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EFFECT OF LACTATION PERIOD ON PROFILE OF FATTY ACIDS, INCLUDING CONJUGATED LINOLEIC ACID (CLA), IN COW'S MILK

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The objective of the study was to determine the effect of lactation period on changes in the profile of fatty acids (including CLA) in milk fat from Holstein-Friesian cows.

Key words: COWS, MILK, LACTATION PERIOD, FATTY ACID PROFILE, CLA

Consumers are becoming increasingly aware of health risks associated with the consumption of animal products rich in cholesterol and saturated fatty acids [5, 28]. Major food products of animal origin include milk, which is a staple of the human diet and serves to feed newborn animals [8]. It contains all nutrients that nourish and promote health [12, 21]. Much recent attention has been given to milk fat, which contains considerable amounts of saturated acids and cholesterol, i.e. compounds that increase the risk of hypercholesterolemia and cardiovascular diseases in humans [16]. Latest research has focused on factors that reduce the concentration of saturated acids and cholesterol while increasing the amount of unsaturated acids, including conjugated linoleic acid (CLA) in milk [1, 18, 25]. This acid is also found in the meat of ruminants. It is formed with the participation of *Butyrivibrio fibrisolvens* bacteria as a product of partial ruminal biohydrogenation of unsaturated fatty acids and during *de novo* synthesis in adipose tissue and mammary gland [14, 22]. The cis-9, trans-11 CLA isomer is able to reduce fatness while increasing gain in muscle tissue; it inhibits the development of cardiac and cardiovascular diseases, boosts animal immunity, has anticarcinogenic effects and antioxidant properties [23, 28].

An important factor that increases CLA content in milk is feeding diets with increased amounts of unsaturated fatty acids, forage, or supplements of plant fats (oils, oilseeds), protected fats (soaps, fatty acid amides) and commercial CLA [3, 8, 10, 11]. In addition to nutrition, milk CLA content is influenced by other factors such as cow's breed [4, 17], age [24] or physiological status [15]. Therefore, this study was conducted with a hypothesis that the lactation period in cows may affect the profile of fatty acids, in particular CLA, in cow's milk.

Materials and methods

The study was carried out in a private dairy farm. Eight cows in the first month of second lactation were selected from a herd of Holstein-Friesian cows (75% HF) having an average milk yield of 7500 l.

The experimental cows were fed a diet formulated to meet nutrient requirements [20] for production of 34 l of milk. Diets were adjusted according to lactation and milk yield of cows in different months. Throughout the study, the basal diet was TMR which contained (d.m. basis): maize silage (53,8 %), brewer's grains (8,07 %) and concentrate mixture (38,13 %). Concentrate mixture contained maize (21,5 %), wheat (20,0 %), barley (20,0 %), field bean (5,0 %), rapeseed meal (5,5 %), rapeseed expeller (8,0 %), soybean meal (18,0 %) and supplements (Blattin Bio Mix mineral-vitamin mixture, sodium bicarbonate, ground limestone; 2,0 %).

The observations were made from February to December. Milk for fatty acid profile analysis was sampled once a month during control milking.

The milk samples were assayed for the profile of fatty acids, including CLA. Fat from milk samples was separated by extraction according to the method described by Anderson and Jansen (1962). Fatty acid profile was determined using Varian 3400 CX gas chromatograph with an FID detector and CP-WAX 58 column (50 m × ø0,53 mm). Working conditions were the following:

carrier gas — argon, injector temperature — 200 °C, detector temperature — 240 °C, column temperature — 60–210 °C.

The results were subjected to one-way analysis of variance using Statistica data analysis software system, ver. 7.1 (StatSoft Inc. 2005).

Significant differences between months were determined using Scheffe's multiple range test. Tabular results designated with letters a, b, c, d and e differ significantly (P≤0,05) and those designated with letters A, B and C differ highly significantly (P≤0,01).

Results and discussion

Lactation period has an individual effect on the content of different acids. The results obtained and the statistical analysis showed highly significant (P≤0,01) differences for the means of individual acids in consecutive months of lactation (table 1). As lactation progressed, SFA content increased and UFA content decreased. Similar results were reported by Bitman and Wood (1990), who showed short-chain fatty acids to increase and linoleic acid to decrease towards the end of lactation. This is confirmed by Kay et al. (2005), who found a marked decline in the level of oleic acid. Our study demonstrated that the level of C_4-C_{16} acids increased significantly with advancing lactation except butyric acid, whose amount increased until peak lactation (6-th month) and then fell drastically. Only C_{10} and C_{15} acids remained stable with an upward tendency at the end of lactation. Significant (P≤0,5) and highly significant (P≤0,01) differences were found for C_8, C_{12} and C_{14}, and highly significant for C_{16} in milk fat. In early lactation they first increased and then decreased, increasing again towards the end of lactation. This result supports the findings of Bitman and Wood (1990) and Stull et al. (1996).

Except $C_{10:1}$, percentage of unsaturated acids with medium carbon chain decreased, after an initial increase, towards the end of lactation.

The content of C_{16} and C_{18} fatty acids in milk fat obtained in different months of lactation varied considerably, with highly significant (P≤0,01) differences. The proportion of C_{16} was similar in the first three months, showed an increase in the next 4 months and decreased during the final months of lactation. An opposite trend was observed for C_{18}, which ranged from 10,52 % to 12,10 % at the beginning of lactation, decreased to about 7,6 % over the next 5 months, and increased to reach the level from the first 2 months of lactation.

Long-chain unsaturared fatty acids showed a significant (P≤0,05) decrease in the amount of milk fat obtained from cows in successive months of lactation except $C_{18:1}$, whose content was high to 8 months of lactation and sharply fell at 9 and 10 months of lactation. Differences in the content of long-chain unsaturated fatty acids in milk with advancing lactation were reported by Bitman and Wood (1990) and Barłowska and Litwińczuk (2006).

Conjugated linoleic acid (CLA) is a valuable component of milk fat. There has been an increasing interest in modifying individual CLA isomers because of its health-promoting properties and the fact that it is easy and inexpensive to increase its content in milk by dietary factors [19, 23, 28]. Our results showed a highly significant (P≤0,01) effect of lactation period on CLA content of milk fat (table, fig.). The amount of CLA increased from the beginning of lactation by about 70 % and peaked in the 5th month of lactation. In the next months, despite the decrease, CLA content remained almost 40 % higher compared to the initial value. Similar results were obtained by Kay [13], who showed CLA concentration to increase by about 70 % from 1 to 16 weeks of lactation in the milk of cows receiving the same dietary ration.

Table

Mean profile of milk fatty acids in consecutive months of lactation

Fatty acids	Month of lactation									
	1	2	3	4	5	6	7	8	9	10
C4 butyric	1,64^{a}	1,55^{ab}	0,94^{b}	1,83^{a}	1,67^{ab}	1,55^{ab}	0,19^{c}	0,21^{c}	0,22^{c}	0,25^{c}
C6 caproic	1,11^{a}	0,51^{bc}	0,43^{c}	0,24^{c}	0,29^{c}	0,28^{c}	0,90^{a}	0,81^{ab}	0,94^{a}	1,04^{a}
C8 caprylic	0,67^{bc}	1,02^{ab}	0,71^{bc}	0,55^{c}	0,52^{c}	0,54^{c}	0,68^{bc}	0,69^{bc}	1,39^{a}	1,38^{a}
C10 capric	2,13^{bc}	2,11^{bc}	1,47^{c}	2,18^{c}	1,73^{c}	1,61^{c}	1,85^{c}	1,95^{ab}	2,79^{ab}	3,10^{a}
C10:1 caproleic	0,12^{a}	0,16^{a}	0,11^{a}	0,32^{a}	0,19^{a}	0,18^{a}	0,19^{a}	0,19^{a}	0,34^{a}	0,30^{a}
C12 lauric	3,46^{abc}	4,13^{d}	2,19^{d}	2,96^{cd}	2,61^{cd}	2,34^{d}	2,64^{cd}	2,47^{abc}	3,45^{abc}	3,85^{ab}
C14 myristic	8,63^{c}	10,14^{c}	8,98^{abc}	8,96^{c}	8,75^{c}	9,24^{bc}	10,00^{abc}	8,74^{c}	11,22^{ab}	11,59^{a}
C14:1 myristoleic	0,56^{c}	0,70^{abc}	1,28^{abc}	1,15^{abc}	1,10^{abc}	1,50^{a}	1,73^{a}	1,48^{ab}	1,15^{abc}	1,14^{abc}
C15 pentadecanoic	0,91^{b}	1,04^{a}	1,35^{a}	1,30^{a}	1,09^{ab}	1,19^{ab}	1,39^{a}	1,29^{a}	1,15^{abc}	1,22^{ab}
C16 palmitic	26,25^{ABC}	26,42^{ABC}	26,60^{ABC}	31,78^{A}	29,95^{c}	31,10^{B}	30,24^{C}	26,60^{ABC}	28,08^{A}	28,79^{A}
C16:1 palmitoleic	2,14^{abc}	1,46^{c}	2,52^{abc}	2,36^{abc}	2,78^{abc}	2,88^{ab}	3,04^{a}	2,56^{abc}	1,62^{bc}	1,57^{c}
C18 stearic	12,10^{A}	10,52^{A}	8,12^{A}	7,7^{AB}	7,09^{B}	7,62^{B}	7,59^{AB}	9,24^{A}	10,73^{A}	11,60^{A}
C18:1 cis-oleic	32,78^{b}	32,08^{b}	37,39^{a}	30,16^{bc}	32,65^{b}	31,68^{bc}	30,74^{bc}	33,72^{ab}	27,27^{cd}	24,62^{cd}
C18:1 trans-elaidic	0,50^{a}	0,26^{b}	0,30^{b}	0,19^{b}	0,18^{b}	0,21^{b}	0,32^{ab}	0,20^{b}	0,16^{b}	0,16^{b}
C18:2 linoleic	4,42^{abcd}	4,86^{ab}	5,43^{a}	3,43^{bcde}	4,71^{abc}	3,45^{bcde}	2,68^{e}	3,24^{cde}	3,05^{de}	3,20^{de}
C18:3 linolenic	0,53^{ab}	0,68^{a}	0,56^{ab}	0,42^{ab}	0,53^{ab}	0,47^{ab}	0,28^{b}	0,39^{ab}	0,32^{ab}	0,31^{b}
CLA	**0,44^{de}**	**0,33^{e}**	**0,63^{cde}**	**0,74^{bcd}**	**1,37^{a}**	**1,08^{ab}**	**0,97^{bc}**	**1,04^{ab}**	**0,87^{bc}**	**0,59^{cde}**
Unidentified acids	1,61	2,04	1,01	2,98	2,80	3,08	4,59	5,18	5,24	5,30
Total saturated acids	56,90	57,45	50,79	58,26	53,70	55,47	55,47	52,00	59,97	62,82
Total unsaturated acids	41,49	*40,51*	48,20	38,76	43,50	41,45	39,94	42,82	34,79	31,88
UFA:SFA	1:1,33	*01:01,4*	01:01,0	1:1,50	1:1,24	1:1,33	1:1,39	1:1,21	1:1,72	1:1,97
n-6:n-3	1:0,11	*1:0,13*	1:0,09	1:0,10	1:0,09	1:0,10	1:0,07	1:0,09	1:0,08	1:0,08

The above authors attributed this to a relationship between CLA and vaccenic acid (VA), whose amount also increased in the first months of lactation. Cis-9, trans-11 CLA isomer is a product of endogenous synthesis catalyzed by Δ^{9-}desaturase, whose substrate is VA. A strong correlation was found between VA and CLA content in milk fat [23]. This goes to show that an increase in vaccenic acid is the main cause of the increase in cis-9 trans-11 CLA in the early lactation period.

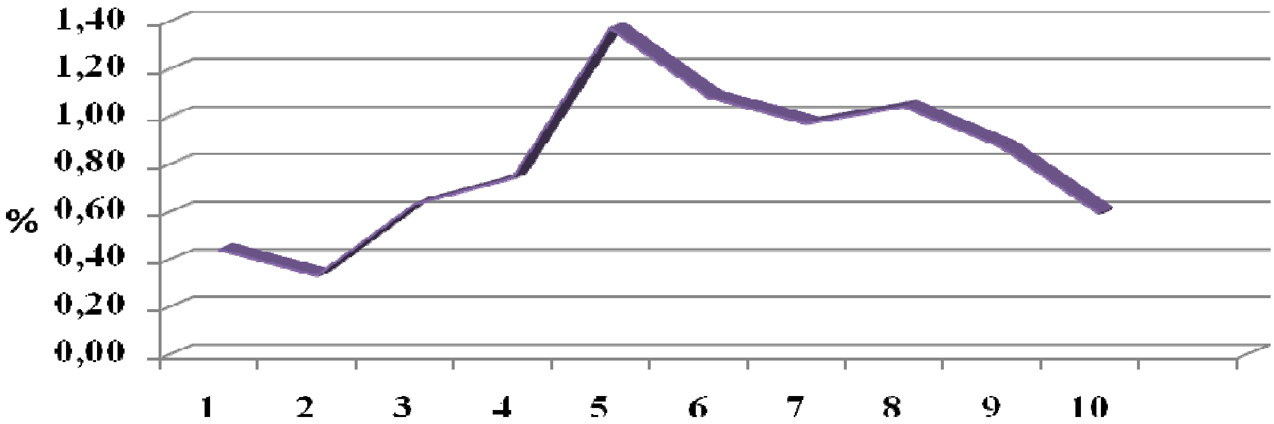

Fig. CLA concentration in total milk fatty acids, by month of lactation

Our results slightly differ from those obtained by Kesley et al. (2003), who found no relationship between the amount of CLA in milk and lactation stage in 200 dairy cows receiving the same diet, suggesting that CLA content could be affected by factors other than lactation stage. Meanwhile, Auldist et al. (citing Kelsey et al. 2003), who compared initial, middle and late stages of lactation showed CLA content to increase with advancing lactation. This would suggest that this period has an effect of the CLA content of cow's milk fat.

Many studies performed with dairy cows and sheep revealed a very strong effect of the dietary factor on CLA content in the milk of these animals [7, 11, 21, 25]. Feeding diets supplemented with vegetable oils, oilseeds (sunflower, rapeseed, linseed) and protected fats increases CLA in milk regardless of lactation period. These supplements are high in linoleic and linolenic acids — the precursors of CLA synthesis.

In summary, it is concluded that the knowledge of relationships between the content of individual fatty acids (including CLA) in the milk of lactating cows and the effect of other factors makes it possible to obtain milk with health-promoting components that meet the requirements of modern consumers.

Conclusions

1. Stage of lactation has a significant effect on the content of conjugated linoleic acid (CLA) in cow's milk. CLA content increases considerably and remains high from 5 to 8 months of lactation.
2. Major changes in the content of other fatty acids in cow's milk take place during the course of lactation.
3. An understanding of the content of fatty acids in consecutive months of lactation may be an additional factor facilitating a favourable change in milk fat.

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ВПЛИВ ЛАКТАЦІЙНОГО ПЕРІОДУ НА ЖИРНОКИСЛОТНИЙ ПРОФІЛЬ ВКЛЮЧАЮЧИ ЛІНОЛЕВУ КИСЛОТУ У МОЛОЦІ КОРІВ

Р е з ю м е

Метою дослідження було визначити вплив лактаційного періоду на зміни у жирно кислотному профілі, включаючи лінолеву кислоту у молочному жирі корів Гольштинської-Фрізіанської породи.

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ВЛИЯНИЕ ЛАКТАЦИОННОГО ПЕРИОДА НА ЖИРНОКИСЛОТНЫЙ ПРОФИЛЬ В ТОМ ЧИСЛЕ ЛИНОЛЕВУЮ КИСЛОТУ, В МОЛОКЕ КОРОВ

Аннотация

Целью исследования было определить влияние лактационного периода на изменения в жирнокислотном профиле, включая линолевую кислоту в молочном жире коров Гольштинской-Фризской породы.

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