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Effects of genotype and dietary oil supplementation on performance, carcass traits, pork quality and fatty acid composition of backfat and intramuscular fat

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ABSTRACT

A 42-day study was conducted to evaluate the effect of genotype: terminal sire line Duroc × F1 (DC×F1); terminal sire line Embrapa MS-115 × F1 (MS-115×F1); and MS-115 × Moura (MS-115×MO) and three dietary oil sources: soybean; canola; and canola + flax, on performance, carcass traits, pork quality, and fatty acid composition. Genotype affected the technological quality of pork and fatty acid profile. MS-115-sired pigs had better meat color and Duroc-sired pigs had higher intramuscular fat content, more saturated fat and better omega-6/omega-3 ratio. Moura breed influenced positively meat tenderness and intramuscular fat. Diet did not affect the technological quality of the meat. Canola or canola + flax oil diet supplementations increased monounsaturated and C18:3 and decreased C18:2 fatty acids, reducing the omega-6/omega-3 ratio. The best omega-6/omega-3 ratio was obtained through supplementation with canola + flax.

1. Introduction

Breed differences in growth, carcass traits and meat quality have been reported in several studies (Augspurger et al., 2002; Brandt, Werner, Baulain, Brade, & Weissmann, 2010; Edwards, Tempelman, & Bates, 2006; Latorre, Medel, Fuentetaja, Lázaro, & Mateos, 2003; Suzuki, Shibata, Kadowaki, Abe, & Toyoshima, 2003), particularly when comparing breeds or highly improved hybrids for growth and lean deposition against less improved breeds (Fabian et al., 2003; Fávero, Figueiredo, Fedalto, & Woloszyn, 2007; Goerl, Eilert, Mandigo, Chen, & Miller, 1995). The Pietrain breed and its progeny are known for low feed intake, slow growth and low carcass fat content compared to other lean type breeds such as Large White and Duroc or its crosses (Augspurger et al., 2002; Bertol et al., 2010; Edwards et al., 2006; Fàbrega et al., 2003; Gispert et al., 2007). Moura is a naturalized Brazilian breed, with low level improvement for growth and lean meat production. The Moura pig and its crosses display slower growth and higher carcass fat than the commercially-improved genotypes (Bertol et al., 2010; Fávero et al., 2007).

It has been reported that the breed of pig influences body fat composition. Breeds or genotypes with higher body fat content tend to have a higher proportion of saturated fatty acids and lower proportion of unsaturated fatty acids (Lo Fiego, Santoro, Macchioni, & de Leonibus, 2005; Suzuki et al., 2003; Zhang et al., 2007). Furthermore, the effect of supplemental fat on carcass fat deposition may be dependent on the genotype (Olivares, Daza, Rey, & Lopez-Bote, 2009). The metabolism of individual fatty acids, including oxidation, synthesis and conversion to other fatty acids differs; depending on numerous factors such as sex, due to the use of some fatty acids for the synthesis of hormones and prostaglandins (Kloareg, Noblet, & van Milgen, 2007).

The fatty acid profile of the diet has been extensively examined in monogastric animal research, in view of the possibility of adjusting the fatty acid composition of animal fat to produce healthier foods for human consumption. However, feeding highly unsaturated oil to pigs could negatively impact carcass fat for further processing due to the reduction of the fat melting point (Averette Gatlin, See, Hansen, & Odle, 2003; Rentfrow, Sauber, Allee, & Berg, 2003). Moreover, the flavor and odor of fresh pork and processed products may be negatively affected due to polyunsaturated fatty acids being more susceptible to oxidation (Daza, Rey, Ruiz, & Lopez-Bote, 2005; Musella et al., 2009). On the other hand, more saturated fat can favor fat quality for processing due to its higher melting point and better oxidative stability. Canola, soy and flax oil possess distinct fatty acid profiles (NRC, 1998), with a predominance of unsaturated fatty acids C18:1, C18:2 and C18:3, respectively. However, the polyunsaturated fatty acid content of soybean and flax oils is twice that of canola oil.

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Dietary supplementation with different vegetable oils or animal fats has been investigated in previous studies, with varying results regarding the performance and carcass quality (Benz et al., 2011; Myer, Lamkey, Walker, Brendemuhl, & Combs, 1992; Nuernberg et al., 2005; Olivares et al., 2009; Soler-Velasquez et al., 1998; Teye et al., 2006). It has been shown that fat deposition in the carcass may be influenced by the degree of fat saturation, genotype and gender (Averette Gatlin et al., 2003; Olivares et al., 2009).

In monogastric animals the fatty acid profile of the diet is reflected in body fat, because part of the ingested fatty acids is deposited directly into the tissues. This effect has been reported in several studies assessing different fat sources for finishing pigs (Apple, Maxwell, Galloway, Hamilton, & Yancey, 2009a; Apple, Maxwell, Galloway, Hamilton, & Yancey, 2009b; Apple, Maxwell, Galloway, Hutchison, & Hamilton, 2009c; Benz et al., 2011; Enser, Richardson, Wood, Gill, & Sheard, 2000; Juárez et al., 2010; Kouba, Enser, Whittington, Nute, & Wood, 2003; Lauridsen, Nielsen, Henckel, & Sorensen, 1999; Nuernberg et al., 2005; Olivares et al., 2009; Teye et al., 2006; Zanardi et al., 1998). These changes in the fatty acid profile have been observed in different body fat depots, resulting in changes in the omega-6/omega-3 ratio and in the melting point of the fats.

Considering that, the metabolism of individual fatty acids may be dependent on genotype and sex, fatty acids may alter the genetic expression linked to the development of adipose tissue, and part of the ingested fatty acids can be deposited directly into adipose tissue, the dietary fatty acid profile might influence not only the fatty acid profile of body fat, but also the amount of fat deposited depending on the genotype. Taking this into account, the aim of this study was to evaluate the effect of genotype and source of dietary oil on the performance, carcass traits, pork quality and fatty acid composition of pigs.

2. Material and methods

2.1. Animals and treatments

The experimental protocol was approved by the Ethics Committee for Animal Experimentation of Embrapa Swine and Poultry, in accordance with the ethical principles for animal experimentation established by the Brazilian College of Animal Experimentation.

The study was conducted in a randomized complete block design with a 3 × 3 × 2 factorial arrangement: a) Genotype: pigs were the progeny of (1) Terminal sire line Duroc × F1 females (DC×F1), (2) terminal sire line Embrapa MS-115 × F1 females (MS-115×F1), and (3) MS-115 × Moura breed females (MS-115×MO); b) Treatments consisted of dietary oil supplementation from different sources (1) 3% soybean oil, (2) 3% canola oil, and (3) 1.5% canola oil + 1.5% flax oil; and c) Gender: gilts and barrows.

Ninety pigs (45 barrows and 45 gilts), with an initial age of 130.7 ± 3 days were assigned to the treatments according to genotype, gender and block (initial weight within gender and genotype), with a total of 5 barrows and 5 gilts from each genotype per treatment. Moura is a traditional local breed, with a low level of improvement for growth and lean meat production. Terminal sire line Embrapa MS-115 is the synthetic line of Pietrain (62.5%), Large White (18.75%) and Duroc (18.75%) breeds. The Duroc sire line was representative of the Duroc breed in Brazil, Canada and the USA. The MS-115, Duroc and Moura stock originated from the nucleus farm of Embrapa's genetic breeding program. The F1 females came from commercial suppliers. Prior to the experiment, the animals had been reared at an Embrapa Swine and Poultry confined pig production unit.

2.2. Diets and handling procedure

The diets were based on corn and soybean meal and were formulated to be isocaloric and to meet or exceed the nutritional requirements established by Rostagno (2005) for pigs weighing 70 to 120 kg (Table 1). The energy contents of the oils used to compose the diets were obtained from the NRC (1998). For the flaxseed oil, the energy content was the same as that of the canola oil. The oils were assayed for fatty acid profile (Table 2).

The pigs were housed in individual pens, with part-compact, part-slatted concrete floor, and equipped with nipple drinkers and semi-automatic feeders, allowing the pigs *ad libitum* access to feed and water. The pens were delimited by slatted walls.

Individual body weight and feed intake were measured after 21 days and at the end of the experiment. After 42 days of the experiment, the pigs were transported to the slaughterhouse, located 100 km from the experimental facilities, and killed by bleeding after electrical stunning, according to industry standards. The pigs were weighed in the morning and the diets were withdrawn at 3:00 p.m. the day before slaughter. The following morning, the pigs were loaded at 3:00 a.m., transported to the slaughterhouse, and killed after 4 h of lairage. Following the slaughter procedures the carcasses were stored in a chilling room at 2 to 4 °C for 24 h.

Backfat and loin depth were measured in the hot carcass, 6 cm from the mid-line on the last rib using a Henessy Grading Probe (Henessy Grading System probe, model GP4). The lean percentage of the carcass was predicted from hot carcass weight, backfat and loin depth, using the equation from the slaughterhouse.

Table 1
Feed ingredients and nutrient content of experimental diets.

	Weeks 1–3			Weeks 4–6		
	T1	T2	T3	T1	T2	T3
Ingredients, %						
Corn	63.555	63.155	63.155	68.059	67.607	67.607
Soybean meal	18.858	18.728	18.728	12.641	12.588	12.588
Wheat bran	12.054	12.584	12.584	13.915	14.424	14.424
Soybean oil	3.000	–	–	3.000	–	–
Canola oil	–	3.000	1.500	–	3.000	1.500
Flaxseed oil	–	–	1.500	–	–	1.500
Limestone	0.780	0.784	0.784	0.670	0.673	0.673
Di-calcium phosphate	0.699	0.693	0.693	0.707	0.700	0.700
Salt	0.355	0.355	0.355	0.355	0.355	0.355
L-Lysine HCl	0.186	0.188	0.188	0.180	0.180	0.180
DL-Methionine	0.021	0.021	0.021	–	–	–
L-Threonine	0.056	0.057	0.057	0.038	0.038	0.038
Vitamin premix[a]	0.100	0.100	0.100	0.100	0.100	0.100
Mineral premix[b]	0.100	0.100	0.100	0.100	0.100	0.100
Adsorbent	0.200	0.200	0.200	0.200	0.200	0.200
Growth promoter[c]	0.020	0.020	0.020	0.020	0.020	0.020
BHT	0.015	0.015	0.015	0.015	0.015	0.015
Calculated nutrient content (as fed)						
ME, MJ/kg	13.95	13.95	13.95	13.95	13.95	13.95
Crude protein, %	15.35	15.34	15.34	13.11	13.12	13.12
True digestible lysine, %	0.81	0.81	0.81	0.66	0.66	0.66
Ca,%	0.55	0.55	0.55	0.50	0.50	0.50
Available P, %	0.25	0.25	0.25	0.25	0.25	0.25
Ether extract, %	6.38	6.38	6.38	6.51	6.50	6.50
∑ Saturated fatty acids, %	0.87	0.64	0.72	0.88	0.65	0.74
C18:1, %	1.37	2.37	1.85	1.39	2.39	1.87
C18:2, %	3.25	2.32	2.27	3.32	2.40	2.34
C18:3, %	0.26	0.34	1.12	0.26	0.33	1.11
Analyzed nutrient content (as fed)						
Crude protein, %	15.53	15.65	15.73	13.23	14.07	14.14
Ether extract, %	6.03	5.65	5.85	6.13	6.19	6.33

[a] Content/kg of diet: 7000 UI vitamin A; 1300 UI vitamin D3; 40 UI vitamin E; 1.5 mg vitamin K3; 1.35 mg vitamin B1; 4 mg vitamin B2; 2.3 mg vitamin B6; 25 mcg vitamin B12; 0.15 mg biotin; 1 mg folic acid; 30 mg nicotinic acid; 13 mg pantothenic acid.
[b] Content/kg of diet: 118 mg Fe; 20 mg Cu; 40.6 mg Mn; 105 mg Zn; 1 mg Co; 0.29 mg I and 0.25 mg Se.
[c] Tylan 40.