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Milk yield, composition and cholesterol level in dairy cows fed rations supplemented with zinc and fatty acid calcium salts

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ABSTRACT

In an experiment conducted on 16 Red-and-White cows in a 2 x 2 Latin square design, the effect of two levels of zinc and calcium fatty acid salts on milk yield, composition and cholesterol level were studied. Cows were a fed diet consisting of maize and grass silage, ground barley, wheat bran and rapeseed meal with mineral mixtures, which in the control groups had a low level of Zn and fatty acid salts but in the experimental groups was supplemented with 6% (DM basis) calcium fatty acid salts and mineral mixture enriched with 6 g Zn/ kg that corresponds to 480 mg Zn/ cow/day. Intake of DM was 19.2 ± 0.28 kg/d, in this 12.1 ± 0.22 kg was from silages and 7.1 ± 0.16 from concentrate. Mean milk yield did not differ significantly between the treatments and was 26.2 ± 0.68 kg/day; cows on the diet with the higher level of Zn produced 0.9 kg/day less, those receiving fatty acid salts gave about 0.93 kg/d more milk, but the differences did not reach statistical significance. Milk from cows fed the diet supplemented with 6% fatty acid salts contained less fat and protein ($P<0.05$) but had a higher acidity ($P<0.01$) and renneting time ($P<0.05$). Enrichment of the diet with Zn did not significantly affect the content of the nitrogen fraction including casein. Addition of fatty acid salts to the diet resulted in a significant decrease of total-N, protein-N, casein-N fractions ($P<0.01$) and saturated fatty acids ($P<0.05$) but increased the unsaturated fatty acid ($P<0.05$) level in milk. The higher Zn level fed with the diet elevated its content in the blood ($P<0.01$), whereas the level of other determined metabolites did not differ significantly between treatments. Feeding cows CaFA salts significantly elevated triglyceride, total cholesterol, HDL ($P<0.01$), alkaline phosphatase and magnesium levels ($P>0.05$) in blood plasma. Feeding cows with diets supplemented with Zn or CaFA salts did not change milk total cholesterol levels, with the mean concentration in milk being 17.2 ± 0.4 mg/100 ml.

KEY WORDS: dairy cow, feeding, zinc, calcium fatty acid salts, milk yield, milk composition, cholesterol

INTRODUCTION

Studies on laboratory animals suggest that lipid metabolism, including cholesterol, depends on the level of copper and zinc in the diet (Mazur et al., 1993; Rayssiguier et al., 1993). Studies aiming decreasing the cholesterol level in food of animal origin, mainly eggs and meat, have been undertaken by supplementing the diets for animals with various additives such as garlic, calcium salts of long-chain unsaturated fatty acids, linseed or rape seed (Konjufca et al., 1997; Barowicz, 2000). Attempts to decrease the cholesterol level in cow's milk are not numerous and have not brought satisfactory results, e.g., lowering the Cu level in the diet for dairy cows failed to decrease the cholesterol level in milk (Brzóska and Sala, 2001). Other studies suggest that the Zn content in diets for dairy cows can modify the level of lipids in blood, as lower levels of Zn in the diet increase the lipid oxidation rate in the liver (Roussel et al., 1993). Kirchgessner et al. (1993) reported a lowered level of total and free cholesterol, triglycerides, phosphoglycerides and alkaline phosphatase activity in blood of rats fed a Zn-deficient diet; unfortunately the cholesterol content in milk of experimental animals was not determined.

The aim of the experiment was to test the hypothesis that a low content of Zn and addition of CaFA salts to the diet for dairy cows results in decreasing the cholesterol level in blood and milk, and to examine their effects on milk yield and composition.

MATERIAL AND METHODS

Animals and diets

The experiment was carried out on 16 Red-and-White dairy cows of 590±30 kg body weight (BW), at 6-8 weeks after calving, in a two factorial 2 x 2 Latin square design to verify the effect of two levels of zinc or calcium fatty acid salts (CaFA salts) on milk yield, content of cholesterol and other components in milk. The experiment comprised 4 periods, each lasting 21 days, including 3 final days during which milk yield was measured and milk and blood from the jugular vein were sampled for analysis. All of the cows were fed grass and maize silages to appetite and offered concentrate in an amount of 0.28 kg/kg milk. The rations were provided twice daily during milking at 7.00 and 16.00. The concentrate was composed of ground barley, wheat bran and rapeseed oilmeal, dicalcium phosphate, limestone and common salt and contained 16% crude protein. A mineral mixture (BASF Kutno, Poland) with a low level of Zn and fatty acid salts were given to control groups; this diet was supplemented for experimental animals

with 6% (DM basis) CaFA salts and enriched with 6 g Zn/ kg which corresponded 480 mg Zn/cow/day (Table 1). The control ration was deficient in Zn, whereas the experimental diet covered the requirement for this element; copper intake was maintained at a level of 230 mg/day, which covered the requirements of cows for this element (MAFF, 1984; Rogers, 1996). CaFA salts in the form of the modified feed fat preparation Erafet was produced (Fosbac Co. Ltd., Wiąg, Poland) from rape seed and fish oils (0.8 : 0.2) and given mixed with concentrate to experimental cows in the amount of 6% of diet DM, i.e. 900 g preparation per cow/day.

TABLE I

Ingredients of diets for dairy cows, % DM

Item	Diets	
	wthout CaFA	with CaFA
Maize silage	28.25	28.25
Grass silage	34.60	34.57
Barley ground	17.27	11.50
Wheat bran	10.40	8.40
Rapeseed meal	8.00	10.00
CaFA salt (Erafet)	–	6.00
Limestone	0.40	0.20
Dicalcium phosphate	0.60	0.60
Magnesium oxide	0.20	0.20
Sodium chloride	0.20	0.20
Mineral premix[1]	0.08	0.08

[1] content in g/1 kg: Ca 100; P 100, Na 100, Mg 50, Zn 6, Mn 4, Cu 2.8 and I 0.1

Chemical analyses

The nutrient contents in feeds were determined by conventional methods (AOAC, 1990) and feed nutritive value was expressed according to the INRA-88 system and calculated using Winwar 1.3 software. Feed DM was determined at 105°C and its content in silages was adjusted for volatile substances (Dulphy and Demarquilly, 1981). Milk fat, protein, and lactose contents, renneting time, density and pH were determined according to Polish Standards (PN 68/A-86122; 1968). Total nitrogen and its fractions in milk were determined by the Kjeldahl procedure. Individual fatty acids in milk were assayed as methyl esters using a GLC Varian 3400 gas chromatograph with DB-FFAP column according to the method of Atwal et al. (1990). Five ml of milk were shaken with 35 ml of chloroform-methanol mixture (2:1 v/v) and centrifuged. Four ml of the bottom layer were evaporated in a nitrogen atmosphere and hydrolysed with 0.5 ml for 20 min at 80°C and analy-

sed. The glucose, urea, triglyceride, and cholesterol contents and selected enzyme activities in blood plasma were determined using enzyme-linked tests from Cormay Diagnostyka S.A. (Lublin, Poland). Minerals in feeds, milk and blood plasma were determined by atomic mass spectroscopy using Philips PU 9000 equipment.

Statistical analysis

The results were subjected to statistical analysis of variance using the Statgraphic 6.0 software package to determine the influence of zinc, fat and their interactions on the analysed parameters.

RESULTS

The composition of the rations, nutrient contents, and nutritive value are given in Tables 1 and 2. Intake of dietary DM was 19.2 ± 0.28 kg/d, including 12.1 ± 0.22 kg

TABLE 2

Chemical composition and nutritive value of feeds

Item	Maize silage	Grass silage	Concentrate	
			without CaFA	with CaFA
Dry matter, %	23.96	37.47	85.66	867.7
Nutrients, g.kg^{-1} DM				
organic matter	962.3	919.1	961.3	944.6
crude protein	68.8	164.6	163.0	156.5
ether extract	31.8	42.4	34.7	56.2
crude fibre	283.1	277.4	72.2	70.9
N-free extractives	578.6	434.7	691.4	661.0
ash	37.7	80.9	38.7	55.4
NDF	452.0	431.1	–	–
ADF	303.1	294.4	–	–
ADL	40.9	43.2	–	–
Ca	3.38	7.48	7.15	8.50
P	1.87	3.82	6.95	5.75
Mg	1.01	2.46	3.01	2.65
Zn, mg.kg^{-1}	36.15	34.78	33.73	31.98
ME, MJ	10.48	9.68	12.18	13.40
NEL, MJ	6.34	5.69	6.88	7.51
UFL	0.91	0.88	1.01	1.20
PDIN	42.3	95.9	109.5	108.7
PDIE	73.8	80.3	99.7	99.2

from silages and 7.1 ± 0.16 from concentrate. Daily zinc intake in the control group was 631 mg Zn/day and in the experimental group, 1142 mg Zn/day which equals a Zn concentration of 32.8 or 59.4 mg/kg DM of ration. The average milk yield was similar in all groups of animals, amounting to 26.2 ± 0.68 kg/day with a slight, but not significant, tendency to be lower (0.9 kg/day) in the animals receiving the diet with the higher level of Zn. Milk yield was significantly higher in the animals kept on the diet supplemented with CaFA salts ($P<0.05$). Daily production of fat, protein and lactose (kg/day) in milk was not affected ($P>0.05$) by the Zn or CaFA salt levels in the diets, but the concentration of fat and protein in milk of cows kept on diets supplemented with 6% CaFA salts was lower ($P<0.05$) than in milk of the control group. Acidity and renetting time of milk from cows fed the CaFA salts diet were significantly higher ($P<0.01$) but did not influence milk density. The differentiated level of Zn in diets did not significantly influence the value of these parameters (Table 3).

TABLE 3

Feed intake, milk yield and composition

Item	Level of Zn		CaFA salt		SE	P value		
	low	high	without	with		zinc (z)	fat (f)	z x f
Feed intake, kgDM/d	19.35	19.09	19.00	19.44	0.28	0.643	0.436	0.747
silage	12.05	12.11	12.00	12.17	0.22	0.894	0.696	0.697
maize	5.41	5.44	5.37	5.49	0.11	0.870	0.596	0.792
grass	6.63	6.67	6.62	6.68	0.21	0.943	0.889	0.788
concentrate	7.30	6.98	7.01	7.27	0.16	0.320	0.417	0.989
mineral premix	0.08	0.08	0.08	0.08	0.00	0.380	0.502	0.897
Milk yield, kg/d	26.83	25.62	25.76	26.76	0.68	0.380	0.502	0.897
FCM, kg/d	27.47	25.77	26.84	26.44	0.72	0.168	0.274	0.658
fat, %	4.16	4.04	4.28	3.92	0.05	0.242	0.001	0.288
protein, %	2.99	2.99	3.08	2.89	0.03	0.974	0.001	0.983
lactose, %	5.09	5.01	5.01	5.08	0.03	0.227	0.247	0.703
fat, g d^{-1}	1103	1030	1095	1038	27	0.188	0.302	0.713
protein, g d^{-1}	795	760	782	773	18	0.349	0.795	0.777
lactose, g d^{-1}	1367	1286	1295	1359	37	0.286	0.398	0.940
Acidity, °SH	6.33	6.38	6.81	5.90	0.09	0.732	0.000	0.846
Renneting time, s	119	112	99	132	8	0.632	0.039	0.433
Density, g/cm^3	1.0291	1.0297	1.0297	1.0291	0.0001	0.113	0.138	0.113

FCM-milk corrected for 4% of fat

Cholesterol, Ca, P, Mg and Zn levels in milk were not affected by the Zn level in diets (P>0.05) but feeding the diet supplemented with CaFA salts significantly (P<0.05) increased the Ca, P and Mg concentrations in milk (Table 4).

TABLE 4

Total cholesterol and minerals content in milk

Item	Level of Zn		CaFA salt		SE	P value		
	low	high	without	with		zinc (z)	fat (f)	z x f
Total cholesterol, mg/100ml	17.26	17.09	17.43	16.91	0.40	0.832	0.523	0.832
Ca, mg/100 g	121.4	122.3	117.8	126.0	1.3	0.710	0.001	0.283
P, mg/100 g	101.2	102.4	96.5	107.2	1.3	0.591	0.000	0.931
Mg, mg/100 g	9.8	9.9	9.6	10.1	0.1	0.576	0.044	0.813
Zn, mg/100 g	0.53	0.53	0.52	0.54	0.02	0.873	0.164	0.838

The concentration of nitrogen fractions, including casein-N, as well as the fatty acid composition of milk were not affected by the level of Zn in the rations. Rations supplemented with CaFA salts decreased (P<0.01) the concentration of total-N, protein-N, casein-N and the ratio of casein-N to total-N (Table 5) and content of saturated (lauric, palmitic) fatty acids in milk (P<0.05), but the content of mono- and polyunsaturated fatty acids: oleic, linolenic, conjugated linoleic (P<0.01) and eicosopentaenoic (P<0.05), increased. Hypocholesterolemic (DFA) acid levels were higher, while hypercholesterolemic acids (OFA) were lower in the milk of cows fed CaFA salts (P<0.01) (Table 6).

TABLE 5

Nitrogen fraction in the milk, %

Item	Level of Zn		CaFA salt		SE	P value		
	low	high	without	with		zinc (z)	fat (f)	z x f
Total N	0.472	0.475	0.493	0.454	0.005	0.724	0.000	0.646
True protein N	0.446	0.444	0.461	0.429	0.005	0.832	0.003	0.799
Casein N	0.477	0.381	0.398	0.360	0.005	0.667	0.000	0.728
Whey N	0.095	0.095	0.095	0.095	0.001	0.531	0.561	0.871
NPN	0.028	0.028	0.028	0.028	0.006	0.889	0.692	0.625
True protein N, % of total N	93.92	94.13	93.89	94.17	0.15	0.498	0.357	0.908
Casein N, % of total N	79.85	80.00	79.22	80.63	0.26	0.763	0.007	0.863

TABLE 6

Fatty acid composition of the milk fat, g/100 g of total fatty acids

Item	Level of Zn		CaFA salt		SE	P value		
	low	high	without	with		zinc (z)	fat (f)	z x f
C_{8}	2.01	1.98	2.04	1.95	0.05	0.829	0.089	0.301
C_{10}	3.87	3.82	4.03	3.65	0.11	0.789	0.439	0.465
C_{12}	4.16	4.10	4.38	3.88	0.13	0.803	0.045	0.451
C_{14}	12.76	12.39	12.99	12.16	0.28	0.506	0.138	0.333
C_{16}	36.44	35.93	38.36	34.01	0.59	0.640	0.000	0.897
$C_{16:1}$	1.40	1.44	1.46	1.38	0.03	0.449	0.253	0.255
C_{18}	11.38	10.89	10.81	11.46	0.25	0.328	0.188	0.064
$C_{18:1}$	23.62	24.58	21.93	26.27	0.71	0.471	0.002	0.995
$C_{18:2}$	2.37	2.58	2.23	2.72	0.10	0.291	0.017	0.707
$C_{18:3\ n-6}$	0.34	0.36	0.27	0.42	0.03	0.675	0.008	0.902
$C_{18:3\ n-3}$	0.86	1.02	0.75	1.13	0.08	0.298	0.014	0.677
CLA	0.56	0.57	0.48	0.65	0.03	0.828	0.002	0.488
$C_{20:0}$	0.14	0.13	0.13	0.13	0.005	0.391	0.705	0.142
$C_{20:4}$	0.12	0.11	0.12	0.11	0.005	0.292	0.207	0.914
$C_{22:5}$	0.06	0.05	0.05	0.06	0.003	0.143	0.019	0.426
$C_{22:0}$	0.06	0.06	0.07	0.06	0.004	0.744	0.092	0.157
$C_{22:1}$	0.01	0.01	0.01	0.01	0.003	0.181	0.359	0.656
SFA	70.81	69.31	72.81	67.31	0.90	0.378	0.002	0.945
UFA	29.19	30.69	27.19	32.69	0.90	0.378	0.002	0.945
MUFA	24.94	26.02	23.32	27.63	0.73	0.434	0.003	0.956
PUFA	4.25	4.67	3.86	5.06	0.22	0.314	0.005	0.920
PUFA-6	2.81	3.05	2.61	3.24	0.12	0.313	0.012	0.664
PUFA-3	0.91	1.06	0.79	1.18	0.08	0.930	0.007	0.770
DFA	41.11	41.26	38.54	43.86	0.99	0.594	0.002	0.671
OFA	59.43	58.42	62.01	55.84	1.01	0.280	0.004	0.581
PUFA-6/PUFA-3	0.42	0.47	0.38	0.51	0.02	0.501	0.003	0.859
UFA/SFA	0.71	0.76	0.63	0.83	0.03	0.827	0.006	0.762
DFA/OFA	0.37	0.40	0.33	0.44	0.02	0.501	0.003	0.859
MUFA/SFA	0.06	0.07	0.05	0.08	0.005	0.393	0.001	0.748
PUFA/SFA	3.35	3.31	3.57	3.09	0.09	0.231	0.005	0.610

Metabolite levels determined in blood plasma were not altered by the level of Zn in the diet, but cows fed rations with CaFA salts had increased concentrations of triglycerides, total cholesterol, high density lipoprotein (HDL), alkaline phosphatase (ALP), and magnesium, whereas the remaining metabolite levels were similar as in the plasma of control animals (Table 7).

TABLE 7

Metabolite and minerals content in blood plasma

Item	Level of Zn		CaFA salt		SE	P value		
	low	high	without	with		zinc (z)	fat (f)	z x f
Glucose, mg/100 g	57.10	57.14	58.87	56.95	1.85	0.942	0.202	0.942
Urea, mg/100 g	12.47	11.04	12.99	10.51	0.71	0.315	0.083	0.367
Triglycerols, mg/100 g	6.22	6.25	5.52	6.96	0.31	0.967	0.019	0.892
Total cholesterol, mg/100 g	233.90	226.43	203.98	256.34	8.32	0.633	0.001	0.565
HDL, mg/100 g	190.33	188.69	170.51	208.51	5.70	0.877	0.001	0.585
LDL, mg/100 g	28.67	31.78	33.48	26.97	2.02	0.441	0.110	0.545
AST, U/L	54.15	52.23	52.03	53.55	1.22	0.442	0.770	0.834
ALT, U/L	27.99	26.66	28.49	26.16	0.92	0.473	0.213	0.567
ALP, U/L	14.39	15.31	15.73	14.97	2.04	0.816	0.062	0.769
LDH, U/L	889.9	893.61	886.30	888.29	18.47	0.740	0.958	0.827
Ca, mg/100 g	14.02	15.00	14.15	14.86	0.37	0.335	0.188	0.828
P, mg/100 g	9.40	9.81	9.54	9.67	0.30	0.494	0.832	0.365
Mg, mg/100 g	2.35	2.39	2.32	2.42	0.02	0.353	0.048	0.634
Zn, mg/100 g	0.40	0.44	0.40	0.41	0.01	0.011	0.661	0.763

AST - aspartate aminotransferase
ALT - alanine aminotransferase
ALP - alkaline phosphatase
LDH - lactate dehydrogenase

DISCUSSION

The requirements of milking cows for Zn depends on their milk yield, and a value 600-800 mg Zn/day is accepted (MAFF, 1984; Rogers, 1996). This means that at an intake of 20 kg of DM/d, the concentration of Zn in the diet should be 30-40 mg/kg DM. The Zn contents of roughage depend on the Zn level in the soil. Analysis of the Zn content in fodder plants gave values of 24.5 in meadow fescue, 38.0 in cocksfoot, and about 30 mg/kg DM in cereals. The variability of Zn content in fodder plants was ± 40% depending on the site, soil parameters and rainfall intensity. Assimilation of Zn from roughage, according to Rogers (1996), is low and does not exceed 30% since in the digesta, phytic acid of plant origin creates insoluble compounds with Zn, Ca and Cu (Ashes and Jeppsen, 1993). Therefore, the main source of microelements for dairy cows are premixes, mineral mixtures or metal-organic chelate compounds.

The results of the present experiment demonstrated that decreasing the Zn content in diets for milking cows to the level of its content in natural roughage and concentrate without including Zn in the mineral mixture did not significantly lower milk yield or its components such as fat, protein, and lactose; milk acidi-

ty, renneting time and density did not differ significantly between the respective groups of cows.

Daily milk yield was 0.93 kg higher in cows fed the diet with CaFA salts than in control animals, however this difference was not statistically significant. In an earlier similar experiment by Bielak et al. (1994), cows fed diets supplemented with CaFA salts produced 1.73 kg milk more than without this supplement. Kim et al. (1991), Schauff et al. (1992), Bielak et al. (1994) or Potkański et al. (1997) reported that supplementing diets with CaFA salts for milking cows resulted in decreased fat and even protein content in produced milk. The Erafet preparation is produced from a mixture of rape seed and fish oils and represents a mixture of fatty acids calcium salts and glycerol obtained through alkaline hydrolysis of fats. The decrease in the fat content in the milk of cows fed the CaFA salts diet might be induced by glycerol, which is a source of more easily available energy for bacteria in the rumen than energy from dietary fibre. Decreased fibre digestion could explain the lower content of fat in the milk.

Lower protein content in milk from cows fed diets with the addition of CaFA salts are documented in numerous experiments (e.g., Andrew et al., 1991; Schauff and Clark, 1992; Brzóska et al., 1999a,b) but the reason is still not understood. There are some suggestions that feeding cows diets with CaFA salts may decrease the blood level of somatotropin secreted by the pituitary gland. Casper and Schingoethe (1989) suggested that absorption of amino acids from the blood into the mammary gland is controlled by somatotropin and insulin, therefore consequently affects milk protein synthesis.

Acidity and renneting time of milk from cows fed the diet supplemented with CaFA salts were significantly higher than in milk from control cows, but the density of milk from cows of both groups was similar. It may be suggested that feeding the diet with CaFA salts resulted in increased fatty acid levels in the blood of cows, leading to increased oxidation in the animals' bodies, which in turn might raise the milk bicarbonate level and acidity. This fact, hitherto not confirmed by other investigations, may influence the suitability of milk for production of dairy products.

Differentiated levels of Zn in the diets did not affect the total cholesterol concentration in milk, which suggests that there is no dependence between the level of Zn in the diet and cholesterol concentration in blood and milk of cows. This finding does not support the data obtained by Kirchgessner et al. (1993) in experiments on laboratory animals, since in the plasma of Zn-deficient rats, the total cholesterol (-31%), free cholesterol (-49%), triglyceride (-46%), phospholipid (-22%) concentrations and alkaline phosphatase activity (-45%) were lower compared with rats fed diets with higher Zn levels. The results obtained in the present experiments with cows did not demonstrate a similar tendency as in rats. However, the contrast in the levels in Zn content in the diets for rats was more pronounced than in diets for cows, as in the control diets for cows, silage and concentrate contained slight

amounts of Zn. This suggests that a lowered Zn level in the diet for cows did not affect 3-hydroxy-3-metylglutaryl-CoA which is responsible for low density lipoprotein (LDL) synthesis in the liver of mammals. Our data indicates that Zn is not a factor influencing the activity of this enzyme.

The triglyceride and total cholesterol concentrations in the blood of cows fed the diet with CaFA salts were significantly higher than in the control group, confirming the results of other experiments (West and Hill, 1990; Christensen et al., 1994; Brzóska et al., 1999a,b). The higher level of total cholesterol in the blood of animals fed CaFA did not result in elevating its concentration in milk. The cholesterol concentration in milk was rather stable and changed only in a small range between the groups of cows, but its mean value was slightly higher than reported in other studies (Pabst and Walte, 1991; Brzóska and Sala, 2001). This suggests that the milk cholesterol level does not depend on its content in blood plasma and is modulated in the process of milk component synthesis. It can not be excluded that the epithelium of the mammary gland contains milk cholesterol receptors that catch the excess cholesterol from plasma. Our results suggest that the level of Zn and CaFA salts in the diet does not affect the cholesterol level in milk. A similar situation was found in the case of Zn transport from plasma, as its level in milk did not depend on the Zn level in the diet or blood. However, transport of Ca, P and Mg from plasma into milk is controlled by different mechanisms, since the higher level of Ca in the diet and blood plasma resulted in a significant increase of these elements in milk.

The content of protein-N and casein-N in milk was not affected by the Zn level in rations but the contents of total-N, protein-N and casein-N in milk from cows fed diets containing CaFA were significantly lower than in the milk of the cows kept on the diet without CaFA salts.

The level of Zn in the diet did not change the profile of fatty acids in milk as their concentration in milk was similar in both groups of cows. Feeding cows diets containing CaFA produced from vegetable and fish oils changed the profile of fatty acids in milk. The milk of this group of cows contained less saturated fatty acids but more unsaturated acids such as oleic, linoleic from the n-3 and n-6 families, conjugated linoleic and eicosopentaenoic acids as compared with the fatty acid composition of control milk. As a result of these changes in the fatty acid profile of milk, the proportion of acids in total fatty acids was 43% whereas in milk of the control group it was significantly lower, 38%. The Zn level in the diet did not change the fatty acid profile and the proportion of hypocholesterolemic acids was 41% in the milk of both groups of cows. These results are in accordance with changes in fatty acid profiles described in experiments carried out with cows fed diets supplemented with different types of fat as canola seeds, rape seeds 00, tallow or CaFA salts (Mansbridge and Blake, 1997; Brzóska et al., 1999a,b).

Feeding cows with diets differing in their Zn level did not result in changes in the levels of glucose, urea, triglycerides, total cholesterol and its fractions, enzymes or macroelements, but the Zn level was significantly higher in the blood plasma of cows fed supplemented diets. This suggests that the concentration of Zn in diets for dairy cows does not affect the indices of energy, protein and fat metabolism in cows. Kirchgessner et al. (1993) reported that the activity of alkaline phosphatase in blood is correlated with the dietary Zn level, but such a dependence was not found in our experiment.

Feeding cows diets containing CaFA salts significantly increased the concentration of triglycerides, total cholesterol, high density lipoproteins (HDL), and magnesium similarly as reported by other authors (Drackley et al., 1994; LaCount et al., 1994; Brzóska et al., 1999a). Increased triglyceride concentrations in blood plasma at their higher dietary intake is evident as they are highly digested in the digestive tract of cows. The increased concentration of HDL in blood plasma might be caused by increased delivery of long-chain fatty acids protected from biohydrogenation in the rumen, enhancing their concentration in blood plasma. The higher level of HDL in blood may stimulate the mammary gland to increase the content of unsaturated fatty acids in milk fat. On the other hand, long-chain fatty acids are known as a factor decreasing the LDL content in the liver, which at their declining tendency in blood plasma, could influence the increased HDL content. The significant effect of dietary CaFA salts on alkaline phosphatase activity and magnesium content in blood plasma obtained in our study was not found in earlier studies and is rather difficult to explain.

The level of cholesterol in milk changes to some degree depending on its level in blood plasma, suggesting the existence of regulatory mechanisms governing its level in milk, probably in the epithelial cells of the mammary gland adapted to synthesis of milk. This mechanism is independent of Zn levels ranging from 39 to 59 mg Zn/kg of ration dry matter and CaFA salts in the range from 0 to 6% in dry matter of diets for cows.

CONCLUSIONS

Feeding dairy cows a diet with the addition of calcium fatty acid salts, produced from a mixture of rape seed and fish oils, does not increase milk yield or cholesterol level, but significantly elevates the level of unsaturated fatty acids, acidity and renneting time. It also slightly decreases the milk protein and fat contents.

Zinc at levels ranging from 39 to 59 mg/kg of the diet for dairy cows does not affect milk yield, cholesterol or other metabolite levels in blood plasma or milk. Cows fed diets with higher levels of zinc efficiently absorb this element, increasing its concentration in blood plasma but not in milk, suggesting the existence of a mechanism blocking its transport into the milk.

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STRESZCZENIE

Wpływ dodatku cynku i soli wapniowych kwasów tłuszczowych do dawek dla krów na wydajność i skład mleka z uwzględnieniem cholesterolu

W doświadczeniu przeprowadzonym na 16 krowach rasy czb, w układzie kwadratu łacińskiego 2 x 2, porównywano wpływ dodatku do diet kontrolnych 25 mg cynku lub 60 g soli wapniowych kwasów tłuszczowych (CaFA) w postaci preparatu Erafet na wydajność i skład mleka z uwzględnieniem zawartości cholesterolu. Krowom grupy doświadczalnej podawano cynk w mieszance mineralnej (80 g/dzień) wzbogaconej o 6 g cynku/kg. Krowy pobierały średnio 19,2±0,28 kg/dzień suchej masy dawki pokarmowej, w tym 12,1±0,22 kg z kiszonek z traw i kukurydzy oraz 7,4±0,16 kg z mieszanki treściwej. Średnia wydajność mleka krów wynosiła 26,2±0,68 kg/dzień. Poziom cynku w dawce nie różnicował istotnie wydajności mleka oraz ilości tłuszczu, białka i laktozy w mleku, chociaż zarysowała się tendencja spadku produkcji mleka o 0,9 kg, a przy podawaniu CaFA wzrost o 0,9 kg/dzień. Podawanie krowom CaFA obniżyło zawartość tłuszczu i białka w mleku ($P<0,05$), zwiększyło kwasowość i czas krzepnięcia ($P<0,01$) mleka. Poziom cynku w dawce nie wpłynął na zawartość frakcji azotowych w mleku, natomiast podanie z dawką soli CaFA spowodowało obniżenie stężeń N-ogólnego, N-białkowego i N-kazeinowego ($P<0,01$) oraz nasyconych kwasów tłuszczowych, natomiast podwyższyło stężenie nienasyconych kwasów tłuszczowych ($P<0,05$). Zwiększenie pobrania cynku spowodowało wzrost jego stężenia w osoczu krwi ($P<0,01$), natomiast po podaniu CaFA podwyższył się w osoczu poziom trójglicerydów, cholesterolu całkowitego, HDL ($P<0,05$) i magnezu oraz aktywności fosfatazy alkalicznej. Stężenie cholesterolu całkowitego w mleku nie zmieniało się istotnie po podaniu cynku bądź CaFA, a jego średni poziom wynosił 17,2±0,4 mg/100 ml mleka.