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Milk Lipids Profiling of Minor Speciesfor Assessing Quality of Nutritional Input:A Review

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Abstract

Lipids are the most important components of milk in terms of cost, nutrition and physical and Sensory characteristics that impart to dairy products. The principle function of lipid is to serve as a source of energy for neonate and the concentration of fat in milk represent the energy requirement of that species. The biggest component, about 97%, of the lipid fraction of milk is Triacylglycerols (TAG), including a large number of esterifies Fatty acids. The lipid fraction also contains simple lipids such as diacylglycerols, monoacylglycerols and cholesterol esters, complex lipids as phospholipids and lipo-soluble compounds as sterols, Cholesterol esters and hydrocarbons, vitamins etc. Milk fat contains about 400 vital fatty acids beneficial for human health. Special attention is given to the Fatty Acids (FAs) that could play a positive role for human health. Butyric, oleic acid, caproic, caprylic and capric acids, lauric acids present in milk of these species are responsible for various types of medicinalproperties and directly affect human health. Hence milk from these species can be utilized for formulation of various health promoting foods. Based on these considerations, lipid profile of different species is compared.

Keywords: Essential Fatty Acids; Fatty Acids; Milk Lipids; Triacyl Glycerides

Abbreviations:

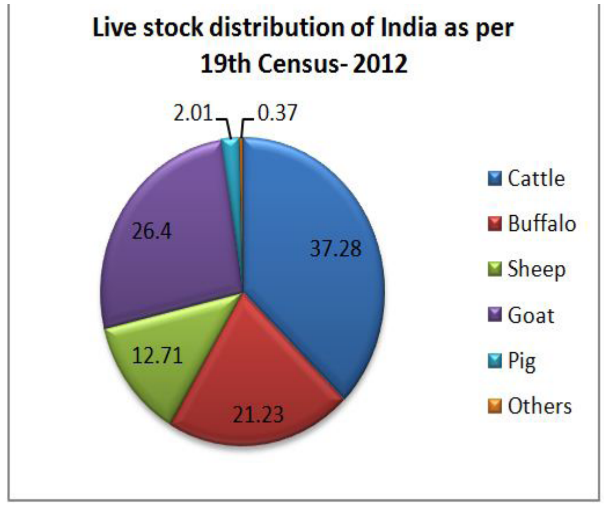
SCFA	:	Short Chain Fatty Acids
LCFA	:	Long Chain Fatty Acids
UFA	:	Unsaturated Fatty Acids
MUFA	:	Monounsaturated Fatty Acids
PUFA	:	Poly Unsaturated Fatty Acids
MCFA	:	Medium Chain Fatty Acids
FAME	:	Fatty Acid Methyl Ester
COX	:	Cyclo-Oxygenase Enzyme
MFGM	:	Milk Fat Globule Membrane
CLA	:	Conjugate Linoleic Acid
LDL	:	Low Density Lipoprotein
HDL	:	High Density Lipoprotein

Introduction

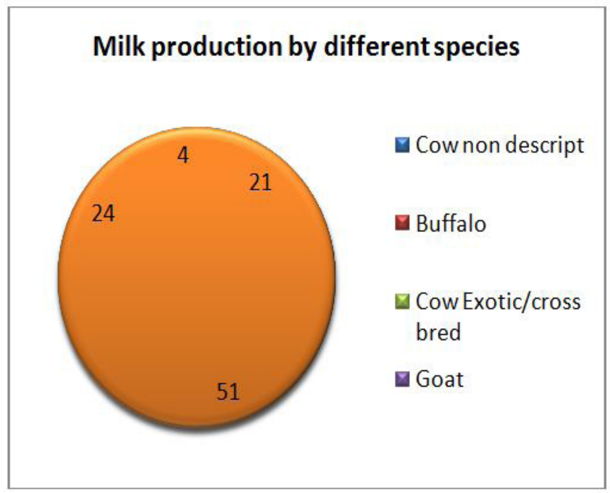
Today's consumers in developing and developed countries are more and more interested and enthusiastic to know about the composition and constituents in milk products as they relate to human health. Hardly anybody paid much attention or knew much about good and bad types of fat and fatty acids until recently. Today's nutrition labeling on food products indicates not only for protein, fat, carbohydrates, sodium, calcium, and vitamins but also for such special ingredients such as saturated, unsaturated, omega-3, conjugated, and trans-fatty acids. This open knowledge leads to interest into ascertaining which dairy products may be superior to others. Milk has been known as nature's most complete food and balance food in terms of nutrients and provides approximately all essential nutrients and an important source of dietary energy, high-quality proteins and fats. Their consumption can add diversity to plant-based diets. However, the traditional and contemporary view of the role of milk has been remarkably expanded beyond the horizon of nutritional subsistence of infants. Milk is more than a source of nutrients for any neonate of mammalian species, for growth of children and nourishment of adult human being.Milk possess an important role in the diets of the populations with very low-fat intakes and limited access to other animal source foods. In terms of milk for infants or sick patients, answers are sought as to which milk is closest to human milk and best for babies, or which milk creates fewer allergies, which one is better tolerated by people with gastrointestinal ailments, and which dairy product causes no lactose intolerance symptoms.

Bovine milk is the predominant domesticated animal species for milk production.However, in certain part of world and in developing countries, the milk from other species has a significant share. Globally, Bovine milk accounts for 85% of milk production worldwide followed by Goat 2.3%, sheep 1.4% and camel 0.2% [1]. There is nostatistical data available forproduction of milk frompig.Goat, sheep, camel and pig are among the smallest domesticated animals and have served mankind longer than cattle all over the world. Especially goat and sheep are known as poor man's cow and camel as ship of desert.These are multi- functional animals apart from milk. These animals are used for meat, skin and other agricultural purpose and play a significant role in the economy and nutrition of landless, small and marginal farmers in developing countries. Generally, pigs are not used for milking purpose, and majorly considered for meat and body fat known as lard. The milk of this animal is only used for the nutrient of piglets. The domestication of these minor species is beneficial, easy and cheap as they can efficiently survive on available shrubs and trees in adverse and harsh environment in low fertility lands where no other crop can be grown.

As per 19^{th} Livestock Census-All India report 2012, in India there were 37.28% cattle, 21.23% buffaloes, 12.71% sheep, 26.40% goats and 2.01% pigs and others 0.37% (Graph -1). As per 2014-15 statistics of India, milk production was 146.3Million Ton with per capita availability 322gms/day[2]. This is contributed by different species as shown in Graph 2. The species of dairy animal, its breed, age and diet, along with the stage of lactation, parity (number of parturitions), farming system, physical environment and season influence the colour, flavour and composition of milk and allow the production of a variety of milk products. These animals can be classified as ruminant and non-ruminant.Goat, sheep and camel falls under ruminant category and pig is a non-ruminant animal. A ruminant synthesized milk fat from carbohydrate-derived precursor, addition of dietary fat in their feed can causes slight effect on fat content whereas in non-ruminant dietary fat has a significant effect on fat content and their composition. Milk obtained from Goat, sheep and camel is known for better digestibility, alkalinity, buffering capacity and certain therapeutic values in medicine and human nutrition. Milk of these species is easily digested by lactose-intolerant individuals.



Graph 1: Livestock population of India.



Graph 2: Milk production by different species.

The smaller fat globules in milk of these species make it easy to digest. A high state of dispersion of milk fat from these species and greater total surface area has a positive influence on lipolytic enzymes and more easily hydrolyzed by pancreatic lipase.Smaller fat globules makes less susceptible to creaming and are therefore naturally homogenized. Apart from fat, milk of these species is important source of protein and lactose in human diet. The main advantage is that milk from these species does not show any allergic reaction. As milk proteins of such species contain very less or lack of β- lacto globulin and α_1- casein which are responsible for allergic reaction and make more similar to human milk. Lactoferrin in these species milk has also medicinal values such as antibacterial, antiviral and anti-tumor properties. Certain disease-fighting small size immunoglobulin's present in milk of these species, are responsible for boosting the effectiveness of the immune system by allowing penetration of antigens.Goat and sheep milk contains caproic, capric and caprylic acid, which are mainly involved in delaying tumor growth. Another important component is Butyric acid (C4:0) also known as modulator of gene function, and it have important role in prevention of cancer. Lauric acid has antibacterial and antiviral role it is also involved in inhibition of COX1 and Cox II molecules [3]. Camel milk is rich in vitamins and minerals, especially B vitamins, vitamin C and iron compare to other milk and known for longer shelf life. It can be stored up to 2-3 days at room temperature without deterioration[4].This feature is may be due to low pH exert by vitamin C, stabilizes the milk for relatively longer shelf-life. The higher vitamin C content may also be attributed to the more synthetic activity in the mammary tissues during early phase of lactation. Camel milk exhibits hypoglycemic effect when given as an adjunctive therapy, which might be due to presence of insulin/insulin like protein, making it a great treatment option for Type 1 or Type 2 diabetics as well as Gestational Diabetes [5]. As a rich source of volatile fatty acids, α-hydroxyl fatty acids which are responsible for plump the skin and fine line. PUFA present in camel milk fat also helps to reduce the inflammationand giving rise to the potent signaling molecules called as eicosanoids. Hence Camel milk has been used for the treatment of food allergies, Crohn's disease (inflammatory bowel disease)[5] and Autism; primary autoimmune disease affects an intestinal enzyme responsible for the formation of the amino acid from the milk protein casein. Normally casein breaks down in to the amino acid in intestine. But autism causes breakdown of casein (primarily β-casein and β-lactoglobulin) in to the casomorphin not in amino acids. These casomorphin is a powerful opioid, more potent than morphine. That leads to typical cognitive and behavioral symptoms so eventually this casomorphin causes brain damage. Animal experimentation has shown that casomorphin causes autistic like symptoms. For treating this it is therefore advisable to restrict milk and milk product that can leads to the formation of casomorphin.In such case camel milk might be a best option due to larger sizecasein micelles and low Ph compare to other milk. Hence in gastrointestinal tract casein micelles do not breakdown into individual casein and whey and therefore do not form casomorphins [6].Pig milk is similar in composition to milk of other species, though higher in fat. Little information is available on pig milk as it is seldom utilized for human uses. It is not considered to be a viable agricultural product, as pigs are difficult to milk as duration of milk flow is only for few 20 seconds. Therefore, their milk is used only fortheir offspring growth. This article presents a brief overview of some aspects of the review of the chemistry and biochemistry of the milk lipid and their constituents with comparative data for Goat milk, sheep, camel milk and pig milk.

Gross composition of milk from different pecies

Table 1(a) and (b) shows the gross composition and physicochemical constant of milk of four different species. The fat, protein, lactose and ash content of milk from different species vary between 3.5-7.9%, 3.1-5.9%, 4.6-5.1%, 0.7-0.9% respectively. Goat milk contains less fat compare to other species followed by camel, sheep and pig milk. Sheep milk is similar in composition as goat milk, except that it is slightly have more total solids and major nutrient than goat milk. Pig milk has highest solids content. Camel milk shows low pH compare to other species. Camel milk has highest melting point and iodine value due to more LCFA and UFA, whereas sheep and goat milk lipid shows nearly same melting range and iodine value. Saponification value is highest in case of sheep milk fat because of higher amount of SCFA.Milk fat from different species has remarkable variation compare to other constituents.

Species	Fat	Protein	Lactose	Ash	Total solids	pH
Goat	3.5	3.1	4.6	0.8	12.1	6.5-6.8
Sheep	5.3	5.5	4.6	0.9	14.4	6.51-6.85
Camel	4.9	3.7	5.1	0.7	14.4	6.2-6.5
Pig	7.9	5.9	4.9	0.9	19.6	-

(Park and Haenlein 2008)[7].

Table 1(a): Gross Composition (%) of Milk from Minor domesticated animals.

Species	**Melting Point (0C)**	**Acid value**	**Iodine value**	**Saponification Value**	**Reichert Meissel value**	**Polenske Value**
Goat	28.1-30.2	0.48	27-33	232-243	24-26	7-12
Sheep	30.9	0.28	31-39	240-276	29.4-30.39	1.4-8.7
Camel	41.4-44.1	0.54	43-55	200-217	1.1-2.12	0.50-0.62
Pig	-	-	-	-	-	-

(Park and Haenlein 2008) [7].

Table1(b): Physico-chemical constant of Milk fat from Minor domesticated animals.

Fatty acid profile of Milk lipids

Milk fat contains more than 400 fatty acids. They have wide variation in different species (Table 2). Ruminant milk fat especially from goat and sheep milk differs in contents of their fatty acids significantly from other milk fat, being much higher in butyric (C4:0), caproic (C6:0), caprylic (C8:0) and high level of short chain fatty acid (SCFA) compare to camel whereas, in non-ruminanti.e. pig milk fat, these short chain fatty acids are absent. The high concentration of C:4, C:6 and C:8 in these species is due to synthesis of short chain fatty acids by microorganism in rumen. Camel milk contains low concentration of these fatty acids compare to sheep and goat. Apart from SCFA goat and sheep milk have high concentration of Medium Chain Fatty Acid (MCFA) i.e. capric (C10:0), lauric (C12:0), myristic (C14:0), and long chain fatty acid such as palmitic (C16:0), linoleic (C18:2), but lower in stearic (C18:0), oleic acid (C18:1), cholesterol and conjugated linoleic acid. Ruminant milk fat (goat, sheep and camel) contain low level of polyunsaturated fatty acids (PUFA) in comparison to non-ruminant (pig) milk fats. This is because a higher proportion of fatty acids in pig are derived from dietary lipids. In case of ruminant animals unsaturated fat present in diet gets converted to saturated fatty acid due to bio-hydrogenation in rumen.Sheep milk lipid contains the highest concentration of saturated fatty acids (SFA) out of total milk Fatty Acids (FA) with an average of 71.35 g/100g of Fatty Acid Methyl Ester (FAME) (Table 3). The concentration of Mono-unsaturated Fatty Acids (MUFA) is highest in camel milk.

Component	Goat	Sheep	Camel	Pig
Short chain				
C4:0	2.6	4.0	0.37	-
C6:0	2.9	2.8	0.9	-
C8:0	3.94	3.45	0.6	-
Medium chain				
C10:0	6.54	8.61	1.4	0.7
C12:0	7.64	5.37	4.6	0.5
C14:0	11.92	10.18	7.3	4.0
Long chain				
C16:0	26.40	22.04	29.3	32.9
C16:1	2.2	3.4		11.3
C18:0	6.66	10.5	11.1	3.5
C18:1	18.76	15.35	38.9	35.2
C18:2	2.04	3.47	3.8	11.9
C18:3	<1.0	<1.0	<1	0.7

(Mohamad and Mustafa 2016, Saroha2014 and Fox and McSweeney 2006)[8-10].

Table 2: Comparative profile of major fatty acids in Goat, Sheep, Camel and Pig milk fat.

Component	Goat	Sheep	Camel	Pig
SFA	70.02	71.35	62.5	22.65
MUFA	24.46	22.1	42.6	21.42
PUFA	4.67	6.54	3.9	55.94
UFA	28.8	28.64	46.5	77.36
ω- 6 : ω- 3 ratio	4.0	1.0-3.8	5.88	9.43
Conjugate Linoleic acid	0.3-1.2	0.6-1.1	0.4	0.13-0.19

(Mohamad and Mustafa 2016 and Saroha2014)[8,9].

Table 3: Fatty acid composition (%) of different milk.

Goat and sheep milk Fat

Goat and sheep milk fat are very much similar in fatty acids profile. The comparative fatty acid profile of goat and sheep milk is shown in Table 4. Sheep milk lipids contain higher concentration of C4:0, C6:0, C8:0 compare to goat milk. Goat milk has higher C10:0, C12:0 and C16:0 fatty acids.Medium Chain Fatty Acids (MCFA) may play a role in the flavor profile of goat and sheep milk. Three of the fatty acids; caproic (C6:0), caprylic (C8:0) Capric (C10:0) have actually been named after goats, because of their predominance in goat milk. The high levels of MCFA in sheep and goat's milk have important influence on energy utilization and production. MCFA have become established medical treatments for an array of clinical disorders, including malabsorption syndromes, chyluria, steatorrhea, hyperlipoproteinemia, intestinal resection, premature infant feeding, non-thriftiness of children, infant malnutrition, epilepsy, cystic fibrosis, coronary by-pass, and gallstones, because of their unique metabolic ability to provide direct energy instead of being deposited in adipose tissues.The MCFA are hydrolyzed in the gastrointestinal tract, they are quickly absorbed by the intestinal cells without the need for esterification and carried by the hepatic portal vein to the liver where they can be oxidized for quick energy and because of their quick metabolism produces a thermal expenditure which may play an important role in weight reduction as well as reducing circulating cholesterol, especially low density lipoproteins [11].Branched-chain fatty acids have been studied in goat milk recently, because they lend characteristic flavors to dairy foods. Goat milk fat contains about 31 branched chained fatty acids. Goat-like flavors is due to 4-ethyloctanoic acid, which is present at 0.227 mg/g of total fatty acids among 31 minor branched-chain fatty acids[12,13]. Monomethyl-branched substitutions on C4 and C6 fatty acids are present only in goat milk and not in other milk. A comparatively high number of minor branched-chain fatty acids is found in goat milk and the content of trans-C18:l fatty acids is significantly lower in goat milk under average feeding regimes than in other milk, also a benefit for coronary heart disease risks by limiting cholesterol deposition in body. There are numerous factors which affect the level of milk fats and their fatty acids profiling such as season, stage of lactation, climate, milking frequency, breed and feed. Guo et al. (2001) [14]studied the seasonal changes in the properties of goat's milk and reported that winter milk contained higher levels of fat. The influence of feeding systems was investigated. They found that goats fed primarily on pasture had lower cholesterol than the silage fed counterparts. In addition, they also found that retinol and α-tocopherol was higher in the goats fed primarily on pasture. Conjugated Linoleic Acids (CLA) have gained much attention in recent years due to their implication in human health. CLA may have beneficial health benefits including suppression of cancer cells, anti-obesity, modulation of the immune system, reduction of atherosclerosis, and diabetes. However, sheep and goat's milk does not contain fair levels of CLA as but it has been reported in research publications that CLA content in milk is depends on the diet composition. Seasonal variations in CLA levels in several herds of goat and sheep. There was a dramatic increase of CLA during the early summer months in sheep milk, whereas in goat milk remained constant throughout the summer. This may be due to the eating behavior of sheep; they eat the rapidly growing green grass while the goat diet consists mainly shrubs. As expected, the levels of CLA in sheep's milk were observed to be higher, however the levels of CLAs in both sheep and goat's milk was higher than the milk taken from the non-grazing animals kept indoors year round.Nudda, et al. (2003) [15] also reported that CLA was higher in sheep milk fat in April when diet was mainly pasture, but not in May when concentrate feeding was increased.This can be explained by the differences in grazing behavior of animals.Diet of either alfalfa hay or Rumiluz (dehydrated alfalfa plus forage) showed an increase in the production of trans-11-C18:1 fatty acid, or vaccenic acid, a precursor of CLA. The fatty acid composition varied by season, and the main variation involved especially caprylic (C8:0), capric (C10:0) and 2-decylenoic acids were present in higher concentration in the spring season. Palmitic acid (C16) was lower in winter. Arachidic acid (C20:0) content was higher in winter than in all other seasons.

Fatty Acid	Goat Milk	Sheep Milk
C4:0	1.97-2.44	3.07-3.93
C6:0	2.03-2.70	2.68-3.44
C8:0	2.28-3.04	2.10-3.27
C10:0	8.85-11.0	5.54-9.73
C10:1	0.19-0.38	0.23-0.31
C12:0	3.87-6.18	3.48-4.92
C12:1	0.10-0.40	0.03-0.05
C13:0	0.06-0.28	0.13-0.22
C14:0	7.71-11.2	9.85-10.7
iso-C15:0	0.12-0.15	0.26-0.43
anteiso-C15:0	0.17-0.24	0.33-0.60
C14:1	0.17-0.20	0.19-0.50
C15:0	0.46-0.85	0.89-1.11
iso-C16:0	0.17-0.40	0.17-0.26
C16:0	23.2-34.8	22.5-28.2
iso-C17:0	0.24-0.52	0.44-0.59
anteiso-C17:0	0.30-0.50	0.26-0.36
C16:1	1.00-2.70	0.74-1.27
C17:0	0.52-0.90	0.58-0.70
C17:1	0.24-0.48	0.17-0.22
C18:0	5.77-13.2	8.51-11.0
C18:1 total	15.4-27.7	17.8-23.0
C18:2 total	2.49-4.34	2.89-3.57
C20:0	0.08-0.35	0.36-0.52
C18:3	0.19-0.87	0.52-1.04
C18:2 conjugate total	0.32-1.17	0.56-0.97

(Mayer and Fiechter 2012 and Park, et al. 2007)[16,17].

Table 4: Main fatty acids (% in total fatty acid methyl esters) in sheep and goat milk fat.

Camel milk fat

Camel milk is also unique in its fatty acid profile. Twenty-four fatty acids were reported by [18]in camel milk from farming and pastoral system (Table 5). Camel milk contains 6 to 8 times lesser short chain fatty acids compared to milk from cows, goats, sheep, and buffalo. Milk shows considerable variation of fatty acids and contained 67.5% and 63.8% Saturated Fatty Acids (SFA), 29.8% and 34.4% monounsaturated acids, and 2.7% and 1.8% polyunsaturated acidsfrom farming and pastoral system respectively. The major SFA were palmitic acid (C16:0) and stearic acid (C18:0), the major MUFA were oleic (C18:1ω 9) and palmitoleic (C16:1) acids and the major PUFA was linoleic acid (C18:2 ω 6). The predominant fatty acids were palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1 ω 9), and formed 72.5% and 76.1% of total fatty acids in milk from farming and pastoral system respectively. The short-chain fatty acids (SCFA) which was represented by caproic acid (C6:0) only was 0.13% in milk from farming system and 0.2% in milk from pastoral system. The proportion was 8.9% and 10.7% for medium chains (MCFA), 90% and 89% for long chains (LCFA) in milk of the two systems, respectively. The omega 3 and 6 (ω -3/ ω -6) ratio was 0.17 and 0.08 for milk from farming and pastoral system, respectively.CLA was also reported in camel milk, which has numerous functional properties. The most biologically active is the diene of configuration cis-9, trans-11(octadecadienoic); it is claimed to inhibit the occurrence and development of cancer of the skin, breast, colon, and stomach, while its isomer trans-10, cis-12 is thought to prevent obesity (Wang and Jones, 2004). Additionally, CLA reduces the levels of triglycerides, total cholesterol, including LDL, and thus improves the ratio of LDL/HDL in plasma, which is a crucial factor in the prevention of coronary heart disease and artheriosclerosis. CLA also is said to inhibit the development of osteoporosis, to improve the metabolism of lipids, to reduce the blood glucose level, and to stimulate the immune system.

Fatty acids	Farming system	Pastoral system
Capric acid (C10:0)	0.13	0.12
Lauric acid (C12:0)	0.35	0.41
Tridecanoic acid (C13:0)	0.09	0.13
Myristic acid (C14:0)	7.11	8.43
Pentadecanoic acid (C15:0)	0.83	1.05
Palmitic acid (C16:0)	27.92	30.74
Heptadecanoic acid (C17:0)	0.51	0.67
Stearic acid (C18:0)	22.11	21.11
Arachidic acid (C20:0)	0.6	0.48
Behenic acid (C22:0)	0.28	0.24
Tricosanoic acid (C23:0) IS	3.99	0.11
Lignoceric acid (C24:0)	3.43	0.14
Myristoleic acid (C14:1)	0.36	0.58
Palmitoleic acid (C16:1)	5.77	7.81
Heptadecanoic acid (C17:1)	0.27	0.4
Elaidic acid (C18:1ω9t)	0.82	1.25
Oleic acid (C18:1 ω9c)	22.44	24.21
Eicosenoic acid (C20:1)	0.17	0.13
Linolelaidic acid (C18:2ω6t)	0.11	0.12
Linoleic acid (C18:2ω 6c)	1.41	1.4
Linolenic acid (C18:3ω3)	0.14	0.13
Docosadienoic acid (C22:2)	0.9	0.13
Eicosapentaenoic (C20:5ω3)	0.12	-

(Mohamed, and Mustafa 2016)[8].

Table 5: Fatty acid profile (%) of camel milk fat from farming and pastoral systems.

Pig Milk Fat: Many researchers emphasize in their reports that the content of milk fatty acids is strongly associated with the quality of fat introduced into the feed of non-ruminant animal(Table-6). Pig fat does not contain short and medium chain fatty acids but a rich source of long chain fatty acids. Also rich in omega-3 and 6 fatty acids compare to ruminant species. Linoleic (ω-6) and linolenic (ω-3) acids fulfill a number of biological functions in animal. Among others, they determine the structure of cell membranes; they constitute a source of tissue hormones, the so-called eicosanoids (often referred to as vitamin F) and regulate insulin secretion. Hence favors better health to piglets.

Fatty acid	Content (%)
C14:0	0.54
C16:0	16.92
C16:1 ω −7	0.37
C18:0	2.61
C18:1 ω −9	19.76
C18:2 ω −6	53.13
C18:3 ω−3	5.25
C20:1 ω−9	0.46
C20:5 ω −3	0.17
C22:0	0.31
C22:1 ω−9	0.11
C22:3 ω−3	ND
C22:5 ω−3	ND
C22:6 ω−3	0.03
Saturated Fatty Acid	22.65
Mono-Unsaturated Fatty Acid	21.42
Poly-Unsaturated Fatty Acid	55.94
Totalω −6	50.58
Total ω −3	5.36

(laws et al, 2009) (ND- not detected)[19].

Table 6: Fatty acid profile of Pig milk fat.

Phospholipid

The phospholipids fraction accounts for roughly 0.8% of total lipids [20]. They play a particularly important role, being present mainly in milk fat globule membrane and other membranous material in milk. The beneficial effects of dietary PLs concerning heart diseases, inflammation and cancer would seem to have been known since the early 1900s. Sphingolipids are abundant in the apical membrane in the absorptive epithelium in the gut, and their digestion products (ceramides and sphingosine) are considered as the most bioactive compounds, having important effects on cell regulation. These compounds are critical for the maintenance of membrane structure, modulating the behavior of growth factor receptors and serving as binding sites for some microorganisms, microbial toxins and viruses. Ceramide is a major lipid messenger that inhibits cell proliferation and induces apoptosis, whereas sphingosine-1-phosphate is a second messenger inside the cell and there is evidence that indicates the important role of the latter molecule in regulation of cell growth, angiogenesis, immune function and lymphocyte traffic. The oral application of dietary PLs with a specific FA composition seems able to modify the FA composition of the membrane of a certain cell type, modulating thus the cellular functions, as well as the activity of membrane bound enzymes. The compositions of various phospholipids are shown in Table-7. Goat milk shows lowest content of phosphatidyl ethanolamine and pig milk fat contains highest PE and sphingomyelin.Phosphatidyl serine is reported to be highest in camel milk fat. In general there is no remarkable difference in composition, may be that they have same origin and perform similar structural function in all species. Apart from the health benefits they have technological application as emulsifying agent. Milk PLs are mainly located in MFGM in association with protein and other polar lipids. Emulsifying properties of PLs are due to the simultaneous presence in the molecule of a water-loving hydrophilic head and an oil-loving hydrophobic tail. Because of its original function in emulsifying the fat globules in whole milk, they are considered to be an efficient natural surface-active material, highly effective in lowering the interfacial tension and have application in various food formulations.

Species	PE	PC	PI	PS	SM	LP
Goat	31.7	28.5	6.3	8.3	25.2	0.5
Sheep	36.0	29.2	3.4	3.1	28.3	-
Camel	34.3	22.1	4.9	10.5	28.1	1.0
Pig	36.3	21.6	3.3	3.4	34.9	-
PE- Phosphatidyl Ethanolamine, PC-Phosphatidylcholine, PI-Phosphatidylinositol PS-Phosphatidyl Serine, SM-Sphyngomyelin, LS-Lysophospholipids						

(Fox and McSweeney 2015 and Contarini and Povolo 2013) [10,20].

Table 7: Major Phospholipids (%) in milk fat of different species.

Sterol content

The sterol fraction of milk is of nutritional interest because high levels of cholesterol in plasma are associated with an increasing risk of cardiovascular disease. Through analyses of the sterol fractions adulterant vegetable fats can be detected in milk and dairy products. Table 8 shows the comparative profile of different sterols in goat, sheep, camel and pig milk fat.

Sterols	Goat	Sheep	Camel	Pig
Cholesterol	341.8	288.4	313-371	600
Lathosterol	1.47	1.81	-	-
Desmosterol	1.39	0.41	-	-
Dihydrolanosterol	2.25	4.15	-	-
Lanosterol	9.75	6.86	-	-

(Claeys, et al. 2014, Fraga, et al. 2000 andGoudjil, et al. 2003) [21-23].

Table 8: Concentration of different sterols in milk fat of different species (mg/100 g fat).

Fat Globules size

Fat is present in milk as droplets of triacylglycerols surrounded by a complex membrane derived from the mammary epithelial cell called the Milk Fat Globule Membrane (MFGM). It is made up of many different components including glycoprotein, non-polar lipids, phospholipids and Sphingolipids which all contribute to the nutritional and technological aspects of the MFGM. The average fat globule size is smaller in ruminant milk compare to pig milk (Table 9). This is advantageous for digestibility and a more efficient lipid metabolism compared with porcine milk fat. Additionally, goat and sheep milk and camel milk fat globules do not causes creaming up on storage due to absence of agglutinin protein responsible for creaming up process especially in bovine milk. Hence milk from these species is naturally homogenized. The major protein of MFGM is lactadherin from goat and sheep milk appears as a single polypeptide chain whereas two identified for lactadherin from camel milk.

Parameter	Goat	Sheep	Camel	Pig
Fat Globules dia (mm)	3.49	3.3	3.0	2-5
*Nature of major-protein (lactad-herin) in MFGM	Single polypeptide chain	Single polypeptide chain	Double polypeptide chain	-

(Cibo and Martin 2012, Park, et al. 2007 and Fox and McSweeney 2015) [10,17,24].

Table 9: Fat globules characteristics of milk fat from different species.

Vitamin content in milk of different species

The total vitamin content of milk is highly variable and depends on the vitamin status and the feeding regime of the mother. This is given in Table 10. An exception is the vitamin C level, which is relatively high in camel [21]. Additionally, it is noted that camel milk has higher vitamin A content.Their milk is whiter than other milk due to their ability to convert the yellow β-carotene to vitamin A [17].

Vitamins	Goat	Sheep	Camel	Pig
Vitamin A	50-68	41-50	5-97	-
Col-calciferol Vit D_3	0.25	0.18-1.18	0.30-1.6	-
Vitamin E	-	120	21-150	-
Vitamin C	900-1500	425-6000	2400-18400	-

(Claeys, et al. 2014)[21].

Table 10: Vitamin content (microgram/100ml) of different milk.

Conclusion

Milk from goat, sheep and camel is a potential source of varieties of fatty acids, especially short chain fatty acids. The size of fat globules is smaller and possesgreater total surface area which makes them easily hydrolyzed by lipolytic enzymes and pancreatic lipase. Hence milk from these species are easily digestible even by lactose-intolerance individual.Apart from it milk from these species does not shows any allergic reaction and make them similar to human milk. Due to smaller fat globules size milk from these species are less susceptible to creaming on prolong storage and therefore considered as naturally homogenized. Hence milk from these animals does not require any homogenization process. Due to all these positive characteristics of milk fat from these species, have great potential for formulation for nutritious foods especially for infants. Whereas pig milk fat do not have such potential, as it is rich in long chain saturated fatty acids and also unable to milking of this animal.

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References

1. Gantner V, Mijić P, Baban M, Škrtić Z, Turalija A (2015) The overall and fat composition of milk of various species. Mljekarstvo 65: 223-231.
2. National Dairy Development Board (NDDB) (2015) Annual report 2014-2015.
3. Sun CQ, Oconnor CJ, Roberton AM (2002) The antimicrobial properties of milk fat after partial hydrolysis by calf pregastric lipase. Chem Biol Interact 140: 185-198.
4. Patel AS, Patel SJ, Patel NR, Chaudhary GV (2016) Importance of camel milk - An alternative dairy food. Journal of Livestock Science Pg No: 19-25.
5. Agrawal PP, Swami SC, Beniwal R, Kochar DK, Sahani MS, et al. (2003) Effect of raw camel milk on glycemic control, risk factors and diabetes quality of life in type-1 diabetes: a randomised prospective controlled study. Journal of Camel Practice and Research 10: 45-50.
6. Gizachew A, Teha J, Birhanu T (2014) Review on Medicinal and Nutritional Values of Camel Milk. Nature and Science 12.
7. Park YW, George FW Haenlein (2008) Hand book of Milk of Non-Bovine Mammals. Blackwell publishing, USA.
8. Mohamed E, Mustafa A (2016) Fatty Acids Content in Milk of Dromedary Camel (Camelus dromedarius) from Farming and Pastoral Systems in Sudan. International Journal of Science and Research 5:570-573.
9. Saroha V, Kumar D, Sharma A, Jayakumar S, Tyagi AK, et al. (2014) Quantitative analysis of fatty acid in Indian goat milk and its comparison with other livestock. J of Livestock Sci5: 1-8.
10. Fox PF, Uniacke-Lowe T, McSweeney PLH, O'Mahony JA (2015) Dairy Chemistry and Biochemistry. Milk lipid 2:69-144.
11. Hosam H M, Wissam IH, Schneider-Stock R, Hassan HM (2013) Camel milk lactoferrin reduces the proliferation of colorectal cancer cells and exerts antioxidant and DNA damage inhibitory activities. Food Chemistry 141: 148-152.
12. Haenlein GFW (2004) Goat milk in human nutrition. Small Ruminant Research 51: 155-163.
13. Ha JK, Lindsay RC (1993) Release of volatile branched-chain and other fatty acids from ruminant milk fats by various lipases. J Dairy Sci 76: 677-690.
14. Alonso L, Fontecha J, Lozada L, Fraga MJ, Juarez M (1999) Fatty acid composition of caprine milk: major, branched-chain,and trans fatty acids. J Dairy Sci 82: 878-884.
15. Guo MR, Dixon PH, Park YW, Gilmore PS, Kindstedt J (2001) Seasonal changes in the chemical composition of comminglrd goat milk. 84: 79-83.
16. Mayer HK, Fiechter G (2012) Physical and chemical characteristics of sheep and goat milk in Austria. International Dairy Journal 24: 57-63.
17. Park YW, Juarez M,Ramos M, Haenlein GFW (2007) Physico-chemical characteristics of goat and sheep milk. Small Ruminant Research 68: 88-113.
18. Nudda A, Mele M, Battacone G, Usai MG, Macciota NPP (2003) Comparison of Conjugated Linoleic Acid (CLA) content in milk of ewes and goats with the same dietary regimen. Ital J Anim Sci 2: 515-517.
19. Laws J, Amusquivar E, Laws A,HerreraE, Lean IJ,et al. (2009) Supplementation of sow diets with oil during gestation: Sow body condition, milk yield and milk composition. Livestock Science 123: 88-96.
20. Contarini G, Povolo M (2013) Phospholipids in Milk Fat: Composition, Biological and Technological Significance, and Analytical Strategies.International Journal of Molecular Science 14: 2808-2831.
21. ClaeysWL, Verraes C, Cardoen SJ, De Block JD, Huyghebaert A , et al. (2014) Consumption of raw or heated milk from different species: An evaluation of the nutritional and potential health benefits. Food Control 42: 188-201.
22. Fraga MJ, Fontecha J, Lozada L, Martinez-Castro I, Juarez M (2000) Composition of the sterol fraction of caprine milk fat by gas chromatography and mass spectrometry. J Dairy Res67: 437-441.
23. Goudjil H, Torrado S, Fontecha J, Fraga MJ, Ju´arez M (2003) Composition of cholesterol and its precursors in ovine milk. Lait 83: 1-8.
24. Cebo C, Martin P (2012) Inter-species comparison of milk fat globule membrane proteins highlights the molecular diversity of lactadherin. International Dairy Journal 24:70-77.