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CHANGES IN FATTY ACID PROFILE OF GOAT BUTTER FROM GOATS FED ALGAE

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Abstract

The feed is one of the most important factors affecting goat milk composition. The purpose of this study was to investigate the influence of freshwater algae *Chlorella vulgaris* addition and marine algae *Japanochytrium* sp. addition into goat diet on the fatty acid profile of goat butter.

Forty-five White Shorthaired dairy goats during their second lactation were divided into three groups of fifteen animals. The feed in the experimental group E1 was enriched by the addition of 10 g/day of granulated *Chlorella vulgaris* and by 5 g/day of granulated *Japanochytrium* sp. in the experimental group E2 respectively. The control group C was fed a standard diet without algae supplementation. Additionally, for nutritional reasons, the fatty acid profile of butter blends (goat : cow 50 : 50, and 25 : 75) were also studied. Fatty acids were re-esterified into the corresponding methyl esters and analyzed by gas chromatography with a flame ionization detector.

Our results suggest that the feed supplementation with *Japanochytrium* sp. led to an increased content of vaccenic acid (by 16%), conjugated linoleic acid (by 5%), cis-8,11,14-eicosatrienoic (by 140%) and docosahexaenoic acid (by 80%) in the goat butter compared with the control group. *Chlorella vulgaris* supplementation hasn't increased the content of these fatty acids in the butter. The addition of cow cream into butter made from goat cream of *Japanochytrium* group caused a decrease of saturated fatty acids (by 5% in 25 : 75 butter, and by 3% in 50 : 50 butter respectively) and polyunsaturated fatty acids (by 17% in 25 : 75 butter, and by 10% in 50 : 50 butter respectively). On the other hand, monounsaturated fatty acids increased significantly in both butters (by 23% in 25 : 75 butter, and by 13% in 50 : 50 butter respectively).

Algae supplementation to the goat diet may increase the content of nutritionally beneficial polyunsaturated fatty acids (PUFAs) in goat butter which is dependent on the type of algae and their composition.

Key words: *Goat milk, Goat butter, Fatty acids, Chlorella vulgaris, Japanochytrium sp.*

1. Introduction

Goat milk and milk products are very valuable sources of essential components in human nutrition. Due to the increased demand for quality products made of goat milk, breeding programmes significantly expanded in recent years in developing as well as developed countries [1]. Goat milk is mainly processed into cheese. Other dairy products as: fortified/flavoured milk, condensed milk, milk powder, ice cream, butter and yogurt are only rarely manufactured [2 - 4].

Goat milk fat is one of the most important components involved in cheese yield, firmness, texture, colour and flavour [5]. Another benefit of goat milk fat is its better digestibility in comparison with cow milk fat. This is caused by the smaller size of lipid micelles which allows for better lipase accessibility during digestion [6 - 7]. Compared with cow milk, goat milk fat contains more short chain saturated fatty acids (SCFA) like caproic (C6:0), caprylic (C8:0) and capric acid (C10:0) [7]. Short chain fatty acids possess nutritional benefits to the consumer. Goat milk contains 10 - 18% SCFA, whereas cow milk only 5 - 9% [6, 8]. Short chain fatty acids are associated with positive outcomes in: treating heart diseases, intestinal disorders, malabsorption, cystic fibrosis and cholecystitis [2, 8, and 9]. SCFA impart the characteristic odour and flavour of goat products.

To date many studies have focused on the feasibility of increasing the content of beneficial fatty acids in goat milk and other milk products; among those on conjugated linoleic acid (CLA) and omega-3 and omega-6 polyunsaturated fatty acids to boost consumers' health [10 - 11]. The chief factor in producing such change is the animal's nutrition per se. Some algae species are convenient sources of nutritionally valuable lipids containing polyene fatty acids, in particular omega-3 and omega-6 [12]. It has been reported that the addition of the algae into the feed of ruminants causes a significant decrease of saturated fatty acids while the content of conjugated linoleic acid and other polyunsaturated fatty acids in milk goes up [13 - 14].

Several unrelated groups of organisms are commonly called 'algae' even though they belong taxonomically to several kingdoms and only a few of them show similarities with plants. *Chlorella vulgaris* belongs to the green freshwater algae of the class *Trebouxiophyceae*, family *Chlorellaceae* and provides significant amounts of linoleic and alpha-linolenic acid [15]. *Japanochytrium* sp. is a marine alga of the kingdom *Chromista,* class *Thraustochytriaceae*, family *Labyrinthulomycetes* [16]. A *Japanochytrium* alga doesn't contain any chlorophyll. However, some members of the *Thraustochytrids* class are a great source of the very valuable docosahexaenoic acid (all-*cis*-4,7,10,13,16,19-C22:6; DHA) [17].

The aim of this study was to compare the fatty acid profiles of goat butter produced with the milk of goats fed with two different types of algae. For nutritional reasons, the fatty acid profiles of butter blends (goat : cow 50 : 50, and 25 : 75) were also investigated.

2. Materials and Methods

2.1 Animals and feed

Czech breed of White Shorthaired goat was used in this experiment. The milk was collected separately for each animal during the second lactation period in the months of May (day 0) and June (day 49) 2014. Treatment groups (E1 - *Chlorella*, E2 - *Japanochytrium*) comprised 15 animals each. Each goat received either 10 g of granulated *Chlorella vulgaris* or 5 g of granulated *Japanochytrium* supplement per day in the total mixed ration (TMR). The control group (C) of 15 animals received the same TMR with no algae supplement. Algae supplementation has started the day after the first milk samples had been gathered. The fatty acids (FA) analysis of first milk gathering before the algae administration had started was used to check the uniformity and prove the same initial conditions in all groups. Before the start of the experiment goats were housed indoors (adaptation period) for a month at a farm near Liberec (Czech Republic) and all fed with the same TMR. Indoor housing continued also during the experiment. The TMR consisted of: hay ad libitum, grasslands (2 kg/head/day), and grain mix (300 g/head/day).

2.2 Butter production

Goat cream was produced from pooled milk (of the respective goat group; at day 56) using a laboratory centrifuge. The particular cream of the C, E1 and E2 groups contained 51.5% fat, 50.5% fat 49.3% fat respectively. The cream was pasteurized for 5 min. at 90 ^{0}C. Churning of cream into butter followed after its physical ripening at 8 ^{0}C for 4 hours. In this way, three samples of goat butter were produced (C, E1, E2).

Next, goat : cow cream blends were produced. In those blends E2 (*Japanochytrium*) goat cream was mixed with a regular cow cream (origin: Bohušovická mlékárna, a.s.; 40.3% fat). Cream blends were processed into butter the same way as described above. The following two butter blends were made: (a) 50 : 50 goat/cow (fat w/w), and (b) 25 : 75 goat/cow (fat w/w).

2.3 Fatty acid analysis

After the milk fat extraction [18], FA were re-esterified into the corresponding methyl esters according to a modified method described elsewhere [19]. Approximately 40 mg of milk fat were weighed into a 25 mL centrifuge screw cap tube and both 0.5 mL methanol, and 0.5 mL methanolic-base (0.5 N) were added. The solution was vigorously shaken and heated for 2 min. at 80 ^{0}C. Next, 1.5 mL of hexane and 10 mL of saturated sodium chloride solution were added and tubes briefly shaken again. The methyl esters were separated by gas chromatography using Agilent 7890A gas chromatograph fitted with a flame ionization detector and a SP-2560 capillary column (100 m × 0.25 mm × 0.2 µm, Supelco). The operation parameters were as follows: detector temperature, 280 ^{0}C; injection port temperature, 280 ^{0}C; column temperature, 140 ^{0}C for 5 min., and programmed to increase by 4 ^{0}C x min^{-1} up to 240 ^{0}C with a final holding time of 20 min.; carrier gas, helium, 1.2 mL.min^{-1}; injection 1 µL with split ratio 1 : 100. Thirty seven fatty acids were identified using FAME standard (Supelco, USA). The individual FA ratio was calculated using the particular FA peak area to all areas of FAs observed.

2.4 Algae analysis

The FA profile of *Chlorella* and *Japanochytrium* algae was analysed according to the method described elsewhere [20].

2.5 Statistical analysis

The data were analysed using STATISTICA software (version 12, StatSoft, Inc). Post-hoc Tukey's HSD test ($P < 0.05$) was used for the evaluation of differences between the control and experimental group.

3. Results and Discussion

In order to assess the effect of algae addition into goat feed it is important to know the FA composition in the algae used in our experiment. The results for *Japanochytrium* and *Chlorella* algae are shown in Table 1.

It is evident that *Chlorella* is in fact a significant source of polyunsaturated FA (62.1%) of which linoleic acid and α-linolenic comprise 28.3% and 33.7%. Surprisingly low concentration of PUFA was found in *Japanochytrium* (7.7%) which significantly differed from *Chlorella*. *Japanochytrium* also contains rather large amounts of palmitic (50.0%), and oleic acid (25.7 %).

Before we evaluate the results obtained in this study for goat butter it is essential to briefly point out the major outcomes for goat milk published in a new study by Borková *et al.*, [21] which proved that the addition of *Japanochytrium* and *Chlorella* algae has a positive impact on FA profile of goat milk (results of this study are summarized in Table 2).

Unlike small caps in superscript (a, b) show statistical differences between May and June (for each group; P < 0.05); unlike large caps in superscript (A, B) show statistical differences between groups (in a particular month; P < 0.05).

Saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA) showed a significant difference between the control (C) and both treatment groups (E1, E2) after 49 days of algae supplementation only in the case of C18:0 and vaccenic acid (*trans*-11-C18:1). Statistically significant increase in polyunsaturated fatty acids (PUFA) was recorded for all-*cis*-6,9,12-C18:3; CLA; all-*cis*-8,11,14-C20:3 and DHA in *Japanochytrium* group (E2).

Results for FA profiles of goat cream (groups C, E1, E2) together with cow cream (Cm) used for butter blends are given in Table 3.

Table 1. Fatty acid composition of *Chlorella* and *Japanochytrium* algae (as per cent of total fatty acids)

Fatty acids	*Chlorella*	*Japanochytrium*
C14:0	0.77	5.49
C16:0	16.2	50.0
***Cis*-9-C18:1**	16.7	25.7
all-*cis*-9,12-C18:2	28.3	4.05
all-*cis*-6,9,12-C18:3	ND	0.36
all-*cis*-9,12,15-C18:3	33.7	0.27
all-*cis*-8,11,14-C20:3	ND	0.54
all-*cis*-5,8,11,14-C20:4	0.14	0.99
all-*cis*-5,8,11,14,17-C20:5	ND	0.18
all-*cis*-4,7,10,13,16,19-C22:6	ND	0.81
SFA - saturated fatty acids	19.2	65.5
MUFA - monounsaturated fatty acids	18.7	26.9
PUFA - polyunsaturated fatty acids	62.1	7.65

ND not detected.

Table 2. Effects of *Japanochytrium* and *Chlorella* supplementation on major fatty acids in goat milk (as per cent of total fatty acids)

Fatty acids	Group	May (t = 0 d)	June (t = 49 d)	Group G	Time T	G × T
C4:0 Butyric acid	E1	2.26 ± 0.43^{a}	2.60 ± 0.34^{bA}	NS	NS	**
	C	2.54 ± 0.34	2.35 ± 0.25^{AB}			
	E2	2.24 ± 0.37	2.23 ± 0.30^{B}			
C6:0 Caproic acid	E1	2.35 ± 0.35^{a}	2.70 ± 0.27^{b}	NS	***	NS
	C	2.44 ± 0.30	2.62 ± 0.19			
	E2	2.50 ± 0.36	2.61 ± 0.27			
C8:0 Caprylic acid	E1	2.35 ± 0.49^{a}	2.77 ± 0.41^{b}	NS	***	NS
	C	2.44 ± 0.38^{a}	2.85 ± 0.16^{b}			
	E2	2.61 ± 0.46	2.82 ± 0.31			

C10:0 Capric acid	E1	7.17 ± 1.55^{aA}	9.44 ± 1.38^{b}	*	***	NS
	C	7.94 ± 1.13^{aAB}	9.74 ± 0.59^{b}			
	E2	8.79 ± 1.25^{B}	9.89 ± 1.01			
C12:0 Lauric acid	E1	2.72 ± 0.51^{aA}	3.56 ± 0.50^{b}	***	***	NS
	C	3.02 ± 0.41^{aAB}	3.63 ± 0.32^{b}			
	E2	3.39 ± 0.47^{B}	3.85 ± 0.32			
C14:0 Myristic acid	E1	8.74 ± 0.76^{aA}	9.99 ± 0.44^{b}	**	***	NS
	C	9.14 ± 0.53^{aAB}	10.12 ± 0.52^{b}			
	E2	9.73 ± 0.93^{B}	10.28 ± 0.42			
C16:0 Palmitic acid	E1	25.52 ± 2.37^{a}	29.47 ± 1.86^{b}	NS	***	NS
	C	26.69 ± 2.41^{a}	29.47 ± 1.29^{b}			
	E2	27.59 ± 2.64^{a}	29.63 ± 1.66^{b}			
C18:0 Stearic acid	E1	11.98 ± 1.66^{aA}	9.31 ± 0.88^{bAB}	**	***	NS
	C	11.41 ± 1.82^{aAB}	9.80 ± 1.18^{bA}			
	E2	10.45 ± 1.61^{aB}	8.36 ± 0.97^{bB}			
***trans*-11-C18:1** Vaccenic acid	E1	1.29 ± 0.28	1.22 ± 0.13^{A}	***	*	***
	C	1.39 ± 0.29	1.31 ± 0.15^{A}			
	E2	1.47 ± 0.17^{a}	1.83 ± 0.21^{bB}			
***cis*-9-C18:1** Oleic acid	E1	23.46 ± 2.88^{aA}	17.59 ± 1.74^{bA}	***	***	NS
	C	21.25 ± 2.10^{aB}	17.16 ± 0.84^{bA}			
	E2	19.16 ± 1.71^{aC}	15.22 ± 1.18^{bB}			
all-*cis*-9,12-C18:2 Linoleic acid	E1	1.96 ± 0.18^{a}	1.80 ± 0.16^{b}	NS	***	NS
	C	1.93 ± 0.19^{a}	1.67 ± 0.13^{b}			
	E2	1.98 ± 0.15^{a}	1.80 ± 0.07^{b}			
all-*cis*-6,9,12-C18:3 γ-linolenic acid	E1	0.04 ± 0.00	0.04 ± 0.01^{A}	**	NS	***
	C	0.04 ± 0.00	0.04 ± 0.00^{A}			
	E2	0.04 ± 0.01^{a}	0.05 ± 0.01^{bB}			
all-*cis*-9,12,15-C18:3 α-linolenic acid	E1	1.08 ± 0.14	1.17 ± 0.12	NS	***	NS
	C	1.03 ± 0.12	1.10 ± 0.10			
	E2	1.08 ± 0.13^{a}	1.22 ± 0.12^{b}			
CLA Conjugated linoleic acid	E1	0.60 ± 0.14	0.62 ± 0.09^{A}	**	**	**
	C	0.65 ± 0.12	0.65 ± 0.05^{A}			
	E2	0.65 ± 0.09^{a}	0.80 ± 0.09^{bB}			
all-*cis*-8,11,14-C20:3 Eicosatrienoic acid	E1	0.01 ± 0.00^{A}	0.01 ± 0.00^{A}	***	***	***
	C	0.02 ± 0.00^{AB}	0.02 ± 0.00^{A}			
	E2	0.02 ± 0.00^{aB}	0.05 ± 0.01^{bB}			
all-*cis*-5,8,11,14-C20:4 Eicosatetraenoic acid	E1	0.12 ± 0.02	0.11 ± 0.01	NS	***	NS
	C	0.12 ± 0.02^{a}	0.10 ± 0.01^{b}			
	E2	0.13 ± 0.02^{a}	0.11 ± 0.01^{b}			
all-*cis*-5,8,11,14,17-C20:5 Eicosapentaenoic acid	E1	0.09 ± 0.02	0.10 ± 0.02	NS	NS	NS
	C	0.09 ± 0.02	0.09 ± 0.01			
	E2	0.10 ± 0.02	0.10 ± 0.01			
all-*cis*-4,7,10,13,16,19-C22:6 Docosahexaenoic acid	E1	0.06 ± 0.02^{A}	0.05 ± 0.01^{A}	***	*	***
	C	0.07 ± 0.02^{aAB}	0.05 ± 0.01^{bA}			
	E2	0.08 ± 0.02^{B}	0.09 ± 0.02^{B}			

A part of the data in Table 1 has already been published in [21].
E1 goats fed *Chlorella;* E2 goats fed *Japanochytrium;* C control.
Mean ± SD (N = 15)
*P < 0.05, **P < 0.01, ***P < 0.001, NS not signif. difference (P > 0.05).

The contents of SFA and PUFA in creams differed from control only in *Japanochytrium* group. Similar conclusion was made for milk (see above). The addition of *Japanochytrium* increased the PUFA (to the final 5.35% in E2 versus 4.98% in C) and decreased SFA (to the final 73.3% in E2 versus 73.8% in C).

For goat cream, large differences were found between FA profiles of goat fat and cow fat. In general, goat cream has a higher amount of SFA (73.7% in E1; 73.8% in C; 73.3% in E2) compared with the cow cream (67.6%). This difference can be due to the higher amounts of beneficial FA in goat fat as C6:0, C8:0 and C10:0 (14.9% in E1; 15.2% in C; 15.1% in E2) compared to their content in cow cream (6.46%). Goat cream showed lesser amount of MUFA (21.4% in E1; 21.2% in C; 21.4% in E2 and 28.0% in Cm), which may be caused mainly by *cis*-9-C18:1 (16.8% in E1; 16.5% in C; 15.5% in E2 and 19.7% in Cm). The highest content of PUFA in goat cream was recorded for E2 group (5.35%). On the other hand, PUFA in Cm was 4.39%. Also, higher amounts of omega-3 FA were found in goat fat (1.42% in E1; 1.39% in C; 1.43% in E2) compared with Cm (0.51%). There was a higher amount of omega-6 FA in cow fat (2.49%) as in goat fat (2.01% in E1; 1.96% in C; 2.03% in E2). Omega-6/omega-3 ratio is important for nutritional reasons which have been shown to be different in goat and cow fat (1.41 in E1; 1.41 in C; 1.42 in E2 and 4.89 for Cm). It is widely accepted that in human nutrition the omega-6/omega-3 ratio should be at most 5 : 1 [22]. Our results clearly show that goat cream has a much more favorable omega-6/omega-3 ratio. This was also the reason why we have decided to make butter blends and to follow the changes of this ratio (see below).

FA profiles of goat butter E1, C, E2 and butter blends 50 : 50 (goat : cow, fat w/w) and 25 : 75 respectively are shown in Table 4.

Table 3. Fatty acid profiles of goat cream with comparison to cow cream (day 56; as per cent of total fatty acids)

Parameters	**Goat group**			**Cow**
	E1	**C**	**E2**	**Cm**
Fatty acids	%			
C4:0	2.52	2.43	2.23	3.13
C6:0	2.69	2.70	2.61	2.19
C8:0	2.78	2.82	2.79	1.30
C10:0	9.48	9.66	9.74	2.97
C12:0	3.49	3.54	3.64	3.39
C14:0	9.93	10.1	10.1	10.9
C16:0	30.0	29.9	29.6	31.0
C18:0	9.57	9.46	9.26	9.05
***trans*-11-C18:1**	1.34	1.57	1.88	1.20
***cis*-9-C18:1**	16.8	16.5	15.5	19.7
all-*cis*-9,12-C18:2	1.81	1.77	1.80	2.13
all-*cis*-6,9,12-C18:3	0.04	0.04	0.05	0.05
all-*cis*-9,12,15-C18:3	1.23	1.22	1.21	0.43
CLA[1]	0.61	0.74	0.77	0.39
all-*cis*-8,11,14-C20:3	0.02	0.02	0.05	0.11
all-*cis*-5,8,11,14-C20:4	0.11	0.10	0.10	0.17
all-*cis*-5,8,11,14,17-C20:5	0.10	0.09	0.10	0.06
all-*cis*-4,7,10,13,16,19-C22:6	0.04	0.04	0.08	0.00
Fatty acid groups	%			
SFA; saturated fatty acids	73.7	73.8	73.3	67.6
MUFA; monounsaturated fatty acids	21.4	21.2	21.4	28.0
PUFA[2]; polyunsaturated fatty acids	4.92	4.98	5.35	4.39
Total for C6:0, C8:0, C10:0	14.9	15.2	15.1	6.46
HFA[3]; hypercholesterolemic fatty acids	43.5	43.5	43.4	45.2
omega-6 fatty acids	2.01	1.96	2.03	2.49
omega-3 fatty acids	1.42	1.39	1.43	0.51
	ratio			
omega-6 fatty acids/omega-3 fatty acids	1.41	1.41	1.42	4.89

E1 goats fed *Chlorella;* E2 goats fed *Japanochytrium;* C control; Cm cow cream.
[1] Conjugated linoleic acid.
[2] Comprises *cis* and *trans* isomers of C18:2.
[3] Total for C12:0, C14:0 and C16:0.

Table 4. Fatty acid profile of goat butter and butter blends (day 56; as per cent of total fatty acids)

Parameters	Pure goat butter			Butter blends	
	E1	C	E2	25:75[a]	50:50[b]
Fatty acids	%				
C4:0	2.50	2.32	2.12	3.08	2.91
C6:0	2.75	2.67	2.61	2.26	2.47
C8:0	2.87	2.83	2.79	1.52	2.05
C10:0	9.75	9.71	9.76	3.98	6.35
C12:0	3.57	3.55	3.67	3.54	3.58
C14:0	10.0	10.1	10.3	11.1	10.7
C16:0	29.5	29.9	29.9	31.7	30.9
C18:0	9.66	9.48	9.01	8.61	8.75
***trans*-11-C18:1**	1.39	1.58	1.83	1.29	1.48
***cis*-9-C18:1**	16.7	16.6	15.6	18.2	17.0
all-*cis*-9,12-C18:2	1.80	1.77	1.79	2.02	1.92
all-*cis*-6,9,12-C18:3	0.04	0.04	0.05	0.05	0.05
all-*cis*-9,12,15-C18:3	1.24	1.23	1.20	0.53	0.81
CLA[1]	0.60	0.73	0.77	0.43	0.57
all-*cis*-8,11,14-C20:3	0.02	0.02	0.05	0.10	0.08
all-*cis*-5,8,11,14-C20:4	0.11	0.10	0.10	0.16	0.14
all-*cis*-5,8,11,14,17-C20:5	0.11	0.10	0.10	0.06	0.08
all-*cis*-4,7,10,13,16,19-C22:6	0.04	0.04	0.08	0.01	0.04
Fatty acid groups	%				
SFA; saturated fatty acids	73.8	73.7	73.4	69.5	71.2
MUFA; monounsaturated fatty acids	21.3	21.3	21.3	26.1	24.0
PUFA[2]; polyunsaturated fatty acids	4.94	4.99	5.33	4.43	4.81
Total for C6:0, C8:0, C10:0	15.4	15.2	15.2	7.8	10.9
HFA[3]; hypercholesterolemic fatty acids	43.1	43.5	43.9	46.4	45.2
omega-6 fatty acids	2.00	1.96	2.02	2.36	2.22
omega-3 fatty acids	1.43	1.41	1.43	0.63	0.96
	ratio				
omega-6 fatty acids/omega-3 fatty acids	1.40	1.39	1.42	3.76	2.30

[a] Butter blend made of 25:75 (E2 goat fat:cow fat, w/w)
[b] Butter blend made of 50:50 (E2 goat fat:cow fat, w/w)
Superscript notes are the same as shown in Table 3.

Similarly to goat cream, our results for butter revealed differences only in SFA and PUFA contents in E2 and C. *Japanochytrium* addition decreased SFA and increased PUFA (to the final 5.33% in E2 and 4.99% in C). The decrease in SFA content may be caused by a lowered amount of C18:0 in this group (9.01% in E2 versus 9.48% in C). Algae PUFAs may have caused the decrease in C18:0 which inhibited the reduction of vaccenic acid (*trans*-11 C18:1) in the rumen; eventually leading to the C18:0 decrease and a simultaneous increase in PUFA. A similar tendency has already been mentioned by Tsiplakou and Zervas [23] in goat plasma and milk when C18:0 content decreased and PUFA increased in goats administered fish and soy oil.

E2 goat butter revealed an increase in *trans*-11-C18:1 (1.83%) compared to the control group (1.58%). The increase of *trans*-11-C18:1 by 16% has probably been caused by either PUFA hydrogenation or by microbial isomerization of *cis*-9-C18:1 in rumen [24]. In this respect, *Japanochytrium* is a better source of *cis*-9-C18:1 than *Chlorella*.

From the PUFA class we observed an increase in the content of CLA (by 5%); all-*cis*-8,11,14-C20:3 (by 140%) and DHA (by 80%). The increase of CLA may have been caused by two different biosynthetic pathways. The first of them proceeds by the partial biohydrogenation of PUFA in rumen whereas the second by vaccenic acid desaturation by delta-9 desaturase in the udder [25 - 26]. An increase in all-*cis*-8,11,14-C20:3 and DHA in E2 goat butter is in line with their increase in *Japanochytrium* alga. In case of those FA only trace amounts were observed during the experiment therefore it is necessary to increase the amount of algae added to the feed.

The addition of cow cream into butter made from E2 goat cream decreased both SFA (by 5% in 25 : 75 butter blend and by 3% in 50 : 50 butter blend, respectively) and PUFA (by 17% in 25 : 75 butter blend and by 10% in 50 : 50 butter blend, respectively). The decrease of SFA content may generally be regarded as beneficial for humans. The replacement of some of the goat cream by cow cream in butter blends leads to the decreased content of C6:0, C8:0, C10:0 FA (by 49% in 25 : 75 butter blend and by 28% in 50 : 50 butter blend, respectively) compared to the pure goat butter E2. The ratio of hypercholesterolemic FA as C12:0, C14:0 and C16:0 did also increase by 6% in 25 : 75 butter blend and by 3% in 50 : 50 butter blend, respectively. The decrease in PUFA was caused by decreased amount of CLA (by 44% in 25 :7 5 butter blend and by 26% in 50 : 50 butter blend, respectively) and by α-linolenic acid (by 56% in 25 : 75 butter blend and by 33% in 50 : 50 butter blend, respectively). On the other hand, MUFA increased significantly in both butter blends (by 23% in 25 : 75 butter blend, and by 13% in 50 : 50 butter blend, respectively). This tendency was caused by augmented level of oleic acid (by 17 % in 25 : 75 butter blend, and by 9 % in 50 : 50 butter blend). Increased ratio of goat fat in the butter led to an increase in omega-3 FA (1.43% in E2; 0.96% in 50:50; 0.63% in 25 : 75) and thus positively affected the omega-6/omega-3 ratio (1.42 in E2; 2.30 in 50 : 50; 3.76 in 25 : 75). This fact is the ultimate evidence why pure goat butter and its butter blends (compared with the pure cow butter) are nutritionally very beneficial for humans and their increased consumption can be recommended.

4. Conclusions

- The addition of *Japanochytrium* algae into goat feed of Czech White Shorthaired breed changed the fatty acid profile of the milk and butter.

- On the other hand, the addition of *Chlorella vulgaris* algae didn't show a significant change in PUFA content in goat milk and butter.

- It has been proven that the addition of algae into goat feed is a suitable way for manufacturing and development of new products with increased content of nutritionally beneficial fatty acids as CLA, all-*cis*-8,11,14-C20:3 and DHA.

- Nevertheless the choice of the right type of algae and optimal inclusion quantity into the feed is immensely important to guarantee any success. Our study proved a high potential of *Japanochytrium* algae.

- A very interesting alternative to pure cow butter are blends thereof with goat butter. Such blends can increase the consumption of nutritionally essential fatty acids as C6:0, C8:0, C10:0 and α-linolenic acid.

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