

## Fatty Acids Profile of Milk of Cow, Buffalo, Sheep, Goat and Camel by Gas Chromatography

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**Abstract:** Milk fat contains roughly 400 vital fatty acids beneficial for health maintenance and disease prevention. Milk fat obtained from different species of Nili Ravi Buffalo, Sahiwal Cow, Kajli Sheep, Betal Goat and Marecha Camel from livestock farm of Faisalabad, Bahawalpur, Sahiwal and Okara were analyzed for their fatty acids profile by GC. It was determined that Oleic acid C18:1 was the highest in Nili Ravi Buffalo (19.13g/100g), Sahiwal Cow (19.03g/100g), Kajli Sheep (19.01g/100g), Betal Goat (18.97g/100g) and Marecha Camel (18.77g/100g) while Arachidic acid was the lowest 1.68g/100g in Nili Ravi Buffalo, Erucic acid 1.60g/100g in Sahiwal cow, Linoleic acid in Kajli Sheep (0.99g/100g), Betal Goat (0.85/100g) and Marecha Camel (0.87g/100g). The high and low concentration was compared to all other animals of different districts. Sahiwal cow and Kajli Sheep milk contained higher concentration of Caprylic acid, Capric acid and Lauric acid (1.92g/100g), (3.00g/100g) and (6.52 g/100g) as compared to buffalo, cow, goat and camel milk of different districts.

**Key words:** Milk • Fatty acid esters • Gas chromatography

### INTRODUCTION

Pakistan is the 3<sup>rd</sup> largest milk producing country in the world with annual production of about 42 billion liters. Agriculture Statistics of Pakistan reveals that the livestock population of cattle is 33.0, buffalo 29.9, sheep 27.4, goat 58.3 and camel 1.0 million. Contribution of buffalo milk is 70%, cow milk is 25% while sheep, goat and camel milk contribute about 5% of total milk production in the country. 30 to 35 million rural people derive up to 30 to 40% of their income from livestock. Per capita availability of milk is 146 kg per annum. Punjab with a share of about 80% leads others provinces in milk production [1].

Nili Ravi is found in between the Ravi and Sutluj rivers of Punjab, Nili Ravi is the best performing animal producing more milk than the other breeds of the world (2500 liters per lactation) while milk yield for Kundi breed is 1700-2200 liters with a 6-7% butter fat. Sahiwal cow is famous in Punjab with annual milk production of 2000 liters per lactation [2].

Cow milk is yellowish in color due to carotene which is not present in goat and sheep milk giving it white color. Rough handling during milking process releases short

chain fatty acids (SCFA) in goat milk. Cow milk is somewhat acidic while goat milk is alkaline due to high protein and different arrangement of phosphates groups, beneficial for overcoming acidity problems [3].

The camel still being neglected specie in Pakistan has not yet gets attention for research purpose by researchers. Pakistani camel has excellent potential as milch animal including, Marecha, producing 4,179 liters of milk per year might be the best milk yielder in the world. [4].

Milk composition is important for milk producers and processors. It consists of approximately 13% solids and 87% water. "Milk is a complex, nutritious product that contains more than 100 substances that are in either solution, suspension or emulsion in water" [5].

Ruminant fat bears a significant position in human diet representing approximately 75% of total fat consumption. The milk of all ruminants contains lipids but the concentration varies widely between species from 2 to 8% [6]. The fat content of milk is of prime economic importance since it is sold in various parts of world on fat content basis. The lipid fraction of milk is composed mainly of triacylglycerols (95.80%) with

minor contributions of diacylglycerols (2.25%), monoacylglycerols (0.08%), sterols (mostly cholesterol, 0.46% or 100-200 mg/L), phospholipids (1.11%), fat-soluble vitamins [7]. The triacylglycerols of milk fat include a variety of fatty acids, which vary in concentration depending on a range of factors including the stage of lactation and the diet of the cow. About 400 various fatty acids have been recognized in milk fat, but only 10 of them are present at concentrations higher than 1% [8]. The main fatty acids found in milk are: Long chain C14-myristic 11%, C16-palmitic 26%, C18-stearic 10% and C18:1-oleic 20% and short chain (11%) C4-Butyric, C6-Caproic, C8-Caprylic, C10-Capric acid [9].

In this study, different species of cow, buffalo, sheep, goat and camel are studied for their fatty acid profile.

## MATERIALS AND METHODS

The research was conducted in the laboratories of the National Institute of Food Science and Technology and High Tech. Lab. of University of Agriculture, Faisalabad - Pakistan. The materials and methods from various resources have been utilized and stated as below under different headings and sub headings.

**Procurement of Raw Materials:** Milk of Nili Ravi Buffalo, Sahiwal Cow, Kajli Sheep, Betal Goat and Marecha Camel was taken from livestock farm of Bahawalpur, Sahiwal, Okara and Faisalabad. Animal breed and lactation stage were recorded. The animals were kept under routine management and feeding conditions throughout the experiments. Milk samples were collected during morning milking in 100 mL sterile plastic bottles and kept at 4°C throughout the experiment.

### Fatty Acids Analysis of Milk

**Milk Fat Extraction:** Milk fat extraction was carried out using method described by [10] with some modifications. 20 mL milk sample was taken in a 50 mL conical plastic tube and was subjected to centrifugation (Centrifuge sigma 3K30, Germany) at 12,000 rpm for 30 min at 4°C.

An aliquot (1.0 g) of the fat cake layer was transferred to a 1.5 mL micro tube and placed at room temperature (20-25°C) for approximately 30 min till the melting point. Sample was then centrifuged at 13,000 rpm for 20 min at room temperature using micro centrifuge (Sigma 1-15). After centrifugation, the milk sample was separated into 3 layers: the top layer of lipid; the middle layer of protein, fat and other water insoluble solids; and the bottom layer of water.

**Methyl Esters Formation:** 40 mg of separated lipid was transesterified by the transmethylation procedure of [11]. Hexane (2 mL) was added to 40 mg of butter oil followed by 40 mL of methyl acetate. After the mixture was vortexed, 40 mL of methylation reagent (1.75 mL methanol: 0.4 mL of 5.4 mol/L sodium methylate) was added. The mixture was vortexed and allowed to react for 10 min; then 60 mL of termination reagent (1 g oxalic acid/30 mL diethyl ether) was added. The sample was then centrifuged for 5 min at 2400 rpm at 5°C leaving a clear layer of hexane; an aliquot of the hexane was taken in vials and stored at -20°C.

**Gas Chromatographic Conditions:** Fatty acid methyl esters were quantified using a Shimadzu Gas Chromatograph Model 14-A (Shimadzu Co., Japan) fitted with a methyl lignose rate coated (film thickness = 0.25µm), polar capillary column SP-2330 (30m x 0.32mm). Conditions are as follows:

Injector temperature	230°C
Column oven temperature	180°C-2min-4°C/min-210°C
Detector temperature	250°C
Detector	FID (Flame Injection Detector)
Carrier gas	Oxygen free nitrogen
Flow rate	5mL/min
Volume of fatty acid oil	0.1-0.2 µl

Under the same chromatographic conditions, Peaks were identified using standard mixture of known fatty acids and compared the retention time of unknown samples with the standard for identification.

**Statistical Analysis:** Data was analyzed statistically and results were drawn using Statistix 8.1 software package [12].

## RESULTS AND DISCUSSION

The results obtained during the analysis of milk of different species are discussed here under different headings.

**Milk Fatty Acids Composition (G/100g) of Nili Ravi Buffalo in Various Districts:** The data on milk fatty acid composition of Nili Ravi Buffalo in various districts is presented in Table A. The fatty acid composition is also depicted graphically in the Figure 1 and 2. It is indicated from the statistical table that milk fatty acid composition of Nili Ravi Buffalo was found to be highly significant.

Table A: Milk fatty acids composition (g/100g) of Nili Ravi Buffalo in various Districts

Fatty Acids	Bahawalpur	Sahiwal	Okara	Faisalabad	Means
Caprylic Acid (C8:0)	1.71±0.08	1.68±0.08	1.81±0.07	1.75±0.01	1.72
Capric Acid (C10:0)	2.91±0.07	2.84±0.07	2.82±0.01	2.95±0.05	2.99
Lauric Acid (C12:0)	6.11±0.11	6.02±0.06	6.22±0.11	6.22±1.11	6.15
Tridecanoic Acid (C13:0)	2.91±0.07	2.82±0.06	2.71±0.24	2.91±0.01	2.97
Myristic Acid (C14:0)	3.11±0.06	3.06±0.01	3.02±0.02	3.21±0.03	3.05
Myristoleic Acid (C14:1 n9c)	1.87±0.12	1.72±0.06	1.98±0.11	1.91±0.04	1.73
Pentadecanoic Acid (C15:0)	1.84±0.22	1.85±0.09	1.84±0.11	1.93±0.02	1.69
Palmitic Acid (C16:0)	12.0±0.210	11.05±1.01	11.50±1.11	12.50±1.10	12.25
Palmitoleic Acid (C16:1n9c)	6.39±0.11	6.25±0.88	6.31±1.10	6.45±0.99	6.04
Heptadecanoic Acid (C17:0)	3.08±0.09	3.14±0.11	3.05±0.98	3.50±0.98	3.03
Stearic Acid (C18:0)	6.22±0.33	6.11±0.07	6.11±1.01	6.31±0.10	6.01
Elaidic Acid (C:18:1 n9t)	2.40±0.01	2.31±0.01	2.31±0.02	2.50±0.10	2.22
Oleic Acid (C18:1 n9c)	19.56±1.13	19.72±1.12	19.91±0.99	19.70±0.11	19.13
Linoleic Acid (C18:2 n6c)	1.82±0.87	1.71±0.09	1.71±0.05	1.91±0.98	1.88
Linolenic Acid (C18:3n3)	1.21±0.87	1.65±0.02	0.35±0.04	1.85±0.01	1.69
Arachidic Acid (C20:0)	1.81±0.91	1.78±0.02	1.74±0.02	1.85±0.11	1.68
Eicosenoic Acid (C20:1)	1.85±0.81	1.75±0.08	1.85±0.01	1.83±0.54	1.79
Behenic Acid (C22:0)	1.85±0.97	1.75±0.05	1.85±0.11	1.85±0.44	1.74
Erucic Acid (C22:1 n9c)	1.81±0.01	1.74±0.11	1.79±0.02	1.89±0.02	1.73
Means	4.68	3.12	3.65	4.21	

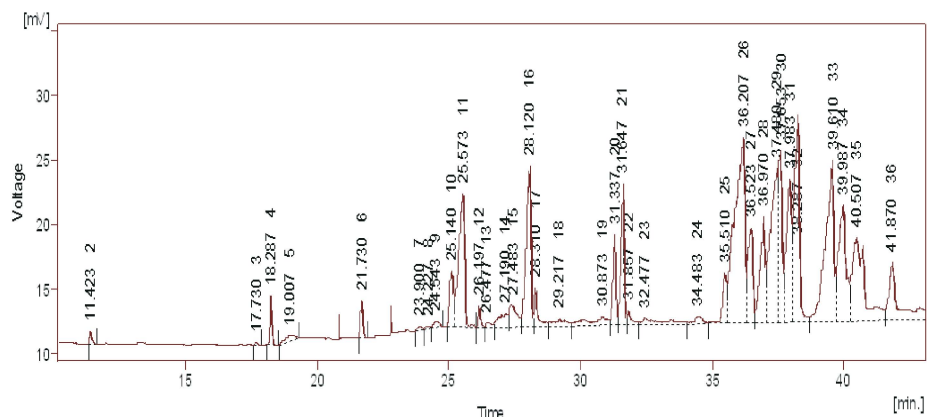


Fig. I: Gas chromatogram of standard of fatty acid methyl esters

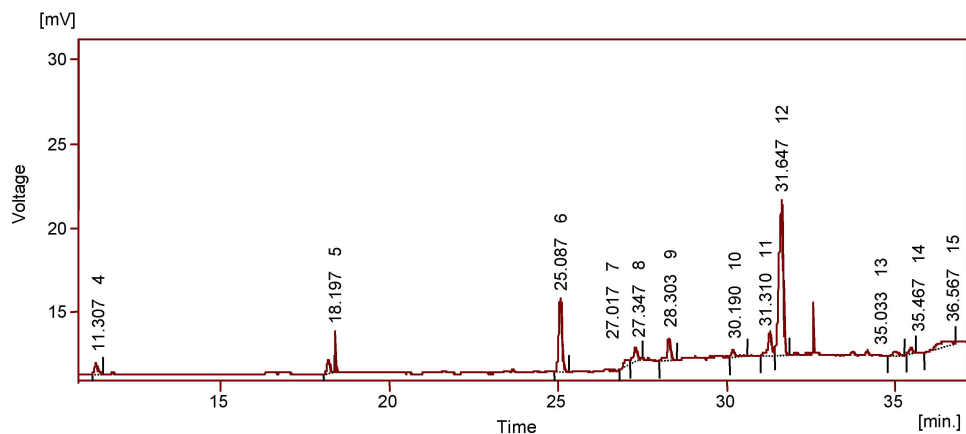


Fig. I: Gas chromatogram of Buffalo milk fat by gas chromatography (Bahawalpur)

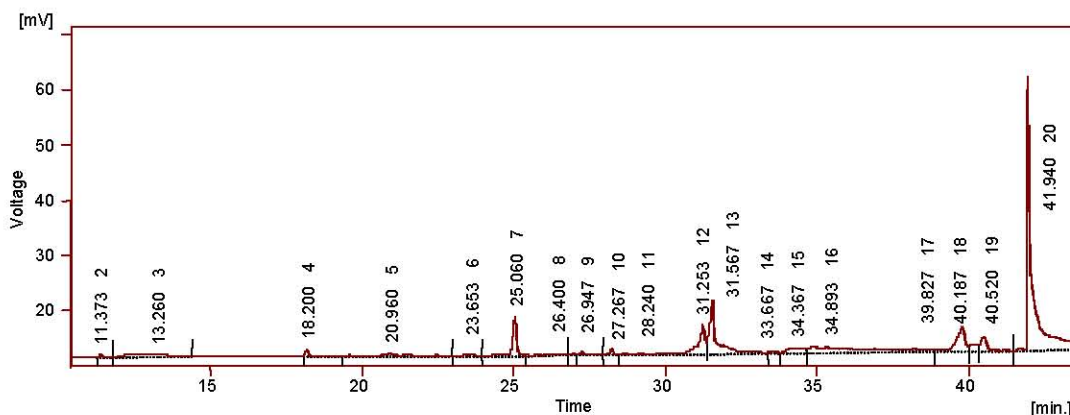


Fig. 2: Gas chromatogram of Buffalo milk fat by gas chromatography (Faisalabad)

The average mean value of Arachidic acid (C20:0) 1.68g/100g was minimum as compared to other fatty acids in different areas whereas maximum average value was noticed in Long chain fatty acid Oleic acid (C18:1 n9c) 19.13g/100g followed by Palmitic acid (C16:0) 12.25 g/100g in different districts.

The results of milk fatty acid composition of Nili Ravi Buffalo of various districts showed that SCFA like Caprylic acid (C8:0) and Capric acid (C10:0) represented 1.72g/100g and 2.99g/100g respectively. Medium chain fatty acids presented (17 g/ 100g) in total and long chain fatty acids like Palmitic acid (C16:0) presented 12.25 g/100g. Among the Long chain but mono unsaturated fatty acids, Oleic acid (C18:1 n9c) in fatty acid composition was the highest 19.13g/100g. The concentration of Oleic acid (C18:1 n9c) in buffalo milk was highest as compared to all other milk samples from different animals of different districts. Long chain saturated Arachidic acid (C20:0) was the lowest (1.68g/100g).

Nili Ravi Buffalo milk contained higher amount of fat (7.78 g/100g) as compare to other animals. Comparable values for fat (7.58-8.30g/100g) has been reported for Italian Mediterranean Buffalo and lactating Buffalo from Nepal that also indicate the variation in milk fatty acid composition depending upon species, breed, feed and environment of the animals [13]. Similar differences in milk fatty acid composition have been previously observed by [14] for Holstein and Brown Swiss Cow.

This result was also similar to the findings of Talpur *et al.* [15] that Buffalo produced 7% higher stearic (C18:0) and 12% higher oleic acid (C18:1) content [16] also reported that Jersey Cow produced 13% more Oleic acid concentration.

The researchers also concluded that proportion of C18:2 and C18:3 were not significantly different in Buffalo's milk fatty acid during their studies which is in support of the data obtained in this manuscript. This was also reported by Talpur *et al.* [15] that there is no difference in C18:2 and C18:3. [17] has described lower CLA proportions (0.48g /100g) in River Buffalo from Argentina.

The mean proportions of unsaturated fatty acids especially long chain fatty acids Arachidic acid (C20:0) and Erucic acid (C22:1 n9c) did not differ significantly ( $P < 0.01$ ) and are comparable with data presented by [18]. Although EPA and DHA are present in milk fat in negligible amounts which cannot be ignored because they are important components of the cell membrane associated process.

#### Milk Fatty Acids Composition (G/100g) of Sahiwal Cow in Various Districts:

The data on milk fatty acid composition of Sahiwal Cow in various districts is presented in Table B. The fatty acid composition is also depicted graphically in Figure 3 and 4. It is indicated from the statistical table that milk fatty acid composition of Sahiwal Cow was found to be highly significant ( $P < 0.01$ ). The average mean value of Erucic acid (C22:1 n9c) was minimum 1.60g/100g as compared to other fatty acids in different areas whereas maximum average value of Long chain fatty acid Oleic Acid (C18:1 n9c) of 19.03 g/100g was noticed followed by Palmitic Acid (C16:0) 11.50 g/100g in different districts.

The results of milk fatty acid composition of Sahiwal Cow of various districts showed that SCFA like Caprylic acid (C8:0) and Capric acid (C10:0) represented 1.69g/100g and 2.87g/100g respectively. Medium chain fatty acids

Table B: Milk fatty acids composition (g/100g) of Sahiwal Cow in various Districts

Fatty Acids	Bahawalpur	Sahiwal	Okara	Faisalabad	Means
Caprylic Acid (C8:0)	1.63±0.04	1.54±0.06	1.72±0.04	1.69±0.02	1.69
Capric Acid (C10:0)	3.01±0.09	2.93±0.08	3.50±0.02	3.50±0.09	2.87
Lauric Acid (C12:0)	6.02±0.09	5.95±0.05	6.41±0.21	6.14±0.98	6.02
Tridecanoic Acid (C13:0)	2.82±0.84	2.62±0.04	2.65±0.21	2.82±0.03	2.99
Myristic Acid (C14:0)	2.85±0.07	2.71±0.02	2.73±0.11	2.91±0.04	2.98
Myristoleic Acid (C14:1 n9c)	1.74±0.09	1.65±0.05	1.81±0.07	1.82±0.03	1.86
Pentadecanoic Acid (C15:0)	1.72±0.11	1.74±0.07	1.72±0.87	1.71±0.01	1.77
Palmitic Acid (C16:0)	11.0±0.110	10.06±1.02	11.05±1.05	11.50±1.20	11.50
Palmitoleic Acid (C16:1n9c)	6.14±0.10	6.05±0.78	6.12±1.02	6.21±0.88	5.89
Heptadecanoic Acid (C17:0)	3.50±0.11	3.02±0.99	3.02±0.88	3.11±0.88	2.98
Stearic Acid (C18:0)	6.13±0.11	6.21±0.09	6.21±1.02	6.41±0.12	6.11
Elaidic Acid (C:18:1 n9t)	2.40±0.01	2.32±0.01	2.32±0.01	2.50±0.12	2.31
Oleic Acid (C18:1 n9c)	19.23±1.11	19.42±1.02	19.32±0.98	19.50±0.99	19.03
Linoleic Acid (C18:2 n6c)	1.05±0.98	1.92±0.09	1.95±0.06	1.11±0.87	1.68
Linolenic Acid (C18:3n3)	0.18±0.89	0.71±0.03	1.62±0.03	0.91±0.02	1.64
Arachidic Acid (C20:0)	1.75±0.82	1.65±0.01	1.65±0.01	1.75±0.21	1.71
Eicosenoic Acid (C20:1)	1.82±0.80	1.75±0.06	1.83±0.04	1.81±0.44	1.68
Behenic Acid (C22:0)	1.83±0.95	1.75±0.06	1.82±0.99	1.83±0.34	1.65
Erucic Acid (C22:1 n9c)	1.75±0.02	1.65±0.98	1.65±0.01	1.79±0.01	1.60
Means	4.34	4.25	3.78	4.36	

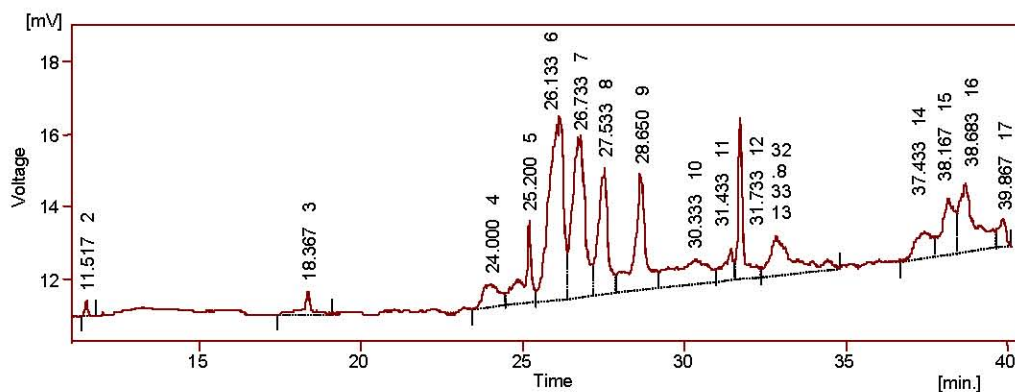


Fig. 3: Gas chromatogram of Cow milk fat by gas chromatography (Bahawalpur)

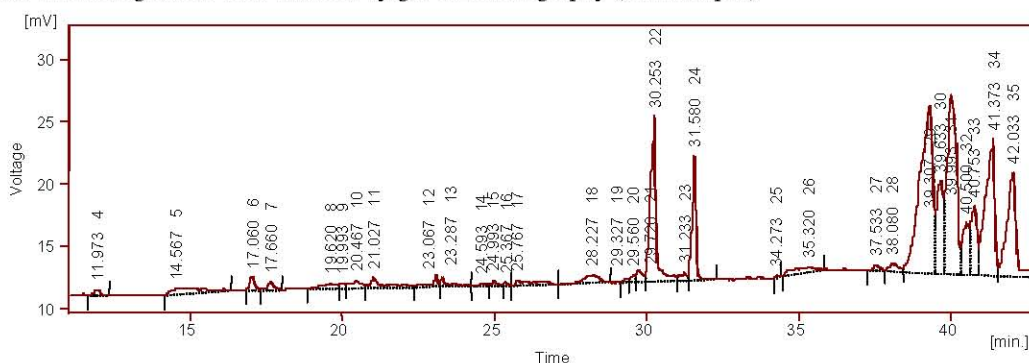


Fig. 4: Gas chromatogram of Cow milk fat by gas chromatography (Faisalabad)

represented (16 g/100g) in total and long chain fatty acids like Palmitic acid (C16:0) represented 11.50 g/100g. Among the long chain but mono unsaturated fatty acids Oleic acid (C18:1 n9c) in fatty acid composition was the highest 19.03g/100g. Long chain Erucic acid

(C20:0) was the lowest one 1.60g/100g. The concentrations of fatty acids present in Sahiwal Cow of different districts were lower as compared to the fatty acids composition of Nili Ravi Buffalo of different districts.

Table C: Milk fatty acids composition (g/100g) of Kajli Sheep in various Districts

Fatty Acids	Bahawalpur	Sahiwal	Okara	Faisalabad	Means
Caprylic Acid (C8:0)	1.84±0.09	1.73±0.07	1.85±0.08	1.85±0.01	1.92
Capric Acid (C10:0)	3.02±0.08	2.95±0.06	3.50±0.11	3.50±0.09	3.00
Lauric Acid (C12:0)	6.52±0.09	6.14±0.07	6.53±0.31	6.32±1.13	6.52
Tridecanoic Acid (C13:0)	3.03±0.09	3.01±0.07	2.85±0.29	3.20±0.04	2.44
Myristic Acid (C14:0)	3.02±0.09	2.92±0.01	2.91±0.01	3.12±0.21	2.75
Myristoleic Acid (C14:1 n9c)	1.61±0.01	1.54±0.04	1.72±0.08	1.73±0.01	1.69
Pentadecanoic Acid (C15:0)	1.55±0.12	1.53±0.04	1.69±0.85	1.57±0.001	1.68
Palmitic Acid (C16:0)	10±0.90	9.07±0.99	10.33±1.12	11.63±1.30	11.02
Palmitoleic Acid (C16:1n9c)	5.92±0.96	5.84±0.45	5.81±1.01	6.03±0.67	6.02
Heptadecanoic Acid (C17:0)	3.15±0.08	3.01±0.54	3.21±0.99	3.20±0.77	2.98
Stearic Acid (C18:0)	6.24±0.95	6.33±0.11	6.32±1.10	6.52±0.10	6.01
Elaidic Acid (C:18:1 n9t)	2.51±0.03	2.42±0.11	2.43±0.01	2.62±0.31	2.31
Oleic Acid (C18:1 n9c)	19.06±0.99	18.25.51±1.01	18.87±0.88	19.02±0.87	19.01
Linoleic Acid (C18:2 n6c)	1.21±0.82	1.83±0.07	0.84±0.07	0.20±0.85	0.99
Linolenic Acid (C18:3n3)	1.08±0.98	10.2± 0.89	0.24±0.08	0.99±0.01	1.13
Arachidic Acid (C20:0)	1.70±0.78	1.60±0.03	1.60±0.01	1.70±0.10	1.72
Eicosenoic Acid (C20:1)	1.71±0.76	1.64±0.05	1.73±0.01	1.71±0.33	1.81
Behenic Acid (C22:0)	1.70±0.86	1.60±0.04	1.70±0.85	1.70±0.52	1.79
Erucic Acid (C22:1 n9c)	1.75±0.01	1.65±0.88	1.65±0.02	1.78±0.01	1.67
Means	4.87	3.11	4.25	3.56	

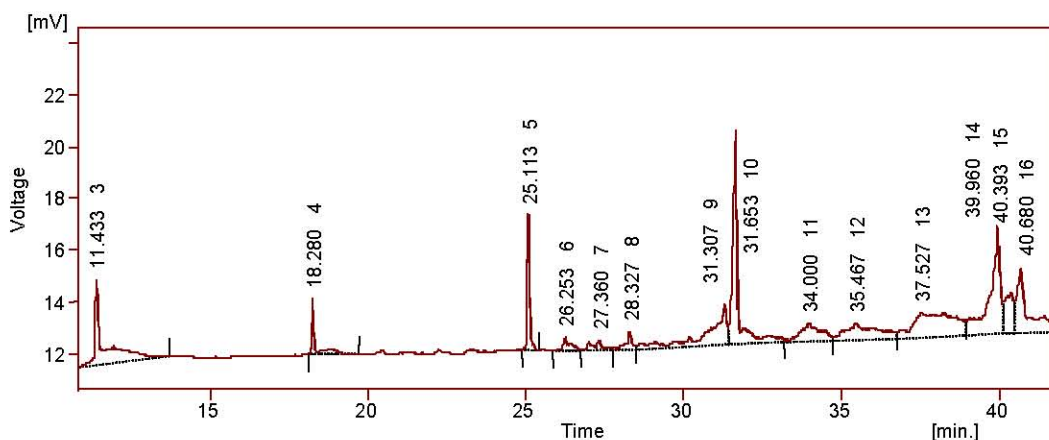


Fig. 5: Gas chromatogram of Sheep milk fat by gas chromatography (Bahawalpur)

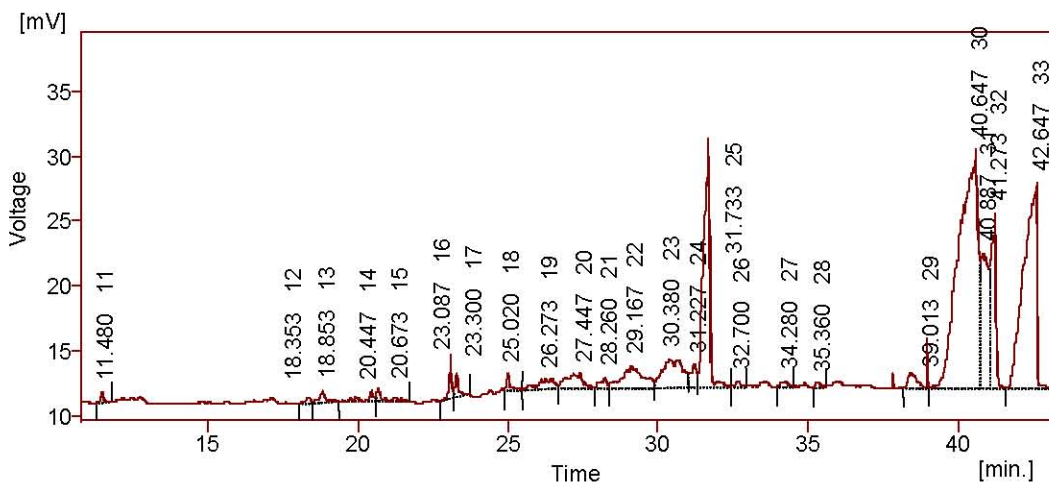


Fig. 6: Gas chromatogram of Sheep milk fat by gas chromatography (Faisalabad)

These results were similar to the findings of [16] that Holstein Cow produced 8-42% short chain fatty acids. These values reported by [19] for Holstein and Jersey Cow when pasture and concentrate were given to these breeds. It was also determined that a lower production of SCFA in milk fat seems to be favorable for human health because of their native role in arteriosclerosis. Palmitic acid (C16:0) accounted for the highest proportions in the milk fat. [14] also reported similar results for cow fatty acids. However, Talpur *et al.* [15] determined a lower proportion of Myristic acid as presented in this manuscript.

[20] and [21] reported a lower content of C16:1 in milk fat from Jersey and Holstein Cow. Lower contents of C14:1 and C18:1 in milk fat different cow breeds with changed and unchanged C18:0 suggests less desaturase activity in mammary tissues [22, 16].

#### **Milk Fatty Acids Composition (G/100g) of Kajli Sheep**

**District in Various Districts:** The data on milk fatty acid composition of Kajli Sheep in various districts is presented in Table C. The fatty acid composition is also depicted graphically in Figure 5 and 6. It is indicated from the statistical table that milk fatty acid composition of Kajli Sheep was found to be highly significant ( $P < 0.01$ ). The average mean value of Linoleic acid (C18:2 n6c) was minimum 0.99g/100g as compared to other fatty acids in different areas whereas maximum average value of Oleic acid (C18:1 n9c) of 19.01 g/100g was noticed followed by Palmitic acid (C16:0) 11.02 g/100g in different districts.

The results of milk fatty acid composition of Kajli Sheep of various districts showed that SCFA like Caprylic acid (C8:0) and Capric acid (C10:0) represented 1.81g/100g and 3.00g/100g respectively. Medium chain fatty acids represented (16 g/ 100g) in total and long chain fatty acids like Palmitic acid (C16:0) represented 11.02g/100g. Among the Long chain but mono unsaturated fatty acids Oleic Acid (C18:1 n9c) in fatty acid composition was highest 19.01g/100g. Long chain poly unsaturated fatty acid like Linoleic acid (C18:2 n6c) was the lowest one 0.99g/100g.

Fatty acids composition of sheep milk contained higher level of fatty acids like Caprylic acid (C8:0) 1.92g/100g, Capric acid (C10:0) 3.00g/100g and Lauric acid (C12:0) 6.52g/100g. This amount of fatty acids was higher as compared to all other animals of same districts and different districts.

The above results were similar to the finding of Talpur *et al.* [15] that there was variation in milk fatty acid composition of similar species of sheep in various districts which is accordance to this study described in this manuscript [23] determined that sheep milk yields can

differ more than 10 times between breeds and within breeds and lactation lengths can vary by 100%, even normal sheep milk composition may differ between 6% and 9% for fat. This change in milk fat composition represents change in the milk fatty acids composition of sheep.

#### **Milk Fatty Acids Composition (G/100g) of Betal Goat in**

**Various Districts:** The data on milk fatty acid composition of Betal Goat in various districts is presented in Table D. The fatty acid composition is also depicted graphically in Figure 7 and 8. It is indicated from the statistical table that milk fatty acid composition of Betal Goat was found to be highly significant ( $P < 0.01$ ). The average mean value of Linolenic acid (C18:3n3) was minimum 0.85g/100g as compared to other fatty acids in different areas whereas maximum average value of Oleic acid (C18:1 n9c) of 18.97 g/100g was noticed followed by Palmitic acid (C16:0) 10.78 g/100g in different districts.

The results of milk fatty acid composition of Betal Goat of various districts showed that SCFA like Caprylic acid (C8:0) and Capric acid (C10:0) represented 1.78g/100g and 3.01g/100g respectively. Medium chain fatty acids represented (15 g/ 100g) in total and long chain fatty acids like Palmitic Acid (C16:0) represented 10.78 g/100g. Among long chain but mono unsaturated fatty acids Oleic acid (C18:1 n9c) in fatty acid composition was highest 18.97 g/100g. Long chain poly unsaturated fatty acid Linolenic acid (C18:3n3) was the lowest one 0.85g/100g.

Milk fatty acid composition of goat contain higher level of fatty acids like Caprylic acid (C8:0) 1.78g/100g, Capric acid (C10:0) 3.01g/100g and Lauric acid (C12:0) 6.48 g/100g. This amount of fatty acids was higher as compared to cow, buffalo and camel of different districts.

Goat milk is also different from cow and sheep milk in several other ways. It has a greater proportion of medium and SCFA and lacks the agglutinating protein that causes the clustering of fat globules and the rapid separation of cream.

The above results were similar to the findings of Talpur *et al.* [15] which is accordance to this manuscript. This was also reported by Haenlein [24] who reported that goat and sheep milk fat contain higher proportion of C6:0, C8:0 and C12:0. [25] also determined that the fatty acid composition of goat milk fat using capillary gas chromatography. Milk was obtained from five goat herds belonging to different breeders in the Murcia region (Spain) and collected monthly (from November to May). The results showed significant differences among herds mainly in long chain fatty acids (C<sub>16:0</sub>, C<sub>18:0</sub> and C<sub>18:2</sub>).

Table D: Milk fatty acids composition (g/100g) of Betal Goat in various Districts

Fatty Acids	Bahawalpur	Sahiwal	Okara	Faisalabad	Means
Caprylic Acid (C8:0)	1.84±0.08	1.72±0.06	1.85±0.88	1.85±0.04	1.78
Capric Acid (C10:0)	3.11±0.07	2.04±0.99	3.13±0.21	3.27±0.08	3.01
Lauric Acid (C12:0)	6.13±0.07	6.28±0.08	6.45±0.28	6.41±0.99	6.48
Tridecanoic Acid (C13:0)	3.21±0.13	3.11±0.88	2.94±0.29	3.11±0.01	2.79
Myristic Acid (C14:0)	2.91±0.07	2.85±0.21	2.85±0.02	3.03±0.02	2.99
Myristoleic Acid (C14:1 n9c)	1.57±0.2	1.44±0.03	1.64±0.05	1.64±0.02	1.81
Pentadecanoic Acid (C15:0)	1.61±0.11	1.47±0.04	1.65±0.79	1.28±0.002	1.83
Palmitic Acid (C16:0)	11.5±0.85	10.08±1.05	11.05±1.13	10.50±0.99	10.78
Palmitoleic Acid (C16:1n9c)	6.02±0.85	5.94±0.56	6.04±1.04	6.12±0.56	6.02
Heptadecanoic Acid (C17:0)	2.97±0.04	2.81±0.04	2.92±0.87	3.10±0.65	3.21
Stearic Acid (C18:0)	6.10±0.12	5.91±0.4	6.02±1.01	6.12±0.11	6.02
Elaidic Acid (C:18:1 n9t)	2.32±0.01	2.27±0.21	2.24±0.02	2.43±0.10	2.44
Oleic Acid (C18:1 n9c)	19.11±0.13	18.08±1.02	18.02±1.11	19.32±0.67	18.97
Linoleic Acid (C18:2 n6c)	1.37±0.01	0.65±0.08	0.63±0.02	1.81±0.52	1.12
Linolenic Acid (C18:3n3)	0.15±0.10	0.43±0.05	0.34±0.01	21.65±0.01	0.85
Arachidic Acid (C20:0)	1.85±0.53	1.75±0.44	1.75±0.05	1.80±0.21	1.75
Eicosenoic Acid (C20:1)	1.65±0.50	1.55±0.03	1.65±0.02	1.64±.43	1.76
Behenic Acid (C22:0)	1.75±0.74	1.65±0.11	1.75±0.06	1.75±0.31	1.77
Erucic Acid (C22:1 n9c)	1.70±0.01	1.60±0.25	1.60±0.22	1.72±0.10	1.73
Means	3.56	4.54	4.77	3.65	

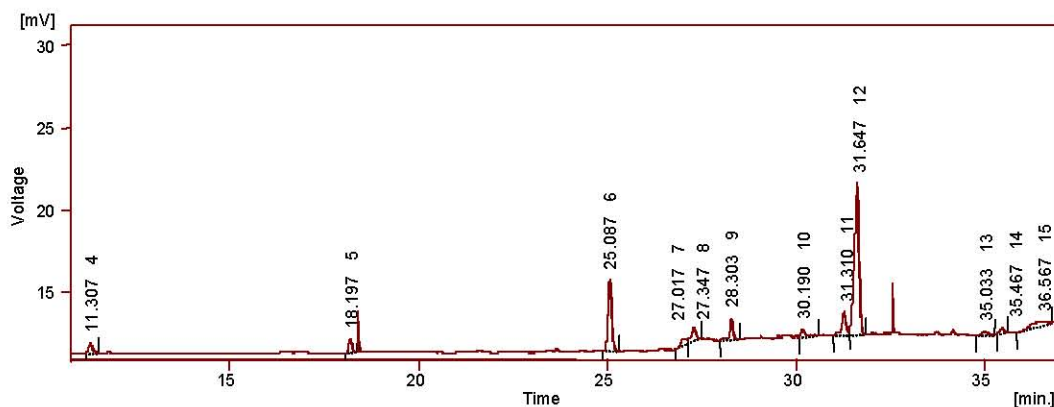


Fig. 7: Gas chromatogram of Goat milk fat by gas chromatography (Bahawalpur)

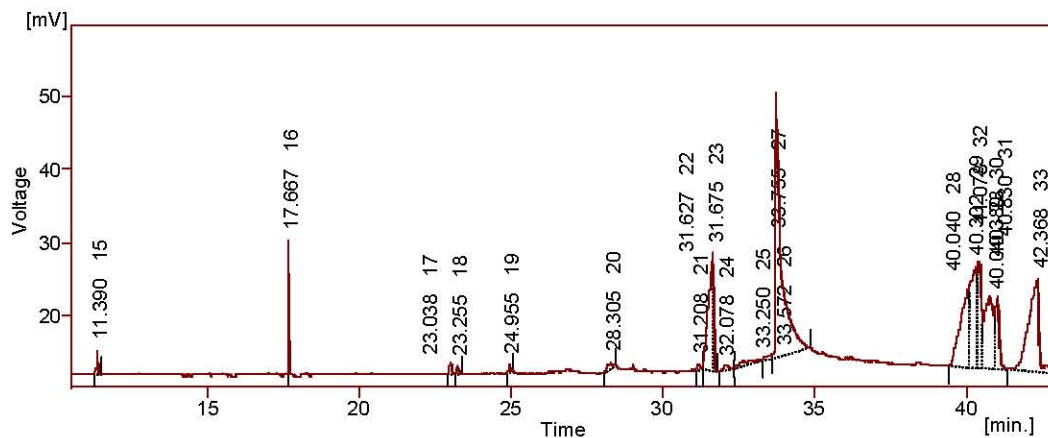


Fig. 8: Gas chromatogram of Goat milk fat by gas chromatography (Faisalabad)



Table E: Milk fatty acids composition (g/100g) of Marecha Camel in various Districts

Fatty Acids	Bahawalpur	Sahiwal	Okara	Faisalabad	Means
Caprylic Acid (C8:0)	1.71±0.06	1.54±0.04	1.78±0.02	1.74±0.01	1.71
Capric Acid (C10:0)	3.01±0.03	2.81±0.01	3.42±0.21	3.40±0.08	2.98
Lauric Acid (C12:0)	6.02±0.06	5.94±0.05	6.20±0.24	6.02±0.56	6.51
Tridecanoic Acid (C13:0)	2.82±0.10	2.64±0.11	2.76±0.08	2.17±0.03	2.97
Myristic Acid (C14:0)	3.01±0.08	2.75±0.11	2.69±0.21	2.81±0.04	3.05
Myristoleic Acid (C14:1 n9c)	1.75±0.12	1.61±0.81	1.85±0.99	1.75±0.02	1.73
Pentadecanoic Acid (C15:0)	1.65±0.10	1.72±0.06	1.63±0.55	1.71±0.01	1.69
Palmitic Acid (C16:0)	10.05±0.78	10.65±0.98	11.12±1.14	11.52±1.10	11.25
Palmitoleic Acid (C16:1n9c)	6.15±0.74	6.15±0.12	6.05±1.12	6.14±0.43	6.04
Heptadecanoic Acid (C17:0)	3.51±0.11	3.12±0.09	3.02±1.12	3.20±0.52	3.03
Stearic Acid (C18:0)	6.03±0.41	6.22±0.07	6.22±1.02	6.35±0.21	6.01
Elaidic Acid (C:18:1 n9t)	2.42±0.01	2.33±0.11	2.35±0.01	2.41±0.21	2.22
Oleic Acid (C18:1 n9c)	18.23±0.98	17.02±1.01	19.02±0.97	19.01±0.87	18.77
Linoleic Acid (C18:2 n6c)	1.91±0.04	0.86±0.05	0.85±0.06	1.04±0.10	1.12
Linolenic Acid (C18:3n3)	1.00±0.03	1.10±0.06	0.55±0.04	0.85±0.04	0.87
Arachidic Acid (C20:0)	1.65±0.55	1.64±0.11	1.62±0.06	1.75±0.10	1.68
Eicosenoic Acid (C20:1)	1.75±0.56	1.66±0.01	1.81±0.05	1.80±3600	1.79
Behenic Acid (C22:0)	1.71±0.62	1.74±0.02	1.79±0.11	1.81±0.26	1.74
Erucic Acid (C22:1 n9c)	1.74±0.02	1.64±0.21	1.65±0.11	1.80±0.01	1.73
Means	3.54	4.31	3.86	3.14	

### Milk Fatty Acids Composition (G/100g) of Marecha Camel in Various Districts:

The data on milk fatty acid composition of Marecha Camel in various districts is presented in Table E. It is indicated from the statistical table that milk fatty acid composition of Marecha Camel was found to be highly significant ( $P < 0.01$ ). The average mean value of Linolenic acid (C18:3n3) 0.87g/100g was minimum as compared to other fatty acids in different areas whereas maximum average value was noticed in Long chain fatty acid Oleic acid (C18:1 n9c) 18.77g/100g followed by Palmitic acid (C16:0) 11.25g/100g in different districts.

The results of milk fatty acid composition of Marecha Camel of various districts showed that SCFA like Caprylic acid (C8:0) and Capric acid (C10:0) represented 1.71g/100g and 2.98g/100g respectively. Medium chain fatty acids represented (17 g/100g) in total and long chain fatty acids like Palmitic acid (C16:0) represented 12.25g/100g. Among the Long chain but mono unsaturated fatty acids Oleic acid (C18:1 n9c) in fatty acid composition was the highest 19.13g/100g. The concentration of Oleic acid (C18:1 n9c) in Marecha Camel was highest as compared to all other milk samples from different animals of different districts. Long chain Linolenic acid (C18:3n3) was 0.87g/100g.

The above results were similar to the findings of (Kelsey *et al.*, 2003) that there was high concentration of Oleic acid present in camel milk fat.

### CONCLUSION

Fatty acids proved to be essential components of human diet playing an important role in metabolism and

growth and are classified as essential or non-essential based upon their properties. Conjugated linoleic acids (CLA) and butyric acid originated from ruminants (buffalo, cow, sheep, goat and camel) metabolism are of major interest due to their anti-carcinogenic and anti-diabetic properties in human. Fatty acids composition varies within species and among other species of the different districts. The study of fatty acid compositions of milk of Nili Ravi Buffalo, Sahiwal Cow, Kajli Sheep, Betal Goat and Marecha Camel revealed that species have statistically significant impact on fatty acid composition of ruminants. There are few fatty acids which are not significantly different. It was determined that Nili Ravi Buffalo milk fat contain higher concentration of Oleic acid C18:1 (19.13g/100g) and Palmitic acid C16:0 (12.25g/100g). This concentration was higher as compared to all other animals of different districts. Sheep and goat milk contain higher concentration of Caprylic acid C8:0, Capric acid C10:0 and Lauric acid C12:0 as compared to buffalo, cow and camel milk respectively.

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