Effect of triacylglycerols of medium-chain fatty acids on growth rate and mortality of rabbits weaned at 25 and 35 days of age

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ABSTRACT: Three hundred Hyplus rabbits reared on a commercial farm were weaned at the age of 25 days and 300 rabbits were weaned at the age of 35 days. Early-weaned and conventionally weaned rabbits were assigned to three groups and fed diets supplemented with protected palm fat (PPF), coconut oil (CO) and an oil containing triacylglycerols (TAG) of caprylic and capric acid (Akomed R) at 10 g/kg. The principal fatty acids in these supplements were palmitic, lauric and caprylic acid, respectively. Diets were fed until slaughter at 77 days of age. Mortality of early-weaned rabbits fed the diet supplemented with oil containing TAG of caprylic and capric acid (23%) was significantly lower than that of rabbits fed PPF (45%), and non-significantly lower than mortality of rabbits fed CO (37%). Corresponding mortality rates in rabbits weaned at 35 days of age were 6, 14 and 16%. In all groups, the highest mortality occurred in the 2nd and the 3rd week after weaning. The final body weights of surviving early-weaned rabbits were not significantly different. In conventionally weaned rabbits, however, final body weight was significantly lower in rabbits fed PPF. It can be concluded that under practical field conditions early weaning represents a risk for animal health and leads to a high mortality of young rabbits. The negative effect of early weaning can be alleviated by commercially available TAG of caprylic and capric acid.

Keywords: rabbits; early weaning; lipid supplements; mortality

The energy output in the rabbit milk during lactation is very high, thus, there is an interest to reduce the doe body energy deficit by shortening the lactation length (Pascual et al., 2006). Feugier et al. (2006), however, concluded that early weaning increased the susceptibility of young rabbits to digestive disorders, which is the major reason of mortality in the post-weaning period. Maternal milk contains antimicrobial factors that protect young rabbits from coliform infections, thus the intake of milk is beneficial for health even after the start of the intake of solid feed (Gallois et al., 2007). The nature of these factors has not been fully elucidated. Various substances present in milk have been shown to have antimicrobial activity: immunoglobulins (Cowie et al., 1980), fucosylated oligosaccharides (Gustafsson et al., 2005), lactoferrin, lactoperoxidase, lysozyme (Shah, 2000), and antimicrobial lipids (Sprong et al., 2001). Rabbit milk fat contains triacylglycerols (TAG) of medium-chain fatty acids (MCFA) that are synthesized in the mammary gland and represent approximately one half of TAG in milk (Jones and Parker, 1981). The antimicrobial activity of MCFA has been known for a long time (Hassinen et al., 1951; Nieman, 1954). The principal MCFA in the rabbit milk are caprylic (C 8:0) and capric (C 10:0) acid. Both acids inhibited growth of *Escherichia coli* strains on glucose, whereas strains of *Clostridium perfringens* were inhibited by lauric (C 12:0) and myristic (C 14:0) acid (Skrivanova et al., 2006). According to Skrivanova

Supported by the Czech Science Foundation (Grant No. 523/07/P340).

and Marounek (2002, 2006), caprylic acid and TAG of caprylic and capric acid significantly decreased mortality of young rabbits in commercial rabbitries, without affecting the weight gains and the intake of feed. Thus, the aim of the present study was to evaluate the effect of two lipid supplements containing MCFA on the post-weaning growth and mortality of rabbits weaned at 25 and 35 days of age. The experiment was carried out on a commercial farm.

MATERIAL AND METHODS

Animals and diets

Three hundred rabbits of both sexes, Hyplus genotype were weaned at 25 days of age and randomly assigned to three groups. Rabbits were housed in all-wire cages, four per cage (0.07 m^2 per a rabbit). Environmental conditions were as follows: temperature ca 18°C, relative humidity ca 65%, light schedule 6:00–18:00. Rabbits of the control group were fed a granulated diet supplemented with 10 g/kg Megalac^{TM}, which is protected palm fat (PPF) produced by Agro-Best Ltd (Bestovice, Czech Republic). Megalac^{TM} consists of Ca salts of fatty acids (FA). Rabbits of experimental groups were fed the same diet supplemented with 10 g/kg Akomed R (Karlshamns, Sweden), or with coconut oil from the same firm. The diets and water were available *ad libitum*. Table 1 presents ingredients and chemical composition of the diet. Table 2 presents fatty acid profile of the lipid supplements. Similarly, 300 rabbits of both sexes, Hyplus genotype, were weaned at 35 days of age and randomly assigned to three groups. Housing and feeding of rabbits was the same as described above.

The weights of individual rabbits were recorded weekly. Faeces of five rabbits in each group were collected at the same time and examined for the presence of coccidia. The feed intake was measured per group and feed efficiency calculated as total feed consumed during growth divided by weight of rabbits sold minus weight of rabbits weaned. Dead rabbits were autopsied in the State Veterinary Institute in Prague and examined using ISO bacteriological methods (http://www.iso.org).

Analyses and calculation

Concentrations of nutrients in the feed were determined as described previously (Skrivanova and Marounek, 2006). Gas chromatography of methyl esters was performed using a programmed 60 m capillary column to estimate the FA composition of lipid supplements (Marounek et al., 2007). Samples of faeces were examined microscopically for the presence of coccidia oocysts according to Pavlasek (1991).

Data were statistically analyzed by one-way analysis of variance using the GLM procedure of SAS, version 8.2 (SAS Institute, Cary, NC, USA). Differences ($P < 0.05$) were identified by the Tukey's test. The effect of lipid supplements on mortality of rabbits was analyzed using the Fisher's test.

Table 1. Ingredients and chemical composition of the rabbit diet

Ingredients	(g/kg)	Composition	(g/kg)
Alfalfa meal	300	Dry matter	920
Wheat bran	225	Crude protein	167
Oats	90	NDF	350
Barley	80	ADF	206
Sugarbeet pulp	60	Fat	39
Sunflower meal, extracted	170	Starch	117
Soybean meal, extracted	35	Ash	60
Lipid supplement*	10		
Mineral supplement**	20		
Vitamin supplement	10		
Robenidin	0.066		

*protected palm fat, coconut oil or Akomed R; **limestone, dicalcium phosphate and salt

Table 2. Fatty acid profile (mg/kg of fatty acids determined) of the lipid supplements added to diet at 10 g/kg

Fatty acid		Protected palm fat	Coconut oil	Akomed R
Caproic	C 6:0	0	4.3	0.4
Caprylic	C 8:0	0	62.5	539.0
Capric	C 10:0	1.1	55.4	452.5
Lauric	C 12:0	6.2	449.8	1.3
Myristic	C 14:0	16.3	183.9	0.2
Palmitic	C 16:0	566.0	101.0	1.7
Stearic	C 18:0	40.8	31.2	1.1
Oleic	C 18:1, *cis*-9	293.5	82.6	2.2
cis-vaccenic	C 18:1, *cis*-11	5.6	0	0
Linoleic	C 18:2	58.1	23.0	0.8
Linolenic	C 18:3	1.4	0.2	0
Arachidic	C 20:0	2.9	1.2	0
Other acids		6.0	4.5	0.8

RESULTS

The FA profile of lipid supplements is shown in Table 2. The principal FA in PPF, CO and Akomed R were palmitic, lauric and caprylic acid, respectively. Twenty-four and 42 early weaned rabbits died in the 2nd and the 3rd week after weaning, respectively (Table 3). The highest and the lowest mortality rate was in rabbits fed diets supplemented with PPF and Akomed R, respectively. Mortality of rabbits fed Akomed R (23%) was significantly lower than that of rabbits fed PPF (45%), and non-significantly lower than mortality of rabbits fed CO (37%). The effects of lipid supplements on the growth rate in the course of the experiment were not consistent, the final weights of surviving rabbits and their total weight gains, however, were not significantly influenced. Table 4 presents performance parameters and mortality of rabbits weaned at 35 days of age. The mortality of rabbits fed Akomed R (6%) was significantly lower than that of rabbits fed CO (16%) and non-significantly lower than the mortality of rabbits fed PPF (14%). Again, the highest mortality rate occurred in the 2nd and 3rd week after weaning. Final weights and total weight gains of survivals were significantly higher in rabbits fed MCFA-containing lipid supplements than in rabbits fed PPF.

Feeds contained the Robenidin coccidiostat, thus only sporadic occurrence of *Eimeria* sp. oocysts in faeces was observed (1–3 oocysts per a microscopic field at 450× magnification in 10 times diluted samples). The main causes of mortality were similar to those reported previously (Skrivanova and Marounek, 2006). Necropsy of dead rabbits revealed enteritis and pathological changes of organs (hyperaemia of liver, kidney and spleen, bronchopneumonia, cathar of the small intestine), cachexy, watery intestinal contents, tympany of the colon. Non-hemorrhagic *Escherichia coli*, *Klebsiella pneumoniae* and *Clostridium perfringens* were identified bacterial pathogens in the intestine, *Bordetella bronchiseptica* in the respiratory tract, and *Escherichia coli* and *Staphylococcus aureus* in other organs. No obvious relationship between a treatment and results of post-mortem examination was apparent.

DISCUSSION

Blas and Gidenne (1998) have suggested that an overload of starch in the hindgut favours the incidence of diarrhoea, which is the major cause of morbidity and mortality in growing rabbits. Gidenne and Fortun-Lamothe (2002) concluded that feeding a low-starch diet during the period around weaning could improve the health of the fattening rabbits. In the present study, however, the mortality of early-weaned rabbits was high, in spite of rather low dietary starch (117 g/kg), and high

Table 3. Weight gains, mortality and feed intake in rabbits fed different lipid supplements and weaned at 25 days of age (mean values ± S.D.)

	Protected palm fat	Coconut oil	Akomed R
Initial number of rabbits	100	100	100
Initial weight (g)	576 ± 72	561 ± 75	571 ± 79
Final weight (g)	2 573 ± 407	2 570 ± 416	2 681 ± 327
Total gain (g)	1 997 ± 402	2 009 ± 394	2 110 ± 302
Daily gain (g)			
1st week	34.0 ± 16.7	39.0 ± 12.4	34.2 ± 16.1
2nd week	37.0 ± 16.2[a]	28.8 ± 21.2[b]	32.4 ± 21.8[ab]
3rd week	39.4 ± 20.1	35.9 ± 25.6	40.4 ± 20.8
4th week	42.3 ± 14.3	43.5 ± 11.7	45.2 ± 8.4
5th week	24.5 ± 6.3[a]	43.2 ± 11.6[b]	41.6 ± 10.7[b]
6th week	50.6 ± 7.0[a]	38.0 ± 12.5[b]	45.4 ± 10.0[c]
7th week	33.7 ± 7.1[a]	35.1 ± 13.5[a]	39.8 ± 12.8[b]
Mortality			
1st week	3	1	0
2nd week	16[a]	7[ab]	1[b]
3rd week	14	18	10
4th week	7	2	5
5th week	3	2	3
6th week	2	7	4
7th week	0	0	0
Total	45[a]	37[ab]	23[b]
Feed intake per group (kg)	458.1	539.1	672.5
Feed conversion (kg/kg)	4.17	4.26	4.14

[abc]values in the same row with different superscripts differ ($P < 0.05$)

NDF and ADF concentrations (350 and 206 g/kg, respectively). Recent study by Feugier et al. (2006) showed a negative effect of early weaning on health status of young rabbits. According to the authors, the weaning age had a stronger effect on health status than the feeding strategy. Our results support this opinion. In contrast with results of Feugier et al. (2006), the compensatory growth was apparent in the present experiment, leading to final body weights of early-weaned survivals similar to those of rabbits weaned at 35 days of age.

Negative effects of early weaning were significantly alleviated by the addition of oil containing TAG of caprylic and capric acid. A corresponding effect of coconut oil containing lauric and myristic acid was not observed. In our previous study Akomed R significantly reduced faecal output of coliform bacteria in rabbits experimentally infected with enteropathogenic *E. coli* of the O103 serogroup, and non-significantly decreased mortality of infected rabbits (Skrivanova et al., 2008). In conventionally weaned rabbits Akomed R significantly decreased mortality without affecting the growth and feed conversion which has already been reported earlier (Skrivanova and Marounek, 2006).

Dead rabbits were examined in a specialized laboratory, etiology of mortality, however, was unequivocal and difficult to establish as mortality causes were multiple. Enteropathogenic *E. coli* strains, susceptible to caprylic and capric acid, might be primary pathogenic agents, rather than clostridia, which are susceptible to lauric and myristic acid present in coconut oil. Coccidia were almost absent in faeces in the present experiment.

Table 4. Weight gains, mortality and feed intake in rabbits fed different lipid supplements and weaned at 35 days of age (mean values ± S.D.)

	Protected palm fat	Coconut oil	Akomed R
Initial number of rabbits	100	100	100
Initial weight (g)	1 039 ± 134	1 054 ± 107	1 046 ± 125
Final weight (g)	2 511 ± 358[a]	2 682 ± 300[b]	2 648 ± 288[b]
Total gain (g)	1 472 ± 335[a]	1 628 ± 271[b]	1 602 ± 231[b]
Daily gain (g)			
1st week	39.3 ± 13.9	40.9 ± 12.2	39.3 ± 14.2
2nd week	34.6 ± 11.1[a]	40.7 ± 12.1[b]	34.0 ± 17.8[a]
3rd week	29.5 ± 19.9[a]	33.5 ± 11.9[b]	36.2 ± 11.0[b]
4th week	38.9 ± 16.3	39.7 ± 15.5	36.7 ± 17.6
5th week	33.3 ± 18.2[a]	35.4 ± 14.4[ab]	39.2 ± 12.5[b]
6th week	33.8 ± 15.2[a]	42.5 ± 14.8[b]	43.4 ± 15.4[b]
Mortality			
1st week	1	4	1
2nd week	5	4	0
3rd week	4	5	4
4th week	0	1	0
5th week	2	0	0
6th week	2	2	1
Total	14[ab]	16[a]	6[b]
Feed intake per group (kg)	441.8	481.4	554.2
Feed conversion (kg/kg)	3.49	3.52	3.68

[ab]values in the same row with different superscripts differ ($P < 0.05$)

Canas-Rodriguez and Smith (1966) identified caprylic and capric acid released from the milk fat as antimicrobial agents responsible for the virtual sterility of the upper digestive tract of suckling rabbits. The presence of these acids in the milk could, at least in part, explain its health-promoting influence, although the significance of other antimicrobial factors in rabbit milk can not be ruled out.

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Received: 2008–05–28
Accepted: 2009–01–20

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