Quantitative analysis of fatty acid in Indian goat milk and its comparison with other livestock

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Abstract

Milk fat contains 400 vital fatty acids beneficial for human health. Special attention is given to fatty acids (FAs) that could play a positive role for human health; such are butyric, oleic acid, caproic, caprylic and capric acids. Keeping the medicinal properties of milk fatty acids in consideration, goat milk samples were analyzed for estimation of fatty acid contents in Indian goat milk by using gas chromatography. Analysis of goat milk samples revealed the highest concentration saturated fatty acids (SFA) out of total milk fatty acids (FA) with an average of 69.55 g/100g of fatty acid methyl ester (FAME) ranging from 43.26 to 88.05g/100g of FAME. Within saturated fatty acid the major contribution was given by palmitic (C16:0) 26.99% followed by myristic (C14:0) 11.77%, stearic (C18:0) 7.66% and capric (C10:0) 6.75% respectively. The concentration of short chain fatty acids (SCFAs, C4 to C10) was found to be 13.51 g/100g varying from 2.23 to 33.63 g/100g of FAME. Whereas the concentration of medium chain fatty acids (MCFAs , C12to C15) was 20.05% varying from 7.470 to 45.27 g/100 g of FAME and Long chain FA (LFA, C16 to C24) was 35.08% varying from 4.77 to 51.22 g/100g of FAME. The average concentration of unsaturated fatty acids (UFAs) was 28.50 g/100grm of FAME varying from 10.44 to 45.74 g/100g of FAME which includes monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) with an average of 24.57 g/100g of FAME ranges varying from 4.79 to 39.40 g/100g of FAME and 3.96 g/100g of FAME ranges varying from 0.5928 to 18.30g/100 g of FAME, respectively.

Key words: Goat milk; fatty acid; SFA; MUFA; PUFA

Introduction

Goat is among the smallest domesticated ruminants and have served mankind longer than cattle or sheep all over the world that's why it is known as poor man's cow. Goat is multi- functional animal and plays a significant role in the economy and nutrition of landless, small and marginal farmers in the country and efficiently survive on available shrubs and trees in adverse harsh environment in low fertility lands where no other crop can be grown. Goat is mainly used for milk, meat and skin. Goat milk differs from cow or buffalo milk in having better digestibility, alkalinity, buffering capacity and certain therapeutic values in medicine and human nutrition (Haenlein and Caccese, 1984). It is an important source of protein and fat in human diet the main advantage is that it has no allergic reaction and easily digestible that makes it suitable for future research. Triacylglycerols (TAG) represent the most abundant lipid fraction in milk fat. They constitute the biggest group (nearly 98%), including a large number of esterified fatty acids, which vary in concentration depending on a range of factors including the stage of lactation and diet. The other part consists mainly of sterols and phospholipids, which are primarily associated with the fat globules membrane (Jensen et al., 1991). Milk fat is formed basically by triglycerides that contain short (C4-C10), medium (C12-C15) and long (C16-C24) chain fatty acids (Alonso, 1993). About 400 various fatty acids have been recognized in milk fat, but only 10 of them are present in concentration higher than 1 % (Creamer et al., 1996). FAs play a major role in maintaining health (Kramer et al., 1998). Increasing public awareness regarding health benefits of FAs as anticarcinogenic, antiatherogenic, antiobesity, and antidiabetic (Ma et al., 1999 and Ritzenthaler et al., 2001) has stimulated interest in sources of these FAs for human consumption.

There is quit less information is present in this particular area. The objective of present study is to estimate the actual status of Indian goat milk and to know where Indian goats are stands among other livestock species. This information could be used to bring the ideal composition that is SFA should be 8%, MUFA >82%, and PUFA <10% (Grummer et al., 1991) into existence. This study is just one step ahead towards this approach.

Materials and Methods

Samples and reagents

Milk samples of 700 animals of Sirohi breed of goat from Udaipur, Rajasthan were randomly collected in bottles which contain Sodium Azide (500µl of 10X solution) as preservatives and these samples were stored at 4°C for the subsequent analysis.

Chemical composition and physical traits of milk

Each milk sample was analyzed for fat, protein, lactose and solid not fat content. The contents of components and parameters of milk were estimated using a milk-o-scan.

Fatty acid analysis

The method chosen for Fatty acid methyl esters (FAME) preparation was given by (Fallon et al., 2007). FAME was prepared directly from milk without prior organic solvent extraction. The milk sample were placed into a 16 × 125 mm screw-cap Pyrex culture tube to which 1.0 ml of the C13:0 internal standard (0.5 mg of C13:0/mL of MeOH), 0.7 mL of 10 N KOH in water, and 5.3 mL of MeOH were added. The tube was

incubated in a 55°C water bath for 1.5 h with vigorous hand-shaking for 5 s every 20 min to properly permeate, dissolve, and hydrolyze the sample. After cooling below room temperature in a cold tap water bath, 0.58 ml of 24 N H_2SO_4 in water was added. The tube was mixed by inversion and with precipitated K_2 SO_4 present was incubated again in a 55°C water bath for 1.5 h with hand-shaking for 5 s every 20 min. After FAME synthesis, the tube was cooled in a cold tap water bath. Three milliliters of hexane was added, and the tube was vortex-mixed for 5 min on a multitube vortex. The tube was centrifuged for 5 min in a tabletop centrifuge, and the hexane layer, containing the FAME, was placed into a GC vial. The vial was capped and placed at −20°C until GC analysis. The FAME was analyzed on gas chromatography equipped with an auto sampler injector. The FAME was separated in 60 mm capillary column (60X 0.25 mm 70 µm) film thickness. Here FID was used as a functional unit. It worked on polarizing voltage of 300V. The effluent from the column was mixed with hydrogen and air and get ionization. Then it would produce ions and electrons which can conduct electricity through the flame. A large electrical potential was applied at the burner tip and collector electrode is located above the flame. The current resulting from the pyrolysis of any organic compounds was measured. Helium was used as carrier gas at a flow rate of 2mL/min. The injector and detector temperatures were 260°c and 270°c respectively. The temperature program was as follows: the initial temperature was held at 60°c for 1 min after sample injection, then programmed to increase at 2°C/min to 240°C,and held there for 5 min. Sample (1µL) were injected by split injection (split ratio 10:1). Identification of FAME was performed from the retention times by using standards of 37 individual FAME (Supelco, Bellefonte, PA) was used to determine response factors. The peak areas in the chromatogram were calculated and normalized using response factors. The individual FA contents were expressed as weight percentages (g/100 g of FAME).

Results

Fatty acid profile in goat milk is presented in (Table 1). Analysis of goat milk samples revealed the highest concentration saturated fatty acids (SFA) out of total milk fatty acids (FA) with an average of 69.55% ranging from 43.26 to 88.05. Within saturated fatty acid the major contribution was given by palmitic (C16:0) 26.99% followed by myristic (C14:0) 11.77%, stearic (C18:0) 7.66% and capric (C10:0) 6.75% respectively. The concentration of short chain fatty acids (SCFAs, C4 to C10) was found to be 13.51% varying from 2.23 to 33.63. Whereas the concentration of medium chain fatty acids (MCFAs, C12to C15) was 20.05% varying from 7.470 to 45.27 and Long chain FA (LFA, C16 to C24) was 35.08% varying from 4.77 to 51.22 %. The average concentration of unsaturated fatty acids (UFAs) was 28.50 varying from 10.44 to 45.74 which includes monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) with an average of 24.57% ranges varying from 4.79 to 39.40 and 3.96 % ranges varying from 0.5928 to 18.30% respectively.

Table 1 Milk composition and percent contribution of each fatty acid in Goat, Camel, Sheep, Buffalo and Cattle

Fatty acid	**Variables**	**mean**	**minimum**	**max**	**SD**
CLA	cla	4.873	0.393	16.724	2.878
cis9tran11	cis9tran11	2.943	0.0063	7.875	1.433
trans10 cis12	trans10 cis12	0.823	0.021	3.592	0.824
Butyric acid	c4:0	1.349	0.020	7.272	1.230
Caproic acid	c6:0	2.611	0.415	15.73	2.033
Caprylic acid	c8:0	3.660	0.463	9.722	1.612
Capric acid	c10:0	6.750	0.266	20.953	4.531
Undecanoic acid	c11:0	1.744	0.159	17.897	5.429
Lauric acid	c12:0	6.825	1.772	20.045	4.278
Short chain fatty acid	**SCFA**	13.461	2.239	33.631	6.818
Tridecanoic acid	c13:0	0.5886	0.136	14.386	3.276
Myristic acid	c14:0	11.770	0.315	24.881	3.899
Myristoleic acid	c14:1	1.353	0.113	15.465	2.600
Pentadecanoic acid	c15:0	1.667	0.0585	24.902	4.005
cis10-pentadecenoic acid	c15:1	0.494	0.121	11.133	1.278
Palmitic acid	c16:0	26.991	1.097	41.707	5.730
Palmitoleic acid	c16:1	2.731	0.206	19.129	2.379
Medium chain fatty acid	**MCFA**	20.056	7.470	45.270	6.096
Hepiadecanoic acid	c17:0	0.757	0.196	9.679	1.533
cis-10-heptadecenoic	c17:1	0.832	0.0567	18.287	2.233
Stearic acid	c18:0	7.665	0.3752	21.297	4.075
Elaidic acid	c18:1n9t	1.497	0.240	19.946	3.087
Oleic acid	c18:1n9c	19.088	0.783	31.947	6.222
Linolelaidic acid	c18:2n6t	0.735	0.141	6.778	1.526
Gamma linolenic acid	c18:3n6	1.682	0.0754	7.948	1.089
Linoleic acid	c18:2n6c	2.423	0.0257	15.063	3.015
Arachidic acid	c20:0	0.700	0.0957	13.892	2.532
cis-11-eicosenoic acid	c20:1	0.735	0.088	17.937	2.131
Linolenic acid	c18:3 n3	0.255	0.053	4.243	0.808
Heneicosanoic acid	c21:0	0.371	0.055	11.081	1.841
cis11,14 eicosadienoic acid	c20:2	0.215	0.102	2.887	0.878
Long chain fatty acid	**LCFA**	35.089	4.774	51.228	5.313
Saturated fatty acid	**SFA TOTAL**	69.595	43.263	88.053	5.446
Mono unsaturated fatty acid	**MUFA**	24.572	4.790	39.408	5.384
Polyunsaturated fatty acid	**PUFA**	3.966	0.592	18.309	3.593
Unsaturated fatty acid	**USFA**	28.502	10.449	45.741	5.236
Unsaturated index	**USFA*100/SFA**	41.595	12.575	84.303	10.196

Table 2. Comparative study of major fatty acid in goat, camel, sheep, buffalo and cattle

components	**Goat**	**Camel** (Khan et al 2001)	**Sheep** (De Fuente et al. 2009)	**Buffalo** (Qureshi et al 2012)	**Cattle** (Mansson, 2008)
C8:0	3.94	1.71	3.45	1.57	1.4
C10:0	6.54	2.98	8.61	2.72	2.7
C12:0	7.64	6.51	5.37	2.53	3.30
C14:0	11.92	3.05	10.18	12.02	10.9
C16:0	26.40	11.25	22.04	31.24	30.60
C18:0	6.66	6.01	10.50	11.43	12.20
C18:1	18.76	18.77	15.35	21.41	22.8
C18:2	2.04	1.12	3.47	1.32	1.60
SFA	70.02	62.5	71.35	70.41	69.40
MUFA	24.46	42.6	22.10	23.91	25.0
PUFA	4.67	3.9	6.54	3.85	2.3
UFA	28.8	46.5	28.64	35.04	27.3

Discussion

There are certain FAs in goat milk which works magical to human health but very less data is present regarding this aspect. By having comparative analysis of basic component and fatty acid compositions the actual status of goat milk among other livestock species could be ascertained. Various studies were carried out in buffalo (Qureshi et al 2012), cow (Mansson 2008), sheep (De La Fuente et al., 2009), goat (Strazalkowska et al., 2009) and camel (Khan and Arshad 2001). If we compare our result with other livestock data we actually come to know where goat stands among them (Table 2). We estimated in goat milk SFA contributes 69.55 % in total FAs where as in cattle it contributes 69.5%, buffalo 70.41%, camel 62.5% and ovine has highest contribution that is 71.35% among them. Another important component is MUFA and PUFA. In buffalo it was estimated 23.91% and 3.85%, cattle 25% and 2.3% where as in ovine 22.1% and 6.54%, camel 42.6% and 3.9% and in goat milk we estimated 24.5% and 4% respectively. MUFA was found highest in camel followed by cattle, goat, buffalo and ovine. PUFA was highest in ovine milk followed by goat, camel, buffalo and finally cattle.

There are some fatty acids which directly affect human health which mainly includes Lauric acid (C12:0) It was reported by Sun et al (2002) that lauric acid has antibacterial and antiviral role it is also involved in inhibition of COX1 and Cox II molecules. In goat milk it was estimated 6.89 g/100g of FAME which is higher than

camel 6.51 followed by sheep 5.37, buffalo 2.53 and cow 3.30 respectively. Oleic acid and Linoleic acid are considered as cardioprotective. It also have some properties that work against cancer (Ip, 1997) was estimated 19.08 and 2.42 g/100g of FAME which is more than other livestock species. Caproic , capric and caprylic acid are mainly involved in delaying tumor growth (Thormar et al., 1994) estimated as 2.61, 6.75 and 3.66 g/100g of FAME which higher than other livestock species. Another important component is Butyric acid (C4:0) 1.34g/100g of FAME also known as modulator of gene function, and it have important role in prevention of cancer (German, 1999). Myristic acid (C14:0) 11.77g/100g of FAME which is higher than estimated value in cattle and sheep but lower that buffalo. This fatty acid plays a very critical role in human health like it involve in increase HDL and LDL (German, 1999). It has beneficial effects as the reverse cholesterol transport is increase and this HDL act as antioxidant and prevents oxidation of LDL particles in blood and it may protect against certain microbe infection (German and Dillard, 2004). One of the most important components of milk is CLA, 4.87g/100 of FAME. It improves plasma cholesterol concentration status (Tricon et al., 2004) it also has anticarcinogenic effects (Ha et al., 1987). It also reduces the risk of colorectal cancer and it suppress or reduce the release of pro-inflammatory cytokines such as TNF-alpha and interleukins (Akahoshi et al., 2004) CLA also reduces the B cell activation and there for it reduces cytokines adhesions molecules and other stress- induced molecules (Cheng et al., 2004) it is positively correlated with cis9trans11 and trans10cis12. All these properties present in goat milk makes it complete functional food suitable for infants and old people and makes it different from other livestock.

Conclusions

The total saturated fatty acid in goat milk was found to be 70.02% which is higher than (62.5%) in camel, (69.4%) in cattle but lower than sheep (71.35%) and buffalo (70.41%) g/100g of FAME. Monounsaturated fatty acid (MUFA) was estimated to be 24.46 which is higher than buffalo (23.91%), sheep (22.10%) but lower than camel (42.6%) and cow (25.0%) g/100g of FAME. Polyunsaturated fatty acid (PUFA) was found to be 4.67% which is higher than buffalo (3.85%), cattle (2.3%), camel (3.9%) but lower then sheep (6.54%) g/100g of FAME.

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