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POSSIBILITIES TO PRODUCE HEALTHY, TASTY MEAT AND TO IMPROVE ITS NUTRITIONAL VALUE*

Karin Nuernberg, Klaus Ender, Dirk Dannenberger

Research Institute for Biology of Farm Animals, Department of Muscle Biology and Growth Dummerstorf, Germany

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Consumers want a healthy, tasty quality meat with a high nutritional value from cattle, lambs and pigs. Grass-based feeding systems increased ($p \leq 0.05$) the percentage of *n*-3 fatty acids in the *longissimus* muscle lipids of beef and lamb meat. Besides the contribution from landscape maintenance as well as nature preservation, a pasture feeding system can be tailored to the consumer's demand for healthier meat. To produce quality bulls and lambs by keeping on pasture grassland of good quality is needed. For cattle a finishing indoor period before slaughter is recommended. Feeding linseed oil (5%) to pigs significantly increased the relative content of linolenic acid and longer chain *n*-3 fatty acids in lipids of muscle at the expense of arachidonic acid. Oleic acid was accumulated in muscle lipids by feeding 5% olive oil.

INTRODUCTION

Consumers today are more interested in knowing what they are really eating. Farmers try to offer healthier meat for human consumption through changing animal feed composition and genetic improvement. The fat content and the fatty acid composition play an important role in meat quality. It is suggested that the contribution of fat and saturated fatty acids to dietary energy intake should not exceed 30% and 10% of the total intake; and the ratio of *n*-6 to *n*-3 polyunsaturated fatty acids (PUFA) should be less than 5:1 [DGE, 2000]. The predominant sources of long chain *n*-3 fatty acids are fish and meat. The correct balance of *n*-6 and *n*-3 fatty acids in the meat and milk products of farm animals can increase the dietary intake of these beneficial *n*-3 fatty acids and can improve human health [Simopoulos, 2003]. Recently it has been shown that 43% of the health-promoting very long chain *n*-3 fatty acid intake of adults in Australia derives from beef, lamb meat, poultry and pork, whereas fish and seafood account for 48% [Howe *et al.*, 2004].

Farm animals are normally fattened indoor on concentrate diets, which may be unfavourable to the ratio of *n*-6/*n*-3 polyunsaturated fatty acids in meat because the fat in concentrates contains higher levels of C18:2*n*-6. The lipids of certain plants (linseed, rapeseed, Perilla, grass) contain high or moderate amounts of α-linolenic acid (C18:3*n*-3). Including forage in the diet of farm animals should enhance the *n*-3 fatty acid concentrations because forages are a good source of C18:3*n*-3 [Scollan *et al.*, 2001]. Changing the diet and fatty acid composition of meat may also affect sensory eating quality and colour and/or lipid stability of the meat during retail display [Vatansever *et al.*, 2000; Nuernberg *et al.*, 2005a]. However, the PUFA concentration should not exceed the limit of 12% to guarantee good fat quality [Fischer, 2001]. Grass provides natural antioxidants (vitamin E) which help to maintain high *n*-3 PUFA levels in the meat and to reduce quality deterioration during processing and retail display.

The aim of the experiments with cattle, lamb and pig was to enhance beneficial fatty acids by different production systems including dietary fat sources.

MATERIALS AND METHODS

Beef experiment. In total 64 cattle (5–6 months old) were randomly assigned to two dietary treatments (concentrate *versus* grass-based) in the experiment. For indoor housing the concentrate group consisted of 16 German Simmental (GS) and 17 German Holstein (GH) bulls. They were fed semi *ad libitum* maize silage, concentrate, hay, straw and a mixture of minerals and vitamins up to 620 kg live weight. Fifteen GS and 16 GH bulls, were kept on pasture during the summer period. During the following winter period and three months before finishing these bulls were kept in a stable and were fed wilted silage, hay, a pelleted concentrate diet and a mixture of minerals and vitamins up to 620 kg. The pelleted concentrate for the pasture group was a mixture of 12% barley, and 10% coarsely cracked linseed (Vollkraft Mischfutterwerk, Güstrow). *Longissimus* muscle samples for meat quality and fatty acid analysis were taken at the 6^{th}–13^{th} rib of the left carcass side 24 h after slaughter. Details of feed composition, animal keeping and methods for fatty acid analyses are described by Nuernberg *et al.* [2005a].

Author's address for correspondence: Klaus Ender, Research Institute for the Biology of Farm Animals, Wilhelm-Stahl-Allee 2, 18196 Dummerstorf, Germany; tel.: (49 38208) 68850; e-mail: ender@fbn-dummerstorf.de

Lamb experiment. A total of 34 male crossbred lambs (Texel x Bleu du Maine) were included at 20 kg live weight. Fourteen lambs were reared indoor and fed intensively with concentrates until slaughter, 13 lambs grazed on pasture with their mothers until slaughter, and 7 lambs grazed on pasture without their mothers until slaughter. Lambs were slaughtered at 40 kg live weight in the abattoir of the Research Institute for the Biology of Farm Animals in Dummerstorf, Germany. The slaughter and dressing procedures were in accordance with EU specifications. *Longissimus* muscle samples were removed at the 13th rib, 24 h after slaughtering and cooling of the carcasses, and stored at -18°C until lipid extraction.

Detailed data are reported by Nuernberg *et al.* [2001].

Pig experiment. A total of 13 female and 12 castrated pigs (Pietrain x German Landrace) were divided into two groups at approximately 40 kg of live weight. They were housed individually and fed a conventional pig diet twice daily according to a target daily gain of 750 g. The animals were fed 95% basal concentrate supplemented with 5% linseed oil (linseed group, 5 castrates, 7 females) or 5% olive oil (olive group, 7 castrate, 6 females) until slaughter at 105 kg live weight. *Longissimus* muscle samples were removed at the 13th rib of the left carcass side 24 h after slaughter. Detailed information about feed composition is reported by Nuernberg *et al.* [2005b].

RESULTS AND DISCUSSION

Beef experiment

Discussion of the nutritional value of beef has been relatively controversial. Often more attention has been focused on negative nutritional concerns such as saturated fat and cholesterol. Results from epidemiological studies and controlled clinical trials have indicated that replacing saturated fat and *trans* fatty acids with unsaturated fat, especially *n*-3 fatty acids, is more effective in lowering the risk of coronary heart disease than simply reducing total fat consumption [Renaud *et al.*, 2002; Hu & Willett, 2002; Sanders, 2003]. Feeding strategies that induce a decrease in saturated fat and enhance the *n*-3 fatty acids of intramuscular fat would improve the nutritional value of beef. The objective of the study with bulls was to establish whether the grass and linseed concentrate feeding system is sufficient to accumulate muscle *n*-3 fatty acids, especially the long chain *n*-3 PUFA and CLA *cis*-9, *trans*-11. Despite the biohydrogenation of C18:3*n*-3 in the rumen, the linolenic acid contained in the lipids of grass and linseed was deposited at higher concentrations in muscle of bulls on the grass-based diet. Bulls grazing on pasture and finished on a diet containing linseed accumulated two to three fold higher concentrations of total *n*-3 fatty acids in their muscles compared to concentrate fed bulls. The increased concentrations of C20:5*n*-3

TABLE 1. Total fatty acid composition (mg/100 g) of intramuscular fat in *longissimus* muscle of German Holstein and German Simmental bulls.

	German Holstein				German Simmental				Signif. (p≤0.05)
	Concentrate		Pasture		Concentrate		Pasture		
	LSM	SEM	LSM	SEM	LSM	SEM	LSM	SEM	
C12:0	1.79	0.17	1.28	0.18	1.171	0.18	0.69	0.18	B,F
C14:0	84.53	8.81	51.87	9.08	50.59	9.08	30.30	9.38	B,F
C16:0	870.60	74.09	531.90	76.38	616.3	76.38	350.1	78.88	B,F
C16:1	129.00	12.18	66.16	12.55	83.43	12.55	37.84	12.97	B,F
C18:0	498.90	45.44	421.90	46.84	423.0	46.84	276.8	48.38	B,F
Σ C18:1*trans*[c]	93.93	11.3	102.03	11.6	80.39	11.6	70.99	11.9	-
C18:1*cis-9*	1361.0	112.0	786.70	115.5	976.8	115.50	496.1	119.2	B,F
C18:2 *n*-6	124.70	5.45	87.17	5.62	114.1	5.62	77.43	5.80	F
C18:3 *n*-3	11.02	1.64	35.28	1.69	11.00	1.69	27.80	1.74	B,F,B*F
C20:3 *n*-6	8.92	0.46	6.31	0.47	8.340	0.47	6.04	0.49	F
C20:4 *n*-6	39.78	1.78	27.18	1.84	36.96	1.84	28.16	1.90	F
C20:5 *n*-3	3.57	0.40	10.71	0.42	1.734	0.42	10.76	0.43	B,F,B*F
C22:4 *n*-6	5.45	0.27	2.01	0.28	5.920	0.28	2.05	0.29	F
C22:5 *n*-3	9.70	0.53	15.08	0.55	6.231	0.55	15.58	0.57	B,F,B*F
C22:6 *n*-3	2.22	0.16	2.69	0.17	1.001	0.17	2.03	0.17	B,F
SFA[a]	1506.0	129.6	1047.0	133.6	1126,4	133.50	685.80	137,9	B,F
UFA[b]	1913.2	146.20	1226.7	150.7	1410.5	150.70	826.80	155.7	B,F
PUFA	223.30	10.10	196.40	10.40	199.80	10.40	177.10	10.80	B,F
n-3 FA[e]	28.09	2.16	65.07	2.22	20.50	2.22	57.31	2.29	B,F
n-6 FA[f]	181.70	7.20	124.70	7.50	167.70	7.50	115.10	7.70	F
n-6/*n*-3 ratio[g]	6.47	0.14	1.92	0.15	8.18	0.15	2.01	0.15	B,F,B*F

LSM – Least square means, SEM – Standard error of LSM; B – significant influence of breed; F – significant influence of feed; B*F – significant interactions of breed*feed;

[a] – Sum of saturated fatty acids : C10:0+C11:0+C12:0+C13:0+C14:0+C15:0+C16:0+C17:0+C18:0+C20:0+C21:0+C22:0+C23:0+C24:0;

[b] – Sum of unsaturated fatty acids: C14:1+ C15:1+ C16:1+ C17:1+ C18:1*trans*+ C18:1*cis9*+ C18:1*cis11*+ C18:2*trans*+ C18:2-6+C18:3*n*-3+ +C18:4*n*-3+ C20:3*n*-6+C20:4*n*-6+ C20:5*n*-3+ C22:1+ C22:4*n*-6+ C22:5*n*-3+ C22:6*n*-3+ *cis9*,tr11CLA+C18:3*n*-6+ C20:2*n*-6+C20:3*n*-3+ C22:2*n*-6+ C24:1; [c] – Sum of the isomers C18:1*trans*-6 until C18:1*trans*-11; [e] – Sum of C20:3*n*-3+ C22:6*n*-3+ C22:5*n*-3+ C20:5*n*-3+ C18:4*n*-3+ C18:3*n*-3; [f] – Sum of C22:2*n*-6+ C20:2*n*-6+ C18:3*n*-6+ C22:4*n*-6+ C20:3*n*-6+ C18:2*n*-6+ C20:4*n*-6; [g] – Quotient of the sum of *n*-6 and *n*-3 fatty acids

(EPA), C22:5*n*-3 (DPA) and C22:6*n*-3 (DHA) in muscle of animals fed on grass suggests that the high availability of 18:3*n*-3 in the diet has resulted in an enhanced synthesis of these *n*-3 long chain PUFA. In our experiment there was a decrease in the amounts of C18:2*n*-6 and all long chain *n*-6 fatty acids in muscle fat in the grass-based system.

The consumption of beef from grass-based bulls with increased *n*-3 fatty acid concentrations can contribute to human daily requirements for these fatty acids, especially C18:3*n*-3, EPA, DPA and DHA. Meat, milk and eggs are the only sources of long-chain *n*-3 fatty acids in the diet for people who do not consume fish. The diet did not increase the concentration of saturated fatty acids. This is also positive for human nutrition. In this study the grass-based diet did not increase the concentration of the sum of C18:1*trans* isomers (C18:1*trans*6-11; Table 1). At present it has not been shown which isomer of the *trans* fatty acids is responsible for the negative effects on blood lipids. However, there is some evidence that the dominant *trans* isomer in meat and milk, the *trans* vaccenic acid (C18:1*trans*-11) is not a significant risk factor for cardiovascular disease compared with those *trans* fatty acids arising from the chemical hardening of oils [Willett *et al.*, 1993].

Regardless of the origin of CLA isomers, changes in the biohydrogenation process remain an important route to accumulation of CLA *cis*-9, *trans*-11 and *trans* vaccenic acid (C18:1*trans*-11) in milk, muscle and fatty tissues in ruminants. Under our experimental conditions the percentage of CLA*cis*-9,*trans*-11 (0.87% *vs*. 0.72% in GS; 0.84% *vs*. 0.75% in GH) in muscle was significantly higher in animals on the grass-based system (Table 2). There was no influence of feeding grass/linseed when the absolute content in muscle was calculated, explained by the lower fat content of muscle in grass-based animals. There was an influence of the breed on the concentration of CLA*cis*-9,*trans*-11. GH bulls accumulated a higher amount of CLA*cis*-9,*trans*-11 (17.1 mg concentrate and 17.3 mg/100 g muscle grass-based) compared to GS bulls (13.3 mg *vs* 11.5 mg/100g, respectively). Feeding linseed to steers also increased CLA *cis*-9, *trans*-11 in muscle in a study by Enser *et al.* [1999]. Replacing barley grain by linseed in the diet of lactating cows for two weeks also increased the 18:3*n*-3 and CLA *cis*-9, *trans*-11 percentage in milk [Soita *et al.*, 2003]. More detailed results of the beef experiment were already reported earlier [Nuernberg *et al.*, 2005a; Dannenberger *et al.*, 2004]. Further studies are required to examine the accumulation of CLA isomers in beef under various dietary and feeding conditions.

Lamb experiment

The influence of feeding fat on the fatty acid profile of tissues in sheep is relatively small because of partial or complete hydrogenation in the rumen. Ruminants being forestomach fermenters, reduce unsaturated fatty acids in the rumen. Predominantly saturated fatty acids are then available for subsequent intestinal absorption. However, in young lambs there is an influence of different feeding systems upon the fatty acid composition of intramuscular fat of the *longissimus* muscle. The fat content of grass is low. The percentage contribution of the fatty acid composition of *longissimus* muscle is shown in Table 3. The data demonstrate that different diets (concentrates *versus* grass) can change the fatty acid profile. The relative concentration of total *n*-3 fatty acids is significantly increased in lamb muscles kept on extensive pasture in comparison to lambs fed the concentrate. Despite the biohydrogenation of C18:3*n*-3 in the rumen the mean values of total *n*-3 concentration of muscle on the quantitative basis are 33.6 mg/100 g, 79.5 mg/100 g and 83.2 mg/100g for lambs fed concentrate indoor, or grass on extensive pasture with mother and without mother, respectively. The elevated biosynthesis of *n*-3 LCPUFA proved the 1.8-2.7-fold increase of C20:5*n*-3, C22:5*n*-3 and C22:6*n*-3. Only in tendency a decrease of *n*-6 fatty acids in muscle was determined. In former experiments with Black Head lambs and crossbred Black faced

TABLE 3. Fatty acid composition of *longissimus* muscle of lambs (%).

FA (weight-%)	Concentrate LSM_{SEM} n=14	Pasture suckling lambs LSM_{SEM} n=13	Pasture weaning lambs LSM_{SEM} n=7
Intramuscular fat (%)	$1.6_{0.1}^{a}$	$1.5_{0.1}$	$1.3_{0.2}^{b}$
C12:0	$0.02_{0.02}$	$0.06_{0.02}$	$0.04_{0.03}$
C14:0	$1.29_{0.2}^{a}$	$2.26_{0.2}^{b}$	$0.51_{0.2}^{c}$
C16:0	$20.84_{0.4}$	$20.68_{0.4}$	$19.66_{0.5}$
C16:1	$1.07_{0.04}^{a}$	$0.92_{0.05}^{b}$	$0.71_{0.06}^{c}$
C18:0	$15.03_{0.3}^{a}$	$17.96_{0.3}^{b}$	$21.86_{0.5}^{c}$
C18:1*cis*-9	$35.97_{0.8}^{a}$	$30.4_{0.9}^{b}$	$30.02_{1.2}^{b}$
C18:1*cis*-11	$1.97_{0.06}^{a}$	$1.32_{0.06}^{b}$	$1.25_{0.09}^{b}$
C18:2n-6	$9.31_{0.6}$	$7.9_{0.6}$	$7.72_{0.9}$
C18:3*n*-3	$0.73_{0.1}^{a}$	$2.25_{0.1}^{b}$	$3.4_{0.2}^{c}$
C20:4*n*-6	$3.08_{0.2}^{a}$	$3.16_{0.2}^{a}$	$2.41_{0.3}^{b}$
C20:5*n*-3	$0.59_{0.1}^{a}$	$1.45_{0.1}^{b}$	$1.59_{0.2}^{b}$
C22:5*n*-3	$0.55_{0.08}$	$0.98_{0.08}$	$1.05_{0.1}$
C22:6*n*-3	$0.25_{0.07}$	$0.59_{0.08}$	$0.38_{0.1}$
SFA	$38.86_{0.5}^{a}$	$42.35_{0.5}^{b}$	$43.36_{0.7}^{b}$
n-3 Fatty acids	$2.1_{0.3}^{a}$	$5.3_{0.3}^{b}$	$6.4_{0.4}^{c}$
n-6 Fatty acids	$13.21_{0.8}$	$12.24_{0.9}$	$11.36_{1.1}$
n-6/*n*-3 ratio	$7.3_{0.4}^{a}$	$2.3_{0.4}^{b}$	$1.8_{0.6}^{b}$

LSM – Least square means, SEM – Standard error of LSM; a, b – significant difference between groups ($p \leq 0.05$)

TABLE 2. CLA*cis*-9,*trans*-11* concentration in *longissimus* muscle of German Holstein and German Simmental bulls (GC data).

	German Holstein				German Simmental				Signif. ($p \leq 0.05$)
	Concentrate		Grass-based		Concentrate		Grass-based		
	LSM	SEM	LSM	SEM	LSM	SEM	LSM	SEM	
	n = 17		n = 16		n = 16		n = 15		
CLA *cis*-9,*trans*-11 (%)	0.75	0.04	0.84	0.04	0.72	0.04	0.87	0.04	F
CLA*cis*-9,*trans*-11 (mg/100 g muscle)	17.11	1.72	17.34	1.77	13.32	1.77	11.51	1.83	B

* – coeluation with C18:2*trans*-7,*cis*-9 and C18:2*trans*-8,*cis*-10; LSM – Least square means, SEM – Standard error of LSM; B – significant influence of breed; F – significant influence of feed

sheep significantly lower values for *n*-6 fatty acids in grass-fed animals were detected [Nuernberg *et al.*, 1996; Demise *et al.*, 1998]. However, the ratio of *n*-6/*n*-3 was beneficially low in grazing lamb muscle (1.8-2.3). Grazing lambs with or without mothers had higher muscle concentrations of C18:0 and of the sum of saturated fatty acids reflecting a high rumen activity for biohydrogenation of PUFA. The intramuscular fat quality of *longissimus* muscle in lambs fed on pasture was more valuable for human nutrition because of the high proportion of *n*-3 fatty acid. More detailed results of this experiment are described by Nuernberg *et al.* [2001].

Pig experiment

Fatty acid profile of intramuscular fat of *longissimus* muscle is shown in Table 4. Linolenic acid was significantly increased in muscle lipids by feeding 5% linseed oil. The proportions of EPA (castrate: 1.3%; female: 2.3%) and DPA (castrate: 1.2%; female: 1.7%) were significantly higher in the linseed fed group. The proportion of total *n*-3 fatty acids in muscle was 0.72% in German Landrace pigs fed a typical diet for growing-finishing pigs [Ender *et al.*, 2002]. In this experiment the *n*-6/*n*-3 ratio was markedly decreased by feeding linseed oil, which was due to the significant increase in C18:3*n*-3, EPA, and DPA percentage and the decrease in C20:4*n*-6. The long-chain derivatives of *n*-3 and *n*-6 fatty acids are produced by the same desaturases and elongases. It seems that in pigs fed linseed oil the enzymes are more focused on the synthesis of C20:5*n*-3 and C22:5*n*-3, but not C22:6*n*-3. From these results it can be concluded that dietary inclusion of linolenic acid by linseed feeding can effectively increase the long-chain *n*-3 fatty acids. That is in general agreement with other studies [Matthews *et al.*, 2000; Kouba *et al.*, 2003].

TABLE 4. Total fatty acid composition (%) of intramuscular fat in *longissimus* muscle of pigs.

Fatty acids	Linseed group		Olive group		Signif.
	Castrates N = 5 LSM_{SEM}	Females N = 7 LSM_{SEM}	Castrates N = 7 LSM_{SEM}	Females N = 6 LSM_{SEM}	($p \leq 0.05$)
Intramuscular fat (%)	$1.8_{0.2}$	$1.1_{0.2}$	$1.9_{0.2}$	$1.0_{0.2}$	S
C14:0	$1.0_{0.1}$	$0.8_{0.08}$	$1.1_{0.08}$	$0.9_{0.09}$	S
C16:0	$22.1_{0.4}$	$20.1_{0.4}$	$22.7_{0.4}$	$20.8_{0.4}$	S
C16:1	$2.1_{0.2}$	$1.7_{0.1}$	$2.5_{0.1}$	$2.0_{0.1}$	S, F
C18:0	$11.7_{0.3}$	$11.3_{0.3}$	$11.6_{0.3}$	$10.3_{0.3}$	S
C18:1*cis*-9	$34.2_{1.4}$	$30.1_{1.2}$	$42.9_{1.2}$	$40.4_{1.3}$	S, F
C18:2*n*-6	$10.9_{1.0}$	$14.8_{0.9}$	$8.5_{0.9}$	$11.7_{0.9}$	S, F
C18:3*n*-3	$8.5_{0.4}$	$9.1_{0.3}$	$0.6_{0.3}$	$0.7_{0.3}$	F
C20:4*n*-6	$1.7_{0.6}$	$3.0_{0.5}$	$3.2_{0.5}$	$5.4_{0.5}$	S, F
C20:5*n*-3	$1.3_{0.2}$	$2.3_{0.2}$	$0.1_{0.08}$	$0.2_{0.09}$	S, F, FxS
C22:5*n*-3	$1.2_{0.2}$	$1.7_{0.1}$	$0.4_{0.1}$	$0.7_{0.1}$	S, F
C22:6*n*-3	$0.03_{0.01}$	$0.04_{0.01}$	$0.08_{0.01}$	$0.09_{0.02}$	S
SFA	$35.1_{0.7}$	$32.4_{0.6}$	$35.6_{0.6}$	$32.2_{0.6}$	S
PUFA	$23.9_{2.0}$	$31.5_{1.7}$	$13.4_{1.7}$	$19.5_{1.9}$	S, F
n-3 fatty acids	$11.0_{0.6}$	$13.2_{0.5}$	$1.3_{0.5}$	$1.8_{0.6}$	S, F
n-6 fatty acids	$12.8_{1.5}$	$18.2_{1.3}$	$12.0_{1.3}$	$17.6_{1.4}$	S
n-6/*n*-3 ratio	$1.2_{0.4}$	$1.4_{0.4}$	$9.5_{0.4}$	$9.6_{0.4}$	F

LSM – Least square means, SEM – Standard error of LSM; S – significant influence of sex, F – significant influence of feeding, FxS – significant interaction between feeding and sex ($p \leq 0.05$)

Feeding olive oil increased the level of oleic acid in the total lipids of muscle (castrates: 42.9%, females: 40.4%). The proportion of the saturated fatty acids stearic acid, palmitic acid, and myristic acid in muscle did not differ between oil supplements. Hoz *et al.* [2003] reported comparable results for muscle after feeding 3% linseed, olive oil or sunflower oil to growing-finishing pigs for 8 weeks. The PUFA content in muscle depends on the amount and structure of dietary fat, the *de novo* synthesis of fatty acids, the conversion rate to other fatty acids and metabolites and the proportion of oxidation for energy consumption. Feeding olive oil to pigs caused a significantly lower proportion of PUFA in total muscle lipids (Table 4). The total proportion of PUFA of all pigs in both feeding groups was too high for acceptable processing quality. The PUFA limit of backfat for producing good fat quality in Germany is 12% [Fischer, 2001].

Sex-related differences were detected for all fatty acid proportions except linolenic acid and the ratio of *n*-6/*n*-3 fatty acids in *longissimus* muscle. Barrows had larger amounts of saturated fatty acids and lower amounts of PUFA in both feeding groups. These differences were caused by the differences in the total lipid concentration in muscle.

CONCLUSIONS

The results of these studies show that feeding grass and linseed to cattle, lambs and pigs can have positive effects on the fatty acid profile of their meat (higher *n*-3 fatty acid and CLA percentages), resulting in a healthier product. The consumption of beef from grass-based bulls and lambs with increased *n*-3 fatty acid concentrations can contribute to human daily requirements for these fatty acids, especially C18:3*n*-3, EPA, DPA and DHA. It is necessary to bring the positive benefits of grass-fed beef and lamb meat to the attention of the public, medical professionals, producers, and consumers. Dietary inclusion of linolenic acid by linseed oil feeding can effectively increase the long-chain *n*-3 fatty acids, whereas olive oil accumulated the oleic acid in pork. It should be taken into account that higher PUFA can cause a higher susceptibility to peroxidation.

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