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Duration of dietary linseed feeding affects the intramuscular fat, muscle mass and fatty acid composition in pig muscle

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Abstract

The aim of the study was to investigate the effect of duration of dietary linseed feeding on subcutaneous fat, intramuscular fat depot and muscle mass of growing–finishing barrows. Two isoenergetic and isonitrogenous diets were formulated, and one of which was the basal diet and another one was the linseed diet including linseed at the level of 10%. Twenty-four Landrace × Yorkshire barrows weighing 35 ± 3.7 kg were randomly assigned to four treatments with six replications per treatment. Pigs in treatment 1 (T1) fed the control diet throughout the experimental period, while pigs in T2, T3, and T4 fed the control diet except for 30, 60, and 90 d prior to slaughter when the linseed diet were fed. The experiment was conducted for 90 d. Carcass quality and meat quality data were collected and analyzed. The *longissimus muscle* mass, posas minor mass and each muscle mass in the hind leg were weighted. Additionally, fatty acid composition (%) of the diet, the *longissimus dorsi muscle* and the backfat were analyzed by gas chromatography method. No significant difference ($P>0.05$) was observed for average backfat thickness, lean meat percentage, loin muscle area, whereas the intramuscular fat content increased linearly ($P<0.01$) as prolonged the time of feeding linseed diet. As prolonged the time of feeding linseed diet, the *longissimus dorsi muscle* mass, *quadriceps femoris muscle* mass and *semitendinosus muscle* mass increased linearly ($P<0.01$). Duration of feeding linseed diet linearly increased ($P<0.01$) the C18:3*n*-3, C20:5*n*-3 and C22:5*n*-3 concentrations in the *longissimus* muscle and backfat. There was significant quadratic relation between the intramuscular fat content and the *n*-3 polyunsaturated fatty acids (PUFA) enrichment ($R^2=0.87$, $P<0.01$), or C18:3*n*-3 enrichment ($R^2=0.91$, $P<0.01$) in the *longissimus dorsi muscle*. Likewise, the *longissimus dorsi muscle* mass was also quadratically related to the *n*-3 PUFA enrichment ($R^2=0.89$, $P<0.01$), or C18:3*n*-3 enrichment ($R^2=0.86$, $P<0.01$) in the *longissimus dorsi muscle*. These results indicated that duration of feeding linseed diet may stimulate intramuscular fat accumulation, and promote the hypertrophy of the *longissimus dorsi muscle*, *quadriceps femoris muscle mass and semitendinosus muscle* by increasing the *n*-3 PUFA enrichment, especially C18:3*n*-3 enrichment in the *longissimus dorsi muscle*.

Keywords: Barrows; Intramuscular fat; Linseed; Muscle mass; *n*-3 PUFA

1. Introduction

It is possible to enhance the concentration of beneficial *n*-3 polyunsaturated fatty acids (*n*-3 PUFA) in pig tissues by feeding different fat sources (Isabel et al., 2003; Wood et al., 2003). A potential commercial source of *n*-3 PUFA

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is whole linseed which contains about one-third oil, of which over 50% is α-linolenic acid (ALA; 18:3*n*-3) (Matthews et al., 2000). Many studies showed that feeding 100 g whole linseed/kg linseed or 5% linseed oil as a main source of *n*-3 PUFA to pigs can raise the concentrations of *n*-3 PUFA in pig muscle and adipose tissue without incurring detrimental effects on growth performance and meat quality (Romans et al., 1995a,b; Kouba et al., 2003; Nuernberg et al., 2005).

Most of the studies undertaken on the supplementation of *n*-3 PUFA have examined the effect of *n*-3 PUFA on porcine lipid composition, growth, meat quality and sensory characteristics (Irie and Sakimoto, 1992; Fontanillas et al., 1998; Nuernberg et al., 2005). However, effect of dietary *n*-3 PUFA on the body fat deposition and muscle mass in pigs is poorly documented. Recently, Hsu et al. (2004) reported that feeding 20 g/kg docosahexanoic acid (DHA; C22:6*n*-3) to pigs (30 d of age) for 18 d regulated the lipid metabolism related gene expression in the liver, but not in adipose and muscle tissues. Remarkably, in this short term feeding experiment (18d), the DHA contents in the liver was 9.00% of total fatty acid, whereas 1.60% and 2.36% DHA was observed in adipose and muscle tissues, respectively. In this regard, Hsu et al. (2004) concluded that inability of dietary *n*-3 PUFA enrichment to regulate the lipid metabolism related gene expression in porcine adipose and muscle tissue results from the relatively low level of *n*-3 PUFA content.

It is well known that in specific growth and development period, animals develop their specific traits which are considered to be a result of duration manipulation by nutrients and environmental factors. In the present study, linseed was fed to growing–finishing barrows for three different lengths of time before slaughter at 100 g/kg diet, and the dietary ALA content is calculated to 20 g/kg diet. The aim of this study was to investigate the effect of duration of dietary linseed feeding on subcutaneous carcass fat, intramuscular fat and the muscle mass (the *longissimus dorsi muscle, gluteobiceps muscle, quadriceps femoris muscle, semimembranosus muscle, posas minor muscle, semitendinosus muscle and gracilis muscle*).

2. Materials and methods

2.1. Animals

This trial was carried out in accordance with Huazhong Agricultural University Animal Care and Use Committee guidelines. Twenty-four (Landrace × Large white) 80 days old barrows (at 34.48±2 kg) were fed a control or a linseed diet containing 100 g of whole linseed/kg. The fat content and the digestive energy of the control diet (rich in palmitic acid, C16:0) were equal to those of the linseed diet (high in α-linolenic acid, C18:3n-3). All diets were formulated to meet NRC (1998) nutrient requirement, and diet composition is presented in Table 1. Fatty acid composition (g/100 g of total fatty acids) of diets is shown in Table 2. The 24 barrows were randomly allocated into four treatments with 6 replications per treatment. Pigs were individually penned. Pigs in treatment 1 were fed the control diet throughout the experimental period, whereas pigs in the rest treatments (T2, T3, T4) were fed the control diet except for 30, 60, and 90 d before slaughter when the linseed diet were fed. The experiment was conducted for 90 d. The pigs were fed *ad libitum*. Fresh water was freely available via a nipple drinker in each pen. Each pig was weighed monthly, whereas the feed intake per pen was measured daily.

2.2. Carcass evaluation and sample collection

All the pigs were slaughtered at the end of the experiment after 24 h fasting. The pigs were humanely slaughtered at Huazhong Agriculture University, in Wuhan, Hubei Province and were electrically stunned, exsanguinated. The samples of the adipose tissue, *longissimus dorsi muscle* and liver were collected from the dorsal subcutaneous depot at the neck region, the *longissimus dorsi muscle* between the 10th and last ribs, and right lobe, respectively. All the collected samples were stored at −20 °C for fatty acids analysis.

Table 1
Composition and calculated analysis (as-fed basis) of diets (%)

Item	Growing phase (30–60 kg)		Finishing phase (60–115 kg)	
	Control diet	Linseed diet	Control diet	Linseed diet
Ingredients, %				
Corn	48.70	60.50	52.90	65
Wheat middling	18.00	–	20.00	1.00
Soybean meal	27.00	26.50	21.00	21.00
Fat powder[a]	3.30	–	3.10	–
Linseed	–	10.00	–	10.00
Premix[b]	3.00	3.00	3.00	3.00
Analyzed composition				
CP, %	18.07	18.01	16.05	16.08
Ether extract, %	4.60	4.50	5.05	5.10
DE, Mcal/kg	3.42	3.41	3.40	3.40
Lysine, %	1.07	1.05	0.93	0.95
Calcium, %	0.69	0.66	0.65	0.70
Phosphorus, %	0.50	0.51	0.49	0.55

[a] Fat powder : Fatty acid profile of fat powder, Palmitic acid (C16:0) 70–80%; Stearic acid (C18:0), 5–10%; Oleic acid (C18:1), 8–15%.

[b] Provided per kg of the diet: vitamin A, 11,250 IU; vitamin D_3, 2500 IU; vitamin E, 200 mg; menadione, 2.5 mg; thiamine, 2.5 mg; riboflavin, 6.0 mg; niacin, 25 mg; d-panthothenic acid, 8 mg; vitamin B_6, 3.0 mg; vitamin B_{12}, 0.08 mg; d-biotin, 0.1 mg; folic acid, 12.5 mg; copper, 20 mg; iron, 50 mg; manganese, 30 mg; zinc, 80 mg; iodine, 0.8 mg.