# The effect of linseed diet on carcass value traits and fatty acid composition in muscle and fat tissue of fattening pigs

R. Bečková, E. Václavková

Institute of Animal Science in Prague-Uhrineves, Division of Pig Breeding in Kostelec nad Orlicí, Kostelec nad Orlicí, Czech Republic

**ABSTRACT**: The aim of the study was to evaluate the effect of linseed in the diet of fattening pigs on carcass value traits and changes in the fatty acid profile in muscle and fat tissue. Thirty crossbred gilts were divided into two groups (control C and experimental L) and fed a commercial feed mixture for fattening pigs. Ground linseed was added to a feed mixture for the experimental group. The average daily gain, lean meat percentage and intramuscular fat content were not affected by the linseed diet but pH1 value and drip loss were significantly influenced by dietary treatment ($P < 0.01$). The inclusion of linseed increased linoleic and alpha-linolenic acid content in L group ($P < 0.05$, $P < 0.01$) while arachidonic acid content was decreased in both muscle ($P > 0.05$) and fat tissue ($P < 0.01$). The content of total n-6 PUFA and n-3 PUFA and their ratio were also determined. A significant decrease in the n-6/n-3PUFA ratio was found in L group compared to C group ($P < 0.01$). The total SFA content in muscle tissue was not significantly affected ($P > 0.05$) by the linseed diet but it was decreased ($P < 0.01$) in backfat. The MUFA/SFA ratio was not affected by the linseed diet ($P > 0.05$) whereas the SFA/PUFA ratio was reduced ($P < 0.01$).

**Keywords**: linseed; carcass value traits; fatty acid; pig

An interest in the composition of fatty acids of meat mainly stems from the need to find ways of producing healthier meat, i.e. with a higher ratio of polyunsaturated fatty acids (PUFA) to saturated fatty acids (SFA) and a more favourable balance between n-6 and n-3 PUFA (Wood et al., 2004). In recent years the awareness of the importance of a diet in human health has increased. In the Czech Republic, the problem of the better fatty acid profile in meat is often studied in poultry (Schneiderová et al., 2007; Skřivan et al., 2008; Zelenka et al, 2008) and beef cattle (Bureš et al., 2006; Bartoň et al., 2007) but less frequently in pigs. There are important species differences in fatty acid composition. Pigs have much higher proportions of the major PUFA linoleic acid in both tissues than cattle and sheep. Linoleic acid is derived entirely from the diet. In ruminants, the fatty acid is degraded into monounsaturated and saturated fatty acids in the rumen by microbial biohydrogenation and only a small proportion is available for incorporation into tissue lipids (Nürnberg et al., 1998; Wood et al., 2008). There is also a possibility to change the milk fatty acid profile in cattle (Komprda et al., 2005; Liu et al., 2008; Veselý et al., 2009). Fat is typically added to diets as a source of energy. In pig diet, an emphasis is laid on the omega-3 fatty acids in fish oil and vegetable oils (soy, olive, linseed, sunflower, rapeseed). The effect of sunflower oil on the fatty acid composition of adipose tissue, loin and liver was studied by Mitchaothai et al. (2007). The level of food intake and food composition regulate the

Supported by the Ministry of Agriculture of the Czech Republic (Project No. QH 71284)

rate of fatty tissue growth and the composition of lipids. In pigs, the intramuscular fat content appears to be highly heritable – $h^2$ estimates generally of 0.4–0.6 (Schwörer et al., 1990; Selier and Monin, 1994). There exists a strong inverse correlation between the amount of fat and the concentration of the main PUFA linoleic acid in pigs.

## MATERIAL AND METHODS

Thirty crossbred gilts (Czech Large White × Czech Landrace) × (Hampshire × Pietrain) were divided into two groups (15 gilts in each) and fed linseed diet (L, 13.4% of ground linseed, Jordan variety) or control diet (C). The fatty acid composition (21 fatty acids) was determined in linseed. The content of selected fatty acids – oleic, linoleic, alpha-linolenic, arachidonic, saturated (SFA), monounsaturated (MUFA), n-6 polyunsaturated (PUFA) and n-3 PUFA was found to amount to 22.06, 14.67, 50.29, 0.01, 11.25, 23.33, 14.88 and 50.54 g/100 g of total determined fatty acids, the n-6/n-3 PUFA ratio was calculated from all determined n-6 and n-3 PUFA at the level 0.29. The composition of diets is shown in Table 1. The intake of feed mixture and water was *ad libitum*. The average initial live weight was 39.00 ± 5.99 kg in C group and 38.20 ± 4.65 kg in L group, average final live weight was 89.40 ± 8.01 kg (C group) and 87.80 ± 8.84 kg (L group). Lean meat percentage (FOM apparatus), pH1 and pH24 value were measured after slaughter. The samples of *M. longissimus dorsi et thoracis* and backfat were collected 24 hours after slaughter at the point of FOM measurement, put into plastic bags and frozen (–18°C) for further laboratory analyses. The fatty acid content, intramuscular fat content, drip loss and oxidation stability were investigated in meat samples. The fatty acid composition was measured in backfat samples. The intramuscular fat content was determined according to the standard CSN 570185 (1985). The thiobarbituric acid-reacting substances (TBARS) test was used to assess lipid oxidation in meat samples (method by Piette and Raymond, 1999) and the results were reported as mg of malonaldehyde/kg of meat. The lipid fraction was isolated by the method according to Folch et al. (1957), the preparation of fatty acid methyl esters was done in accordance with the standard CSN ISO 5509 (1994), fatty acid methyl

Table 1. The composition of feed mixtures

| | Diet (C) | Diet (L) |
|---|---|---|
| Wheat meal (%) | 45.3 | 26.9 |
| Barley meal (%) | 29.0 | 38.0 |
| Soybean meal (%) | 21.6 | 17.6 |
| Ground linseed (%) | 0.0 | 13.4 |
| L-lysine (%) | 0.3 | 0.3 |
| L-threonine (%) | 0.2 | 0.2 |
| Methionine (%) | 0.3 | 0.3 |
| Sodium chloride (%) | 0.4 | 0.4 |
| Ground limestone (%) | 1.5 | 1.5 |
| ME (MJ/kg) | 12.8 | 12.9 |
| Crude protein (g/kg) | 187.3 | 185.9 |
| Crude fibre (g/kg) | 40.53 | 48.36 |
| Crude fat (g/kg) | 19.02 | 52.57 |
| Alpha-tocopherol (mg/kg) | 31.3 | 31.4 |

Table 2. Carcass value traits in the control and experimental group (mean ± standard deviation)

| | Control group (C) | Linseed group (L) |
|---|---|---|
| Average daily weight gain (g) | 800 ± 69 | 787 ± 30 |
| Lean meat percentage (%) | 59.13 ± 1.92 | 59.22 ± 1.34 |
| Intramuscular fat content (g/kg) | 26.5 ± 3.4 | 24.5 ± 2.6 |
| pH1 | 5.91 ± 0.10$^{B}$ | 6.00 ± 0.08$^{A}$ |
| pH24 | 5.86 ± 0.08 | 5.88 ± 0.10 |
| Drip loss (%) | 4.61 ± 0.61$^{B}$ | 5.83 ± 0.54$^{A}$ |

$^{ab}$means with different superscripts differ significantly $P < 0.05$

$^{AB}$means with different superscripts differ highly significantly $P < 0.01$

esters were analysed by gas chromatography (6890N Agilent Technologies) according to CSN ISO 5508 (1994). The gas chromatograph was equipped with DB-23 cyanopropyl-methylpolysiloxane column (60 m × 0.25 mm × 0.25 μm). Nitrogen was used as carrier gas (flow rate 0.8 ml/min). The temperature regime was as follows: 120°C for 6 min, the temperature was raised to 170°C (15°C/min) and then to 210°C (3°C/min). This temperature was maintained for 13.5 min. Subsequently, the temperature was increased to 230°C (40°C/min) and maintained constant for 7 min. The FID detector temperature was 260°C. Fatty acids were determined by comparison with standards (37 Component FAME Mix, PUFA No. 1, PUFA No. 2, PUFA No. 3; Sigma-Aldrich). Thirty fatty acids were measured in meat and back-fat samples, content of saturated, monounsaturated and polyunsaturated fatty acids was calculated from detected fatty acids. The statistical evaluation was performed using the computer program QCExpert (TriloByte Statistical Software Ltd.) – *t*-test was used to evaluate statistical significance of differences between the control and the experimental group. Data were presented as the mean, standard deviation (SD) of each group and the significance levels.

## RESULTS AND DISCUSSION

Linseed treatment did not affect ($P > 0.05$) the monitored growth parameters (Table 2). The average daily weight gain (ADG) was calculated from

Table 3. Contents of selected fatty acids (g/100 g of total detected fatty acids) and ratio of fatty acids in *M. longissimus dorsi et thoracis* samples

| | Control group (C) | Linseed group (L) |
|---|---|---|
| Myristic C14:0 | 1.11 ± 0.14 | 1.04 ± 0.16 |
| Palmitic C16:0 | 22.95 ± 1.06 | 22.79 ± 1.06 |
| Stearic C18:0 | 11.88 ± 0.62 | 12.34 ± 0.80 |
| Oleic C18:1n-9 | 38.67 ± 2.36$^{B}$ | 35.44 ± 2.61$^{A}$ |
| Linoleic C18:2n-6 | 9.51 ± 1.99$^{b}$ | 11.24 ± 2.54$^{a}$ |
| Alpha-linolenic C18:3n-3 | 0.44 ± 0.09$^{B}$ | 2.27 ± 0.41$^{A}$ |
| Gama-linolenic C18:3n-6 | 0.14 ± 0.04$^{B}$ | 0.10 ± 0.03$^{A}$ |
| Arachidonic C20:4 n-6 | 3.08 ± 0.69 | 2.63 ± 0.72 |
| EPA C20:5n-3 | 0.02 ± 0.02 | 0.04 ± 0.04 |
| DHA C22:6n-3 | 0.12 ± 0.04 | 0.14 ± 0.06 |
| SFA | 36.96 ± 1.40 | 37.84 ± 1.54 |
| MUFA | 47.71 ± 2.60$^{B}$ | 43.22 ± 3.18$^{A}$ |
| PUFA | 15.33 ± 3.20 | 18.95 ± 4.22 |
| Total n-6 PUFA | 13.66 ± 2.86 | 14.58 ± 3.33 |
| Total n-3 PUFA | 1.11 ± 0.22$^{B}$ | 3.79 ± 0.76$^{A}$ |
| MUFA/PUFA | 3.41 ± 1.05 | 2.79 ± 0.93 |
| MUFA/SFA | 1.29 ± 0.08$^{B}$ | 1.14 ± 0.07$^{A}$ |
| SFA/PUFA | 2.55 ± 0.70 | 2.12 ± 0.58 |
| n-6/n-3 PUFA | 12.36 ± 1.06$^{B}$ | 3.83 ± 0.23$^{A}$ |

$^{ab}$means with different superscripts differ significantly $P < 0.05$

$^{AB}$means with different superscripts differ highly significantly $P < 0.01$

PUFA – polyunsaturated fatty acids; MUFA – monounsaturated fatty acids; SFA – saturated fatty acids

content of SFA, MUFA, PUFA – calculated from all detected fatty acids

the initial and the final live weight. Higher ADG (800 ± 69 g) was found in C group but there was not any significant difference between C and L group. Intramuscular fat content was also found higher in C group (26.5 ± 3.4 g/kg) compared to L group (24.5 ± 2.6 g/kg). The lean meat percentage was at a similar level in C and L group (59.13 ± 1.92% and 59.22 ± 1.34%, resp.). Higher drip loss (5.83 ± 0.54%) and susceptibility to PSE (pale, soft, exudative) meat were detected in L group ($P < 0.01$). According to Romans et al. (1995) and Kouba et al. (2003) the linseed treatment did not affect growth and carcass traits. On the contrary, Huang et al. (2008) found an increased intramuscular fat content in pigs fed linseed diet.

The fatty acids (FA) in *M. longissimus dorsi et thoracis* and in backfat samples were determined by gas chromatography. The composition of selected fatty acids in muscle samples is shown in Table 3. Data presented in the table document that it is possible to modify the fatty acid content by means of a dietary source of fatty acids. Feeding linseed to pigs significantly increased linoleic acid content (11.24 ± 2.54 g/100 g of total detected FA, $P < 0.05$) and alpha-linolenic acid content (2.27 ± 0.41 g/100 g of total detected FA, $P < 0.01$) in L group. Arachidonic acid content was decreased in L group compared to C group but without statistical significance ($P > 0.05$). Nuernberg et al. (2005) used n-3 enriched linseed oil in pig diet during the

Table 4. Contents of selected fatty acids (g/100 g of total detected fatty acids) and ratio of fatty acids in backfat samples

| Fatty acid | Control group (C) | Linseed group (L) |
|---|---|---|
| Myristic C14:0 | 1.36 ± 0.11$^{b}$ | 1.28 ± 0.09$^{a}$ |
| Palmitic C16:0 | 25.27 ± 1.23$^{B}$ | 23.81 ± 0.95$^{A}$ |
| Stearic C18:0 | 15.19 ± 1.36 | 14.59 ± 1.23 |
| Oleic C18:1n-9 | 38.98 ± 1.26$^{B}$ | 35.85 ± 1.49$^{A}$ |
| Linoleic C18:2n-6 | 9.18 ± 1.48$^{B}$ | 10.87 ± 1.29$^{A}$ |
| Alpha-linolenic C18:3n-3 | 0.87 ± 0.20$^{B}$ | 4.90 ± 0.79$^{A}$ |
| Gama-linolenic C18:3n-6 | 0.04 ± 0.01 | 0.04 ± 0.02 |
| Arachidonic C20:4 n-6 | 0.21 ± 0.04$^{B}$ | 0.17 ± 0.02$^{A}$ |
| EPA C20:5n-3 | 0.01 ± 0.001$^{b}$ | 0.02 ± 0.001$^{a}$ |
| DHA C22:6n-3 | 0.03 ± 0.01$^{B}$ | 0.04 ± 0.01$^{A}$ |
| SFA | 42.99 ± 1.87$^{B}$ | 40.79 ± 1.96$^{A}$ |
| MUFA | 45.71 ± 1.47$^{B}$ | 41.45 ± 1.77$^{A}$ |
| PUFA | 11.30 ± 1.84$^{B}$ | 17.76 ± 2.24$^{A}$ |
| Total n-6 PUFA | 10.12 ± 1.63$^{B}$ | 11.75 ± 1.37$^{A}$ |
| Total n-3 PUFA | 1.18 ± 0.26$^{B}$ | 6.00 ± 0.92$^{A}$ |
| MUFA/PUFA | 4.15 ± 0.74$^{B}$ | 2.38 ± 0.37$^{A}$ |
| MUFA/SFA | 1.07 ± 0.07 | 1.02 ± 0.08 |
| SFA/PUFA | 3.92 ± 0.73$^{B}$ | 2.34 ± 0.36$^{A}$ |
| n-6/n-3 PUFA | 8.76 ± 1.09$^{B}$ | 1.97 ± 0.16$^{A}$ |

$^{ab}$means with different superscripts differ significantly $P < 0.05$

$^{AB}$means with different superscripts differ highly significantly $P < 0.01$

PUFA – polyunsaturated fatty acids; MUFA – monounsaturated fatty acids; SFA – saturated fatty acids

content of SFA, MUFA, PUFA – calculated from all detected fatty acids

growing-finishing period. Feeding linseed oil reduced arachidonic acid content in muscle although the linoleic acid concentration was enhanced. This decrease is probably a result of arachidonic acid peroxidation. Another explanation is that the two families of PUFA, n-3 and n-6 fatty acids, compete for the same enzymes in their elongation and desaturation metabolism. The increase in n-3 fatty acids in muscle caused a corresponding decrease in arachidonic acid. The desaturase and elongase activities seem to be more focused on the synthesis of n-3 instead of on the synthesis of n-6 fatty acids metabolites. On the contrary, Nolan et al. (1995) did not report a decrease in arachidonic acid content in the longissimus muscle by feeding linseed oil. Sheard et al. (2000) and Hoz et al. (2003) studied the influence of linseed-rich test diet on fatty acid content in meat. The test diet resulted in a higher alpha-linolenic acid level, with major increase in total n-3 polyunsaturated fatty acid (PUFA) content while the n-6 PUFA content was reduced by the test diet. In our experiment, the n-3 PUFA level was increased from 1.11 ± 0.22 in C group to 3.79 ± 0.76 g/100 g of total detected FA in L group ($P < 0.01$) and the n-6 PUFA content was also increased (13.66 ± 2.86 in C group, 14.58 ± 3.33 g/100 g of total detected FA in L group). The increase in n-6 PUFA was not statistically significant ($P > 0.05$).

The n-6/n-3 PUFA ratio was reduced by the linseed diet from 12.36 ± 1.06 in C group to 3.83 ± 0.23 in L group ($P < 0.01$). In the experiment of Rey et al. (2001), meat from pigs fed linseed oil-enriched diets had a higher proportion of n-3 fatty acids and 20% reduction in the n-6/n-3 ratio was observed.

The fatty acid composition was also investigated in backfat (Table 4). The content of linoleic acid was statistically significantly increased from 9.18 ± 1.48 g/100 g of total detected FA in C group to 10.87 ± 1.29 g/100 g of total detected FA in L group ($P < 0.01$) as well as that of alpha-linolenic acid ($P < 0.01$). Alpha-linolenic acid is a precursor fatty acid for the synthesis of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The amount of these fatty acids was analysed as increasing ($P < 0.05$ and $P < 0.01$, resp.). On the contrary, the content of myristic, palmitic, oleic and arachidonic acid was decreased ($P < 0.05$ and $P < 0.01$, resp.) in our experiment. Kouba et al. (2003) stated that feeding the linseed diet increased the content of n-3 PUFA in adipose tissue but DHA was not altered by the diet. Schmidt et al. (2006) also studied the effect of dietary linseed oil supplementation on the fatty acid composition in adipose tissue. The concentration of alpha-linolenic acid was enhanced. On the other hand, the content of oleic acid and stearic acid was decreased. We observed the same result in backfat samples.

Table 4 also shows the content of total n-6 PUFA, total n-3 PUFA, saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA) in backfat samples. The total n-6 PUFA content was higher ($P < 0.01$) in L group (11.75 ± 1.37 g/100 g of total detected FA) compared to C group (10.12 ± 1.63 g per 100 g of total detected FA). The content of total n-3 PUFA was five times higher in L group. It is a reason for a significant ($P < 0.01$) decrease in the n-6/n-3 PUFA ratio in L group (1.97 ± 0.16) compared to C group (8.76 ± 1.09). Both total MUFA and total SFA content was decreased in L group

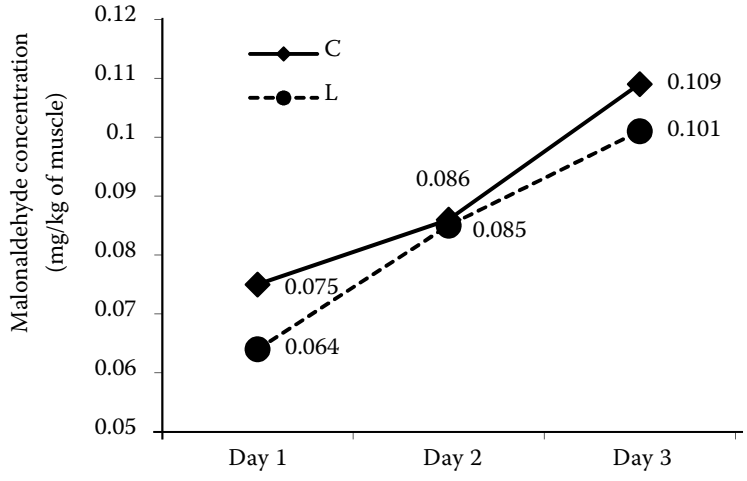


Figure 1. Malonaldehyde concentrations (mg/kg of muscle) in the control and linseed group

($P < 0.01$). Hence their relation to PUFA content was also changed. The MUFA/PUFA ratio was decreased from 4.15 ± 0.74 in C group to 2.38 ± 0.37 in L group ($P < 0.01$) and the SFA/PUFA ratio was reduced from 3.92 ± 0.73 in C group to 2.34 ± 0.36 in L group ($P < 0.01$). The MUFA/SFA ratio was observed to be approximately at the same level in C and L group. Kouba et al. (2003) also observed increased n-3 PUFA content in adipose tissue of pigs fed a linseed diet. The linseed diet produced the PUFA/SFA ratio higher than or equal to 0.4 and a robust decrease in the n-6/n-3 PUFA ratio. In our experiment, the n-6/n-3 PUFA ratio was reduced from 8.76 in C group to 1.97 in L group ($P < 0.01$). This result corresponds with findings of Simopoulos (2001) and Weill et al. (2002) but Bee et al. (1991) reported that the saturated fatty acid content in body fat was not affected by different fat-enriched diets. The proportion of mono- and polyunsaturated fatty acids was affected at a high level. The n-6/n-3 PUFA ratio was sharply reduced (from 9.88 to 2.48) when pigs were fed the linseed oil diet in an experiment conducted by D'Arrigo et al. (2002). Nutritionists criticise the human diet for an unfavourable ratio between n-6 and n-3 which typically exceeds 10:1 and it is very often as high as 25:1, when 5:1 is regarded as ideal for good health (Weill et al., 2002). The n-6/n-3 PUFA ratio was lower in our experiment and it is necessary to find an optimal amount of linseed in pig diet for achievement of the recommended ratio.

The effect of linseed diet on lipid oxidation was also studied in our experiment. The oxidation stability was indicated as milligrams of malonaldehyde/kg of meat (Figure 1). The addition of linseed to the experimental pig diet did not affect the malonaldehyde concentration ($P > 0.05$) in meat. According to the study of Lahučký et al. (2004), feeding linseed oil to animals increased the susceptibility of the meat to oxidation. It was not confirmed in our experiment. Our result corresponds with findings of Corino et al. (2008). Their study showed that the inclusion of linseed in pig diet did not affect oxidation stability.

## CONCLUSION

Ground linseed added to the feed mixture for fattening pigs did not affect growth parameters and had a significant effect on the fatty acid profile in *M. longissimus dorsi et thoracis* and backfat. The linseed diet did not have a negative effect on oxidation stability of pork. The content of fatty acids can be modified to a required level. It is possible to decrease the concentration of saturated fatty acids and, on the other hand, to increase the concentration of polyunsaturated fatty acids. The n-6/n-3 polyunsaturated fatty acid ratio can be modified towards the value beneficial for human health.

## REFERENCES

Bartoň L., Marounek M., Kudrna V., Bureš D., Zahradová R. (2007): Growth performance and fatty acid profiles of intramuscular and subcutaneous fat from Limousin and Charolais heifers fed extruded linseed. Meat Science, 76, 517–523.

Bee G., Wenk C. (1991): Einfluss der Fettsäuren im Futter auf die Fettsäuren im Gesamptkörper beim Schwein. Schweinefleischqualität-Qualitätsschweinefleisch, Tagungsbericht ETH Zürich, Switzerland, 87–92.

Bureš D., Bartoň L, Zahrádková R., Teslík V., Krejčová N. (2006): Chemical composition, sensory characteristics, and fatty acid profile of muscle from Aberdeen Angus, Charolais, Simmental, and Hereford bulls. Czech Journal of Animal Science, 51, 279–284.

Corino C., Musella M., Mourot J. (2008): Influence of extruded linseed on growth, carcass composition, and meat quality of slaughtered pigs at one hundred ten and one hundred sixty kilograms of liveweight. Journal of Animal Science, 86, 1850–1860.

CSN 570185 (1985): Examination of meat, meat products and canned meat. Chemical and physical methods. The Czech Office for Standards, Metrology and Testing Prague, Czech Republic.

CSN ISO 5508 (1994): Animal and vegetable fats and oils. Analysis by gas chromatography of methyl esters of fatty acids. The Czech Office for Standards, Metrology and Testing Prague, Czech Republic.

CSN ISO 5509 (1994): Animal and vegetable fats and oils. Preparation of methyl esters of fatty acids. The Czech Office for Standards, Metrology and Testing Prague, Czech Republic.

D'Arrigo M., Hoz L., Lopez-Bote C.J., Cambero I., Pin C., Rey A.I., Ordonez J.A. (2002): Effect of dietary linseed oil and α-tocopherol on selected properties of pig fat. Canadian Journal of Animal Science, 82, 339–346.

Folch J., Lees M., Sloane Stanley G.H. (1957): A simple method for the isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry, 226, 497.

Hoz L., Lopez-Bote C.J., Cambero M.I., D'Arrigo M., Pin C., Santos C., Ordonez J.A. (2003): Effect of dietary linseed oil and alpha-tocopherol on pork tenderloin (*Psoas major*) muscle. Meat Science, 65, 1039–1044.

Huang F.R., Zhan Z.P., Luo J., Liu Z.X., Peng J. (2008): Duration of dietary linseed affects the intramuscular fat, muscle mass and fatty acid composition in pig muscle. Livestock Science, 118, 132–139.

Komprda T., Dvořák R., Fialová M., Šustová K., Pechová A. (2005): Fatty acid content in milk of dairy cows on a diet with high fat content derived from rapeseed. Czech Journal of Animal Science, 50, 311–319.

Kouba M., Enser M., Whittington F.M., Nute G.R., Wood J.D. (2003): Effect of a high-linolenic acid diet on lipogenic enzyme activities, fatty acid composition, and meat quality in the growing pigs. Journal of Animal Science, 81, 1967–1979.

Lahučký R., Nuernberg G.K., Kuchenmaister U., Bahelka I., Mojto J., Nuernberg G., Ender R.K. (2004): The effect of dietary magnesium oxide supplementation on fatty acid composition, antioxidative capacity and meat quality of heterozygous and normal malignant hyperthermia (MH) pigs. Archiv für Tierzucht, 47, 183–191.

Liu Z.L., Yang D.P., Chen P., Lin S.B., Jiang X.Y., Zhao W., Li J.M., Dong W.X. (2008): Effect of dietary sources of roasted oilseeds on blood parameters and milk fatty acid composition. Czech Journal of Animal Science, 53, 219–226.

Mitchaothai J., Yuangklang C., Wittayakun S., Vasupen K., Wongsuthavas S., Srenanul P., Hovenier R., Everts H., Beynen A.C. (2007): Effect of dietary fat type on meat quality and fatty acid composition of various tissues in growing-finishing swine. Meat Science, 76, 95–101.

Nolan M.R., Kennedy S., Blanchflower W.J., Kennedy D.G. (1995): Lipid peroxidation, prostacyclin and thromboxane $A_2$ in pigs depleted of vitamin E and selenium and supplemented with linseed oil. British Journal of Nutrition, 74, 369–380.

Nürnberg K., Wegner J., Ender K. (1998): Factors influencing fat composition in muscle and adipose tissue of farm animals. Livestock Production Science, 56, 145–156.

Nuernberg K., Fischer K., Nuernberg G., Kuechenmeister U., Klosowska D., Eliminowska-Wenda G., Fiedler I., Ender K. (2005): Effects of dietary olive and linseed oil on lipid composition, meat quality, sensory characteristics and muscle structure in pigs. Meat Science, 70, 63–74.

Pascual J.V., Rafecas M., Canela M.A., Boatella J., Bou R., Barroeta A.C., Codony R. (2007): Effect of increasing amounts of a linoleic-rich dietary fat on the fat composition of four pig breeds. Part II: fatty acid composition in muscle and fat tissues. Food Chemistry, 100, 1639–1648.

Pieszka M. (2007): Effect of vegetable oils supplementation in pig diets on lipid oxidation and formation of oxidized forms of cholesterol in meat. Polish Journal of Food and Nutrition Sciences, 57, 509–516.

Piette G., Raymond Y. (1999): Rancidity in processed meats-Comparative evaluation of methods. Fleischwirtschaf Int., 3, 36–39.

Rey A.I., Kerry J.P., Lynch P.B., Lopez-Bote C.J., Buckley D.J., Morrissey P.A. (2001): Effect of dietary oils and alpha-tocopheryl acetate supplementation on lipid (TBARS) and cholesterol oxidation in cooked pork. Journal of Animal Science, 79, 1201–1208.

Romans J.R., Johnson R.C., Wulf D.M., Libal G.W., Costello W.J. (1995): Effects of ground flaxseed in swine diets on pig performance and on physical and sensory characteristics and omega-3 fatty acid content of pork: I. Dietary level of flaxseed. Journal of Animal Science, 73, 1982–1986.

Schmidt J., Peredi J., Toth T., Zsedely E. (2006): Modification of the fatty acid composition of the most important foodstuffs of animal origin by feeding. Part 1. Lard and Hogmeat. Elelmezesi Ipar, 60, 235–240.

Schneiderová D., Zelenka J., Mrkvicová E. (2007): Poultry meat production as a functional food with a voluntary n-6 and n-3 polyunsaturated fatty acids ratio. Czech Journal of Animal Science, 52, 203–213.

Schwörer D., Morel P., Prabucki A., Rebsamen A. (1990): Genetic parameters of intramuscular fat content and fatty acids of pork fat. In: Proceedings of the 4$^{th}$ World Congress on Genetics Applied to Livestock Production. Edinburgh, UK, 545–548.

Sellier P., Monin G. (1994): Genetics of pig meat quality: a review. Journal of Muscle Foods, 5, 187–219.

Sheard P.R., Enser M., Wood J.D., Nute G.R., Gill B.P., Richardson R.I. (2000): Shelf life and quality of pork products with raised n-3 PUFA. Meat Science, 55, 213–221.

Simopoulos A.P. (2001): N-3 fatty acids and human health: Defining strategies for public policy. Lipids, 36, 83–89.

Skřivan M., Dlouhá G., Mašata O., Ševčíková S. (2008): Effect of dietary selenium on lipid oxidation, selenium and vitamin E content in the meat of broiler chickens. Czech Journal of Animal Science, 53, 306–311.

Tikk K., Tikk M., Aaslyng M.D., Karlsson A.H., Lindahl G., Andersen H.J. (2007): Significance of fat supplemented diets on pork quality – connections between specific fatty acids and sensory attributes of pork. Meat Science, 77, 275–286.

Veselý A., Křížová L., Třináctý J., Hadrová S., Navratilová M., Herzig I., Fisera M. (2009): Changes in fatty acid profile and iodine content in milk as influenced by the inclusion of extruded rapeseed cake in the diet of dairy cows. Czech Journal of Animal Science, 54, 201–209.

Weill P., Schmitt B., Chesneau G., Daniel N., Safraou F., Legrand P. (2002): Effects of introducing linseed in livestock diet on blood fatty acid composition of consumers of animal products. Annals of Nutrition and Metabolism, 46, 182–191.

Wood J.D., Richardson R.I., Nute G.R.; Fisher A.V., Campo M.M., Kasapidou E., Sheard P.R., Enser M. (2004): Effects of fatty acids on meat quality: a review. Meat Science, 66, 21–32.

Zelenka J., Jarošová A., Schneiderová D. (2008): Influence of n-3 and n-6 polyunsaturated fatty acids on sensory characteristics of chicken meat. Czech Journal of Animal Science, 53, 299–305.

Received: 2009–07–17
Accepted after corrections: 2010–01–28

*Corresponding Author*

Ing. Růžena Bečková, CSc., Institute of Animal Science Prague-Uhříněves, Division of Pig Breeding in Kostelec nad Orlicí, Komenského 1239, 51741 Kostelec nad Orlicí, Czech Republic
E-mail: vuzvkostelec@tiscali.cz