Meat Science 108 (2015) 61–66

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Effect of dietary inclusion of a herbal extract mixture and different oils on pig performance and meat quality

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ARTICLE INFO

Article history:
Received 29 July 2014
Received in revised form 15 May 2015
Accepted 19 May 2015
Available online 22 May 2015

Keywords:
Plant extracts
Fattening pigs
Meat quality
Oxidative stability

ABSTRACT

The aim of the study was to evaluate the effect of a herbal extract mixture on pig performance and meat quality. The experiment was performed on 60 fatteners (60 ± 0.5–112 ± 2.0 kg). Group I (control) was fed with standard feed; groups II and III received the same feed supplemented with 150 mg BHT or 500 mg of a herbal extract mixture (sage, nettle, lemon balm and coneflower) per kg of feed, respectively. In each group, half of the animals received 4% rapeseed oil, the other half soybean oil. The herbal extracts had no effect on animal performance but significantly improved meat oxidative stability, lowered cholesterol and TI index and increased PUFA content in meat. Slight differences between animals fed with rapeseed or soybean oils were observed. Gilt meat had significantly better ($P \le 0.01$) AI, TI, and h/H indices than barrow meat. It was concluded that herbal extracts have a beneficial effect on pork health-promoting properties due to changes in lipid fraction.

1. Introduction

Herbs and their extracts have been used in human and veterinary medicine for a long time (Viegi, Pieroni, Guarrera, & Vangelisti, 2003). Herbs have many positive effects, of which antimicrobial and antioxidant activity is the most important (Windisch, Schedle, Plitzner, & Kroismayr, 2008). According to a European Union directive, antibiotics and chemical growth promoters have been withdrawn from farm animal feeds (Anadón, 2006); recently, herbs or herbal extracts have attracted increasing interest as an alternative feeding strategy to replace them (Hernández, Madrid, Garcia, Orengo, & Megias, 2004). The health-related effect of plants depends on their content of active principles. Sage (*Salvia officinalis*) contains phenolics, mainly flavonoid glycosides, which exert anti-inflammatory and antioxidative activity (Lu & Foo, 2001). Lipid peroxidation is reduced by nettle (*Urtica dioica*), which also enhances the antioxidant defense system in rats (Kanter et al., 2003). Another plant with similar properties is lemon balm (*Melissa officinalis*) whose antimicrobial activity *in vitro* was found by Mahady et al. (2005). Also, purple coneflower (*Echinacea purpurea*), used previously in folk medicine, is now the subject of research and its immunologic activity established (Goel et al., 2005).

The quality of fat in animal tissue results not only from genetic background but also from feed components, especially plant-origin oils rich in polyunsaturated fatty acids (PUFA). Data available in the literature indicate that dietary fat affects the fatty acid profile of carcass lipids determining fat and meat quality (Benz et al., 2011b; Xu et al., 2010). From the health point of view, high content of PUFA in pork is desirable; however, their influence on meat oxidative stability, shelf life and processing is undesirable. Moreover, they lead to deterioration of organoleptic quality, since compounds formed during the oxidation process have a negative effect on the meat's taste and flavor (Faustman & Cassenas, 1990; Guo et al., 2006). Fat and meat quality should thus be balanced by feed additives or supplementation.

To our knowledge, there are no reports of the combined impact of herbal extract mixture and oils rich in polyunsaturated fatty acids on growth performance and pork quality. However, these different feeding supplements could have additive or interactive effects. Therefore, a study was conducted to test the hypothesis that dietary supplementation of rapeseed or soybean oils and herbal extract mixture (sage, nettle, lemon balm and coneflower) could improve the performance and meat quality of fattening pigs. In addition, the effect on fatty acid profile, meat oxidative stability and sensory traits induced by herbal extract mixture compared to synthetic antioxidant (BHT, butylated hydroxytoluene) was also investigated.

The aim of the present experiment was to assess the effect of supplementation of feeds containing rapeseed or soybean oils with a mixture of extracts from sage, nettle, lemon balm and coneflower on the performance and meat quality of fattening pigs.

2. Material and methods

2.0.1. Animals and experimental design

The experiment was performed on 60 fattening pigs derived from Polish Landrace × Polish Large White sows mated with a Duroc × Pietrain boar. Pigs were allocated to three groups of 20 animals (10

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http://dx.doi.org/10.1016/j.meatsci.2015.05.020
0309-1740/

gilts and 10 barrows) each. Group I (control) was fed with a basic feed mixture (Table 1) with no supplement. Group II received the same mixture supplemented with 150 mg of BHT per kg. Group III received 500 mg of dried herbal extract mixture per kg of feed. The BHT (butylated hydroxytoluene, a commercially used antioxidant) was supplied by Sigma-Aldrich. The herbal extract was a mixture of water extracts from sage (*Salvia officinalis*), nettle (*Urtica dioica*), lemon balm (*Melissa officinalis*) and coneflower (*Echinacea purpurea*) in a w/w ratio of 40:20:20:20, respectively. Extracts were supplied by Phytopharm Ltd., Nowe Miasto nad Wartą, Poland. In each group half the animals (10 pigs, *i.e.,* 5 barrows and 5 gilts) received 4% rapeseed oil, the second half soybean oil.

At the beginning of the experiment, each pig weighed about 60 ± 0.5 kg. Animals were kept in individual straw-bedded pens and fed individually twice a day with restricted feed amounts, according to body weight: from 2.8 kg/d of feed mixture at 60 kg of body weight to 3.2 kg/d at 80 kg of body weight and up. The individual body weights of all fatteners were recorded every two weeks. During the trial, animals had free access to water. At the end of the experiment all animals were slaughtered at about 112 ± 2.0 kg of body weight.

2.1. Sampling and analysis

2.1.1. Physical parameters

The quality of carcasses was evaluated according to Tyra and Żak (2012). Samples of the *longissimus thoracis* (LT) muscle were taken for analysis from the area of the last thoracic vertebrae. Meat acidity was measured 45 min and 24 h after slaughter with a pH meter equipped with a Metron OSH 12–00 electrode. Using the CIE (L*a* b*) system, the color of fresh meat and meat after 5 months of storage at −20 °C was estimated with a Minolta colorimeter. On this basis, chroma C* and total color difference ΔE* was calculated according to MacDougall (2002):

$$C^* = \left(a^{*2} + b^{*2}\right)^{1/2}$$

$$\Delta E^* = \left[\left(\Delta L^*\right)^2 + \left(\Delta a^*\right)^2 + \left(\Delta b^*\right)^2\right]^{1/2}.$$

The water-holding capacity of meat was measured according to Grau and Hamm (1953).

2.1.2. Cholesterol and fatty acid content

Cholesterol content was estimated according to Rhee, Dutson, Smith, Hostetler, and Reiser (1982). The fatty acid profile was determined using a CP-Wax 58 capillary column (Varian BV, Middelburg, the Netherlands) (25 m, 0.53 mm, df − 1 μm, carrier gas − helium, 6 mL/min), with a column oven temperature program from 90 to 200 °C, using a Varian 3400 gas chromatograph (Varian Associates Inc., Walnut Creek, USA) equipped with a Varian 8200 CX Autosampler (200 °C), FID detector (260 °C), and Star Chromatography Workstation software (ISO, 2011) with extraction of lipids from tissues according to the method of Folch, Lees, and Stanley (1957).

2.1.3. Oxidative stability evaluation

The level of thiobarbituric acid reactive substances (TBA-RS) was analyzed after 2 weeks and 5 months of storage at −20 °C. Meat samples were prepared according to the method of Salih with modifications (Pikul, Leszczyński, & Kummerow, 1989). Lipid quality indices, *i.e.,* atherogenic index (AI) and thrombogenicity index (TI) were calculated (Σg/100 g) according to Ulbricht and Southgate (1991):

$$AI = [(4 \times C14{:}0) + C16{:}0] / [n-6\ PUFA + n-3\ PUFA + MUFA]$$

$$TI = [C12{:}0 + C14{:}0 + C16{:}0 + C18{:}0] / [(0.5 \times MUFA) + (0.5 \times n-6 PUFA) + (3 \times n-3\ PUFA) + n-3 / n-6\ PUFA]$$

The hypocholesterolemic (h) to hypercholesterolemic (H) ratio (h/H) was calculated according to Fernández et al. (2007):

$$h/H = (C18:1 + C18:2 + C18:3 + C20:4 + C20:5 + C22:6) / (C14:0 + C16:0).$$

The peroxidisability index (PI) was calculated (Σg/100 g) according to Arakawa and Sagai (1986):

$$PI = (\%\ monoenoic \times 0.025) + (\%\ dienoic \times 1) + (\%\ trienoic \times 2) + (\%\ tetraenoic \times 4) + (\%pentaenoic \times 6) + (\%\ hexaenoic \times 8).$$

The iodine value (IV) of fat was calculated using the following equation (AOCS, 1998):

$$IV(g/100\ g) = (C_{16:1}) \times 0.95 + (C_{18:1}) \times 0.86 + (C_{18:2}) \times 1.732 + (C_{18:3}) \times 2.616 + (C_{20:1}) \times 0.785 + (C_{22:1}) \times 0.723.$$

2.1.4. Antioxidant capacity assessment

The antioxidant activity of extracts was estimated with the *in vitro* spectrophotometric method using synthetic ABTS radical cation assay (Re et al., 1999). Results were expressed as TEAC (Trolox Equivalent Antioxidant Capacity). The content of phenolic compounds was analyzed spectrophotometrically according to Singleton and Rossi (1965) using the Folin–Ciocalteu reagent. Results were expressed as a GAE (Gallic Acid Equivalent).

2.1.5. Sensory analysis

The sensory evaluation of meat after 5 months of storage at −20 °C was made on a 5-point scale (1: poorest, 5: best). Samples were thawed at +4 °C, cut into slices approximately 30 mm thick and boiled in 0.6%

Table 1
Ingredients, chemical composition and fatty acid composition of basal feeds supplemented with different oils.

	Mixtures containing rapeseed oil	Mixtures containing soybean oil
Ingredients (g/kg)		
Barley, ground	628.1	628.1
Wheat, ground	100	100
Soybean meal	160	160
Wheat bran	50	50
Rapeseed oil	40	–
Soybean oil	–	40
Dicalcium phosphate	2.7	2.7
Limestone	11	11
Salt	2.2	2.2
Vitamin–mineral premix[a]	5	5
L-lysine	1	1
Chemical composition		
Metabolizable energy (MJ/kg)	13.2	13.2
Crude protein (g/kg)	154	154
Lysine (g/kg)	8.42	8.42
Methionine + Cystine (g/kg)	5.41	5.41
Fatty acids composition (% of total fatty acids)		
C14	0.30	0.38
C16	13.72	16.28
C18	2.64	2.83
C18:1	43.77	31.07
C18:2	31.61	44.85
C18:3	6.83	3.99
C20	0.32	0.32
C22:1	0.38	0.16
C22:2	0.43	0.12

[a] Premix in 1 kg: Vitamin A — 1,000,000 IU; Vitamin D_3 — 200,000 IU; Vitamin E — 7.0 g; Vitamin K_3 — 0.15 g; Vitamin B_1 — 0.15 g; Vitamin B_2 — 0.4 g; Vitamin B_6 — 0.3 g; Vitamin B_{12} — 0.002 g; pantothenic acid — 1.0 g; choline chloride — 20 g; biotine — 0.01 g; folic acid — 0.2 g; nicotinic acid — 2.0 g; manganese — 4 g; iodine — 0.08 g; zinc — 8 g; iron — 10 g; copper — 4 g; cobalt — 0.04 g; selenium — 0.02 g.