Differences in fatty acid metabolisms in domestic animals: some dilemmas and ideas to address body composition and obesity control

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Introduction

Relatively high amounts of fats or oils (> 40-50 g/kg diet) are frequently used in animal nutrition. Vegetables oils are richer in polyunsaturated fatty acids than animal fats. Most of the works studying the effect of different dietary fat sources are focused either on the existing differences on fat digestibility depending on their fatty acid composition (Wiseman et al., 1991) or on their effect on the carcass fat fatty acid profile (Sanz et al., 1999a). Information regarding the effect of dietary fat saturation on fat utilization and deposition it is more limited. It is generally assumed that, apart from differences in digestion, fatty acids of different composition are equally used for metabolic purposes.

Dietary fat type vs fat deposition. Observation in growing animals

In growing animals with adequate feed intake there is limited oxidation of dietary lipids, and most digested fatty acids are stored with minor modification (Chwalibog et al., 1992). Thus body lipid composition depends largely on previous fat intake (Sampels et al., 2011). There is a controversy on the effect that dietary fat type may have on body fat accumulation. In one hand, some authors failed to find any effect on dietary fat type on abdominal fat deposition in broiler chickens (Pinchasov and Nir,, 1992). On the other hand, some other reports suggest that feeding broiler chickens with polyunsaturated dietary fat may result in lower abdominal fat deposition (Pan et al., 1979; Vila and Esteve-García, 1996; Crespo and Esteve-Garcia, 2002; Ferrini et al., 2010). Sanz et al. (1999b), fed broiler chicks iso-energetic and iso-nitrogenous diets differing in the fat source (animal fat blend or sunflower oil). Broiler fed sunflower oil enriched diets deposed significantly less abdominal fat than those fed animal fat blend enriched diets. Moreover, the same authors carried out a second trial in which the effect of three dietary fat sources (tallow, lard and sunflower oil) on abdominal and intramuscular fat content was also assessed. Results indicated that as the level of dietary polyunsaturated fatty acids increased, the amount of abdominal fat and breast meat intramuscular fat significantly decreased. In both trials chickens performances were similar among experimental treatments. Results of these experiments suggest that dietary fat saturation markedly affect abdominal fat deposition.

Power and Newsholme (1997) found higher carnitine palmitoyl transferase I (CPT I) activity in heart mitochondrial isolates from rats fed diets enriched in safflower oil, evening primrose oil (both

rich in linoleic acid) and menhaden oil (rich in long chain n-3 fatty acids) when compared to those rats fed low fat diets or diets enriched in olive oil or hydrogenated coconut oil. Sanz et al. (2000) observed that broiler chickens fed a sunflower oil enriched diet had higher specific activity of heart enzymes involved in fat catabolism: CPT I and L-3-hydroxyacyl-CoA dehydrogenase (LHOAD) than broilers fed a tallow enriched diet, suggesting that differences in fat metabolism may, at least partially, accounted for the differences in fat deposition. They also found lower specific activity of fatty acid synthetase enzyme (FAS), the main enzyme involved in fatty acid synthesis in the liver. The information regarding the effect of dietary fat saturation on fat catabolism in swine is limited and not conclusive.

These results support the hypothesis that the lower fat deposition may be explained by a higher fat b-oxidation. Powers and Newsholme (1997) also found higher CPT I activity in heart mitochondrial isolates from rats fed diets enriched in sunflower oil, evening primrose oil (both rich in linoleic acid) and menhaden oil (rich in long chain n-3 fatty acids) when compared to that of rats fed low fat diets or diets enriched in olive oil or hydrogenated coconut oil. On the other hand, Duran-Monge et al. (2008) observed limited effect of dietary fat saturation on growing pig lipid metabolism under anabolic state.

Selective fatty acid mobilization of previously stored lipids. Observations in weaned piglets

Following weaning, piglets usually undergo reduced feed intake, thus impairing growth and survival (Wijtten et al., 2011). Thus, weaned piglets must rely on body energy reserves during the first initial days, thus mobilizing previous glycogen and lipid stores to obtain energy (Le Dividich et al., 1980). Consequently, energy reserves at birth are crucial for newborn piglets to avoid early death. Chapman et al. (2000) found that maternal and early dietary polyunsaturated fatty acid (PUFA) intake after weaning enhances lipid catabolism (LPL activity) in young rats. Rooke et al. (2001) showed that n-3 PUFA supplementation in sow diets increased piglet survival during lactation despite a lower birth weight of piglets. We have recently conducted an experiment to test the hypothesis that dietary fat saturation provided to gestating and lactating sows may affect fatty acid composition and metabolism of weaned piglets. Weaning piglet subcutaneous fat reflected milk fatty acid profile, and therefore differences induced by sow dietary treatment were found for C18:1 n-9, C18:1 n-7, C18:2 n-6 and C20:1 n-9. Total SFA at weaning were not affected by dietary treatment, but subcutaneous concentration of MUFA was higher and PUFA was lower in piglets from sows fed a diet containing lard. Concentration of C16:0 in piglet subcutaneous fat was not affected by dietary treatment, but, contrary to expectations, a higher concentration of C18:0 was observed in subcutaneous fat of piglets from sows receiving a diet containing sunflower oil. Moreover, tendencies to increased C18:0 (P=0.063) and decreased C16:1 n-7 (P=0.092) concentrations over the time were also observed. Bee (2000b) and Cordero et al. (2011) observed that changes from milk to solid feed decreased C16:0 and C16:1 n-7 concentrations in subcutaneous fat. These

two experiments measured fatty acid concentration at weaning (28 days) and several weeks thereafter (5 weeks), thus attributing the effect to the higher concentration of these fatty acids in milk than in the solid diet for weaned piglets. In our experiment we observed no effect of sampling time on C16:0 concentrations, and a tendency (P=0.0925) to a lowering effect of sampling time on subcutaneous C16:1 n-7 concentration during the days that immediately follows weaning. In this critical period, limited feed intake occurs and therefore it is not expected a major effect of piglet diet on fatty acid synthesis, thus, suggesting a selective beta-oxidation of previously stored fatty acids during the initial steps of post-weaning adaptation. A similar effect was observed for C12:0, short chain fatty acid, which concentration in subcutaneous fat decreased over the first week that followed weaning (P<0.023). On the other hand, we observed a tendency toward an increased concentration of subcutaneous fat C18:0 concentration over the seven days that followed weaning (P=0.063). Since concentration of subcutaneous fatty acids is expressed relative to total fatty acids (g/100 g), it is believed that there is not really an increase in the total amount of C18:0, but a relative increase due to selective decrease in the concentration of other fatty acids (e.g. C12:0, C16:1 n-7). Concentrations of other fatty acids were not affected by sampling time. These results contradicts a common assumption that dietary and stored fatty acids are all oxidized at a similar rat. Leyton et al. (1987) provided radioactively labeled fatty acids to weanling rats and observed that C12:0 was the most efficient energy substrate, and that the longer the chain of SFA, the lower the rate of beta-oxidation. Leyton et al (1987) also observed a remarkably high oxidation rate for C18:1 n-9 (representative of long chain MUFA), particularly when compared with C18:0 (representative of SFA). On the other hand, Jones et al. (1985) also provided evidence in human subjects which showed the preferential oxidation of C18:1 n-9 compared with C18:2 n-6. They suggested that MUFA are preferentially incorporated into triglycerides, which are a ready source of energy and this probably explains the relatively high oxidation rate for these fatty acid. Neither Jones et al. (1985) nor Leyton et al. (1987) included C16:1 n-7 in their studies to compare relative oxidation rate of fatty acids, although shorter chain length would suggest a more preferential metabolic utilization than longer chain MUFA (C18:1 n-9, C20:1 n-9, C20:3 n-9). Results from our experiment indicate a preferential oxidation of C16:1 n-7 during the critical days that follows piglet weaning. Experiment from Leyton et al. (1987) produced evidence of selective oxidation of dietary lipids during the weaning period. An interaction effect of sampling time and sow diet was observed for most individual fatty acids in which the decrease in intramuscular fatty acid concentration was more marked in piglets from sows fed the diet containing sunflower oil than in those from sows fed a diet containing lard. Result from our experiment reinforce this observation and indicate that this effect also involved previously stored fatty acids.

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