Animal Nutrition 1 (2015) 12–18

Contents lists available at ScienceDirect

Animal Nutrition

journal homepage: http://www.keaipublishing.com/en/journals/aninu/

Original article

Effect of medium-chain triglycerides on growth performance, nutrient digestibility, plasma metabolites and antioxidant capacity in weanling pigs

Yue Li, Hao Zhang, Li Yang, Lili Zhang, Tian Wang*

College of Animal Science and Technology, Nanjing Agricultural University, Nanjing 210095, China

ARTICLE INFO

Article history:
Received 30 October 2014
Accepted 9 January 2015
Available online 10 March 2015

Keywords:
Medium-chain triglycerides
Growth performance
Nutrient digestibility
Metabolites
Lipid peroxidation
Piglets

ABSTRACT

The aim of this study was to investigate the effect of medium-chain triglycerides (MCTs) on growth performance, nutrient digestibility, plasma metabolites and antioxidant capacity in weanling pigs. A total of 160 weanling (Duroc × Landrace × Yorkshire) pigs (age: 21 ± 1 d; body weight: 7.50 ± 0.28 kg) were randomly allotted to 4 treatments, receiving the following diets for 28 d: control diet [containing 3.5% soybean oil (SO)], MCT1 diet (containing 0.7% MCTs and 2.8% SO), MCT2 diet (containing 1.4% MCTs and 2.1% SO) and MCT3 diet (containing 2.1% MCTs and 1.4% SO). Dietary inclusion of MCTs improved the average daily gain and feed efficiency (FE) of pigs compared with the control during the first 2 weeks post-weaning ($P < 0.05$). A similar positive effect was also observed for the overall FE in MCT2 group ($P < 0.05$). Compared with the control, apparent total tract digestibility (ATTD) of ether extract was improved by MCT2 and MCT3 treatment from day 12–14 post-weaning ($P < 0.05$). In addition, MCT2 treatment also exerted a beneficial effect on the ATTD of dry matter ($P < 0.05$). The increased total protein concentration and decreased urea nitrogen and malondialdehyde levels of plasma were observed in both MCT2 and MCT3 groups on day 14 post-weaning ($P < 0.05$). In conclusion, MCTs could improve growth performance, nutrients utilization, and antioxidant ability of weanling piglets.

1. Introduction

In modern intensive swine production systems, piglets are weaned earlier, usually between 15 and 28 days of age, to maximize the whole herd production (Smith et al., 2008). However, immature development of digestive tract makes weanling swine susceptible to digestive disorders. What's worse, the abrupt changes in feed composition and environment at weaning will aggravate intestinal malabsorption of nutrients and therefore decrease the feed intake of young pigs (Wu, 1998). The decreased feed intake would result in inadequate energy intake of newly weaned pigs, which can damage the growth and development of piglets. Therefore, high energy density diets are usually used to prevent growth lag of weanling piglets.

Long-chain triglycerides (LCTs) are used widely in diets to supply pigs with energy and essential fatty acids. Because of high caloric density, the addition of LCTs to the diet permits the feeding of a smaller volume of diet, a procedure that may help to avoid gastrointestinal distress, regurgitation, and aspiration at birth and in early infancy (Tantibhedhyangkul and Hashim, 1975). However, Cera et al. (1988) have shown that digestibility of LCTs declined to 65–80% at weaning, which may be due to the low activity of pancreatic lipase and intestinal lipase and therefore the absorption of dietary fat from intestine was inefficient (Cera et al., 1988). Furthermore, the newly weaned pigs may require a period of time before they are capable of synthesizing adequate amounts of carnitine, which plays a vital role in facilitating the transport of long-chain fatty acids (LCFAs) into the mitochondria for energy production (Fritz and Yue, 1963). Beyond that, weaning stress can

* Corresponding author.
E-mail address: tianwangnjau@163.com (T. Wang).
Peer review under responsibility of Chinese Association of Animal Science and Veterinary Medicine.

Production and Hosting by Elsevier on behalf of KeAi

http://dx.doi.org/10.1016/j.aninu.2015.02.001

lead to the imbalance of antioxidant defense system, which is involved in the redox balance maintenance (Durak et al., 2000; Zhu et al., 2012). The unsaturated bond of LCFAs is vulnerable to attack by free radicals, and this process can form organic free radicals which will trigger a cascade of damage to endogenous lipids and lead to lipid peroxidation. There is a positive correlation between the degree of unsaturation of dietary fat and the lipid peroxidation of the body (Mehta et al., 1994). Thus, the post-weaning diet must be formulated to well match the young pig's digestive insufficiencies and to improve the symptoms caused by weaning stress.

Medium-chain fatty acids (MCFAs) refer to a mixture of fatty acids which generally consist of 6–12 carbons. Medium-chain triglycerides (MCTs) are MCFAs esters of glycerol, and MCTs-oils are obtained from edible fats (such as coconut oil and milk) through lipid fractionation. Commercial MCTs products are predominantly comprised of C8:0 and C10:0 in worldwide (Babayan, 1987; Hashim and Tantibhedyangkul, 1987). In comparison with LCTs, MCTs are more easily degraded to fatty acids and glycerol by pancreatic lipase, which are then absorbed directly into the portal circulation and transported to the liver for rapid oxidation (Bach et al., 1988; Odle et al., 1989, 1991; Ooyama et al., 2009). Moreover, MCFAs are fully saturated and therefore have a greater oxidative stability than that of LCTs. It has been reported that MCTs exerted a positive effect in improving the growth performance of weanling pigs. Rodas and Maxwell (1992) found that the average daily gain (ADG) and feed efficiency (FE) of weanling pigs were linearly enhanced by MCFAs inclusion (from 20 to 60 g/kg diet) during the first week when compared to those given tallow or milk fat. Similar results were also reported in the result by Hong and his colleagues, who found that MCFAs inclusion enhanced ADG of pigs during the first 2 weeks post-weaning (Hong et al., 2012). Additionally, Price et al. (2013) showed that the digestibility was greater for the MCTs than the LCTs diet (98.5% vs. 93.4%) in newly weaned pigs. Dietary inclusion of MCTs improved the apparent total tract digestibility (ATTD) of dry matter (DM) and nitrogen of piglets at the end of 2nd and 5th week after weaning, and the similar effect exerted by MCTs was also found for energy digestibility (Hong et al., 2012). Study on energetics in newborn piglets clearly demonstrated a superior energetic exploitation of the MCFAs in comparison with the LCFAs. Although our comprehension regarding the benefits of MCTs in swine production has grown significantly, it was far from being complete or even satisfactory. Thereby, the objective of this study was to investigate the effects of MCTs on growth performance, nutrient digestibility, plasma metabolites and antioxidant capacity in weanling pigs.

2. Methods and materials

2.1. Materials

MCTs (consisting of caprylin and decanoin) and soybean oil (SO) were obtained from Yihai Oils & Grains Industries Co., Ltd (Lianyungang, Jiangsu, China). The fatty acid constituents of the test oils as measured by gas chromatography (GC7890; Agilent Technologies, Palo Alto, CA, USA) are presented in Table 1.

2.2. Experimental design, diets and management

The experimental protocols were permitted by the Institutional Animal Care and Use Committee of Nanjing Agricultural University. In total, 160 pigs (Duroc × Landrace × Yorkshire) weaned at 21 ± 1 d of age with a similar body weight (7.50 ± 0.28 kg) were randomly allotted to 4 treatments in a randomized complete block design according to their sex and body weight (4 replicates with 5 gilts and 5 barrows per pen), and then fed 4 formulas (identical in nutrient content except for the type of oil) for 28 d. The 4 diets were as follows: control diet (containing 3.5% SO), MCT1 diet (containing 0.7% MCTs and 2.8% SO), MCT2 diet (containing 1.4% MCTs and 2.1% SO), and MCT3 diet (containing 2.1% MCTs and 1.4% SO). The diets were formulated to meet or exceed the NRC (1998) nutrient requirements (Table 2). The pigs were housed in a total confinement pen (3.7 m × 4.0 m) with concrete-slatted floors. The target room temperature and humidity were 26.1 ± 2.6 °C and 60.9 ± 9.8%, respectively. Feed and fresh water were fed *ad libitum* at all experimental period.

2.3. Sample collection and procedures

Freshly-voided faeces were collected from 0800 to 1600 by hand grab-sampling from pen floors on day 12–14 and 26–28, respectively. Faeces were pooled by pen and frozen at −20 °C. Upon

Table 1
Fatty acid constituents of test oils (g/100 g total fatty acids).

Fatty acid	Diets	
	Soybean oil	Medium-chain triglycerides
8:0	0.1	55.8
10:0	0.1	43.8
12:0	ND[a]	0.2
16:0	12.5	ND
18:0	3.3	ND
18:1	23.1	ND
18:2n-6	52.1	ND
18:3n-3	5.0	ND
Other	3.8	0.2

[a] ND, not detected.

Table 2
Composition of diets (as fed basis, g/kg).

Item	Diets[a]			
	Control	MCT1	MCT2	MCT3
Ingredients				
Corn	449	449	449	449
Wheat flour	100	100	100	100
Soybean meal	120	120	120	120
Extruded soybean	80	80	80	80
Fermented soybean meal	40	40	40	40
Fish meal	82	82	82	82
Glucose	54	54	54	54
Soybean oil	35	28	21	14
Medium-chain triglycerides	0	7	14	21
Premix[b]	40	40	40	40
Nutrient level[c]				
Digestible energy, MJ/kg	14.52	14.51	14.49	14.49
Crude protein	198.2	198.4	198.0	198.5
Lysine	12.9	12.6	12.8	12.7
Methionine + cystine	6.8	6.8	6.8	6.8
Threonine	7.0	7.1	7.0	7.2
Tryptophan	2.0	2.0	2.0	2.0
Calcium	7.8	7.8	7.7	7.8
Total phosphorus, %	6.1	6.0	6.0	6.0
Available phosphorus, %	4.0	4.0	4.0	4.0

[a] Control, diet contained 3.5% soybean oil (SO); MCT1, diet contained 0.7% medium-chain triglycerides (MCTs) and 2.8% SO; MCT2, diet contained 1.4% MCTs and 2.1% SO; MCT3, diet contained 2.1% MCTs and 1.4% SO.

[b] Premix provided per kilogram of diet: Fe, 180 mg as $FeSO_4$; Cu, 230 mg as $CuSO_4$; Zn, 180 mg as $ZnSO_4$; Mn, 50 mg as $MnSO_4$; I, 0.5 mg as $Ca(IO_3)_2$; Se, 0.2 mg as Na_2SeO_3; vitamin A, 15,000 IU; vitamin D_3, 3000 IU; vitamin E, 100 mg; vitamin K-3, 3 mg; vitamin B_1, 3 mg; vitamin B_2, 8 mg; vitamin B_6, 5 mg; vitamin B_{12}, 0.04 mg; biotin, 0.3 mg; pantothenic acid, 20 mg; niacin, 45 mg; folic acid, 2 mg; choline chloride, 450 mg; vitamin C, 160 mg.

[c] All nutrient contents, except digestible energy and available phosphorus, were analyzed values.