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Colostrum of current and rare cattle breeds: fatty acid pattern

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Abstract. Colostra in the early stage of lactation was obtained from cows belonging to different dairy breeds, but were kept under the same feeding and housing conditions. Crude fat content and the fatty acid composition of fat in the form of fatty acid methyl esters were determined.

Key words and phrases: fatty acid, colostrum, dairy cow.

There were not significant differences among breeds regarding the fat content of colostrum. The ratio of the saturated fatty acids within the sum of fatty acids was higher in the case of Jersey ($p < 0.05$) than that of Holstein-Friesian, Brown Swiss and Norwegian red. The fat of colostrum of Brown Swiss contained more monounsaturated fatty acids than that of the Jersey and Ayrshire. Holstein-Friesian proved to have higher ratios of polyunsaturated fatty acids within fat than Swedish red. The ratio of $n6$ fatty acids was higher in samples originated from Holstein-Friesian than that of Swedish red, Jersey, Norwegian red, and Ayrshire while the ratio of the $n3$ fatty acids did not differ among breeds. In consonance with the above results, the $n6/n3$ ratio was the highest in the colostrum of Holstein-Friesian cows.

1 Introduction

Fatty acid composition of colostrum can be affected by several factors. As in the case of normal milk, it depends partially on the lipid profile of the forage even in the case of ruminants. Some part of the long-chain $n3$-polyunsaturated fatty acids ($n3$-PUFA) originated from fish oil was transferred into the colostrum (*Cattaneo et al.*, 2006). Nevertheless, the organisms are willing to provide a certain level of long-chain PUFA in the colostrum, irrespective of the dietary sources and adipose tissue levels, as these fatty acids are important for the neonate (*Leiber et al.*, 2011). The fatty acid composition of normal milk is influenced by breed (*Soyeurt et al.*, 2006). There is scarce information on the genetic effect regarding the fatty acid profile of colostrum; therefore, the aim of our study was to compare the fatty acid composition of colostrum of different dairy cow breeds kept under the same feeding and housing conditions.

2 Material and methods

2.1 Milk sampling

Colostrum samples originated from the "Kőrös-Maros Biofarm" Ltd. from Gyulavári, Hungary. There are about 500 Holstein-Friesian cows in this plant. Individuals of further breeds were imported (Swedish red, Jersey, Brown Swiss, Norwegian red, Ayshire) and an experiment was conducted in order to compare their production. Experimental animals were loose-housed cows kept in small groups. The bedding of the cow-shed was deep litter and the house was provided with concreted open yard. The number of animals was 13–15 per part of the cow-shed. Feed and water were provided in the open yard. The level of the water was fixed in the drinking trough and the feed was prepared with mixer-feeder wagon. Milking was obtained twice a day with herringbone milking parlour.

Feed met the requirements of bioproduction. The daily intake was 9 kg corn silage, 4 kg alfalfa silage, 2 kg alfalfa hay, and 9 kg triticale haylage. The amount of the provided concentrate (6–9 kg) depended on the milk production. The individual dry matter consumption was 19.1 kg, the milk production net energy 125 MJ, and the metabolizable protein content 2017 g.

Colostrum samples were taken on the first, third, and fifth days after calving. Three individuals from each breeds were milked and the lactations of the same animals were followed.

2.2 Chemical analysis

Chemical analysis was carried out at the Department of Chemistry-Biochemistry, Faculty of Animal Science, Kaposvár University. Crude fat content determination was carried out according to the MSZ ISO 8262-3 international standard. Fatty acid profile was determined in the form of fatty acid methyl esters. The homogenized sample was weighed into a flask, 8 cm^3 concentrated hydrochloric acid was added, and it was boiled for 60 minutes. After cooling down, 7 cm^3 ethanol and then 15 cm^3 diethylether was added, following a one-minute shaking. The next extraction was with 15 cm^3 petrolether (b.p.$<$ 60°C). After phase separation, organic phase, which contains about 150–200 mg fat, was separated and evaporated under vacuum on a rotadest. Then 4 cm^3 of 0.5 M sodium-hydroxide in methanol was added and boiled on a water-bath for 5 minutes. Then 4 cm^3 14% boron-trifluoride in methanol was added and boiled for 3 minutes, following the addition of 4 cm^3 n-hexane. It was boiled for one minute, then the level of the organic phase was brought to the neck of the flask with saturated sodium-chloride solution. When phases were separated, samples were taken for the analysis from the organic phase, and it was dry on sodium sulfate.

The fatty acid methyl esters (FAMEs) were separated on a 100 m $\times$ 0.25 mm wall-coated open-tubular (WCOT) column equipped with CP-SIL 88 (FAME) stationary phase. The quantitation of FAMEs was obtained with a flame ionization detector (FID) at 270 °C. The temperature of the splitter injector was 270 °C, the carrier gas was helium with the head pressure of 235 kPa. The oven was temperature-programmed from 140 °C (10 min.) with 10 °C/min increase up to 235 °C (26 min). The injected volume varied between 0.5 and 2 µl. The instrument was a Chrompack CP 9000 gas chromatograph.

The results were calculated as area % (the peak area of the given fatty acid methyl ester was divided by the sum of the peak areas and multiplied by 100) and expressed in fatty acid methyl ester % (w/w).

The influence of the breed and the time after calving on the fat content of colostrum and the fatty acid pattern was evaluated with analysis of variance.

3 Results

The crude fat content of colostrum samples did not differ by breeds ($p \geq 0.05$, Table 1). The variation within breeds was smaller than the variation in the function of time (Fig. 1). The average fat content measured on the first day (8.6%, $n = 18$) was significantly more than the one measured on the third day (3.9%, $n = 18$). In the case of samples milked on the fifth day of lactation, the average value of crude fat content was between the two above values (5.8% $n = 18$).

While the fat content of normal milk is affected by breed, in the case of colostrum, there were not significant differences detected by breeds within the examined time period.

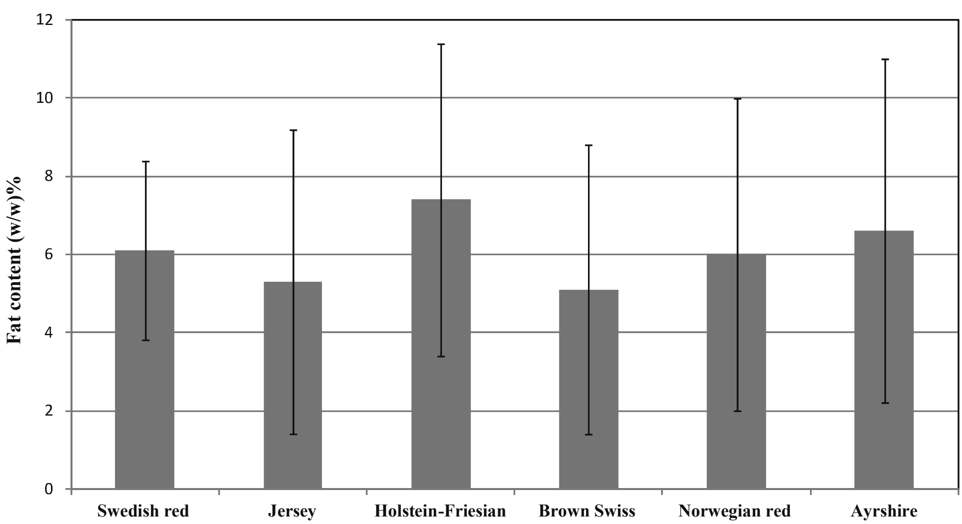

Figure 1: The fat content of colostra from different dairy cow breeds. Average and standard deviation of the samples milked on the first, third, and fifth days ($n = 9$)

Table 1: The characterization of fat content and fatty acid composition[2] of colostra of different breeds (n=9)[1]

	Swedish red		Jersey		Holstein-Friesian		Brown Swiss		Norwegian red		Ayrshire	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Crude fat content (%)	6.1	2.3	5.3	3.9	7.4	4.0	5.1	3.7	6.0	4.0	6.6	4.4
SFA	68.1^{abc}	6.4	72.7 c	3.5	64.5^{ab}	6.5	63.0^{a}	4.7	64.6^{ab}	4.2	69.7^{bc}	5.3
MUFA	27.7^{abc}	6.6	23.1^{a}	3.4	30.5^{bc}	6.9	32.5^{c}	5.1	31.1^{bc}	4.1	26.0^{ab}	4.9
PUFA	3.7^{a}	0.5	3.8^{ab}	0.6	4.7^{b}	0.5	4.1^{ab}	0.6	3.9^{ab}	0.6	3.9^{ab}	0.9
MUFA+PUFA	31.4^{abc}	6.4	27.0^{a}	3.5	35.2^{bc}	6.4	36.6^{c}	4.5	35.0^{bc}	4.1	29.9^{ab}	5.3
SFA:(MUFA+PUFA)	2.3^{abc}	0.6	2.8^{c}	0.5	1.9^{ab}	0.5	1.8^{a}	0.4	1.9^{ab}	0.4	2.4^{bc}	0.6
n3	1.1	0.2	0.9	0.2	1.0	0.2	1.0	0.1	0.9	0.4	1.3	0.5
n6	2.6^{a}	0.3	2.9^{a}	0.5	3.6^{b}	0.3	3.0^{ab}	0.5	3.0^{a}	0.4	2.6^{a}	0.8
n6:n3	2.5^{a}	0.4	3.2^{ab}	0.8	3.7^{b}	0.8	3.0^{ab}	0.3	3.8^{ab}	1.5	2.3^{a}	0.9

[1] Averages in one row with common superscript do not differ ($p \geq 0.05$).
The absence of superscripts in one row means that there are not any significant differences between the means.
SFA = the sum of the ratio of saturated fatty acids
[2] Expressed in fatty acid methyl ester %
MUFA = the sum of the ratio of monounsaturated fatty acids
PUFA = the sum of the ratio of polyunsaturated fatty acid

The ratio of the saturated fatty acids (SFA) in the colostrum fat of Jersey was higher ($p < 0.05$) than that of Holstein-Friesian, Brown Swiss, and Norwegian red (Table 1). The ratio of monounsaturated fatty acids (MUFA) was the highest in the case of Brown Swiss and the colostrum fat of this breed contained significantly more MUFA than the Jersey and Ayrshire.

The colostrum fat of Holstein-Friesian contained the highest amount of polyunsaturated fatty acids (PUFA). The sum of the unsaturated fatty acids (MUFA+PUFA) was significantly higher in the case of Brown Swiss than that of Jersey and Ayrshire.

The colostrum fat of Jersey had more saturated fatty acids related to the amount of unsaturated fatty acids SFA/(MUFA+PUFA) than the Holstein-Friesian, Brown Swiss, and Norwegian red (Fig. 2).

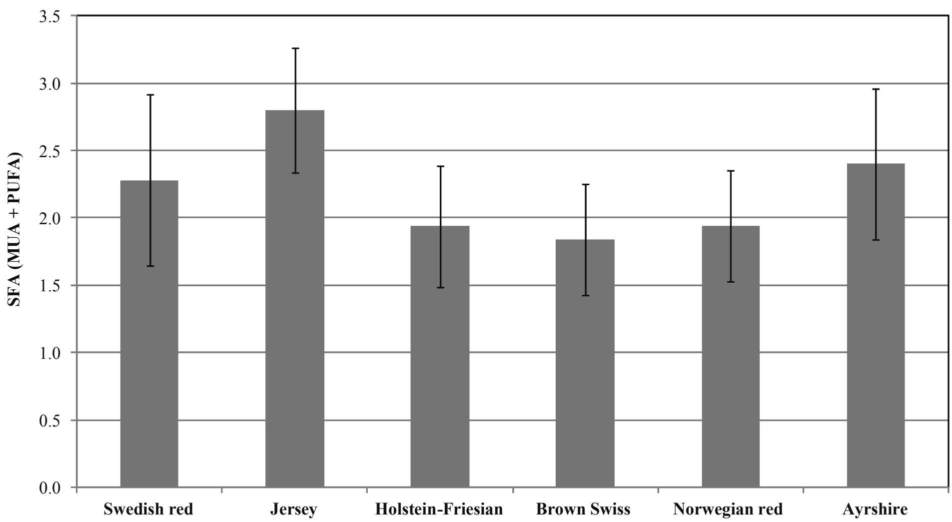

Figure 2: The ratio of the saturated and unsaturated fatty acids SFA/(MUFA+PUFA) in the colostra of different dairy breeds. Average and standard deviation of the samples milked on the first, third, and fifth days ($n = 9$)

The ratio of $n3$-fatty acids did not differ significantly in the colostrum fat of the breeds under investigation; however, some differences were detected in the case of $n6$-fatty acids. The colostrum fat of Holstein-Friesian contained more $n6$ fatty acids than that of Swedish red, Jersey, Norwegian red, and Ayrshire.

The n6/n3 ratio of fatty acids is shown on Fig. 3.

The average fatty acid composition of colostra can be seen in Table 2. In the group of short-chain saturated fatty acids, there was not significant difference in the ratio of butyric acid, caproic and caprylic acid among the breeds. The colostrum fat of Holstein Friesian contained less caprylic acid than the Ayrshire, less undecanoic acid than the Ayrshire, Swedish red, Norwegian red, and Brown Swiss. The ratio of lauric acid was less than the Jersey and the ratio of tridecanoic acid was also less than that of the Jersey, Norwegian red, and Ayrshire. In general, it can be stated that the colostrum fat of Holstein-Friesian contains less C10 – C13 saturated fatty acids than that of the other breeds under investigation.

There are not any obvious tendencies among breeds regarding the ratio of long-chain saturated fatty acids, being present in small amount. The colostrum fat of Holstein-Friesian contains less pentadecanoic acid but more margaric acid than the Jersey. Jersey contained significantly more arachidic acid than Swedish red and there were not significant differences among breeds in the ratios of behenic acid and lignoceric acid.

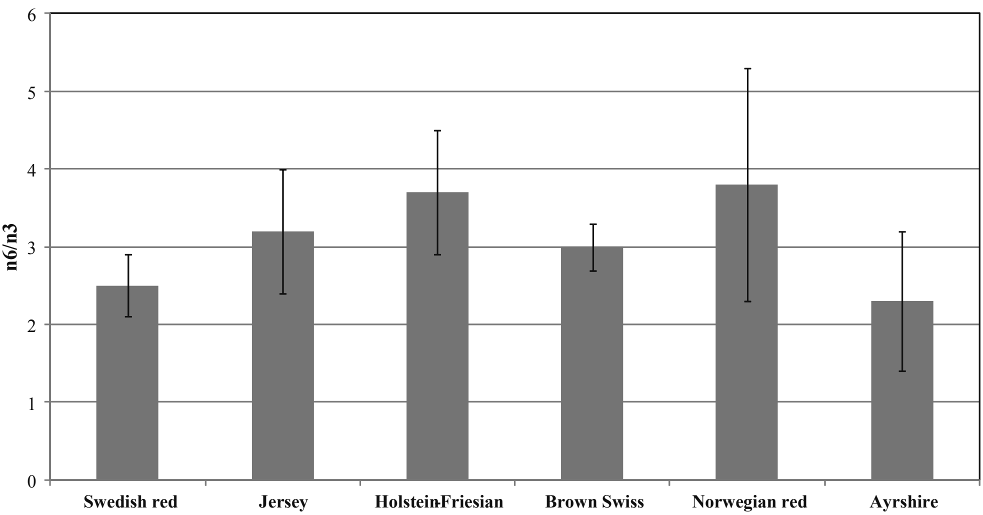

Figure 3: The ratio of n6/n3 fatty acids in the colostrum fat of different dairy breeds. Average and standard deviation of the samples milked on the first, third, and fifth days ($n = 9$)

Table 2: The average fatty acid content of colostrum (1^{st}, 3^{rd}, and 5^{th} days) expressed in fatty acid methyl ester % (n=9)[1]
Part 1: C4-C17 fatty acids

Fatty acid		Swedish red		Jersey		Holstein-Friesian		Brown Swiss		Norwegian red		Ayrshire	
		mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Butyric acid	4:0	0.71	0.17	0.58	0.23	0.63	0.30	0.89	0.70	1.89	1.62	2.44	4.31
Caproic acid	6:0	0.85	0.32	0.80	0.26	0.62	0.13	0.86	0.25	0.88	0.31	0.75	0.22
Caprylic acid	8:0	0.72	0.24	0.66	0.24	0.43	0.09	0.64	0.15	0.65	0.20	0.60	0.16
Capric acid	10:0	1.97^{ab}	0.71	1.85^{ab}	0.67	1.03^{a}	0.28	1.47^{ab}	0.35	1.57^{ab}	0.45	1.60^{b}	0.36
Undecanoic acid	11:0	0.12^{b}	0.05	0.11^{ab}	0.06	0.04^{a}	0.01	0.07^{b}	0.02	0.11^{b}	0.05	0.10^{b}	0.04
Lauric acid	12:0	3.04^{ab}	0.90	2.94^{b}	0.62	1.88^{a}	0.66	2.22^{ab}	0.53	2.34^{ab}	0.51	2.72^{ab}	0.50
Tridecanoic acid	13:0	0.11^{ab}	0.04	0.12^{b}	0.04	0.06^{a}	0.02	0.08^{ab}	0.02	0.10^{b}	0.02	0.10^{b}	0.02
Myristic acid	14:0	12.39	2.97	12.75	1.90	10.13	3.76	10.35	3.07	10.23	2.43	12.65	2.70
Myristoleic acid	14:1	0.92^{c}	0.27	0.68^{abc}	0.20	0.46^{ab}	0.16	0.53^{ab}	0.20	0.62^{abc}	0.24	0.86^{abc}	0.32
Pentadecanoic acid	15:0	0.91^{ab}	0.07	1.01^{b}	0.15	0.75^{a}	0.13	0.85^{ab}	0.07	0.93^{ab}	0.09	0.88^{ab}	0.13
Palmitic acid	16:0	37.01^{ab}	5.07	40.78^{b}	5.16	35.54^{ab}	4.90	31.96^{a}	4.84	33.20^{ab}	4.79	37.75^{ab}	7.44
Palmitoleic acid	16:1	2.26	0.72	1.82	0.28	1.90	0.32	2.27	0.35	2.18	0.29	2.05	0.21
Margaric acid	17:0	0.93^{ab}	0.16	0.82^{a}	0.10	1.07^{c}	0.19	1.09^{c}	0.16	0.96^{b}	0.12	0.85^{ab}	0.13

[1] For superscripts, see Table 1.

Table 2: The average fatty acid content of colostrum (1^{st}, 3^{rd}, and 5^{th} days) expressed in fatty acid methyl ester % (n=9)[1]
Part 2: C18 fatty acids

Fatty acid		Swedish red		Jersey		Holstein-Friesian		Brown Swiss		Norwegian red		Ayrshire	
		mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Stearic acid	18:0	9.10	2.57	9.91	2.63	11.92	3.09	12.21	3.37	11.44	3.13	8.94	3.05
Elaidic acid	18:1n9t	1.14	0.47	1.05	0.32	1.12	0.37	1.53	0.35	1.20	0.46	0.96	0.45
Oleic acid	18:1n9c	22.41[ab]	6.02	18.84[a]	3.19	26.03[ab]	6.32	26.98[b]	4.58	25.94[b]	3.98	21.28[ab]	5.00
7-octadecenoic acid	18:1n7	0.90[ab]	0.21	0.69[a]	0.25	0.94[ab]	0.17	1.07[b]	0.20	1.04[ab]	0.18	0.80[ab]	0.21
Linoleic acid	18:2n6	2.08[a]	0.16	2.19[ab]	0.38	2.85[c]	0.22	2.51[bc]	0.31	2.47[abc]	0.32	1.99[abc]	0.73
γ-linolenic acid	18:3n6	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.02	0.01	0.03	0.01
α-linolenic acid	18:3n3	0.52[ab]	0.15	0.40[a]	0.11	0.43[a]	0.07	0.59[b]	0.06	0.44[ab]	0.11	0.56[ab]	0.22
c9, t11- conjugated linoleic acid	c9,t11-18:2	0.40[bc]	0.08	0.30[a]	0.06	0.29[a]	0.08	0.48[c]	0.11	0.34[ab]	0.09	0.35[ab]	0.11

[1] For superscripts, see Table 1.

Table 3: The average fatty acid content of colostrum (1st, 3rd, and 5th days) expressed in fatty acid methyl ester % (n=9)[1]
Part 3: C20-C24 fatty acids

Fatty acid		Swedish red		Jersey		Holstein-Friesian		Brown Swiss		Norwegian red		Ayrshire	
		mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Arachidic acid	20:0	0.14^{a}	0.02	0.19^{b}	0.04	0.18^{ab}	0.03	0.17^{ab}	0.04	0.17^{ab}	0.04	0.15^{ab}	0.03
Eicosenoic acid	20:1	0.07	0.02	0.07	0.02	0.08	0.01	0.08	0.01	0.09	0.02	0.08	0.03
Eicosadienoic acid	20:2	0.04	0.03	0.03	0.01	0.05	0.02	0.04	0.01	0.04	0.01	0.03	0.01
Behenic acid	22:0	0.11	0.05	0.12	0.04	0.11	0.03	0.10	0.03	0.10	0.04	0.10	0.04
Eicosatrienoic acid	20:3n6	0.17	0.07	0.23	0.08	0.28	0.18	0.20	0.10	0.17	0.08	0.20	0.09
Arachidonic acid	20:4n6	0.35^{ab}	0.09	0.41^{b}	0.08	0.49^{c}	0.15	0.30^{a}	0.11	0.32^{a}	0.12	0.35^{ab}	0.08
Lignoceric acid	24:0	0.04	0.01	0.09	0.05	0.07	0.03	0.07	0.03	0.06	0.01	0.07	0.04
Eicosapentanoic acid	20:5n3	0.15	0.05	0.13	0.05	0.10	0.04	0.10	0.04	0.12	0.07	0.22	0.11
Docosapentanoic acid	22:5n3	0.29	0.11	0.34	0.13	0.31	0.12	0.26	0.12	0.30	0.19	0.43	0.22
Docosahexanoic acid	22:6n3	0.11	0.05	0.07	0.04	0.17	0.17	0.06	0.03	0.06	0.04	0.08	0.05

[1] For superscripts, see Table 1.

The sum of SFA was mostly affected by the saturated fatty acids being present in high quantities. In the case of myristic acid, there were not significant differences among breeds, but the ratio of palmitic acid (dominating in the group of SFA) was not the same among breeds. The highest value was detected for the colostrum fat of the Jersey (40.8%), being significantly higher than what was measured for Brown Swiss (32.0%). The dominancy of palmitic acid within the group of SFA means that the differences in SFA ratio are mainly influenced by the variation of this fatty acid. The abundance of palmitic acid in the colostrum fat of Jersey made this breed having the most saturated character.

The colostrum fat of Holstein-Friesian contained a relatively small ratio of short-chain saturated fatty acids, but the ratio of palmitic acid (35.5%) was between the values of Jersey and Brown Swiss; therefore, instead of Holstein-Friesian, the colostrum fat of Brown Swiss proved to have the most unsaturated character.

There were not differences by breeds in the amount of some minor fatty acids with one double bond (palmitoleic acid, elaidic acid, eicosenoic acid). The colostrum fat of Swedish red contained almost twice as much myristoleic acid (0.92%) as Brown Swiss (0.53). The best source of $18:1n7$ minor fatty acid was the colostrum fat of Brown Swiss.

Oleic acid is the main component of MUFA. The ratio of this fatty acid was significantly higher in the colostrum fat of Brown Swiss and Norwegian red (27.0% and 25.9%, respectively) than that of Jersey (18.8%). The oleic acid content of Holstein-Friesian colostrum fat was also high (26.0%).

In the case of PUFA occurring in smaller quantities, the ratio of $20:3n6$, $20:5n3$, $22:5n3$, and $22:6n3$ in the colostrum fat did not differ by breeds. The only exception was arachidonic acid. The colostrum fat of Norwegian red and Brown Swiss contained the lowest ratio of this fatty acid (0.32; 0.30%). Jersey had a little more (0.41%) and Holstein-Friesian had significantly highest ratio (0.49%) of arachidonic acid than that of the other breeds.

The ratio of $c9,t11$-conjugated linoleic acid ($c9,t11$-CLA) was significantly higher in the case of colostrum fat of Brown Swiss (0.48%) than that of Holstein-Friesian (0.29%) and Jersey (0.30). Similar tendency was observed in the case of linolenic acid (Table 2, Fig. 4). The colostrum fat of Holsten-Friesian contained significantly more linoleic acid (2.85%) than that of Swedish red (2.08%) and Jersey (2.19%) (Table 2).

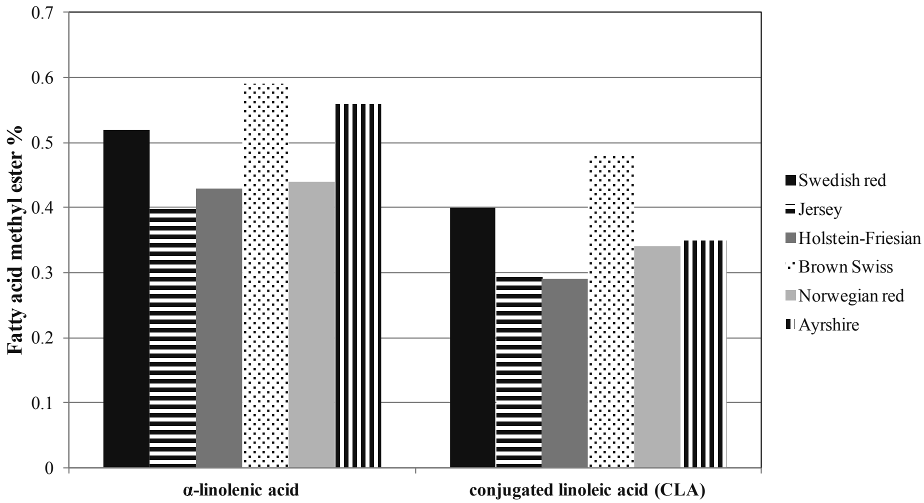

Figure 4: The ratio of $c9, t11$-conjugated linoleic acid ($c9, t11$-CLA) and α-linolenic acid in the colostrum fat of different dairy cow breeds $(n = 9)$

4 Summary

To summarize the results obtained for the fatty acid pattern of colostra, it can be concluded that a higher SFA ratio is characteristic to Jersey, a higher presence of MUFA is characteristic to Brown Swiss, and the colostrum of Holstein-Friesian is more abundant in PUFA than the other breeds. The colostrum fat of Jersey proved to have obviously more saturated character than that of Holstein-Friesian, Brown Swiss, and Norwegian red. The colostrum of Holstein-Friesian – with the exception of Brown Swiss – contained more $n6$ fatty acid than the other breeds under investigation. The pattern of $c9, t11$CLA and α-linoleic acid ratio in the fat is similar across the breeds. With the exception of the arachidonic acid, there were not any differences by breed with respect to the physiologically important long-chain $n3$-polyunsaturated fatty acids.

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