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EFFECTS OF DIFFERENT DIETARY *n-6:n-3* PUFA RATIOS ON GROWTH PERFORMANCE, BLOOD LIPID PROFILES, FATTY ACID COMPOSITION OF PORK, CARCASS TRAITS AND MEAT QUALITY IN FINISHING PIGS

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Abstract

A total of 72 crossbred pigs [(Landrace × Yorkshire) × Duroc] with an average initial BW of 51.59±1.59 kg were used in this 10-wk feeding trial to investigate the effects of different dietary *n-6:n-3* polyunsaturated fatty acids (PUFA) ratios in finishing pigs. Pigs were randomly allotted to 3 dietary treatments (each n=24) with 6 replications and 4 pigs per pen (2 barrows and 2 gilts). Pigs were fed a corn-soybean meal-based diets formulated by replacing soybean oil with linseed oil to achieve *n-6:n-3* close to 5:1, 10:1 and 15:1, respectively. The growth performance, carcass traits and meat quality parameters (meat color, sensory evaluation, cooking loss, drip loss, pH, *longissimus* muscle area and water holding capacity) were not influenced (P>0.10) by various dietary *n-6:n-3* ratios. Pigs fed dietary *n-6:n-3* PUFA ratios of 5:1 had a lower (P<0.05) serum total cholesterol, LDL cholesterol and triglyceride levels. The concentrations of *n-3* PUFA, including C18:3*n-3*, C22:5*n-3* and C22:6*n-3* were improved (P<0.05) in the *longissimus dorsi* muscles of pigs fed dietary *n-6:n-3* PUFA ratios of 5:1. Furthermore, pigs fed dietary n-6:n-3 PUFA ratio of 5:1 decreased (P<0.05) the *n-6* concentrations (C18:2*n-6* and C20:4*n-6*) of *longissimus dorsi* muscles. In conclusion, lowering the dietary *n-6:n-3* ratios to 5:1 could be beneficial for the blood lipid profiles, and improve the nutritional value of pork, without adverse effect on growth performance and meat quality parameters that are related to the consumer acceptance.

Key words: blood lipid profiles, fatty acid composition, finishing pigs, *n-6:n-3* ratios

Polyunsaturated fatty acids (PUFA), including *n-6* and *n-3,* are essential for normal physiological function and the health of humans and domestic animals (Delgado-Lista et al., 2012). It is suggested that the ratio of *n-6:n-3* PUFA is a risk factor in cancers and cardiovascular disease (Simopoulos, 2008), and a lower *n-6:n-3* PUFA ratio is required for the prevention and management of chronic diseases (Leslie et al.,

2015). However, the present Western diet is low in *n-3* fatty acids with a ratio of *n-6:n-3* ranging from 15:1 to 20:1 (Kobayashi et al., 2006). Thus, in recent years, there is an increasing interest in ways to manipulate the fatty acid composition towards a more favourable *n-6:n-3* ratio of meat products.

It has been widely accepted that nutrition is main factor influencing lipid and fatty acid deposition in monogastric animals. Previously, many studies have reported that dietary PUFA content could affect the fatty acid profiles of resultant muscle and adipose tissues. Nuernberg et al. (2011) proved that dietary extruded linseed supplementation at the levels of 2.5% and 4% decreased the ratio *n-6* to *n-3* of muscle and backfat in castrated male pigs. As reported by Tous et al. (2013), inclusion of high dose of conjugated linoleic acid (CLA) in finishing pig diets affected fatty acid composition in subcutaneous fat, liver and muscles. Sobol et al. (2015) demonstrated that the increased linolenic acid (C18:3*n-3*) intake could enhance its deposition in the pork. Recently, Li et al. (2015) reported that the maintained *n-6:n-3* PUFA ratios of 1:1–5:1 could benefit the fatty acid composition and decrease *n-6* to *n-3* ratios of muscle and adipose in finishing pigs. In addition to fatty acid composition of pork, previous studies also suggested that the meat quality could be modified by dietary *n-6:n-3* PUFA ratios. For instance, Dannenberger et al. (2012) reported that providing a lower dietary *n-6:n-3* PUFA ratio by supplementing sunflower seed oil or linseed oil in reduced protein diet decreased drip loss, but had no significant effect on pH, meat color, cooking loss and shear force of porcine *longissimus* muscle. However, little is known about the effects of various dietary *n-6:n-3* PUFA ratios on blood lipid profiles in pigs. Therefore, in order to extend these previous studies and provide consumers with high quality pork products, the purpose of the present study was to investigate the effects of dietary *n-6:n-3* PUFA ratios on growth performance, blood lipid profiles, fatty acid composition of pork, carcass traits and meat quality in finishing pigs.

Material and methods

All experimental protocols were approved by the Animal Care and Use Committees of Dankook University (Cheonan, South, Korea).

Animals and diets

A total of 72 crossbred pigs [(Landrace × Yorkshire) × Duroc] with an average initial BW of 51.59 ± 1.59 kg were used in this 10-wk growth trial. Pigs were randomly allotted to 3 dietary treatments (each n=24) based on their initial BW and sex (6 replications; 4 pigs per pen, 2 barrows and 2 gilts). The pigs in the 3 treatments were fed with different *n-6:n-3* ratios: 5:1, 10:1 and 15:1, respectively. The diets were formulated to be isoenergetic and isonitrogenous and to meet or exceed the NRC (2012) nutrient requirements (Table 1). All the pigs were housed in an environmentally controlled room with a slatted plastic floor. Throughout all the experimental period, each pen was equipped with a 1-sided self-feeder and a nipple waterer to allow the pigs *ad libitum* access to feed and water.

Table 1. Ingredient composition of experimental diets (as-fed basis)

Items	*n-6:n-3*		
	low (5:1)	medium (10:1)	high (15:1)
Ingredient (%)			
corn	66.00	66.00	66.00
soybean meal (47.5% CP)	25.00	25.00	25.00
wheat bran	3.00	3.00	3.00
soybean oil	2.35	2.95	3.2
linseed oil	0.90	0.30	0.05
dicalcium phosphate	1.26	1.26	1.26
salt	0.25	0.25	0.25
limestone	1.01	1.01	1.01
L-lysine-HCL	0.01	0.01	0.01
vitamin premix[1]	0.12	0.12	0.12
mineral premix[2]	0.10	0.10	0.10
Calculated value (%)			
ME (MJ/kg)	14.07	14.07	14.08
crude fat	6.60	6.60	6.60
crude protein	17.40	17.40	17.40
SID Lys	0.91	0.91	0.91
SID Met	0.28	0.28	0.28
Ca	0.70	0.70	0.70
available P	0.60	0.60	0.60
Fatty acids[3]			
C14:0	0.09	0.10	0.10
C16:0	10.54	10.97	11.16
C16:1 (*n-7*)	0.25	0.26	0.26
C18:0	2.82	2.86	2.88
C18:1 (*n-9*)	22.63	23.25	23.50
C18:2 (*n-6*)	52.82	56.70	58.26
C18:3 (*n-3*)	10.85	5.86	3.84
n-6:n-3	4.87	9.68	15.17

SID – standardized ileal digestible.

[1]Provided per kg of complete diet: 11,025 IU vitamin A; 1,103 IU vitamin D_3; 44 IU vitamin E; 4.4 mg vitamin K; 8.3 mg riboflavin; 50 mg niacin; 4 mg thiamine; 29 mg d-pantothenic; 166 mg choline; 33 µg vitamin B_{12}.

[2]Provided per kg of complete diet: 8 mg of Mn (as MnO_2); 60 mg of Zn (as $ZnSO_4$); 5 mg of Cu (as $CuSO_4 \cdot 5H_2O$); 40 mg of Fe (as $FeSO_4 \cdot 7H_2O$); 0.3 mg of Co (as $CoSO_4 \cdot 5H_2O$); 1.5 mg of I (as KI); and 0.15 mg of Se (as $Na_2SeO_3 \cdot 5H_2O$).

[3]Proportion of total fatty acids.

Growth performance

Feed intake was recorded on a daily basis, individual pig BW was measured on the initial day, at the end of wk 5 and wk 10 of the experiment, the feed consumption and pig BW were used to monitor average daily gain (ADG), average daily feed intake (ADFI) and gain:feed (G:F).

Blood lipid profiles

At the end of the experiment, two pigs (one gilt and one barrow) were randomly chosen from each pen (n=36) and blood samples were taken by jugular venipuncture using vacuum tubes (Becton Dickinson Vacutainer Systems, Franklin Lakes, NJ). After collection, the serum samples from vacuum tubes were centrifuged (2,000 × *g*) for 30 min at 4°C. All serum samples were analyzed in duplicates for the concentration of total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) and triglyceride by using an automatic biochemistry analyzer (Hitachi 747; Hitachi Ltd., Tokyo, Japan) with a commercial kit (Sigma Diagnostics, MO, USA) according to the manufacturer's protocol.

Carcass traits

At the final day of the trial, all pigs were slaughtered at a local commercial slaughter house (Cheonan, South Korea). Subsequently, the backfat thickness and lean meat percentage (LMP) measurements were performed using a real time ultrasound instrument (Piglog 105, SFK Technology, Herlev, Denmark).

Fatty acid composition

Fatty acid composition of diet and *longissimus dorsi* muscle were determined by gas chromatography. Approximately 5 g samples of *longissimus dorsi* muscle were rapidly excised after slaughter and the samples were then frozen and stored in liquid nitrogen until further analyses. The samples of diet were frozen and stored in –20°C until analyses. The samples of diet and *longissimus dorsi* muscle were thawed at 4°C. After homogenization (Zhongwang, VEM, Jiangsu, China. 3 × 20 s, 12,000 rpm), the total lipids were extracted in duplicates from the diet and *longissimus dorsi* muscle samples by the chloroform-methanol (2:1, v/v) procedure according to the method of Folch et al. (1957). Heptadecanoic acid (C15:0) was used as an internal standard. Fatty acid methyl esters were prepared by esterification with sodium methoxide: extracted lipids were dried in a glass vial under a stream of nitrogen and dissolved in 1 ml of *n*-hexane, then 1 ml of 0.4 N CH_3ONa was added, the mixture was shaken in a vortex for 1 min. and left at room temperature for 20 min. After that time 1 ml of water was added and the upper (hexane) layer was transferred to the 1.8 ml autosampler vial. Subsequently, the fatty acid methyl esters were analyzed using a Finnigan Focus gas chromatograph with a 100 m capillary column (CP Sil 88 WCOT, 100 m × 0.25 mm, Chrompack, Middelburg, Netherlands). Injector and detector temperatures were 250°C and 255°C, respectively. Oven temperature was 70°C initially. After 4 minutes the temperature was increased by 13°C/min to 175°C, held there for 27 minutes, programmed at 4°C/min to 215°C, held there for 31 minutes and programmed at 10°C/min to a final temperature of 225°C. Helium

was used as the carrier gas at a flow rate of 1.62 ml/minute. The split ratio was 1:34. Fatty acid peaks determined by gas chromatograph were then used to calculate the amount of fatty acids (% of total fatty acids) by theoretical response factors (Demirel et al., 2004). Standard fatty acids of known composition were run to identify the fatty acids in the samples. Muscle control samples was extracted, methylated and analyzed by every 10th sample. The coefficient of variation (CV) for the individual fatty acids was found to vary between 4 and 6%.

Meat quality

After the carcass chilling at 2°C for at least 24 h, a piece of the right loin was removed between the 10th and 11th ribs. The sensory evaluation for visual color, firmness and marbling was conducted using a 5-point scoring system according to NPPC (2000) standards at an ambient temperature of 25°C. Immediately after the subjective tests were determined, the lightness (L*), redness (a*), and yellowness (b*) values were measured at 3 locations on the surface of each sample using a chroma meter (Model CR-410; Konica Minolta Sensing, Inc., Osaka, Japan) (Chen et al., 2008). At the same time, duplicate pH values of each sample were directly measured using a pH meter (Model AR25, Fisher Scientific, Pittsburgh, PA, USA). The water holding capacity (WHC) was measured based on the methods described by Kauffman et al. (1986). Briefly, a 0.3 g sample was pressed at 3,000 psi for 3 min on a 125-mm-diameter piece of filter paper. The areas of the pressed sample and the expressed moisture were delineated and then determined using a sensor (Digitizing Area Line Sensor, MT-10S; M.T. Precision Co. Ltd., Tokyo, Japan). The ratio of water:meat area was calculated, giving a measure of WHC (a smaller ratio indicates increased WHC). The *longissimus* muscle (LM) area was measured by tracing the LM surface at the 10th rib, which was determined using the aforementioned sensor. Drip loss was measured using approximately 4.5 g of meat sample according to the plastic bag method described by Honikel (1998). Cook loss was determined as described previously by Sullivan et al. (2007).

Statistical analyses

All experimental data were analyzed by using the GLM procedure of SAS as a randomized complete block design (SAS Inst. Inc., Cary, NC, USA), the pen served as the experimental unit. Differences among treatments were separated by Tukey's multiple range test. Probability values less than 0.05 were considered significant.

Results

Growth performance

The data presented in Table 2 show that the BW at the end of wk 5 and wk 10 was not significant affected ($P>0.05$) by dietary treatments. Throughout the experiment, the ADG, ADFI and G:F were not affected ($P>0.05$) by dietary treatments.

Table 2. Effect of dietary *n-6:n-3* PUFA ratios on growth performance of finishing pigs

Items	n-6:n-3			SEM[1]	Significance[2]
	low (5:1)	medium (10:1)	high (15:1)		
Animal number (n)	24	24	24		
BW (kg)					
initial	51.58	51.59	51.59	1.59	NS
wk 5	79.31	79.78	80.72	2.63	NS
wk 10	110.53	111.81	112.94	1.88	NS
0–5 wk					
ADG (g)	819	823	832	16	NS
ADFI (g)	2419	2376	2416	66	NS
G:F	0.340	0.348	0.345	0.013	NS
5–10 wk					
ADG (g)	915	902	886	14	NS
ADFI (g)	2880	2829	2835	57	NS
G:F	0.314	0.324	0.325	0.008	NS
Overall					
ADG (g)	869	861	838	12	NS
ADFI (g)	2649	2602	2626	47	NS
G:F	0.326	0.334	0.334	0.009	NS

[1]SEM – standard error of the mean.
[2]NS – not significant.

Blood lipid profiles

The effect of dietary *n-6:n-3* PUFA ratio on blood lipid profiles are described in Table 3. At the end of the experiment, pigs fed the dietary *n-6:n-3* PUFA ratio of 5:1 had a lower ($P<0.05$) serum total cholesterol and triglyceride levels than those of pigs fed the dietary *n-6:n-3* PUFA ratio of 10:1 and 15:1. Furthermore, the LDL cholesterol concentration in serum samples of pigs fed the dietary *n-6:n-3* PUFA ratio of 5:1 was lower ($P<0.05$) than pigs fed the dietary *n-6:n-3* PUFA ratio of 15:1. However, there were no differences ($P>0.05$) in serum HDL cholesterol concentration among dietary treatments.

Table 3. Effect of dietary *n-6:n-3* PUFA ratios on blood lipid profiles of finishing pigs

Items[1] (mmol/L)	*n-6:n-3*			SEM[2]	Significance[3]
	low (5:1)	medium (10:1)	high (15:1)		
Total cholesterol	1.55 b	2.11 a	2.18 a	0.10	**
HDL cholesterol	0.86	0.92	0.66	0.12	NS
LDL cholesterol	1.05 b	1.39 a	1.23 a	0.06	*
Triglyceride	0.60 b	0.96 a	0.89 a	0.05	**

[1]HDL – high-density lipoprotein; LDL – low-density lipoprotein.
[2]SEM – standard error of the mean.
[3]NS – not significant; * $P<0.05$; ** $P<0.01$.
a, b – means in the same row with different superscripts differ ($P<0.05$).

Fatty acid composition of *longissimus dorsi* muscle

The fatty acid composition of the *longissimus dorsi* muscle of pigs fed with the different dietary *n-6:n-3* PUFA ratios is presented in Table 4. The concentration of C14:0 was lowest (P<0.05) in pigs fed the dietary *n-6:n-3* PUFA ratio of 5:1. Saturated fatty acids (SFA) including C16:0 and C18:0, monounsaturated fatty acids (MUFA) including C16:1 and C18:1 were unaffected (P>0.05) by the different dietary *n-6:n-3* PUFA ratios. Additionally, the concentration of *n-3* such as C18:3*n-3*, C22:5*n-3* and C22:6*n-3* were enhanced (P<0.05) in the *longissimus dorsi* muscles of pigs fed the dietary *n-6:n-3* PUFA ratio of 5:1. Moreover, pigs fed the dietary *n-6:n-3* PUFA ratio of 5:1 decreased (P<0.05) the *n-6* concentration (C18:2*n-6* and C20:4*n-6*). The different dietary *n-6:n-3* PUFA ratios had no effect (P>0.05) on the concentrations of SFA, MUFA and PUFA. In general, with the decline in the proportion of dietary *n-6:n-3*, the *n-6:n-3* PUFA ratio in the *longissimus dorsi* muscle was decreased (P<0.05).

Table 4. Effect of dietary *n-6:n-3* PUFA ratios on fatty acid profiles of the *longissimus dorsi* muscle of finishing pigs (% of total fatty acids)

Items[1]	*n-6:n-3*			SEM[2]	Significance[3]
	low (5:1)	medium (10:1)	high (15:1)		
C14:0	1.05 b	1.12 ab	1.28 a	0.05	*
C16:0	25.32	25.89	25.73	0.52	NS
C16:1 (*n-7*)	3.19	3.25	3.43	0.22	NS
C18:0	12.35	13.10	13.74	0.37	NS
C18:1 (*n-9*)	43.20	41.85	38.26	1.86	NS
C18:2 (*n-6*)	10.74 b	11.38 ab	14.05 a	0.28	**
C18:3 (*n-3*)	0.62 a	0.46 b	0.41 b	0.04	**
C20:3 (*n-6*)	0.43	0.48	0.46	0.04	NS
C20:4 (*n-6*)	1.72 b	2.05 a	2.13 a	0.08	*
C20:5 (*n-3*)	0.27	0.18	0.10	0.06	NS
C22:5 (*n-3*)	0.56 a	0.10 b	0.18 b	0.07	**
C22:6 (*n-3*)	0.54 a	0.14 b	0.23 b	0.06	**
SFA	38.72	40.11	40.75	0.69	NS
MUFA	46.39	45.10	41.69	1.62	NS
PUFA	14.88	14.79	17.56	0.97	NS
n-6:n-3	6.48 c	15.81 b	18.09 a	0.68	**

[1]Saturated fatty acids (SFA)=C14:0+C16:0+C18:0;
Monounsaturated fatty acids (MUFA)=C16:1+C18:1;
Polyunsaturated fatty acids (PUFA)=C18:2+C18:3+C20:3+C20:4+C20:5+C22:5+C22:6;
n-6:n-3=(C18:2+C20:3+C20:4):(C18:3+C20:5+C22:5+C22:6).
[2]SEM – standard error of the mean.
[3]NS – not significant; * P<0.05; ** P<0.01.
a, b, c – means in the same row with different superscripts differ (P<0.05).

Carcass traits and meat quality

As described in Table 5, different dietary *n-6:n-3* PUFA ratios did not influence (P>0.05) the backfat thickness and lean meat percentage after slaughter. Furthermore, dietary *n-6:n-3* PUFA ratios had no significant effect (P>0.05) on meat quality parameters, such as meat color, firmness, marbling, cooking loss, drip loss (at d 1, 3, 5, 7), meat pH, *longissimus* muscle area and water holding capacity.

Table 5. Effect of dietary *n-6:n-3* PUFA ratios on carcass traits and meat quality of finishing pigs

Items[1]	*n-6:n-3*			SEM[2]	Significance[3]
	low (5:1)	medium (10:1)	high (15:1)		
Carcass traits					
backfat thickness (mm)	20.8	20.3	20.9	0.6	NS
LMP (%)	51.4	51.8	52.2	0.7	NS
Meat quality					
meat color					
L*	59.93	59.64	59.25	0.83	NS
a*	16.42	16.63	16.76	0.32	NS
b*	6.08	6.26	6.29	0.36	NS
Sensory evaluation					
color	3.34	3.41	3.56	0.11	NS
firmness	2.88	3.09	3.19	0.12	NS
marbling	2.22	2.31	2.44	0.13	NS
Cooking loss (%)	34.02	33.34	33.56	2.92	NS
Drip loss (%)					
d1	7.39	7.44	7.34	0.40	NS
d3	13.06	12.72	12.69	0.52	NS
d5	18.67	18.50	18.52	0.55	NS
d7	23.84	23.72	23.47	0.64	NS
pH	5.50	5.61	5.56	0.06	NS
LM area (cm^2)	68.51	68.40	68.64	1.04	NS
WHC (%)	49.77	50.62	50.56	2.36	NS

[1]LMP – lean meat percentage; LM area, *longissimus* muscle area; WHC, water holding capacity.
[2]SEM – standard error of the mean.
[3]NS – not significant.

Discussion

Effects of dietary *n-6:n-3* ratios on growth performance and carcass traits

In the present study, the growth performance and carcass traits were not affected by various dietary *n-6:n-3* polyunsaturated fatty acid (PUFA) ratios. In agreement with our study, Guillevic et al. (2009) demonstrated that feeding finishing pigs with a high α-linolenic acid (C18:3*n-3*) diet had no effect on growth and carcass perfor-

mances. Sobol et al. (2015) suggested that improved dietary *n-3* PUFA intake by supplementing linseed and fish oil did not influence performance or carcass parameters of growing-finishing pigs. Furthermore, similar findings were also reported in broilers fed diets supplemented with linseed oil, fish oil, and sunflower oil (Marco et al., 2013; Mandal et al., 2014). The absence of a positive effect on growth performance and carcass traits by increasing dietary *n-3* intake may be due to similar dietary metabolizable energy contents and crude protein level among treatments; in these reports, replacing part of the energy of the basal diet by linseed oil did not change the nutritional value or energy content of the diet, and consequently, did not affect the growth performance and carcass traits. In contrast, Duan et al. (2014) and Li et al. (2015) indicated that dietary *n-6:n-3* PUFA ratios of 1:1-5:1 improved the ADG and feed efficiency of finishing pigs compared with those pigs fed dietary *n-6:n-3* PUFA ratios of 10:1. Part of the reasons for these inconsistent results may be related to the supplemental duration of *n-3* PUFA, feed ingredients or the age of pigs.

Effects of dietary *n-6:n-3* ratios on blood lipid profiles

It has been recognized that a lower blood total cholesterol, LDL cholesterol and triglyceride levels, and higher blood HDL cholesterol were beneficial for the health of humans and animals (Ronald and Martijn, 1989; Weststrate and Meijer, 1998; Ford et al., 2002; Zunft et al., 2003). The results of the present study revealed that a low dietary *n-6:n-3* ratios of 5:1 significantly reduced the serum cholesterol, LDL cholesterol and triglyceride concentrations. However, the reports about the effect of different *n-6:n-3* ratios on blood lipid profiles in swine are limited. Previously, in a human trial conducted by Ronald and Martijn (1989), they suggested that the serum LDL cholesterol level decreased by 17.9% in those on the monounsaturated-fat diet and by 12.9% in those on the polyunsaturated-fat diet, but the HDL cholesterol level did not significantly change with both diets. Furthermore, Ewart et al. (2002) indicated that dietary inclusion of *n-3* PUFA enriched oils in guinea pig diets could decrease the serum LDL cholesterol levels and lead to a lower blood triglyceride concentration. Laidlaw and Holub (2003) reported that daily supplementation with 2 g linolenic acid (C18:3*n-3*) significantly decreased plasma LDL cholesterol levels in women. In terms of the mechanisms underlying the lipid-lowering effects of the *n-3* PUFA, it is presumed that *n-3* PUFA-mediated reductions in circulating triglyceride levels include inhibition of hepatic triglyceride synthesis and secretion, reduced intestinal and hepatic apolipoprotein B species, which are responsible for triglyceride clearance, and increased lipoprotein lipase activity (Tinker et al., 1999). Considering the physiology and morphology, the organs of pigs and humans are similar. Therefore, these findings are not only important for maintaining an appropriate balance of the *n-6:n-3* PUFA ratios in animal health and production, but also provide insight to improve the health status of humans.

Effects of dietary *n-6:n-3* ratios on fatty acid composition of *longissimus dorsi* muscle

Currently, consumers are increasingly aware of the health benefits and nutritional quality of the pork they consume. The fatty acids, whether in adipose tissue or muscle,

are central to meat nutritional value (Wood et al., 2008). The present study showed that the concentrations of *n-3* PUFA, including α-linolenic acid (C18:3*n-3*), docosapentaenoic acid (DPA, C22:5*n-3*) and docosahexaenoic acid (DHA, C22:6*n-3*) were markedly increased nearly 1.5, 3 and 2.5 fold in the muscle of pigs fed a low dietary *n-6:n-3* PUFA ratios of 5:1, whereas the C18:2*n-6* and C20:4*n-6* concentrations were reduced accordingly. These findings agreed well with previous studies that the presence of linseed oil in the diet resulted in a higher *n-3* PUFA deposition in the pork (Huang et al., 2008; Tous et al., 2013; Sobol et al., 2015). Moreover, Li et al. (2015) confirmed that decreasing dietary *n-6* and elevating *n-3* PUFA is highly successful in raising the quantities of C18:3*n-3* and the long-chain *n-3* PUFA in pork, thus supplying valuable *n-3* PUFA to the human diet. The *n-3* PUFA in the meat are obtained through diet, and linseed oil provided *n-3* PUFA are mainly C18:3*n-3*. The C18:3*n-3* is the precursor for DPA and DHA *in vivo* (Kartikasari et al., 2012). Therefore, the higher contents of DPA and DHA in the pork could be ascribed to the high concentration of C18:3*n-3* in the diet.

Effects of dietary *n-6:n-3* ratios on meat quality

In regard to the meat quality, the analyzed parameters in this study, such as meat color, sensory evaluation, cooking loss, drip loss, pH, LM area and WHC were not affected by different dietary *n-6:n-3* PUFA ratios. Similarly, it was previously shown that the addition of 2% rapeseed oil and 1% fish oil to diets did not influence the pork quality including pH, drip loss, marbling score, flavor and odor (Leskanich et al., 1997). Additionally, Tous et al. (2013) reported that dietary high dose (4%) of conjugated linoleic acid supplementation in finishing pig diets had no effect on ultimate pH of meat. Owing to lack of available literature, direct comparisons of response to various *n-6:n-3* PUFA ratios in swine is impossible. However, it could be concluded that reduced dietary *n-6:n-3* PUFA ratios had no significant deleterious effect on meat quality parameters relevant to consumer acceptability. This conclusion would be worthy to be further investigated.

Conclusions and implications

To summarize, in comparison with medium (10:1) and higher (15:1) *n-6:n-3* PUFA ratios, a lower dietary *n-6:n-3* PUFA ratios of 5:1 resulted in significant alterations in the blood lipid profiles, and beneficially modulated the fatty acid composition of *longissimus dorsi* muscle. However, the growth performance, carcass characteristics and meat quality were not adversely affected. It is suggested that the reduced dietary *n-6:n-3* PUFA ratios could improve nutritional value of pork and without negative effect on factors relevant to production or consumer acceptability.

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