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Fatty acid profile of the sow diet alters fat metabolism and fatty acid composition in weanling pigs

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ABSTRACT

The purpose of this study was to compare the influence of adding 35 g/kg of different sources of fat (lard *vs.* sunflower oil) to diets for sows on the composition of fatty acids (FA) in the tissues of the progeny at weaning and one week after weaning (28 and 35 days of age respectively). Sows ($n = 20$) were fed with the experimental diets from day 35 of gestation and during lactation. When lard (L) was included in the sows' diet, increased concentrations of C18:1n-9 were found, whereas C18:2n-6 decreased in both colostrum and milk ($P<0.01$). Milk from sows fed L showed higher ($P<0.001$) C16:0 and C18:1n-7 concentration in colostrum than those that were fed sunflower oil (SFO). On the first week after weaning, time effect was observed on intramuscular fat content in the pigs ($P<0.012$). Type of fat of the sow diet affected ($P<0.05$) C14:0, C16:1n-7, C17:1, C18:0, C18:1n-9, C18:1n-7, C18:2n-6, C20:1n-9 and C20:3n-9 concentration in the subcutaneous fat of the offspring. The intramuscular concentration of monounsaturated FA in pigs changed with time ($P<0.001$). In addition, an interaction between sow diet and sampling time in the pigs was observed; the decrease in the concentration of intramuscular FA was more pronounced in pigs from sows fed SFO than in pigs from sows fed the L. Moreover the L3HOAD (EC 1.1.135) activity was higher in pigs from sows fed SFO than in those from sows fed L ($P<0.001$). The administration of polyunsaturated FA to gestating and lactating sows increased FA beta-oxidation in pigs after weaning which could help the mobilization of body reserves in this critical period.

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1. Introduction

Fats are used in swine feeding as a concentrated source of energy. It is assumed that all digested fatty acids (FA) are equally useful for metabolic purposes and consequently, a wide range of dietary FA is used in practical swine nutrition. In growing pigs receiving adequate feed, the oxidation of dietary lipids is limited and most of the digested FA are stored with only minor modifications (Chwalibog et al., 1992). Consequently, body lipid composition depends largely on previous fat intake (Sampels et al., 2011). In lactating sows dietary fat is mainly transferred to mammary glands, increasing milk lipid

Abbreviations: BW, body weight; CPT I, carnitine palmitoyl transferase I; CP, crude protein; EGTA, ethylene glycol tetraacetic acid; FA, fatty acids; FAS, fatty acid synthetase enzyme; G6PD, glucose-6-phosphate dehydrogenase; L3HOAD, L-3-hydroxyacyl-CoA dehydrogenase; L, lard; MUFA, monounsaturated fatty acids; NADPH, nicotinamide adenine dinucleotide phosphate; NE, net energy; PUFA, polyunsaturated fatty acids; SD, standard deviation; SFA, saturated fatty acids; SFO, sunflower oil.

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concentration (Quiniou et al., 2008) and altering the FA composition of the milk and piglets' tissues (Gerfault et al., 1999; Rooke et al., 2001; Cordero et al., 2011).

Fat saturation may affect lipid metabolism. Shimomura et al. (1990) reported that lower fat deposition in rats, fed a diet rich in safflower oil than in those that fed tallow. Power and Newsholme (1997) found higher carnitine palmitoyl transferase I (CPT I) activity in heart mitochondrial isolates from rats fed safflower oil (high in linoleic acid) and menhaden oil (high in long chain n-3 FA) diets than from rats fed diets low in fat or enriched in olive oil or hydrogenated coconut oil. Sanz et al. (2000) observed that broiler chickens fed sunflower oil (SFO) diet had higher specific activity of heart enzymes involved in fat catabolism: CPT I and L-3-hydroxyacyl-CoA dehydrogenase (L3HOAD) than broilers fed tallow. They also found lower specific activity of FA synthetase enzyme (FAS), the main enzyme involved in FA synthesis in the liver. The information regarding the effect of dietary fat saturation on fat catabolism in swine is limited and not conclusive. Duran-Montgé et al. (2008) observed a limited effect of dietary fat saturation in growing pigs under anabolic state. As far as the authors are aware, there is no information on the possible effects of dietary fat on lipid metabolism under challenging productive situations, where energy supply depends on beta-oxidation of previously stored lipids.

Energy reserves at birth are crucial for the survival of newborn pigs. The body fat reserves of the pig at birth are rather low (approximately 20 g/kg) and its contribution to energy supply is of limited importance (Gu and Li, 2003). Chapman et al. (2000) found that maternal and early after weaning dietary polyunsaturated FA (PUFA) intake enhanced lipid catabolism (lipoprotein lipase activity) in young rats. Rooke et al. (2001) showed that n-3 PUFA supplementation of sow diets increased pig survival during lactation. This experiment was conducted to test the hypothesis that the degree of saturation provided to gestating and lactating sows may affect FA composition and metabolism of weaned pigs.

2. Materials and methods

2.1. Animal and experimental diets

The animal care routine and experimental procedures used in this experiment were approved by the Universidad Complutense of Madrid and were in compliance with the Spanish guidelines for the care and use of animals in research (Boletín Oficial del Estado, 2007).

Twenty multiparous sows (Landrace × large white) in the 3–6 parities, with a BW of 276.5 ± 38.04 kg (mean ± SD) were randomly selected and assigned to two dietary treatments that differed exclusively in the fat source: lard (L) and SFO. The sows were housed individually in pens (2.2 m × 2.4 m) with partly slatted floor. At weaning (28 days), eight sows per treatment that farrowed on same day were randomly selected and two male pigs per sow were selected. One pig per sow was slaughtered immediately after weaning and the other was housed individually (1 m × 1 m) and was slaughtered one week after weaning. After weaning, pigs were fed a common diet that contain 10.5 MJ net energy (NE), 1.5 g lysine, 50 g crude fat, 203 g crude protein/kg, and 18 g C16:0, 6.1 g C18:0, 30.1 g C18:1n-9 and 40.4 g C18:2n-6 per 100 g total FA. Room temperature was maintained at 29 ± 2 °C. Pigs were slaughtered by intracardiac injection of a lethal dose (3 mL) of sodium pentobarbital (200 g/L, Dolethal; Vetoquinol, Lure cedex, France).

Ingredient composition and chemical analyses of the experimental diets are shown in Table 1. Sows received the gestation diets twice daily and had *ad libitum* access to water. From day 108 to 111 of pregnancy, sows received 25.5 MJ of NE daily. Farrowing sows received 20 MJ NE per day, and then 20–25 MJ NE for two days after farrowing. Thereafter, feed was provided for *ad libitum* consumption. Piglets had no access to creep or sow feed before weaning.

2.2. Measurements and sampling

Immediately after parturition and 14 days after farrowing colostrum or milk samples were collected from the functional glands of each sow. Briefly, approximately 10 mL of colostrums or milk were obtained after intramuscular injection in the neck of 1 mL oxytocin (Ganadil Pituit, Invesa, Madrid), and samples were frozen immediately at −20 °C for chemical analysis. Backfat thickness was measured by ultrasound at 65 mm from the midline, at the level of last rib both at farrowing and at weaning using a Renco Lean Meater (Renco Corporation, Minneapolis, Minnesota, USA).

Total number of pigs born, born alive and weaned and litters weight were recorded at farrowing and at weaning. Piglets selected for the study were individually weighed at weaning and one week after weaning, heart, liver and subcutaneous fat samples were taken immediately after slaughter and stored in liquid nitrogen until enzyme activity analysis. Then, the carcasses were chilled to 4 °C and samples of muscle Longissimus dorsi and subcutaneous fat were taken and stored at −20 °C.

2.3. Sample analysis

Chemical composition of experimental diets was calculated according to Fundación Española para el Desarrollo de la Nutrición Animal (2010). The FA of the lyophilised samples were extracted and quantified by the one-step procedure as described by Sukhija and Palmquist (1988). Pentadecanoic acid (C15:0) (Sigma–Aldrich, Madrid, Spain) was used as an internal standard. Fatty acid methyl esters were analyzed by gas chromatography using a Hewlett Packard HP-6890 (Avondale, PA,

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