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Seasonal variation in fatty acid profile in the milk of different species under popularly followed feeding system in India

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ABSTRACT

The aim of the study was to evaluate the seasonal variation in fatty acid profile in the milk of different species during summer and winter seasons. Samples were collected in months of summer and winter. Total saturated fatty acids (SFA) content (g/100g of fat) was 13–14% higher in summer than winter in all species. Total monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA) and conjugated linoleic acid (CLA) concentration (g/100g fat) were 10–12%, 3–4%, 30–40% respectively and, higher in winter than summer. MUFA, PUFA and CLA were considerably altered among seasons and species. It was concluded that PUFA and CLA in milk of different species increased during winter season than summer and this may be attributed to the seasonal availability of green fodder.

Key words: CLA, Milk, MUFA, PUFA, Season, Species

Milk is a major source of dietary energy, protein and fat, contributing on average 134 kcal of energy/capita per day, 8 g of protein/capita per day and 7.3 g of fat/capita per day in 2009 (FAOSTAT 2012). Milk and milk products contribute to about 18%–24% total fat, 30%–40% total saturated fatty acid (SFA) and 20%–25% trans fatty acid intake in human diet in Western Europe (Henderson *et al.*2003, Hulshof *et al.* 1999). Ruminant milk fat is most complex of all natural fats with great diversity of fatty acids (Palmquist and Jenkins 2006). Approximately more than 400 different fatty acids (FA) plasma lipids originating from the feed and *de novo* synthesis are in milk fat triacylglycerol (Jensen 2002) in the mammary gland but, only 15 FA above 1% (Parodi 2004). Short (SCFA) and medium chain (C4–14) FA accounts for about 60% of total FA (TFA) and are synthesized *de novo*; while, a half of C16:0 and all long chain FA originate from dietary lipids and lipolysis of adipose tissue triacylglycerol (McGuire and McGuire 2000). Medium and long chain FA, mainly C18:0, may be desaturated in the mammary gland to form corresponding monounsaturated fatty acids (MUFA). SFA, MUFA and polyunsaturated fatty acids (PUFA) account for 69%, 27%, and 4% of the total of milk fat, respectively (Jensen 2002). The main n-3 FA in milk is α-linolenic acid (CLA) in majority of mammals and increased share of n-3 FA in the human diet is beneficial in prevention and treatment of cancers, heart diseases, thrombosis, arterial hypertension, hyperlipidaemia, senile dementia, Alzheimer's disease, depression, or rheumatoid arthritis (MacManus *et al.* 2011).

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Sheep and goat milk are usually good source of CLA than cow's milk because they are predominantly reared by the grazing (Zervas and Tsiplakou 2011). Apart from various factors viz. genetics, breed, feeding etc. season has marked effect on variation in the ruminant milk FA (Lock and Garnsworthy 2003) that could be mainly attributed to the availability of feeds where proportion of green forages in diet enhance unsaturated FAs with simultaneous decrease in the SFA (Komprda *et al.* 2000, DePeters *et al.* 2001, Shingfield *et al.* 2006). It is necessary to document seasonal variation in the FA composition of widely consumed mammals milk by human beings that may be useful to modulate the quality for the health benefits. The objective of the present study was to assess changes in beneficial FA in various mammal milk under popularly followed feeding system in India, thereby creating necessary reference data in feeding practice for lactating animals and ensure the quality of milk for human-being demand as well.

MATERIALS AND METHODS

Animals, feeding and sampling: Five species viz. cattle, buffalo, sheep, goat and camel were taken for the study. Milk samples in cattle and buffalo were collected from livestock research centre, ICAR-NDRI; while, milk samples of goat, sheep and camel were collected from the livestock farms of ICAR-CIRG (Makhdoom), ICAR-CSWRI (Bikaner) and ICAR-NRC on Camel (Bikaner), respectively. Milk samples were collected from 15 animals from each species in morning and evening during the months of summer (from March to July) and winter (from December to February) seasons, thus, accounting to a total of 60 samples. All species were hand milked. Morning and

evening milk samples were pooled for each replicate in both the seasons. Milk samples were kept below 5°C until shifting to laboratory, and stored at –20°C for the chemical analysis. Cows and buffaloes were maintained on dietary regimen during period of time consisted of wheat straw, green fodder and concentrate mixture. However, green fodder varied with the season such as oat, maize, berseem and mustard fodder in winter, and maize and jowar in summer season. The concentrate mixture comprised of maize (28%), barley (5%), oat (9%), groundnut cake (10%), deoiled mustard cake (13%), soybean cake (15%), wheat bran (15%), rice bran (deoiled) (2%), minerals mixture (2%), common salt (1%) and was fed according to level of milk production. Goats were maintained on both stall feeding and grazing throughout the year. Goats were fed fresh maize, jowar fodder and gram straw during summer while berseem and gram straw during winter, and concentrate apart from 400g to each goat/d. Under grazing system, goats browsed on grasses like Metha, Bathua, Sewan etc. and tree leaves like Subabool, Pepal, Ber etc., which were available throughout the year apart from 250 g/d concentrate supplement (CS) and gram straw. Sheep were maintained and let loose for grazing in morning (5–11 AM) and evening (4–6 PM) throughout the year. Grazing resources were sewan, dhaman, bharrot, kanti, and babul pod, neem, loong which are available throughout the year. Under system of intensive management, camels were maintained on moth (*Phaseolous aconitifolius*) fodder, groundnut (*Arachis hypogea*) fodder, guar phalgati (*Cyamopsis tetragonoloba)* while with extensive system camel were given locally available tree leaves *(*Khejri, Neem, Ker, Beri, Sewan, Mung). The chemical and FA composition of different feeds offered to different ruminant species is presented in Table 1 and 2. Linoleic and oleic acids were major FA in CS of different species.

Proximate analysis and preparation of fatty acid methyl ester (FAME): Feed samples were dried at 60°C for 48 h

Table 1. Chemical composition of feed ingredients (% on dry matter basis)

Feed ingredient	DM	CP	EE	Ash	NDF	ADF
Concentrate mixture	89.32	20.8	4.64	8.56	32.00	18.80
Maize green	18.88	7.43	1.62	9.87	67.43	44.78
Wheat straw	90.05	3.46	0.85	11.76	80.75	52.31
Berseem	11.20	19.21	2.45	12.85	40.15	30.23
Oat	28.22	8.87	3.21	9.87	53.65	32.23
Sorghum	24.82	10.24	2.56	8.76	63.34	37.78
Grasses						
Dhaman (*Cenchrus setigerus*)	30.52	9.65	3.26	15.55	62.25	37.33
Anjan (*Cenchrus ciliaris*)	28.78	12.65	2.75	13.44	60.33	30.10
Sewan (*Lasiurus sindicus)*	95.10	8.86	2.10	7.55	62.33	40.24
Bharut (*Cenchrus titflorus)*	29.29	10.56	2.15	13.76	63.60	38.22
Crop residues						
Guar phalgati (*Cymopsis tetragonoloba*)	83.33	7.88	1.43	10.43	40.85	38.69
Ground nut straw (*Arachis hypogea*)	88.65	10.10	2.13	10.23	35.78	27.65
Gram straw (*Cicer arietinum*)	90.56	5.23	1.22	14.95	63.43	42.34
Pennisetum glaucum straw	19.37	5.55	2.13	15.65	64.23	43.56
Tree leave mixture	60.60	15.46	4.66	9.72	43.39	24.00

Table 2. Fatty acid composition of feeds and fodders (% of total fatty acids)

Fatty acids		Butyric acid	Myristoleic acid	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid
Concentrate mixture	Sheep	2.96	ND	2.64	3.94	29.36	38.78	ND
	Goat	2.60	7.66	ND	8.90	21.76	24.56	ND
	Buffalo	1.60	0.62	16.90	4.60	29.50	29.30	2.64
	Cattle	1.60	0.62	16.90	4.60	29.50	29.30	2.64
	Camel	2.20	ND	7.88	ND	51.23	ND	10.26
Berseem		5.15	1.02	5.59	ND	2.21	14.7	63.41
Mustard		1.73	1.35	15.3	1.93	4.36	14.8	54.03
Maize		4.50	ND	11.94	ND	14.9	22.41	0.29
GNC straw		3.84	0.86	3.43	6.62	44.99	33.40	4.9
Wheat straw		2.3	ND	21.46	9.98	23.49	14.68	3.20
Gram straw		3.15	0.21	15.3	2.90	37.13	39.93	4.20
Grass		1.86	0.80	32.56	4.30	8.80	10.76	67.2
Sewan grass		1.74	ND	4.53	ND	4.90	13.87	63.21
Pala grass		3.50	ND	14.54	ND	7.50	11.29	33.29
Acacia leaves		1.39	ND	5.34	ND	4.80	20.54	60.56
Khejri leaves		1.77	ND	3.88	ND	2.45	12.72	0.54

and ground to pass through a 1-mm screen using Wiley mill. Feed samples were analyzed for proximate constituents, neutral detergent and acid detergent fibre (AOAC 2005) with two replicates for each feedstuff. The milk samples were thawed and gently mixed in water bath at 40°C and 15 ml was centrifuged at 10,000 g for 40 min at 4°C to separate the cream. Cream was separated, flushed with N_2 and stored at –20°C until analysis. FAME was prepared from milk fat and feed samples by the method of O'Fallon *et al.* (2007).

Analysis by gas chromatography: The FAME were analysed by gas chromatography (GC-450, M/s Bruker, USA) equipped with an auto sampler and flame ionization detector. The injector and flame ionization detector temperatures were kept at 250°C. Oven temperature was programmed at 75°C for 1 min with an increment of 2°C/min until oven temperature attained 240°C with a holding time of 4°C. Helium was the carrier gas with a pressure of 37 psi and split ratio of 1:100. Standard mixture (C4-C24; M/s Supelco; USA) and linoleic acid and conjugated methyl ester (Sigma Aldrich, USA) were taken as reference for quantification (g FA/100 g fat) of FA and CLA in test samples based on the retention time.

Statistical analysis: Data were analyzed for variance based on following general linear model (GLM): $Y_{ijk} = m + \alpha_i + \beta_j + e_{ij}$; where, Y_{ij}, any observation; m, over all mean; α_i, effect due to species (i = 1, 2); β_j, effect due to season (j =1, 2, 3, 4, 5); e_{ij}, Random error. Differences between means were considered significant at $P<0.05$. All statistical analysis was carried using SAS v.9.31 (SAS Institute Inc., USA)

RESULTS AND DISCUSSION

Variation in milk FA of various mammal species during various seasons under Indian feeding system in general followed in India is shown in Tables 3 and 4.

The present study showed season affected FA composition of milk in all species. SFA were higher (8–10%) in the summer and lower during the winter. The concentration of milk SFA irrespective of species ranged from 56 to 67g/100g FA during the summer and 49 to 59g/100g FA during the winter. The highest concentration of SFA was found in the crossbred cattle during both seasons as compared to other species. Palmitic (C16:0), oleic (9-cis C18:1), stearic (C18:0) and myristic (C14:0) acid accounted for more than 65% of TFA. These results were similar to Rodriguez-Alcala *et al.* (2009) and Talpur *et al.* (2009), who reported SFA as main FA and accounted about 67% to 75% of TFA.

Among different species, total SFA content was higher in crossbred cattle and lower in sheep milk both during the winter and summer. The concentration of C16:0 was higher in camel milk both during the summer (30.23g/100g TFA) and winter (28.30g/100g TFA). Camel milk contained less short fatty acids and higher content of medium chain fatty

Table 3. Seasonal variation in FA composition of milk in buffalo and cattle (g/100g FAs)

	Buffalo		Sahiwal cattle		Crossbred cattle	
Fatty acids	Summer	Winter	Summer	Winter	Summer	Winter
SCFA	9.05±0.52	7.59±0.44	8.52±0.53	6.61±0.40	8.7±0.28	7.23±0.23
C12:0	2.94^{a}±0.03	2.27^{b}±0.05	3.77^{a}±0.05	2.85^{b}±0.03	3.29^{a}±0.06	2.20^{b}±0.01
C14:0	9.51^{a}±0.16	8.57^{b}±0.08	9.21^{a}±0.17	8.06^{b}±0.10	10.28^{a}±0.12	8.88^{b}±0.11
C15:0	1.59^{a}±0.02	1.14^{b}±0.01	0.85^{a}±0.03	0.19^{b}±0.02	0.93^{a}±0.02	0.58^{b}±0.03
C16:0	29.47^{a}±0.33	27.44^{b}±0.13	27.88^{a}±0.32	25.99^{b}±0.09	31.38^{a}±0.20	28.60^{b}±0.12
C17:0	0.18±0.01	0.16^{a}±0.03	0.29^{a}±0.01	0.28^{a}±0.01	0.49±0.03	0.44±0.02
C18:0	9.36^{a}±0.15	8.44±0.07	10.31^{a}±0.13	9.59^{b}±0.08	10.85^{a}±0.13	9.91^{b}±0.08
C20:0	0.20^{a}±0.01	0.22^{a}±0.04	0.38^{b}±0.01	0.59^{a}±.015	1.43^{a}±0.02	1.18^{b}±0.03
C21:0	0.59^{a}±0.01	0.32^{b}±0.07	0.14^{a}±0.05	0.14^{b}±.004	0.08±0.02	0.03^{a}±0.08
C14:1, cis-9	0.59^{b}±0.02	0.69^{a}±0.03	0.45^{b}±0.03	0.67^{a}±.02	0.35^{b}±0.01	0.51^{a}±0.02
C15:1, cis-10	0.28±0.02	0.39±0.11	0.23^{a}±0.02	0.25^{a}±.01	0.27^{b}±0.08	0.33^{a}±0.02
C16:1, cis-9	0.20^{b}±0.01	0.88^{a}±0.04	0.37^{b}±0.01	0.58^{a}±.021	0.28^{b}±0.05	0.75^{a}±0.02
C17:1, cis-10	0.12±0.09	0.13±0.07	0.09^{b}±0.03	0.29^{a}±.017	0.38^{b}±0.02	0.74^{a}±0.28
C18:1, trans	1.45^{b}±0.05	1.66^{a}±0.02	0.31^{b}±0.01	0.94^{a}±.019	0.67^{b}±0.04	0.75^{a}±0.03
C18:1,n-9 cis-9	22.71^{b}±0.36	25.15^{a}±0.25	22.76^{b}±0.26	24.93^{a}±.12	22.30^{b}±0.15	24.97^{a}±0.16
CLA	0.42^{b}±0.08	0.61^{a}±0.02	0.38^{b}±0.01	0.62^{a}±.02	0.37^{b}±0.06	0.55^{a}±0.09
C 18:2, n-6	1.36^{b}±0.06	2.26^{a}±0.03	1.61^{b}±0.02	2.06^{a}±0.13	1.12^{b}±0.01	2.15^{a}±0.03
C 18:3, n-6	0.13^{b}±0.06	0.26^{a}±0.01	0.14^{b}±0.06	0.25^{a}±0.06	0.19^{b}±0.01	0.22^{a}±0.01
C 18:3, n-3	1.22^{b}±0.03	1.65^{a}±0.02	0.18^{b}±0.03	1.12^{a}±0.02	0.23^{b}±0.09	0.73±0.02
Total SFA	62.89^{a}±0.35	56.15^{b}±0.18	61.35^{a}±0.39	54.29^{b}±0.18	67.43^{a}±0.35	59.07^{b}±0.22
Total MUFA	25.36^{b}±0.38	28.90^{a}±0.30	24.20^{b}±0.26	27.68^{a}±0.18	24.24^{b}±0.19	28.06^{a}±0.17
Total PUFA	2.71^{b}±0.07	4.17^{a}±0.04	1.94^{b}±0.02	3.43^{a}±0.03	1.53^{b}±0.08	3.10^{a}±0.04

^{ab}Means bearing different superscripts in a row differ significantly ($P<0.05$). SCFA, short-chain fatty acids (C4:0, C6:0, C8:0 and C10:0); SFA, saturated FAs; MUFA, monounsaturated FAs; PUFA, polyunsaturated FAs; CLA, conjugated linoleic acid.

Table 4. Seasonal variation in FA composition of milk in goat, sheep and camel maintained on widely followed feeding regimes (g/100g FAs)

	Goat		Sheep		Camel	
Fatty acid	Summer	Winter	Summer	Winter	Summer	Winter
SCFA	12.94^{a}±0.70	10.67^{b}±0.52	8.43^{a}±0.71	6.78^{b}±0.54	9.43^{a}±0.50	6.81^{b}±0.37
C12:0	6.55^{a}±0.12	5.12^{b}±0.02	4.79^{a}±0.08	4.01^{b}±0.02	4.86^{a}±0.13	4.31^{b}±0.14
C14:0	7.89^{a}±0.19	6.15^{b}±0.23	7.65^{a}±0.20	6.65^{b}±0.11	7.34±0.14	7.10±0.02
C15:0	0.83^{a}±0.01	0.35^{b}±0.02	0.15±0.01	0.14±0.01	0.39^{a}±0.01	0.27^{b}±0.02
C16:0	24.05^{a}±0.30	23.02^{b}±0.08	27.39^{a}±0.45	24.63^{b}±0.17	30.23^{a}±0.02	28.30^{b}±0.15
C17:0	1.28^{a}±0.03	0.87^{b}±0.02	0.12±0.02	0.19±0.06	1.40^{a}±0.01	1.16^{b}±0.03
C18:0	7.44^{a}±0.14	6.21^{b}±0.04	7.62^{a}±0.18	6.61^{b}±0.07	8.76^{a}±0.24	7.31^{b}±0.05
C20:0	0.25^{b}±0.01	0.27^{a}±0.02	0.14^{b}±0.01	0.43^{a}±0.03	0.20^{b}±0.02	0.26^{a}±0.01
C21:0	0.31^{a}±0.01	0.24^{b}±0.04	0.23±0.01	0.10±0.04	0.26^{a}±0.01	0.22^{b}±0.02
C14:1, cis-9	0.67^{b}±0.02	0.99^{a}±0.02	0.18±0.01	1.20±0.96	0.33^{b}±0.01	0.68^{b}±0.01
C15:1, cis-10	0.35^{b}±0.02	0.60^{a}±0.01	0.11±0.04	0.20±0.01	0.26±0.09	0.27±0.02
C16:1, cis-9	0.48^{b}±0.01	0.85^{a}±0.02	0.16^{b}±0.01	0.21^{a}±0.01	1.79^{b}±0.03	2.03^{a}±0.04
C17:1, cis-10	0.16^{b}±0.06	0.62^{a}±0.02	0.13±0.06	0.33±0.08	0.24^{b}±0.08	0.34^{a}±0.01
C18:1, trans	1.04^{b}±0.03	2.03^{a}±0.08	0.54^{b}±0.04	0.85^{a}±0.03	0.23^{b}±0.09	0.64^{a}±0.02
C18:1n-9, cis-9	22.69±0.33	23.31±0.17	19.74^{b}±0.27	22.84^{a}±0.21	24.59^{b}±0.19	27.50^{a}±0.58
CLA	0.43^{b}±0.01	0.73^{a}±0.01	0.46^{b}±0.01	0.75^{a}±0.02	0.415^{b}±0.01	0.59^{a}±0.01
C18:2, n-6	1.59^{b}±0.05	2.01^{a}±0.02	1.84^{b}±0.03	2.45^{a}±0.04	1.77^{b}±0.01	1.95^{a}±0.04
C18:3, n-6	0.25^{b}±0.01	0.75^{a}±0.02	0.01±0.01	0.12±0.05	0.15^{b}±0.01	0.22^{a}±0.05
C18:3, n-3	0.25^{b}±0.01	0.71^{a}±0.02	0.78±0.02	1.01±0.07	0.86±0.01	0.98±0.02
Total SFA	61.53^{a}±0.41	51.43^{b}±0.23	56.53^{a}±0.52	49.52^{b}±0.17	62.15^{a}±0.41	55.73^{b}±0.19
Total MUFA	25.39^{b}±0.37	28.39^{a}±0.18	20.86^{b}±0.27	24.61^{a}±1.02	27.63^{b}±0.21	31.47^{a}±0.60
Total PUFA	2.55^{b}±0.07	3.47^{a}±0.03	2.63^{b}±0.04	3.58^{a}±0.08	2.78^{b}±0.02	3.15^{a}±0.04

^{ab}Means bearing different superscripts in a row differ significantly (P<0.05). SCFA, short-chain fatty acids (C4:0, C6:0, C8:0 and C10:0); SFA, saturated FAs; MUFA, monounsaturated FAs; PUFA, polyunsaturated FAs; CLA, conjugated linoleic acid.

acids compared to other species.SFA contributes major part of TFA in camel's milk like others species but it contains more unsaturated fatty acids as compared to other species as reported by *Attia et al.* (2000) and Karray *et al.* (2005). In general, camel milk contains less SFA and higher concentration of medium chain FA compared to other species like goat, sheep, cow and buffalo. These results were similar to the finding of Ahamad *et al.* (2013).There was difference in short chain (SCFA) and medium chain FA in milk among Sahiwal and Holstein cow despite similar feeding, which may be due to distinct activity of mammary enzyme (steroyl coenzyme A desaturase) (Medrano *et al.* 1999) which oxidises medium chain fatty acid in to its corresponding unsaturated FAs. White *et al.* (2001) and Capp *et al.* (1999) reported similar results by feeding same diet to different breeds of cows.

It is well known that feeding of grass conservation products (hay or silage) increases the SFA content of milk fat (Ferlay *et al.* 2006) and hay reduced the TFA by over 50% with greater loss of linolenic acid (Doreau and Poncet 2000, Elgersma *et al.* 2003). Hay or silage are mainly fed during lean periods in India. Conversely, the use of cereal grain concentrates generally resulted in significant increases in endogenous SFA (Wijesundera *et al.* 2003). The C18:0 content of ruminant feeds is low (Doreau and Chillard 1997) and elevated concentration of this FA in milk compared with that in the diet is a consequence of extensive biohydrogenation of unsaturated FA by the rumen microorganisms (Griinari and Bauman 2003).

PUFA accounted for about 2 to 4% of TFA in milk of all species (Tables 3, 4). Rodriguez-Alcala *et al.* (2009) and Talpur *et al.* (2009) also observed 3 to 5% of TFA in milk of different species was PUFA. MUFA ranged from 20 to 27 g during summer and 24 to 31g/100g FA in winter while during corresponding seasons, PUFA was 1.53 to 2.78 g and 3.10 to 4.17 g/100 g FA, respectively. Similar to present study, Peterson *et al.* (2000) reported alikeness in total MUFA content between buffalo and cow milk but oleic acid was slightly higher than cow milk both in summer and winter seasons. In contrast to the present result, Talpur *et al.* (2009) reported higher MUFA in summer than winter season which could be attributed to feed resources and feeding pattern. In terms of monounsaturated FA (MUFA), oleic acid (C18: 1) accounted for highest concentration in the winter as compared to the summer in all species except goat milk. The findings were similar with Haenlein and Wendorff (2006). Our result indicated camel milk contained higher PUFA than cow in both the seasons with linoleic acid being the dominant among other FA. Gaukhar *et al.* (2008) compared the lipid components of the milk and blood

of camel under intensive farming and reported similar results.

The higher concentration of oleic acid in ruminant milk could be due to extensive biohydrogenation of PUFA from feeds in rumen and by the use of concentrates. Diet has major impact on the FA acid composition of milk (Palmquistand Jenkins 2003). Season affects the FA composition due to fresh grass feeding in the spring and summer than in winter seasons (Chilliard *et al.* 2003). However, the availability of green fodder and grasses in India is more during the winter than summer season because of high temperature and less rainfall in summer thus, resulting in more dependence on CS. Therefore, increasing the dietary fresh fodder and grasses would increase the intake of PUFA and consequently increases the content of long chain fatty acids and may reduce *de novo* synthesis of shorter chain FA. Many workers reported highest content of PUFA in spring and summer and lowest during winter in sheep and goat milk (Chilliard *et al.* 2001, De La Fuenteet *et al.* 2009, Chilliard *et al.* 2003). Grazing during winter, with lack of vegetation and green herbage, could lead to a lesser content of desirable FA in cheese made out of goat milk (Cuchillo *et al.* 2009). This was contrary to our results, because sufficient green herbage was available for grazing in winter season. Moreover, the differences in botanical composition of grass may modify the bacterial population in rumen and thereby lipid mobilization and affects the proportion of different FA (Collomb *et al.* 2008).

Our results showed average CLA concentration varied from 0.37 to 0.73g/100g FA depending upon the species and season. The CLA level was significantly ($P<0.05$), higher in the winter than summer season. The proportion of CLA was found higher in the sheep milk followed by goat, buffalo, cattle, camel and crossbred cattle, respectively. The sheep and goat milk are usually richer in CLA due to the semi-extensive system of rearing consisting of grazing and stall feeding. Usually, sheep milk has higher CLA content than goat milk under the same dietary treatment which can be explained by the differences found in mRNA of their mammary adipocytes (Tsiplakou *et al.* 2009). Feeding of fresh grass to ruminants elevate the CLA content of milk (Floris *et al.* 2006). The fresh grass contains nearly about 55 to 65% of α-linolenic acid which is biohydrogenated in the rumen to vaccenic (11-trans C18:1) and stearic acid (Chilliard *et al.* 2001). These are further desaturated in the mammary gland to CLA and oleic acid, and released in to milk (Bauman *et al.* 2006, Elgersma *et al.* 2006). Thus grazing modifies the FA composition of ruminant milk towards more desirable components. Tyagi *et al.* (2007) reported higher CLA content in milk of Murrah buffalo by green fodder feeding. Fresh grass promotes the synthesis of CLA in the dairy cow through an increase in delta 9-desaturase activity in the mammary gland and possibly other unknown factors (Lock and Gransworthy 2003). The CLA content found in camel milk was almost similar to cow and buffalo but lower than sheep and goat because of semi-intensive system of rearing in camel.

Variation in FA profile and CLA content among the different ruminant species was affected by season under commonly practiced feeding systems in India. SFA were decreased, and CLA and PUFA were increased during the winter season than summer because of availability of green forages. Information generated on seasonal variation in FA composition of animal milk in the present study may be helpful in producing the designer milk for health benefits.

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