Bulgarian Journal of Agricultural Science, 13 (2007), 729-737
National Centre for Agrarian Sciences

Effect of Fish Oil Supplemented Diet on the Performance, Carcass Composition and Quality in Lambs

P. MARINOVA, T. POPOVA, V. BANSKALIEVA, E. RAICHEVA, M. IGNATOVA and V. VASILEVA
Institute of Animal Science, BG-2232 Kostinbrod, Bulgaria

Abstract

MARINOVA, P., T. POPOVA, V. BANSKALIEVA, E. RAICHEVA, M. IGNATOVA and V. VASILEVA, 2007. Effect of fish oil supplemented diet on the performance, carcass composition and quality in lambs. *Bulg. J. Agric. Sci.,* 13: 729-737

Two groups of 7 animals (age 75 days) each of local Zapadnostaroplaninska sheep breed were fed for 28 days controlled iso-nitrogenous diets, containing either no added fat (control) or fish oil (experimental) added at 2.5 % of wet weight of concentrate.

Dietary fish oil supplementation did not induce significant changes in the feed intake and average daily gain of the animals. Carcasses from both groups were light <13 kg according to (S) EUROP system and classified in category (B). The carcasses from the fish oil supplemented animals had lighter colour and increased thickness (by 33.16%) of the back fat over *m.Longissimus dorsi* at the 11th rib. Half carcass weight and the weights of separate carcass cuts tended to be lower in the lambs fed fish oil. The percentage distribution and the weight of the meat, bones and fats in the half carcass did not differ significantly among the groups. The subcutaneous fat deposition differed among the separate cuts in response to fish oil supplementation. Its content was significantly reduced in the loin of the animals from the experimental group ($P<0.05$).

Fish oil increased the intramuscular fat content in the half carcass of the lambs by 16 % and stimulated its deposition in the separate cuts, significantly in the shoulder ($P<0.05$).

The deposition and distribution of body fat observed in this study suggest that the polyunsaturated fatty acids from the fish oil could be a repartitioning factor for carcass fats in lambs and could have a favorable effect on the carcass fatness and quality.

Key words: lambs, fish oil, performance, carcass composition

Introduction

The requirements of the European market for producing of meat with high nutritional and healthy value as well as the standards for carcass quality necessitate searching ways for production of animal products with definite quality traits.

Numerous researches have revealed the biological importance of n-3 fatty ac-

ids for human health. Increased consumption of these polyunsaturated fatty acids is linked to beneficial changes in cardiovascular health (Schmidt et al., 2001), eicosanoid biosynthesis and gene expression (Shahidi and Miraliakrabi, 2004). Studies with ruminants showed that fish oil supplemented diets influenced the fatty acid composition of meat lipids by increasing the contents of the n-3 polyunsaturated fatty acids (Ponnampalam et al., 2001a; Scollan et al., 2001; Wachira et al., 2002).

According to the European system for carcass classifications (S) EUROP the main parameters forming the quality of the carcasses in ruminants are the content of the muscle and fat tissue as well as their anatomical location. Lower content of carcass fat in lambs is required for efficient lean meat production. On the other hand very low amount of carcass fat could have a negative effect on the quality of meat. In studies with sheep, beef and goats it has been reported that diets containing fish oil or fish meal influence the fat content and deposition in the carcass (Mandel et al., 1997; Scollan et al., 2001; Marinova et al., 2005) and hence the carcass quality and price.

The aim of the present study was to study the influence of the fish oil supplemented diet on the performance, carcass composition and quality in lambs of local Bulgarian sheep breed.

Table1

Ingredients and nutritional value of the concentrate and hay

Ingredients	%
Corn	26.30
Wheat	30.00
Wheat bran	15.00
Sunflower meal	14.00
Soy meal	12.00
Vitamin-mineral premix	0.10
Lime	1.10
Dicalcium phosphate	1.00
Salt	0.50
Crude protein, %	
Concentrate	18.82
Hay	16.91
Metabolizable energy, MJ/kg	
Concentrate	11.38
Hay	8.34

Material and Methods

The experiment was carried out at the Institute of Animal Science, Kostinbrod with two groups of weaned male lambs (7 animals each) at the age of 75 days of the local Zapadnostaroplaninska breed.The mean live weight of the animals was 16.53±1.35 kg.

Both groups were housed indoors and had ad libitum access to commercial concentrate and hay with main ingredients and composition shown in Table 1. Diets of both groups also contained a supplement mixture of micro-elements and a vitamin premix. The animals from the experimental group received concentrate gradually supplemented with fish oil, starting with a level of 0.5% (of concentrate wet weight) to a level of 2.5% at the end of the first week. After the adjustment period, the experimental animals received 2.5% fish oil supplemented diet (prepared fresh every day) for 28 days. The animals were slaughtered at the age of 105 days.

Hot carcass weight was measured 1 h after slaughter, and cold carcass weight – after 24 hours storage at 4° C.

Carcass classification was made up to

1 h post mortem by (S)EUROP system (EEC Regulations No 2137/92; No 461/93; No 1278/94 and Regulation 20/2004 of the Bulgarian Ministry of Agriculture), examined and introduced by Marinova and Raicheva (2002). The carcasses were classified according the carcass weight in the following categories- A-up to 7 kg, B-7.1-10.0 kg, C-10.1-13.0 kg and according to the degree of fatness and the colour of *m.Rectus abdominis*-light rose, rose and other.

The dissection was carried out according to a method adopted in the laboratory of meat quality. The carcass was split along the vertebral column, mid line into two halves. The left half was weighed and the thickness of subcutaneous fat over m. *Longissimus dorsi* at the 11th rib, breast plate and at the base of the tail was measured. After that the half was dissected in the following cuts – leg, loin, shoulder, neck and abdomen. These were further dissected into bone, lean meat, intramuscular and subcutaneous fat, which were weighed. The pelvic and kidney fats were also separated and weighed.

From the carcass half were separated and weighed the muscles as follows: *m. Longissimus lumborum* (m.LDl), *m. Longissimus thoracis* (m.LDt), *m. Semimembranosus*(m.SM), *m. Supraspinatus* (m.SP).

The values are presented as mean and standard deviation for each animal group. The Student's t-test was used to determine the levels of significance between groups with $P>0.05$- NS; $P<0.05$-*, $P<0.01$-**; $P<0.001$-***.

Results and Discussion

Feed intake and performance data of the lambs in response to fish oil supplementation are presented in Table 2.

The initial live weight of the animals averaged 16.5 kg. Fish oil supplementation did not influence the dry matter intake and the average daily gain of the lambs. The results reported from several authors showed that the effect of the fish oil on these traits depends on the species (Wachira et al., 2002; Marinova et al., 2005) and could be explained by its concentration in the diet and the fat content (Wistuba et al., 2005). In cattle Wonsil et al. (1994); Scolan et al. (2001) reported that fish oil in concentrations up to 2 % had no effect on the dry matter intake. Higher concentrations of fish oil (Wistuba et al., 2006) decreased dry matter intake and hence the average daily gain in ruminants. Rule et al. (1989) noted that DMI is often depressed when diets contain more than 8% fat. This is due to the adverse effects of the fat on the microbial population in the rumen as reported by Patil et al. (1993).

The fish oil did not induce significant changes in the final live weight of the experimental animals as well -22.71±1.48 kg vs. 22.50±2.17 kg for the control group. No changes were found in the live weight of kids, receiving the same fish oil supplemented diet for 33 days (Marinova et al., 2005). In our experiment the fish oil supplementation was 2.5 % (in concentrate), which corresponded to 0.9 % of the whole daily diet offered to the lambs. It could be suggested that the applied fat has been too low to substantially affect the animal performance.

The carcass weights of the animals from the control group were heavier than those of the animals received fish oil, but the two groups are classified as "Light" by the (S) EUROP system (Table 3) and belong to category B (7-10.0 kg). In addi-

Table 2

Feed intake and growth performance in lambs in response to fish oil supplementation

Items	Groups				Significance level
	Control		Experimental		
	$\bar{x}$	Sd	$\bar{x}$	Sd	
Initial LW, kg	16.62	1.42	16.44	1.28	NS
DMI, kg/d	1.26		1.26		NS
MEintake,MJ/g	12.36		12.75		NS
ADG, g/d	197.80	62.23	209.10	59.11	NS
Final LW, kg	22.55	2.17	22.71	1.48	NS

Note : NS-P>0.05

Table 3

Degree of fatness, weight and thickness of subcutaneous fat in the lambs

Items	Groups				Significance level
	Control		Experimental		
	$\bar{x}$	Sd	$\bar{x}$	Sd	
Hot carcass weight, kg	10.14	1.29	9.53	1.11	NS
Degree of fatness	2	0	2.17	0.41	NS
Thickness of subc. fat over m.LD (at the 11th rib), mm	2.62	1.84	3.92	1.23	NS
Thickness of subc. fat at the breast plate, mm	4.54	1.93	6.10	3.02	NS
Thickness of subc. fat at the base of the tail, mm	7.49	2.72	6.46	2.50	NS
Kidney fats, g	73.00	10.37	72.50	32.98	NS

Note:NS-P>0.05.

tion to the weight category, the price of the light lamb carcasses is determined by the quality, which combines the colour and the degree of fatness.

Visual evaluation of the colour of *m.Rectus abdominis* showed that the carcasses from both groups had light rose or rose colour (Figure 3). This responded to the requirements for the first quality grade of the category B. Higher percentage of the lambs fed fish oil had light rose colour (67%) whereas most of the animals from the control group (80%) had rose colour of *m.Rectus abdominis*.

The degree of fatness of the studied groups of carcasses did not differ significantly in response to fish oil supplementation as both are characterized by low degree of fatness (2) (Table 3). Fish oil tended to increase the thickness of the subcutaneous fat at the 11th rib (33.16%). Ponnampalam et al. (2001b) reported no significant influence on the fat thickness at the 12-th rib in lambs fed fish oil while other studies with ruminants (Wachira et al., 2002; Wistuba et al., 2006) observed decreased subcutaneous fat over the loin after fish oil supplementation.

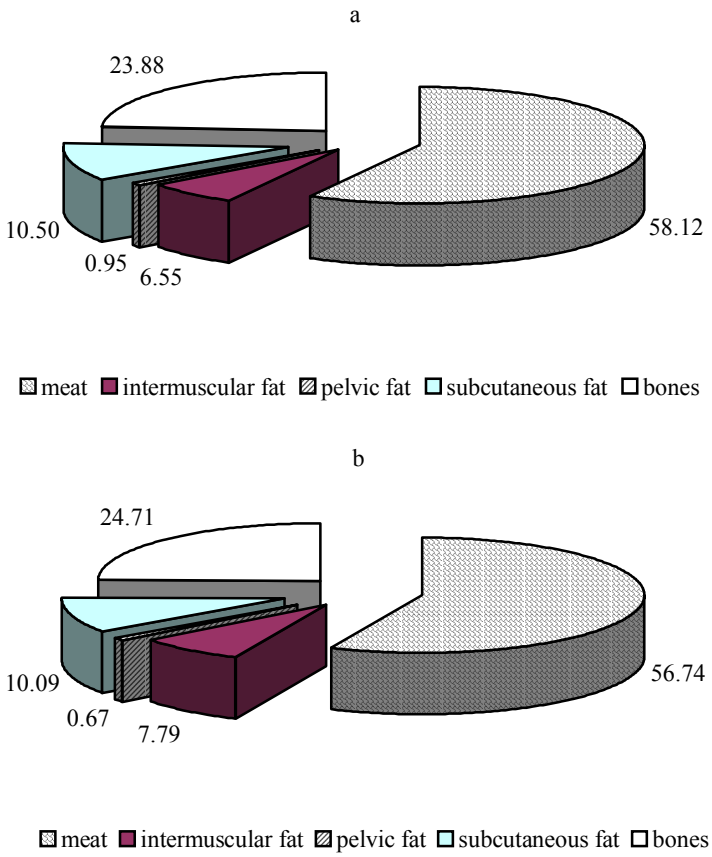

Fig. 1. Percentage of the tissues in the half carcass in animals from the control (a) and experimental (b) groups

The thickness of the subcutaneous fat at the breast plate of the animals fed fish oil was increased by 25.58% and the thickness of the fat at the base of the tail-decreased by 13.76%.

Though not significantly changed by the fish oil supplementation the weights of the half carcass and the separate cuts tended to decrease in the animals from the experimental group (Table 4). Similar trend was reported by Wistuba et al.(2006) in cattle while Marinova et al. (2005) observed higher weight of the carcass and the carcass cuts in kids in response to fish oil supplementation. As a whole the influence of the fish oil on the percentage distribution and the weight of the meat, bones and fats in the half carcass of the animals was not significant, but versatile (Figure 1 and Table 4).

Dietary fish oil supplementation tended to decrease the weight of the meat in the half carcass and the separate cuts as well as the weights of the separated muscles (Figure 2). In the experimental animals the weights of m.LDl and m.SP were10%

Table 4

Dissection data in the lambs in response to fish oil

Items	Groups						Significance level
	Control			Experimental			
	x	Sd	%	*x*	Sd	%	
Half carcass, g	4563.55	626.46	100	4160.31	496.46	100	NS
meat	2654.95	394.57	58.12	2360.14	291.24	56.74	NS
bone	1090.80	166.41	23.88	1029.17	137.31	24.71	NS
subcutaneous fat	473.00	23.61	10.50	417.00	63.52	10.09	NS
intermuscular fat	300.60	85.29	6.55	325.33	59.40	7.79	NS
pelvic fat	44.20	21.52	0.94	28.66	10.89	0.67	NS
Neck, g	340.40	22.77	7.52	332.50	69.01	8.08	NS
meat	185.00	21.79	4.08	180.00	40.49	4.36	NS
bone	84.40	11.15	1.88	90.00	24.08	2.19	NS
subcutaneous fat	34.00	21.04	0.75	24.17	25.45	0.62	NS
intermuscular fat	37.00	13.96	0.81	38.33	27.86	0.91	NS
Leg, g	1609.12	178.40	35.37	1504.80	239.46	36.05	NS
meat	1029.32	127.85	22.60	917.13	149.81	21.99	NS
bone	372.80	52.97	8.18	379.17	57.22	9.09	*
subcutaneous fat	98.40	41.89	2.26	113.67	28.86	2.70	NS
intermuscular fat	64.40	48.65	1.38	66.17	25.02	1.59	NS
pelvic fat	44.20	21.52	0.95	28.67	10.89	0.67	NS
Shoulder, g	1626.88	274.23	35.55	1425.87	208.27	34.31	NS
meat	934.28	153.14	20.42	819.53	113.50	19.70	NS
bone	413.60	76.38	9.02	345.00	57.87	8.29	NS
subcutaneous fat	174.00	36.47	3.79	129.17	49.33	3.14	NS
intermuscular fat	105.00	29.15	2.31	132.17	37.28	3.17	*
Loin, g	412.80	70.40	9.03	323.50	65.79	7.78	NS
meat	240.00	52.46	5.22	201.50	36.49	4.89	NS
bone	74.80	12.15	1.65	66.67	23.59	1.58	NS
subcutaneous fat	51.80	7.98	1.14	25.83	16.25	0.61	*
intermuscular fat	46.20	19.86	1.02	29.50	14.48	0.69	NS
Abdomen, g	574.35	131.62	12.52	573.64	120.3	13.78	NS
meat	266.35	77.67	5.79	241.98	51.53	5.80	NS
bone	145.20	47.67	3.15	148.33	39.70	3.55	NS
subcutaneous fat	114.80	49.73	2.55	124.17	24.17	3.01	NS
intermuscular fat	48.00	17.18	1.03	59.17	17.44	1.42	NS

Note: * $P<0.05$; NS-$P>0.05$.

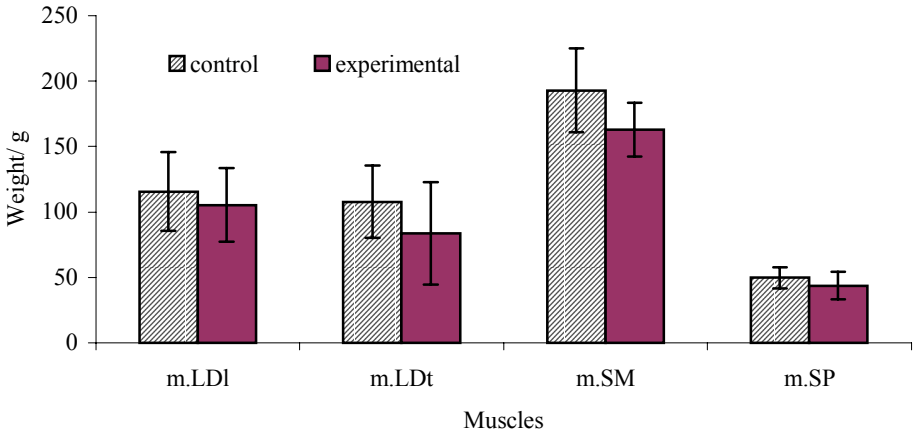

Fig. 2. Weight of the muscles in lambs in response to fish oil supplementation

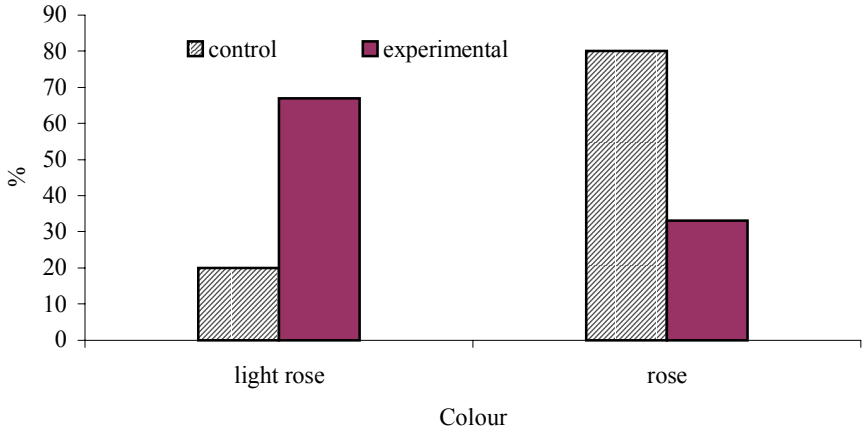

Fig. 3. Percentage of carcasses according to the colour of m.Rectus abdominis in lambs from the control and experimental group

lower, and those of m. LDt and m.SM – 19 % than in the lambs from the control group.

The content of the subcutaneous fat in the half carcass was slightly reduced in the animals supplemented fish oil but it is unevenly distributed among the carcass cuts (Table 4). Subcutaneous fat content was significantly reduced ($P<0.05$) in the loin in response to fish oil supplementation. Similar results were reported by Nicastro et al. (2001). In the neck and shoulder of the animals from the experimental group the content of the subcutaneous fat was reduced by 26% average.

The intramuscular fat content was higher in all the carcass cuts of the animals supplemented fish oil except in the

loin, where it was reduced by 36 %. The highest it was in the shoulder, compared to the rest of the carcass cuts and was significantly increased after fish oil supplementation ($P<0.05$).

There was no significant difference in the content of the pelvic fat between the groups. Yet it tended to be lower in response to fish oil supplementation as it was reduced by 29 % in the animals from the experimental group.

It could be expected that the higher daily fat intake of the animals fed fish oil - 41.86 vs. 32.08 g/animal, rather than the increased energy (with only 0.39 MJ/ animal) affected the distribution of the body fat. The effect of fish oil might be limited or increased by the different stage of development of the fat depots and the specificities of lipid metabolism in the different anatomical locations (Eginoa et al., 2003). The observed tendencies for a different deposition of subcutaneous fat in some anatomical locations and the increase of the intramuscular fats probably as a result of a greater capacity for fatty acid synthesis or a different rates of lipolysis in the carcass adipocytes might be a compensatory mechanism for a changed nutrient supply to the different fat depots (Eginoa et al., 2003).

The reasons for the differences of lipid deposition and the changes in lipid metabolism after fish oil supplementation still are not clear. The changes observed in this study as well as the results of other experiments with ruminants undoubtedly depend on the experimental design where the breed, age and stage of development of the animals are important.

Conclusions

Dietary fish oil supplementation did not influence significantly the feed intake and performance in the lambs.

Carcasses from both groups were light < 13 kg classified by the system (S) EUROP. All the carcasses were of first quality grade.

Subcutaneous fat content was significantly reduced ($P<0.05$) in the loin and intramuscular fat content was higher in the shoulder ($P<0.05$) in response to fish oil supplementation.

The deposition and distribution of body fat observed in this study suggest that the polyunsaturated fatty acids from the fish oil could be a repartitioning factor for carcass fats in lambs and could have a favorable effect on the carcass fatness and the quality of lamb meat.

References

Council Regulation (EEC) No 2137/92, OJ L 214, 1992, p.1-5.

Council Regulation (EEC) No 461/93, OJ L 49, 1993, p.70-74.

Council Regulation (EEC) No 1278/94, OJ L 140, 1994, p.5-6

Eginoa, P., S. Brockelhurst, A. Arana, L. A. Mendizabal, R. G. Vernon and A. Purroy, 2003. Lipogenic enzyme activity in different adipose depots of Pirenaican and Holstein bulls and heifers taking into account adipocyte size. *J. Anim. Sci.,* **81**: 432-440.

Mandell, I. B., J. C. Buchanan- Smith, B. J. Holub and C. P. Campbell, 1997. Effects of fish meal in beef cattle diets on growth performance, carcass characteristics and

fatty acid composition of longissimus dorsi. *J. Anim. Sci.,* **75**: 910-919.

Marinova, P., E. Raicheva and D. Katzarov, 2002. Manual for classification of animals and ovine, bovine and porc carcasses by (S) EUROP system. *SpaceCo. Ltd*, pp.4-37 (Bg).

Marinova, P., V. Banskalieva and V. Tzvetkova, 2005. Body and carcass composition, and meat quality of kids fed fish oil supplemented diet. *Options Mediterraneennes, Series A*, **No 67:** 151-156.

Nicastro, F., L. Zezza and R. Gallo, 2001. Omega-3 fatty acids and meat lamb quality, *J. Anim. Sci*., **79**, *Suppl*., **1**: 439.

Patil, A. R., A. L. Goetsch, P. K. Lewis, Jr. and C. E. Heird, 1993. Effects of supplementing growing steers with high levels of partially hydrogenated tallow on feed intake, digestibility, liveweight gain, and carcass characteristics. *J. Anim. Sci.,* **71**: 2284-2292.

Ponnampalam, E. N., A. J. Sinclair, A. R. Egan, S. J. Blakeley and B. J. Leury, 2001a. Effects of diets containing n-3 fatty acids on muscle long-chain n-3 fatty acid content in lambs fed low- and medium-quality roughage diets. *J. Anim. Sci.,* **79**: 698–706.

Ponnampalam, E. N., A. J. Sinclair, A. R. Egan, S. J. Blakeley, D. Li and B. J. Leury, 2001b. Effect of dietary modification of muscle long-chain n-3 fatty acid on plasma insulin and lipidmetabolites, carcass traits, and fat deposition in lambs. *J. Anim. Sci.,* **79**: 895–903.

Rule, D. C., W. Wu, J. R. Busboom, F. C.Hinds and C. J. Kercher, 1989.Dietary canola seeds alter the fatty acid composition of bovine subcutaneous adipose tissue. *Nutr. Rep. Int.,* **39**: 781-786.

Schmidt, E. B., J. H. Christensen, I. Aardestrup, T. Madsen, S. Riahi, V.E. Hansen and H.A. Skou, 2001. Marine n-3 fatty acids: Basic features and background. *Lipids,* **36**: 65-68.

Scollan, N. D., N. J. Choi, E. Kurt, M. Fisher and J. D. Wood, 2001. Manipulating the fatty acid composition of muscle and adipose tissue in beef cattle. *Br.J Nutr.,* **85**:115-124.

Shahidi, F. and H. Miraliakrabi, 2004. Omega –3 (n-3) fatty acids in health and disease: Part 1 –Cardiovascular disease and cancer. *J. Medic. Food,* **7**: 387-401.

Wachira, A. M., L. A. Sinclair, R. G. Wilkinson, M. Enser, J. D. Wood and A. V. Fisher, 2002. Effects of dietary fat source and breed on the carcass composition, n-3 polyunsaturated fatty acid and conjugated linoleic acid content of sheep meat and adipose tissue. *Br. J. Nutr.,* **88**: 697-709.

Wistuba , T. J., E. B. Kegley, J. K. Apple and M. E. Davis, 2005. Influence of fish oil supplementation on growth and immune system characteristics of cattle. *J. Anim. Sci.,* **83**: 1097–1101.

Wistuba , T. J., E. B. Kegley and J. K. Apple, 2006. Influence of fish oil in finishing diets on growth performance, carcass characteristics and sensory evaluation of cattle. *J. Anim.Sci.,* **84**: 902-909.

Wonsil, B. J., J. H. Herbein and B. A. Watkins, 1994. Dietary and ruminal derived trans-18: 1 fatty acids alter bovine milk lipids. *J. Nutr*., **124**: 556-565.

Received August, 3, 2007; accepted October, 23, 2007.