FACTORS INFLUENCING FATTY ACIDS COMPOSITION IN PORK MEAT: A REVIEW

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Adipose tissues in the carcass are located subcutaneously, between muscles (intermuscular) and inside the muscle (intramuscular). Intramuscular fat can be classified as intra- and intercellular. Intracellular fat consists of lipids within the muscle cell, which are involved in the construction of cell compounds. They have biological functions. Intercellular fat is situated in the perimysium and in the endomysium. It has mainly depot function. Content and chemical properties of lipids in meat are regarded as important factors affecting carcass quality. Moreover the strong reduction of the amount of fat tissue and intramuscular fat has also led to a considerable decline of fat quality. Fat content and fat quality are attracting at great deal of interest from the breeding as well as from the technological and nutritional point of view. Genetics effects play a primary role in the overall variation of the technological and eating qualities of pig meat.

Meat has been identified, often wrongly, as a food having a high fat content and an undesirable balance of fatty acids. In fact lean meat is very low in fat (20-50g/kg), pork has a favourable balance between polyunsaturated (PUFA) and saturated fatty acids (SFA). Meat fatty acid composition can be changed via the diet, linoleic, α-linolenic and long-chain PUFA content responds quickly to feeding higher levels of α-linolenic acid (e.g. in rapeseed) in pigs.

In recent years awareness of the importance of diet in human health has increased. Many authorities have recommended that the contributions of fat and especially SFA to dietary energy intake should be reduced. In pigs, a strong inverse correlation between the amount of fat and the concentration of the main PUFA linoleic acid has been observed in several studies. There were strong correlations between fatty acid concentrations and the firmness of fat tissue; high linoleic acid and low stearic acid concentrations indicated softer fat in leaner carcasses. (Wood et al., 1997).

In the study of Wood et al. (1996) the inverse correlation between unsaturated fatty acid concentration and lipid content was absent for the major n-3 fatty acid α-linolenic which suggests different control factors for the concentrations of linoleic and α-linolenic acids, booth of which are entirely derived from the diet and compete for inclusion in to tissue lipids.

The properties of meat and fat tissue in pigs are important for production and quality of mean products and are largely influenced by feeding and genetic disposition of the animals.

Due to the successful breeding for lean carcasses the relative amount of PUFA, which are efficiently deposited into adipose tissues, is high in pigs.

High amounts of PUFA lead to increased susceptibility to oxidation and, like monoenoic fatty acids (MUFA), impair consistency (Gläser et al., 1999).

Interest in meat fatty acid composition stems mainly from the need to find ways to produce healthier meat, i.e. with a higher ratio PUFA to saturated fatty acids and a more favourable balance between n-6 and n-3 PUFA (Wood et al., 2004). In pigs, the concentration of n-3 fatty acids should be enhanced, while that of n-6 fatty acids be lowered. This is achieved by increasing by share of n-3 rich oils (linseed, rapeseed, soy, fish) or linseed in the diet (Metges, 2004). The Western diets have a ratio n-6/n-3 of 16,74 (Simopoulos, 2001).Nutritionists criticise the Western diet for the fat that is between n-6 and n-3 typically exceeds 10:1 and may be as high as 25:1, when 5:1 is regarded as ideal for good health (anonym, 2002). Reducing the ratio between essential fatty acids: C18:2n-6/ C18:3n-3 down to 5 is recommended by Nutritional guidelines (Weill et al., 2002). Enser et al. (1996) observed the n-6/n-3 ratio in pork 7,2 (7,6).

The mechanism by which the n-3 PUFA prevent fatal ventricular arrhythmias in animals and cultured heart cells, prevent sudden cardiac deaths and potential importance of these fatty acids in human nutrition is mentioned in many studies (Kang et al., 2000; Demaison et al., 2002; Leaf et al., 2003).

The relative proportion of fatty acid composition is influenced by numerous factors including diet, fatness, age (body weight), gender, breed, environmental temperature, depot site, maintenance and hormones (Nürnberg et al., 1998).

Effect of diet on fatty acid composition and meat quality

The level of food intake and composition of food regulates the rate of fatty tissue growth and the composition of lipids. There is a correlation between the amount of fatty tissue and fatty acid composition. The potential for dietary variation of lipid composition in monogastric animals is much greater then in ruminants (Nürnberg et al., 1998). In pigs, dietary fatty acids are absorbed unchanged from the intestine and incorporated into tissue lipids. The PUFA linoleic and α-linolenic can not be synthesized and tissue concentrations respond rapidly to dietary changes. SFA and MUFA on the other hand are synthesized and their concentrations are less readily influenced by diet (Wood, 1997). Vitamin E, α-tocopherol, is the major lipid-soluble antioxidant in animal tissues which acts post-mortem to delay oxidative deterioration of the meat. Dietary supplementation with vitamin E increases its deposition in the muscle and fat so that the oxidation is retarded and shelf-life of the meat is enhanced.

Feeding animals with more unsaturated fatty acids to improve the P:S ratio or feeding n-3 PUFA as linseed or fish oil to lower n-6/n-3 ratio increases the susceptibility of the meat to oxidation. Concomitant increases in dietary vitamin E are therefore necessary to prevent flavour deterioration due to lipid oxidation (Wood et al., 1997). Hartfiel (1991), Fischer et al. (1991), Wenk (1991), Larick et al. (1992), Waylan et al. (2002) mention that the most important quality trait of adipose tissue is oxidative stability which is decreasing with amount of polyenic fatty acids in fat. Performance, fatty acids digestibility, carcass and muscle composition of pigs fed diets enriched with vitamin E and differing in their MUFA/PUFA ratio was studied by Isabel et al. (2004). The partial substitution of dietary PUFA by MUFA produced a higher proportion of intramuscular fat (P=0,04) and a decrease in total fatty acid apparent digestibility only in the case that a basal level of vitamin E was added to the diet. The effect of n-3 fatty acid-enriched diets (in the form of 0,5% linseed oil with either 1,5% sunflower oil or 1,5 % olive oil) and α-tocopheryl acetate supplementation (200mg/kg feed) on lipid oxidation (TBARS) was investigated in longissimus muscle by Rey et al. (2001). Meat from pigs fed 0,5% linseed oil-enriched diets had a higher proportion on n-3 fatty acid then meat from pigs in other dietary groups in neutral (P<0,001) and polar lipids (P<0,001), and 20% reduction in the n-6/n-3 ratio was observed. The influence of different fat source addition (linseed oil, olive oil, sunflower oil, canola oil, rapeseed oil) in feed was studied in works of Myer et al. (1992), Lopez-Bote et al. (2002), Rey et al. (2004) and Kolacz et al. (2004). Bee et al. (1991) mention that saturated fatty acids content in body fat was not affected by different fat-enriched diets. The proportion of mono- and polyunsaturated fatty acids was affected on high level. Samples of subcutaneous fat were analysed for fatty acid composition and samples of loin assessed for meat quality with taste panel score. There were no significant effects (P>0,05) of treatment on daily live- weight gain, food conversion ratio or growth carcass composition. Fatty acid profiles of adipose tissue reflected dietary levels to a variable degree, the more so with oleic acid and the greatest for linoleic and linolenic acids (Wiseman et al., 2000). Sheard et al. (2000), Hoz et al. (2003) studied influence of linseed-rich test diet on sensory quality, oxidative stability after conditioning and storage. There was no significant effect of diet on lipid oxidation and any significant effect of diet on colour changes of pork chops. The test diet resulted in higher α-linolenic acid levels, with major increases in total n-3 PUFA content. The n-6 PUFA content was also reduced by the test diet. The nutritional value of pig meat can be improving by using an α-linolenic enriched diet without adversely effecting normal eating quality parameters. The effect of linseed oil and olive oil on lipid composition, meat quality, sensory characteristics and muscle structure in pigs is mentioned in work by Nürnberg et al. (2005). Feeding linseed oil to pigs significantly increased the relative content of linolenic acid and long chain n-3 fatty acids in lipids of muscle, backfat and heart at the expense of arachidonic acid.

The oxidative stability of muscle lipids was lower in linseed oil-fed pigs compared to olive oil fed pigs. The effect of linseed oil and α-tocopheryl acetate on the fatty acid composition, the susceptibility to oxidation of pig adipose tissue and the subcutaneous fat consistency was investigated by D´Arrigo et al. (2002). Pigs were fed by different diets (control, 3% sunflower oil, 3% linseed oil, 1,5% linseed oil + 1,5% olive oil), α-tocopheryl acetate was added. The n-6/n-3 ratio was sharply reduced (from 9,88 in the control batch to at least 2,48) when pigs were fed diets enriched in linseed oil. Adipose tissue from pigs fed diets enriched in α-linolenic acid showed higher susceptibility to oxidation than that from pigs fed diets containing high levels of linoleic acid, but dietary supplementation with α-tocopheryl acetate markedly reduced the pig fat oxidation in groups fed diets enriched in n-3 fatty acids. VanOeckel et al. (1997) present that PUFA content in the backfat reached a maximum of respectively 18g and 19g per 100g of total fatty acids for pigs, without implications for the consistency of the fat. Kouba et al. (2003) describe experiment with Duroc-cross gilts. Pigs were fed a control or a linseed diet containing 60g of whole crushed linseed/kg. Both diets were supplemented with 150mg of vitamin E/kg. There was no effect (P>0,05) of diet on growth, carcass characteristics or foreloin tissue composition. Feeding the linseed diet increased (P<0,05) the content of n-3 PUFA in plasma, muscle and adipose tissue, but docosahexaenoic acid was not (P>0,05) altered by diet. The proportions of n-3 PUFA were highest (P<0,01) in pigs fed the linseed-diet for 60 d, regardless of tissue (plasma, muscle or adipose tissue) or lipid (neutral lipids and phospholipids) class. Lower concentration of scatole (P<0,001) in pork fat was observed in linseed-fed pigs. Inclusion of linseed (flaxseed) in swine diets is a valid method of improving the nutritional value of pork without deleteriously effecting organoleptic characteristics, oxidation, or colour stability. Mourot (2001), Eder et al. (2001) recommend the importance of the choice of the fat matter in pig feeding. A relation exists between the dietary fatty acids and those that are stored in the adipose tissue and in the muscle. An unsaturated fat matter, particularly high in linoleic acid, stimulates the potential of lipid synthesis and can therefore increase the adiposity of the carcass. These unsaturated fat matters also have consequences on the technological quality of the adipose tissue. Kolacz et al. (2005) studied the effect of dietary halloysite on the performance and profile fatty acids in pork meat. The use of 2% halloysite effected better body weight gain about 5% and better feed efficiency about 4% by simultaneous body fleshing improvement. In muscle fat followed favourable changes: increase of unsaturated acids pool including omega-3 group and fall of acids responsible for hypercholesterolemia.In recent years the interest in conjugated linoleic acid (CLA) which is important for human health was increased (Sebedio, 2001). Effect of feeding CLA on change in pig performance, carcasss composition, change of saturated and unsaturated fatty acids content, lipid oxidation and meat colour was investigated by Thiel-Cooper et al. (2001), Joo et al. (2002), Bee et al. (2002), Dugan et al. (2003), Sun et al. (2004).

The CLA concentration in meat depends on CLA content in feed. Dietary CLA was incorporated into pig tissues and had positive effects on performance and body composition and positively effects the health of consumers.

Effect of breed, gender and fatness on fatty acid composition

Meat fatty acid composition is influenced by genetic factors, although to a lower extent than dietary factors. Differences in fatty acid composition between breeds and genotypes can be largely explained by differences in fatness. The contents of SFA and MUFA increase faster with increasing fatness then those content of PUFA resulting in decrease in the relative proportion of PUFA and consequently in the PUFA/SFA (P/S) ratio. For pork, the intramuscular fat level also affects the P/S ratio, but nutrition will have a larger impact. The fat level also influences the n-6/n-3 PUFA ratio, due to the difference of this ratio in polar and neutral lipids. However, these effects are much smaller then the effects that can be achieved by dietary means. After correction for fat level, breed or genotype differences in the MUFA/SFA ratio and in the longer chain C20 and C22 PUFA metabolism have been reported, reflecting the possible genetic differences in fatty acid metabolism (De Smet et al., 2004). The content of SFA is increased with increasing intramuscular fat content, it means the unsaturated fatty acid content is decreasing. The animals with higher meatness show lower SFA content and higher unsaturated fatty acids content in meat (Altmann et al., 1992). In pig, intramuscular fat content appears to be highly heritable - h^2 estimates generally of 0,4-0,6 (Schwörer et al., 1990; Selier et al., 1994). Lengerken et al. (1991) investigated the carcass fat quality and fatty acid composition in the M. longissimus of castrated pigs and sows. There was no different in the fatty acid composition. The correlation coefficients between fatyy acid composition and parameters of fattening performance and composition were in the low to medium range. Intramuscular fat of Duroc pigs had a higher concentrations of SFA and MUFA, and lower PUFA content then Landrace pigs (Cameron et al., 1991; Mason et al., 2005). The adipocyte diameter of backfat, intermuscular fat and intramuscular fat in Pietrain pigs is lower than in obese phenotypes (Hauser et al., 1997). The effect of breed (Large White and Creole pigs) on carcass composition and meat quality characteristics was studied by Renaudeau et al. (2005). Creole pigs had a higher backfat thickness and showed higher intramuscular fat percentage in longissimus dorsi muscle (3,45 vs. 2,46%, P<0,001), more SFA (40,0 vs. 37,9%) and MUFA (40,6 vs. 38,4%) and lower concentration of linoleic and linolenic acid in backfat than the LW pigs (17,3 vs. 21,1% and 0,96 vs. 1,31%, respectively). Whatever the breed, the females were leaner (P<0,05) than the castrated males. The SFA concentrations were lower in females than in castrated males. The effect of breed and gender on fatty acid composition of intramuscular fat was studied by Nürnberg et al. (1989), Schwörer et al. (1989), Kondracki et al. (1998) and Benito et al. (1998).

The quality traits of the subcutaneous adipose tissue in "traditional" Landrace x Large White and commercial hybrid pigs slaughtered at an average live weight of about 165 kg were studied by Lo Fiego et al (2005). The relationship between lipid composition, live weight and carcass fatness were investigated. The fatty tissue of L x LW pigs showed a higher lipid (91,18% vs. 90,18%, P<0,01) content. The commercial hybrids had higher PUFA (16,53% vs. 13,75%, P<0,01), and a smaller SFA (38,20% vs. 40,26%, P<0,01) content. An increased slaughter weight was associated with a lower degree of lipid unsaturation, but only the lowest weight class (<160kg) showed a significant difference compared to the other two classes, greater than or equal to 160 <170 and greater than or equal to 170 kg. Regardless of genetic type or live weight class, an increase in backfat thickness is associated with an increased SFA, MUFA and a remarkable reduction in PUFA content. The comparison of growth, fat deposition, carcass and meat quality characteristics of the Basque Black Pied and Large White pigs is described in study by Alfonso et al. (2005). Basque pigs showed a lower growth and feed efficiency and higher backfat depth (2,6 vs. 1,7 cm, P P<0,001) than Large White pigs. Differences in fatty acid composition were observed between breeds but there were not statistically significant (P>0,05). No significant differences among the three genotypes (Mangalica, Hungarian Large White x Hungarian Landrace, Mangalica x Duroc) in fatty acid composition were detected by Csapó et al. (1999). Breed influences growth rate and fatness, the modern breeds (Duroc, Large White) are faster-growing with leaner carcasses then traditional breeds (Berkshire, Tamworth). Breed affected the fatty acid composition of intramuscular neutral lipid, with high % values for the SFA in traditional breeds (fat carcasses) and high values for PUFA in modern breeds (Wood et al., 2004). Monin et al. (2003) presents the influence of breed on fatty acid content in Large White and Pietrain pigs. There was higher SFA and MUFA content and lower PUFA content in LW pigs.

References

Applied literature sources are available by request

Supported by the Ministry of Agriculture of the Czech Republic (Project No. MZE 0002701403)