk increased twice on pasteurization. In pasteurized conditions, a steady increase in the acidity of camel milk was observed after 10 h, whereas from 2–4 h and from 6–10 h, it remained unaltered. The acidity of pasteurized cow milk on the other hand kept on increasing at each successive interval. The pasteurized cow milk, when clotted on boiling showed an acidity of 0.207% LA, whereas for camel milk it was 0.189% LA.

The behaviour of raw and pasteurized camel, and cow milk, on storage at refrigerated (7°C) temperature can be seen from Fig. 2**.** The figure shows that the acidity of raw camel milk was similar to that of cow milk for a interval of 4–6 h and 8–10 h in refrigerated (7°C) conditions. Raw cow milk clotted on boiling at 0.189% LA level at 168 h of refrigeration conditions. By this time, raw camel milk had only 0.162% LA and it took further ninety 6 h to show positive COB test.

In pasteurized conditions, camel milk had always lower acidity than cow milk and the gap between acidity levels of camel and cow milk increased with the time. Pasteurized cow milk clotted at 216 h (Nine days) of refrigeration when its acidity levels was 0.198% LA. Camel milk took five more days, i.e. 336 h (fourteen days) to show positive COB test, though, here also its acidity (0.171% LA) level was much lower than that of cow milk. These results revealed that the development of acidity was much slower in camel milk than its bovine counterpart during storage at ambient (25°C) as well as refrigerated (7°C) condition which is due to the reason that camel milk contains a greater content of antimicrobial components such as lysozymes, lactoferrin and immunoglobulins than do bovine milk (Konnuspayeva *et al.* 2007, Benkerroum 2008, Yoganandi *et al.* 2014,

Table 1. Effect of temperature and milk type on acidity (% lactic acid), COB test and alcohol test

Type of milk	Acidity (% lactic acid)			COB test (h)			Alcohol test (h)		
	Ambient temperature	Refrigerated temperature	Mean	Ambient temperature	Refrigerated temperature	Mean	Ambient temperature	Refrigerated temperature	Mean
Raw camel milk	0.171	0.162	0.167	14	264	139	6	36	21
Pasteurized camel milk	0.189	0.171	0.18	18	336	177	12	36	24
Raw cow milk	0.193	0.153	0.173	6	168	87	4	8	6
Pasteurized cow milk	0.207	0.198	0.203	12	216	114	10	36	23
Mean	0.19	0.171		12.5	246		8	29	
	SEm±	CD (P=0.05)	CV (%)	SEm±	CD (P=0.05)	CV (%)	SEm±	CD (P=0.05)	CV (%)
Temp	0.002	0.007	4.33	1.414	4.24	3.79	0.351	1.052	6.57
Milk type	0.003	0.01		2	5.996		0.496	1.488	
Temperature × milk type	0.005	0.014		2.828	8.48		0.702	2.105	

Data represents SEm± of three determinations; CV, cofficient of variance; SEm±Std, error mean; P value, significance level (P=0.05).

Kaskous 2016, Kumar *et al.* 2016, Rahmeh *et al.* 2019, Al Nohair 2021).

Alcohol test: Stability of milk colloidal system is determined by the acidity and salt balance of the milk, besides other factors. The simplest and fastest objective test, which may be employed to assess the stability of milk is alcohol test (Sankhla *et al*. 2013, De 2019). The assessment of stability of camel and cow milk based on alcohol test was carried out at ambient (25°C) and refrigerated (7°C) conditions. Results in Table 1 indicated that the raw camel milk showed positive alcohol test at 6 h of storage as compared to 4 h of cow milk. Pasteurization enhanced the stability of both the camel and cow milk. Camel milk was observed to be stable to 10 h whereas, corresponding figure for cow milk was 8 h, which indicated that the raw as well as pasteurized camel milk had higher stability as compared to cow milk. When refrigerated (7°C), raw as well as pasteurized camel milk was stable up to 24 h as indicated by its negative response to alcohol test up to this time. In contrast to this, under refrigerated (7°C) conditions, raw and pasteurized cow milk showed positive alcohol test at 8 h and 36 h respectively. Results indicated that refrigeration prolonged the stability of both types of milk to ethanol. However, under refrigerated (7°C) condition, the shelf life of raw camel milk was similar to that of pasteurized camel milk, hence, the pasteurization had little effect on the ethanol stability of raw camel milk. It was found to be effective in case of cow milk only which corroborates our findings with those of earlier workers (Emletan and Mohammad 2003)

Data presented in above table revealed that refrigeration caused significantly minimum lactic acid content owing to the reason that camel milk contains a greater content of antimicrobial components such as lysozymes, lactoferrin and immunoglobulins than do bovine milk (Konnuspayeva *et al.* 2007, Benkerroum 2008, Yoganandi *et al.* 2014, Kaskous 2016, Kumar *et al.* 2016, Rahmeh *et al.* 2019, Al Nohair 2021) in comparison to storage at 25°C, whereas CoB+ and alcohol content values were found significantly higher under refrigeration of both camel and cow raw as well as pasteurized milk samples.

Among the two milk types, raw camel milk revealed maximum lactic acid content whereas pasteurized camel milk showed maximum values for CoB+ and alcohol content, respectively.

At 25°C, raw cow milk showed significantly low lactic acid content whereas pasteurized camel milk revealed significantly higher values for CoB+. Thus, interaction reveals camel milk to be superior to cow's milk at all the temperatures studied. A similarity in values for alcohol content measured in raw and pasteurized camel milk samples alongside pasteurized cow's milk samples under refrigeration could be derived.

Free fatty acids: A rancid flavour defect in milk and fat rich dairy products is a serious problem faced by dairy industry. Implicitly of this flavour is due to the accumulation of free fatty acids, hypothetically cleaved from milk fat under catalytic influence of the lipases normally present in the milk (Rahmeh *et al.* 2019, McSweeney *et al.* 2020). Besides changing the natural flavour of milk, it may produce variety of other defects also like lowering of surface tension, deterioration in the quality of cream and butter milk, effective foam depression during the condensing of skim milk and whey, and reduction in fat test of composite milk sample.

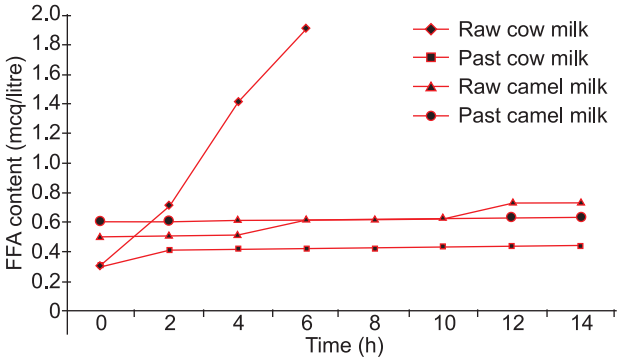

Fig. 3. FFA content of raw and pasteurized camel and cow milk under ambient conditions.

In the light of above facts, free fatty acids (FFA) content of milk samples was determined at successive time intervals, until it clotted on boiling. In fact, milk may or may not clot on boiling but it may become rancid even much earlier. It gives detectable rancid flavour defect when FFA content exceeds 1.2–1.5 meq/L of milk. Under ambient (25°C) temperature conditions, the FFA content in camel milk varied in a narrow range of 0.5–0.7 meq/L. At 14 h of storage, when camel milk clotted on boiling, its FFA content was only 0.7 meq/L. On the contrary, in cow milk, at the inception of experiment itself, FFA content was 0.3 meq/L, which was lower than that of camel milk observed at 0 h of storage. However, as clear from Fig. 3, there was a sharp rise in the FFA content of raw cow milk at each successive interval. At 6 h of storage, when it clotted on boiling, its FFA content was highest at 1.9 meq/L. It can be said that lipolysis process in cow milk initiated at an early hour. For the pasteurized milk samples, FFA content did not change during studies. FFA content in raw camel milk remained constant at 0.6 meq/L, whereas, in cow milk it remained constant at 0.4 meq/L till 14 h elapsed except for the early 2 h, where it increased from initial value of 0.3 meq/L to 0.4 meq/L. This may be due to the fact that the lipase present in milk was inactivated by pasteurization and hence the lipolysis did not proceed further.

Under refrigerated (7°C) conditions (Fig. 4) up to 72 h of storage, raw camel milk showed FFA content of 0.54 meq/L. In next 24 h, it increased to 0.6 meq/L and thereafter remained constant up to 336 h of storage. On the contrary, in raw cow milk, an increasing trend of FFA content was noticed, up to 8 h of storage, with FFA content of 0.9 meq/L (tolerable limit). After this, it crossed the tolerable limit and became rancid. At 168 h of storage, when the samples showed positive COB test, the FFA content reached highest of 2.6 meq/L. These results indicated that camel milk was less prone to lipolysis as compared to cow

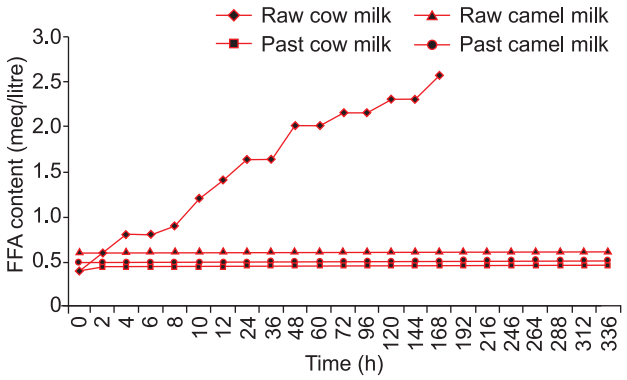

Fig. 4. FFA content of raw and pasteurized camel and cow milk under refrigerated conditions.

milk under experimental conditions. Under refrigerated (7°C) conditions of storage, FFA content did not increase on storage till end of the experiment.

Fresh camel milk and their products are a good nutritional source for the people living in the arid and urban areas. Assessment of shelf life in terms of % Lactic acid, Clot on boiling test, free fatty acids content and ethanol stability indicated that development of acidity was much slower in camel milk than cow milk during storage at ambient (25°C) as well as refrigerated (7°C) condition. Camel milk was less prone to lipolysis as compared to cow milk under experimental conditions. Both raw and pasteurized camel milk had better shelf life at ambient (25°C) and refrigerated (7°C) temperatures as compared to cow milk. Hence, it can be transported to processing units even without the need of chilling facility. Also, camel milk products with better shelf life as compared to cow milk can easily find local as well as export markets.

SUMMARY

In the present study, cow and camel raw milk showed positive clot on boiling (COB) test after 6 h and 14 h respectively. Pasteurization enhanced the shelf life of cow milk twice without any substantial increase in the shelf life of camel milk. Both raw and pasteurized camel milk had better shelf life at ambient (25°C) as well as refrigerated (7°C) temperatures than that of cow milk. Development of acidity was much slower in camel milk as compared to cow milk. Further, camel milk was found to be less prone to lipolysis as compared to cow milk. FFA content in COB positive camel and cow milk was 0.7 meq/L for 14 h storage and 1.9 meq/lit for 6 h storage only. Camel and cow raw milk showed positive alcohol test at 6 h and 4 h of storage at ambient (25°C) temperature respectively. Pasteurization and refrigeration enhanced the shelf life of camel and cow milk.

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