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Effects of dietary linseed and corn supplement on the fatty acid content in the pork loin and backfat tissue

J. Čítek, R. Stupka, M. Okrouhlá, K. Vehovský, L. Brzobohatý, M. Šprysl, L. Stádník

Department of Animal Husbandry, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Prague, Czech Republic

ABSTRACT: The influence of linseed and corn dietary supplements on the fatty acid (FA) composition of pork was evaluated. The effects of their appropriate use and dosage on pork meat and fat technological quality were also investigated. In total 72 pigs fed complete feed mixtures were divided into 4 groups: control (C), corn- (CD), linseed- (LD), and corn + linseed-supplemented (CLD). After slaughter the lean meat share, intramuscular fat content, meat and fat colour, shear force, drip loss, and malondialdehyde content were determined. Subsequently, the FA content and sum of saturated (SFA), monounsaturated (MUFA), polyunsaturated (PUFA) fatty acids, the n-6/n-3 fatty acid ratio, and atherogenic and thrombogenic indexes in the loin and backfat tissue were determined. Corn and lineseed supplementation increases the content of myristic, linoleic, α-linolenic, and eicosapentaenoic acids and reduces the amount of palmitic, palmitoleic, oleic, eicosenoic, and arachidonic acids. Therefore it reduces the PUFA/SFA ratio and improves atherogenic and thrombogenic indexes. No negative effects of linseed and corn supplementation on the technological characteristics of pork meat and backfat were registered. Due to the positive effects on indicators related to human health, linseed and maize supplementation can be recommended in pig diet.

Keywords: pork meat; backfat; diets; nutrition; physical and chemical characteristics; fatty acid composition

INTRODUCTION

A very significant factor in the quality of pork is the fatty acids (FA) content. Pork contains a higher amount of fat, however, the low ratio of polyunsaturated/saturated fatty acids (PUFA/SFA) representation is rather unfavourable. The unfavourable FA ratio in pork can be an important cause of cardiovascular diseases. Excessive intake of saturated fat and its association with a high incidence of cardiovascular diseases in the Czech Republic, Poland, and Russia was documented e.g. by Boylan et al. (2009). One of the possibilities of lowering the saturated fat content is a nutrient food treatment. The principle of this method lies in a desirable optimization of the FA profile (Corino et al. 2008). Based on the recommendations (Enser et al. 2000), the PUFA/SFA ratio should be higher than 0.4 and the n-6/n-3 PUFA ratio should be less than 5. The PUFA/SFA ratio in pig intramuscular fat (IMF) oscillates around an unfavourable level of 0.3, with the values in backfat ranging from 0.2 to 0.3. The n-6/n-3 PUFA ratio in IMF varies from 9 to 12, in backfat from 8 to 12. Because the common European diet is characterized by a high intake of SFA (when compared to PUFA), and the consumption of n-3 PUFA is lower than that of n-6 PUFA, there is much interest focused on the possible ways to manipulate the fatty acid composition of pork meat. One of the propositions is to give the pigs feed ingredients that improve these ratios (Corino et al. 2008), such as linseed (Rentfrow et al. 2003), sunflower (Guillevic et al. 2009), and corn or fish oil (Haak et al. 2008).

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PUFA (linoleic and α-linolenic) cannot be synthesized by the pigs' metabolism, unlike the SFA and monounsaturated fatty acids (MUFA). Therefore, their content depends on the lipid composition of the diet. A diet change mostly consists in linseed supplementation. However, this method negatively affects the compound feed price, and thus the meat production economy. The effects of adding more affordable components, such as corn, have not been adequately described yet. Some authors, however, in addition to the negative economic effect, describe the negative impact of the above mentioned feed ingredients on the quality of pork meat and fat (Wood et al. 2004). Too high amount of PUFAs in the intramuscular and depot fat negatively affects technological traits and meat quality, especially the sensory traits. PUFAs are characterized by a greater susceptibility to oxidation processes, which influence taste, flavour, and colour (Lisiak et al. 2013). Besides the positive effects of the FA spectrum in meat, these components can also affect some of the quality indicators, such as technological (Wood et al. 2004), nutritional, and sensory (Mourot and Lebret 2009) parameters. Although this problem is currently being extensively investigated and worked on, the research results published so far have not been uniform.

The present paper describes the effects of combining the supplement of linseed and maize in the pig diet with the aim to positively influence the fatty acids profile in the pork fat by improving the n-6/n-3 PUFA ratio, while at the same time managing not to impair the technological properties of fat and meat (colour, texture, water holding capacity). The presented literature review concerning the use of supplements of linseed and maize in pig nutrition did not give a full answer to what kind of supplement and in which dose must be used to obtain a raw product of a high slaughter value and good meat quality. Human health can be positively influenced and improved by changing the profile of FA in fat. This potential effect can be expressed with the use of atherogenic and thrombogenic indexes. The working hypothesis is that the supplement of corn, linseed, and their combinations in the diet will improve the PUFA profile and n-6/n-3 PUFA ratio, as well as the atherogenic and thrombogenic indexes. At the same time an appropriate use and dosage of these components should not impair the technological quality of pork meat and fat.

MATERIAL AND METHODS

Experimental design. The experiment involved a total number of 72 pigs of the (LW_D × L) × LW_S genotype. All of the animals were of balanced sex (36 barrows and 36 gilts), an average age of 69 days, and an average live weight of 28.7 kg. The pigs were penned in the same-sex pairs.

The animals were fed complete feed mixtures (CFMs) *ad libitum*. The CFMs were composed of wheat, barley, soybean meal, and feed supplement (Table 1). With respect to the hypothesis and objective of the study, the pigs were divided into four groups per 18 animals: control (C), corn-supplemented (CD), linseed-supplemented (LD), and corn + linseed-supplemented (CLD). At the end of the experiment the pigs at an average live weight (LW) of 110 kg were slaughtered in a commercial slaughterhouse.

The muscle lean meat share was determined ca. 45 min *post mortem* (Sprysl et al. 2007). Before dissection, the carcasses were stored at +2°C for 24 h. Then the carcass analysis was carried out and the carcasses were divided into carcass cuts. The carcasses were dissected in accordance with the methodology published by Walstra and Merkus (1995).

For the loin muscle above the last thoracic vertebra (*m. longissimus lumborum et thoracis* – MLLT) the following quality indicators were determined: meat colour MLLT-lightness (L^*), MLLT-chroma (a^*), and MLLT-hue (b^*) (CM-2500d spectrophotometer; Minolta, Tokyo, Japan), shear force (3342 Machine; Instron, Norwood, USA) and drip loss were determined 24 h *post mortem*. For the backfat retrieved from the MLLT, the following indicators were determined: colour FAT-lightness (L^*), FAT-chroma (a^*), FAT-hue (b^*) (CM-2500d spectrophotometer; Minolta).

Homogenized samples of MLLT were subjected to basic chemical analysis. Water content was assessed by gravimetric method following drying and intramuscular fat content (IMF) was determined using gravimetric method following extraction with petroleum ether in a solvent extractor (SER 148; VELP Scientifica, Usmate, Italy). Furthermore, malondialdehyde level (mg/kg) in MLLT was established using the methodology of Tarlagdis et al. (1960).

The FA methyl esters in MLLT and backfat were determined following the extraction of lipids (method of Folch et al. 1957). Isolated methyl esters were determined using a Master GC Dani gas chromatograph (DANI Instruments, Milan,

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Table 1. Ingredients and nutrient composition of the pig diets

Ingredients (g/kg)	Body weight 28–34.9 kg				Body weight 35–64.9 kg				Body weight 65–110 kg			
	C	CD	LD	CLD	C	CD	LD	CLD	C	CD	LD	CLD
Wheat	405.0	270.0	283.0	165.0	450.5	385.2	308.9	204.6	470.0	530.0	320.0	320.0
Barley	383.0	300.0	400.0	300.0	394.9	328.8	400.0	372.0	400.0	340.0	400.0	400.0
Corn	–	200.0	–	200.0	–	128.0	–	128.0	–	0.0	–	0.0
Crushed linseed[1]	–	–	150.0	150.0	–	–	150.0	150.0	–	–	150.0	150.0
Soybean meal	182.0	200.0	137.0	155.0	124.6	128.0	111.1	115.4	100.0	100.0	100.0	100.0
Vitamin-mineral premix[2]	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Dry matter	880.9	882.7	885.2	886.8	879.6	880.4	884.5	885.0	879.0	878.5	884.3	884.3
ME by calculation (MJ/kg)	12.7	12.9	13.4	13.6	12.7	12.8	13.4	12.6	12.6	12.7	13.4	13.4
Crude protein	188.5	187.1	185.3	184.4	168.4	165.2	176.4	172.2	159.9	161.9	172.6	172.6
Crude fibre	37.1	34.8	42.2	39.5	36.3	34.4	41.7	40.6	36.0	34.8	41.5	41.5
Lysine	11.0	11.3	10.5	10.7	9.5	9.4	9.8	9.8	8.8	8.8	9.5	9.5
Lysine/MEP	0.87	0.87	0.78	0.79	0.75	0.74	0.73	0.73	0.70	0.69	0.71	0.71
Threonine	7.0	7.1	6.9	7.0	6.1	6.1	6.5	6.5	5.7	5.7	6.4	6.4

C = control, CD = corn diet, LD = linseed diet, CLD = corn + linseed diet, ME = metabolizable energy

[1]content of selected fatty acids (in % of total determined fatty acids): oleic acid 20.51, linoleic acid 15.34, α-linolenic acid 52.25, SFA 10.17, MUFA 21.78, n-6 PUFA 15.55, n-3 PUFA 52.50; fat content 27.53%

[2]1 kg of vitamin-mineral premix provided: retinol 400 000 IU, cholecalciferol 66 000 IU, α-tocopherol 3600 mg, menadione 100 mg, thiamine 60 mg, riboflavin 150 mg, niacin 800 mg, Ca pantothenate 375 mg, vitamin B_6 100 mg, vitamin B_{12} 1 mg, choline Cl 15 000 mg, folic acid 15 mg, Fe 3500 mg as $FeSO_4{\cdot}H_2O$, Zn 3600 mg as ZnO, Mn 3100 mg as MnO, Cu 330 mg as $CuSO_4{\cdot}5H_2O$, I 75 mg as $Ca(IO_3)_2$, Co 15 mg as $2CoCO_3{\cdot}3Co(OH)_2{\cdot}H_2O$, Se 13 mg as Na_2SeO_3, 6-phytase (EC 3.1.3.26) 25 000 FTU, Ca 220 g, P 20 g, Na 50 g, Mg 10 g, lysine 85 g, methionine 15 g, threonine 15 g

Italy), on a column with the stationary phase represented by polyethylene glycol (FameWax – 30 m × 0.32 mm × 0.25 mm). Atherogenic and thrombogenic indexes were calculated using the procedures of Chilliard et al. 2003 and Ulbricht and Southgate 1991, respectively.

Statistical analysis. The SAS software (Statistical Analysis System, Version 9.2, 2009) and the ANOVA method were applied. Differences between the observed characteristics were tested using the GLM procedure of SAS. Significant differences ($P < 0.05$) were tested according to the model

$$y_{ijk} = \mu + D_i + S_j + e_{ijk}$$

where:

y_{ijk} = value of the trait
μ = overall mean
D_i = effect of diet (i = C, CD, LD, CLD)
S_j = effect of sex (j = 1, 2)
e_{ijk} = random residual

RESULTS

The results shown in Table 2 (qualitative indicators) indicate that the diet composition did not significantly affect the lean meat share in the carcass or IMF share in the loin. On the contrary, the diet influenced the colour of both meat and fat. In the case of corn supplement in the CFM (group CD) a lighter meat was found, while the supplement of linseed (group LD) caused its darker colour. This trend was also demonstrated in the fat colour, although the difference between the fat groups was lower if compared to meat groups. The colour chroma (a^*) values were higher for LD group if compared with CD group for both meat and fat. There was also a difference detected between LD and the other groups regarding drip loss ($P = 0.05$) and shear force ($P = 0.02$). Unexpectedly, the supplement of CD and LD had no negative impact on the malondialdehyde level.

The overview of FA in Table 3 shows that the loin IMF, regardless of the feeding supplement, consists of the most saturated FAs (prevailingly palmitic (16:0) and stearic (18:0) acids). A significant decrease in the amount of palmitic acid ($P \le 0.01$) was registered for the combination of CFM with linseed plus corn. The amount of stearic acid (18:0), however, was not affected. Concerning the MUFA, well represented were oleic (18:1) and palmitoleic (16:1) acids, to a lesser extent eicosenoic (20:1)

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Table 2. Carcass characteristics of grower-finisher pigs fed linseed and corn diet

Item	C	CD	LD	CLD	SEM	*P*-value
LM (%)	56.94	56.98	56.26	56.43	0.85	0.911
IMF (%)	2.07	1.50	1.83	1.85	0.20	0.153
Colour MLLT						
(L^*)	52.47^a	52.67^a	48.54^b	51.51	1.33	0.015
(a^*)	–0.62	–0.57	–0.26	–0.29	0.38	0.873
(b^*)	9.78	9.63	8.61	9.27	0.61	0.572
Colour FAT						
(L^*)	80.16	80.55	79.92	79.08	0.65	0.459
(a^*)	–0.82	–1.01	–0.69	–0.54	0.12	0.080
(b^*)	7.44	7.78	7.26	7.47	0.23	0.486
Drip loss (mg/g)	80.07^b	70.72	50.60^a	80.41^b	7.46	0.049
Shear force (N)	43.08	39.37^a	41.92	50.90^b	2.38	0.018
Malondialdehyde	0.276	0.261	0.278	0.364	0.04	0.453

$^{a–c}$statistically significant differences between rows are indicated by different superscripts ($P < 0.05$)

C = control, CD = corn diet, LD = linseed diet, CLD = corn + linseed diet, SEM = standard error of the mean, LM = lean meat share, IMF = intramuscular fat, MLLT = *musculus longissimus lumborum et thoracis,* FAT = backfat, (L^*) = lightness, (a^*) = chroma, (b^*) = hue

acid. It is obvious that their proportion (with the exception of palmitoleic acid) was not affected by the corn supplement (CD group). However, their representation was significantly reduced by the supplement of linseed (LD group) or its combination with corn (CLD group).

The supplement of linseed and corn reduces the monitored SFA and MUFA contents in the loin IMF and simultaneously causes a significant increase in the PUFA fatty acids. In this case, it is clearly demonstrated by the increase of linoleic acid (C18:2-9, 12c) and α-linolenic acid (C18:3-9, 12,15c) at the expense of MUFA and PUFA. Furthermore, in relation to the linseed supplement or its combination with corn, there was an almost 5–7-fold increase of the eicosapentaenoic acid (C20:5-5,8,11,14,17c) content. However, this finding does not apply to arachidonic acid showing an opposite trend.

With regards to the total FA profile and the feeding supplement, based on the values in Table 3 it is evident that the SFA proportion remains practically unaffected by nutrition. The MUFA and PUFA proportion significantly ($P \leq 0.001$) fluctuates even in the case of linseed as the only supplement.

A diet change was reflected in the reduction of atherogenic and thrombogenic index values ($P \leq 0.001$).

The fatty acid profile in the backfat is shown in Table 4. The highest share of total FA have the oleic, palmitic, and stearic acids. The proportion of stearic acid in the backfat if compared to that in the loin IMF is twice as high. The linoleic acid proportion in the backfat is by one third lower than that in the loin IMF. Thus not only the FA content in the loin IMF is influenced by nutrition, but similar trends are observable for the FA content in the backfat. Supplementation with linseed and corn, or the combination of both, lowers the share of myristic, palmitic, palmitoleic, oleic, and eicosenoic acids. In contrast, the linoleic, α-linolenic, eicosapentaenoic acid shares increase. The stearic proportion was not affected by dietary changes. Regarding the SFA profile, with the changing diet a higher difference in the backfat if compared to the loin IMF was recorded. Compared to the control, a change in the SFA proportion was not demonstrated in the case of the CD diet, however, a slight change was registered in the case of LD. There was a significant SFA decrease in the backfat, and in the case of the CLD diets, the SFA proportion decreased both in the IMF and backfat. Concerning the MUFA proportion, the dietary changes showed only a small effect (a slight reduction).

DISCUSSION

The supplement of linseed, corn, and their combination did not affect the lean meat share and loin IMF content in pigs. This finding is consistent

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Table 3. The IMF loin fatty acids profile

Fatty acid (%)		C	CD	LD	CLD	SEM	*P*-value
Myristic	C14:0	2.66	2.35[a]	2.81[b]	2.36	0.13	0.0496
Palmitic	C16:0	29.48[a]	29.91[a]	28.39	26.95[b]	0.57	0.0045
Palmitoleic	C16:1-9*c*	6.72[a]	6.09[b]	4.97[c]	4.15[d]	0.32	< 0.0001
Stearic	C18:0	8.67	8.52	8.68	8.8	0.32	0.9393
Oleic	C18:1-9*c*	34.39[a]	34.05[a]	29.31[b]	30.19[c]	0.72	< 0.0001
Linoleic	C18:2-9.12*c*	10.45[a]	11.7	12.52	13.77[b]	0.75	0.0253
γ-Linolenic	C18:3-6.9.12*c*	0.1[a]	0.18[b]	0.03[c]	0.04[d]	0.02	< 0.0001
α-Linolenic	C18:3-9.12.15*c*	1.41[a]	0.73[a]	6.68[b]	7.56[c]	0.54	< 0.0001
Eicosenoic	C20:1-11*c*	0.41[a]	0.38[a]	0.27[b]	0.28[c]	0.04	0.0188
Arachidonic	C20:4-5.8.11.14*c*	3.23[a]	4.04[a]	2.25[b]	2.15[b]	0.33	0.0005
Eicosapentaenoic	C20:5-5.8.11.14.17*c*	0.09[a]	0.01[a]	0.49[b]	0.71[c]	0.06	< 0.0001
SFA		42.12	41.81	42.64[a]	40.46[b]	0.58	0.1053
MUFA		42.06[a]	41.1[a]	35.02[b]	34.89[c]	0.95	< 0.0001
PUFA		15.82[a]	17.05[a]	22.35[b]	24.65[c]	1.32	< 0.0001
n-6 PUFA		13.78	15.91	14.81	15.96	0.99	0.3075
n-3 PUFA		1.5[a]	0.74[a]	7.17[b]	8.27[c]	0.58	< 0.0001
n-6/n-3 PUFA		15.22[a]	22.36[b]	3.6[c]	1.94[c]	1.62	< 0.0001
MUFA/PUFA		2.92[a]	2.49[a]	1.67[b]	1.47[b]	0.22	< 0.0001
PUFA/SFA		0.38[a]	0.41[a]	0.53[b]	0.61[b]	0.04	0.0002
MUFA/SFA		1.0[a]	0.98[a]	0.82[b]	0.86[b]	0.02	< 0.0001
Atherogenic index		0.7[a]	0.68	0.69	0.62[b]	0.04	0.0275
Thrombogenic index		1.29[a]	1.33[a]	0.89[b]	0.76[b]	0.11	0.0035

IMF = intramuscular fat, C = control, CD = corn diet, LD = linseed diet, CLD = corn + linseed diet, SEM = standard error of the mean, SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids
[a–d]means with the same superscript in the same row are statistically different ($P \leq 0.05$)

with the results published by Kouba et al. (2003) and Okrouhla et al. (2013). However VanOecke et al. (1997) reported that the lean meat percentage was less favourable for the highest linseed level tested (10 g α-linolenic acid per kg feed) compared to an intermediate level (7 g α-linolenic acid per kg feed). This fact is explained by Okrouhla et al. (2013) stating that linseed addition to feed increases its energy content. Stupka et al. (2008) brought attention to the fact that the carcass quality is more influenced by sex of the pig than by dietary changes. They found significant differences in the meatiness and IMF content between barrows and gilts.

Previous studies showed a negative effect of linseed or corn diet on technological quality traits (Corino et al. 2008). Our results are in agreement with those of Haak et al. (2008) and Huang et al. (2008) who reported significant differences in drip loss and shear force. Linseed supplementation increases the water holding capacity and meat tenderness, while its combination with corn significantly reduces meat tenderness.

The linseed and corn addition to the diet affects meat and fat colour (L^* and a^*), as it was previously shown also by VanOecke et al. (1997) or Corino et al. (2008). Too high amount of PUFAs in the intramuscular and depot fat affects the fat consistency (soft, sticky), worsens the taste, and also durability (Leksanich et al. 1997). In our study, corn in diet was fed only to pigs 65 kg live weight and lower, because of its negative effect on technological quality of meat and fat. Larick et al. (1992) demonstrated that the supplement of corn can lead to a lighter, greenish meat, which is related to its increased oxidation stability. The cause of this phenomenon is the change in the binding of the central iron atom and subsequently the methemoglobin formation, which later leads to a grey-brown colour.

The determination of the fatty acid profile corresponds with that of Miller et al. (1990) and Juarez

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Table 4. The backfat fatty acids profile

Fatty acid (%)		C	CD	LD	CLD	SEM	*P*-value
Myristic	C14:0	1.77[a]	1.79[a]	1.56[b]	1.36[b]	0.08	0.0012
Palmitic	C16:0	29.08[a]	28.49[a]	25.38[b]	24.37[b]	0.38	< 0.0001
Palmitoleic	C16:1-9*c*	3.59[a]	3.36[a]	2.1[b]	1.75[b]	0.19	< 0.0001
Stearic	C18:0	16.06	16.6	14.84	16.2	0.63	0.290
Oleic	C18:1-9*c*	36.44[a]	35.88[a]	31.58[b]	30.15[b]	0.56	< 0.0001
Linoleic	C18:2-9.12*c*	8.74[a]	9.71[a]	10.09	11.5[b]	0.54	0.0138
γ-Linolenic	C18:3-6.9.12*c*	0.01[a]	0.01[a]	0.0[b]	0.0[b]	0.0	0.0049
α-Linolenic	C18:3-9.12.15*c*	1.05[a]	1.02[a]	10.38[b]	10.71[b]	0.3	< 0.0001
Eicosenoic	C20:1-11*c*	1.13[a]	1.06	0.87[b]	0.83[b]	0.09	0.0663
Arachidonic	C20:4-5.8.11.14*c*	0.17[a]	0.19[a]	0.09[b]	0.08[b]	0.02	< 0.0001
Eicosapentaenoic	C20:5-5.8.11.14.17*c*	0.15[a]	0.13[a]	1.38[b]	1.37[b]	0.04	< 0.0001
SFA		47.78[a]	47.74[a]	42.72[b]	42.81[b]	0.74	< 0.0001
MUFA		41.57[a]	40.65[a]	34.79[b]	32.94[b]	0.63	< 0.0001
PUFA		10.62[a]	11.56[a]	22.46[b]	24.21[b]	0.82	< 0.0001
n-6 PUFA		8.92[a]	9.91[a]	10.18	11.58[b]	0.55	0.0238
n-3 PUFA		1.2[a]	1.15[a]	11.76[b]	12.08[b]	0.33	< 0.0001
n-6/n-3 PUFA		7.91[a]	8.69[a]	0.87[b]	0.96[b]	0.37	< 0.0001
MUFA/PUFA		4.03[a]	3.67[a]	1.58[b]	1.4[b]	0.21	< 0.0001
PUFA/SFA		0.22[a]	0.25[a]	0.53[b]	0.57[b]	0.02	< 0.0001
MUFA/SFA		0.87[a]	0.86[a]	0.82	0.77[b]	0.02	0.0175

C = control, CD = corn diet, LD = linseed diet, CLD = corn + linseed diet, SEM = standard error of the mean, SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids
[a–d]means with the same superscript in the same row are statistically different ($P \leq 0.05$)

et al. (2009). The decrease in palmitic acid, caused by the feed ingredients, was also mentioned by Kouba et al. (2003) who came to similar findings as the previous authors. The confirmed MUFA spectrum is consistent with the results of Woods and Fearon (2009). The authors demonstrated a higher oleic acid proportion in pork. However, they also indicated that the corn supplement does not change the MUFA proportion. They are of the opinion that the reduction of MUFA and SFA results from the action of linseed or its combination with corn at the expense of PUFA increase, which was indicated by Cameron et al. (2000) and Beckova and Vaclavkova (2010). The FA spectrum detected by these authors (higher amounts of linoleic acid, α-linolenic acid at the expense of γ-linolenic acid) and the increase of EPA and eikosapenthaenoic acid correspond (with the exception of arachidonic acid) with the results of Romans et al. (1995) and Enser et al. (2000). Our findings are in line with Enser et al. (2000), because we also observed the increase in the PUFAs proportion, especially in favour of the n-3 FA with respect to the change of diet. Opposite to the cited authors, the positive effect on FA composition was achieved also with a zero content of corn in the diet in the terminal phase of fattening. The fact that for the fat composition influence, adding corn to diet only to 65 kg live weight is sufficient has been proven. As was consistently indicated also by Haak et al. (2008), the change in diet positively affected the PUFA/SFA ratio. In accordance with the results of our study, Beckova and Vaclavkova (2010) also found a decrease in the MUFA content. Matthews et al. (2000) described an increase in the n-3 PUFA and a decrease in the n-6/n-3 PUFA ratio (from 7.2 to 3.9). The n-6/n-3 PUFA ratio was decreased both in barrows and gilts due to the supplement of linseed. Corino et al. (2008) also reported a significant ($P \leq 0.05$) reduction of the n-6/n-3 PUFA ratio both in loin (from 12 to 4.5) and backfat (from 11 to 3). The n-6/n-3 PUFA ratio in loin was significantly influenced by dietary linseed, which was due to increases ($P \leq 0.05$) in n-3 PUFA (especially α-linolenic acid) and decreases in γ-linolenic, arachidonic acids and n-6 PUFA contents (D'Arrigo et al. 2002;

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Hoz et al. 2003). The MUFA/PUFA (from 3.41 to 2.79) and MUFA/SFA (from 1.29 to 1.14) ratios showed a decreasing trend, similarly as stated by Beckova and Vaclavkova (2010). Nurnberg et al. (2011) also reported an increase in the PUFA/SFA ratio in animals supplemented with linseed.

Considering the atherogenic and thrombogenic indexes, the present study confirmed a decline in these indicators in relation to dietary changes. A similar effect was also demonstrated for the linseed supplement in the study by Okrouhla et al. (2013). Both indexes confirm the positive effect on the pork meat quality, especially the quality of backfat. Therefore, it can be stated that the linseed and corn dietary supplementation in pigs can reduce an excessive content of saturated fats in human diet associated with a high incidence of cardiovascular diseases (Boylan et al. 2009). Cardiovascular disease (CVD) is the leading cause of morbidity and mortality in the patients with diabetes. Dyslipidemia (elevated low-density lipoprotein cholesterol, low high-density lipoprotein cholesterol, and/or high triglycerides levels) is a major modifiable risk factor for the development of atherosclerosis, a precursor of CVD.

CONCLUSION

The study has demonstrated that the linseed and corn supplements and their combinations in the diet of pigs had no negative effect on the colour of pork meat and backfat. The supplement of lineseed increases the content of myristic, linoleic, α-linolenic, eicosapentaenoic acids and reduces the amount of palmitic, palmitoleic, oleic, eicosenoic, and arachidonic acids and increases positively the PUFA/SFA ratio. The linseed and corn supplement primarily influenced the atherogenic and especially the thrombogenic index in a very positive way, especially from the viewpoint of human health.

Due to the demonstrated positive effects on indicators related to human health, while maintaining high technological quality of pork meat and fat, the linseed and corn diet supplementation in pigs can be recommended. The best results were achieved if both these components were included.

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Corresponding Author

Ing. Jaroslav Čítek, Ph.D., Czech University of Life Sciences Prague, Faculty of Agrobiology, Food and Natural Resources, Department of Animal Husbandry, Kamýcká 129, 165 21 Prague 6-Suchdol, Czech Republic
Phone: +420 224 383 054, e-mail: citek@af.czu.cz