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Original research article

Effects of the ratio of unsaturated fatty acid to saturated fatty acid on the growth performance, carcass and meat quality of finishing pigs

Wandee Tartrakoon [a, *], Tinnagon Tartrakoon [b], Nattporn Kitsupee [a]

[a] Department of Agricultural Science, Faculty of Agriculture, Natural Resource and Environment, Naresuan University, Phitsanulok 65000, Thailand
[b] Faculty of Sciences and Agricultural Technology, Rajamangala University of Technology Lanna, Phitsanulok Campus, Chiang Mai 50300, Thailand

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ABSTRACT

The effects on finishing pigs (80–100 kg BW) fed diets supplemented with oil sources containing different ratios of unsaturated to saturated fatty acids (UFA:SFA ratio) were evaluated in 15 barrows and 15 gilts (Duroc × Large White × Landrace). Three experimental diets were evaluated using a randomized complete block design, with broken rice, soybean meal and rice bran as the main feedstuffs in the control diet. Diets 2 and 3 consisted of the control diet supplemented with 3% oil, with UFA:SFA ratios of 2.5:1 and 5:1, respectively. Overall, there was no significant difference ($P > 0.05$) found in the average daily gain (ADG) of the pigs fed the treatment diets; however, the pigs fed the control diet and diet 3 had better ($P < 0.05$) feed conversion ratios (FCR) than the pigs fed diet 2. The pigs fed diets 2 and 3, which were supplemented with oil at UFA:SFA ratios of 2.5:1 and 5:1, had greater ($P < 0.05$) average daily feed intakes (ADFI) than the pigs in the control group. Additionally, it was found that the gender of the pigs had an effect ($P < 0.05$) on the FCR. Interaction effects between the experimental diets and the gender of the pigs ($P < 0.05$) were found in the ADFI and FCR. There were no significance differences ($P > 0.05$) among the treatment groups with regard to the carcass quality of the pigs; however, it was found that the gilts had greater ($P < 0.01$) loin eye areas than the barrows fed diets 2 and 3 and the loin eye area of pig fed diet 2 was the largest ($P < 0.05$). In the case of the meat quality parameters, it was clearly found that the pigs fed the control diet had a greater ($P < 0.05$) lightness (L^*) in the meat colour, and the lowest cooking loss was found in the pigs fed the diet supplemented with fat containing the UFA:SFA ratio of 5:1. Overall, the dietary treatment did not significantly affect the drip loss, thawing loss and shear force of the pork. In conclusion, the supplementation of oil with UFA:SFA ratios of 2.5:1 and 5:1 has the potential to improve pork quality.

1. Introduction

The goal of the production of high-quality pork in the pig industry has been focused on for decades (Dokmanovic et al., 2015). However, feeding during the finishing period (80–100 kg BW), not only to obtain the optimum feed efficiency (FE) and growth rate, also effects on the carcass and meat quality should be considered. The composition of the diet directly affects the carcass and meat quality of finishing pigs, and interest in the fatty acid composition of the meat stems mainly from the need to find ways to produce healthier meat (Wood et al., 2003). Recent studies have demonstrated that dietary arginine supplementation beneficially promotes muscle gain and reduces body fat accretion in growing-finishing pigs (Tan et al., 2009). Due to arginine differentially regulates expression of fat-metabolic genes in skeletal muscle and white adipose tissue, therefore favouring lipogenesis in muscle but lipolysis in adipose tissue (Tan et al., 2011).

The components of the technological meat quality influenced by fatty acids include the fat tissue firmness (hardness) and flavour. Although it has been suggested that dietary fatty acids influence

* Corresponding author.
E-mail address: wandeeta@nu.ac.th (W. Tartrakoon).
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tenderness and juiciness, they are more likely to be affected by the total amount of fatty acids rather than the individual ones. The effects of the fatty acids on firmness are due to the different melting points of the fatty acids in the meat (Enser, 1984), and many researchers have studied the effects of diets supplemented with different sources or levels of fat on pig performance and fatty acid composition (Mitchaothai et al., 2007; Olivares et al., 2009; Apple et al., 2009; Realini et al., 2010; Duran-Montgé et al., 2010; Kim et al., 2014; Ivanovic et al., 2015). In addition, some research has been done on pork eating quality (Corino et al., 2002; Teye et al., 2006; Tikk et al., 2007; Alonso et al., 2012). Overall, there are a number of other fat sources and combinations of fat sources which may affect the pig carcass composition and meat quality. For example, Powles et al. (1994) determined that the increase in the unsaturated fatty acid to saturated fatty acid ratio (UFA:SFA ratio) is accompanied by a curvilinear increase in the digestible energy (DE) values. Improvement in the DE with an increasing UFA:SFA ratio occurred up to the maximum ratio studied (5.71), which is in contrast with previous observations of growing/finishing pigs, where the greatest improvement in the fat utilization occurred up to ratios of 2.08, with little improvement thereafter (Powles et al., 1993; Wiseman et al., 1990). This may reflect the age of the pigs, since young pigs may require more UFA in the diet for the efficiency of fat utilization than the growing/finishing pigs (Gu and Li, 2003). In addition, Li et al. (2015) found the maintaining of the dietary n-6:n-3 polyunsaturated fatty acid (PUFA) ratios of 1:1–5:1 would facilitate the absorption and utilization of fatty acids and free amino acids, and result in improved muscle and adipose composition. Not only energy sources from the fatty acid composition in feed should be considered, but also the protein:energy ratio is important for the production performance and utilization of available feed resources by animals. Increased protein consumption by mammals leads to elevated feed costs and increased nitrogen release into the environment. However, Liu et al. (2015) found the dietary protein:energy ratio did not affect the growth performance of Bama mini-pigs and suggested that, in swine production, low dietary protein:energy ratio may be useful for reducing feed costs and minimizing the adverse effects of ammonia release into the environment. More information about the effect of muscle and fat deposition such as, soy isoflavones regulated the BW gain and fat percentage of Chinese *Guangxi* minipigs, which also showed changes in insulin-like growth factor-I (IGF-I) system and Peroxisome proliferator activated receptor-ϒ (PPAR-$_{\gamma}$) (Li et al., 2011a). More reference concerned muscle or adipocyte development demonstrating the metabolic mechanism by molecular biology methods. Li et al. (2011b) reported that myostatin suppressed 3T3-L1 preadipocyte differentiation and regulated lipid metabolism of mature adipocyte via activation of extracellular-regulated kinase 1/2 (ERK 1/2) signalling pathway.

As far as we know, no previous work has dealt with the effects of the UFA:SFA ratio of the diet on the productive performance, carcass or meat quality. Therefore, the objectives of this study were to evaluate the effects of adding a 3% combination of oil sources containing ratios of 2.5:1 and 5:1 (UFA:SFA), compared with a diet with no added oil, on the growth performance, carcass and meat quality of finishing pigs.

2. Materials and methods

2.1. Animals and diets

This experiment was conducted with 15 barrows and 15 gilts (Duroc × Large White × Landrace), which were divided into three groups of 10 pigs each. Each group was fed one of the three experimental diets in a randomized complete block design, using broken rice, soybean meal and rice bran as the main feedstuffs in the control diet. Diets 2 and 3 consisted of the control diet supplemented with 3% oil, which contained a mixture of coconut and canola oil to UFA:SFA ratios of 2.5:1 and 5:1, respectively. The composition and proximate analysis of the diets are shown in Table 1 and Table 2. All of the diets contained gross energy equal to 3,250 ± 100 kcal/kg and 13 ± 0.5% CP. Broken rice was used to adjust metabolizable energy value in the control diet to have calculated ME equal to 3,164 kcal/kg. The pigs were housed in individual pens with concrete floors, equipped with nipple drinkers and single feeders, allowing the pigs *ad libitum* access to feed and water.

2.2. Growth performance and sampling procedures

The pigs' body weights and feed consumption were recorded and measured from the beginning of the trial to a final average live weight of 100 ± 5 kg to calculate the average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (feed: gain; FCR). The proper care and use of the animals in this research procedure was performed by trained researcher under Naresuan University animal care and use committee. The animals were killed in a DLD (Department of Livestock Development, Thailand) licensed abattoir in the Phitsanulok Province. The pigs had access to water, but were fasted for 24 h prior to slaughter. They were transported to the slaughterhouse, located 30 km from the experimental facilities, and killed by bleeding after electrical stunning, according to industry standards. The initial pH (pH_{45}) in the muscularis longissimus was measured at the last rib position, after slaughtering, with a digital pH meter (Oakton waterproof pH spear pocket pH tester, Virginia, USA). The ultimate (final) pH ($pH_{24\ h}$) was measured at 24 h after slaughter. In addition, the back fat thickness (P2) was measured 6.5 cm from the dorsal midline at the last rib position. The right muscularis longissimus muscle was removed, and chops of about 2.5 cm in thickness were cut from the anterior end for

Table 1
Composition of the three experimental diets.

Item	Diets[1]		
	Control	Diet 2	Diet 3
Ingredients, g/kg (as fed basis)			
Broken rice	670	640	640
Rice bran	200	200	200
Soybean meal	110	110	110
Coconut oil	–	8.9	3.7
Canola oil	–	21.1	26.3
Di-calcium phosphate	7.0	7.0	7.0
$CaCO_3$	7.0	7.0	7.0
$NaCl_2$	3.5	3.5	3.5
Vitamin and mineral premix[2]	2.5	2.5	2.5
Chemical analysis composition, g/kg (DM basis)			
Gross energy, kcal/kg	3,540	3,655	3,647
Crude protein	132.8	130.5	130.5
Ether extract	10.7	39.3	39.1
Calculated composition, g/kg (DM basis)	0.63	0.62	0.62
Metabolizable energy, kcal/kg	3,164	3,313	3,315
Lysine	6.3	6.2	6.2
Methionine	2.4	2.3	2.3
Tryptophan	1.6	1.6	1.6
Threonine	4.6	4.5	4.5

[1] Control, diet without oil supplementation; diets 2 and 3 consisted of the control diet supplemented with 3% oil, which contained a mixture of coconut and canola oil to UFA:SFA ratios of 2.5:1 and 5:1, respectively.

[2] Vitamin and mineral premix provided per kilogram of diet: 450 mg Fe; 400 mg Cu; 250 mg Zn; 150 mg Mn; 0.5 mg I; 0.25 mg Se; 8,000 IU vitamin A; 2,000 vitamin D_3; 37.5 mg vitamin E; 0.925 mg vitamin K-3; 8.43 mg vitamin B_2; 0.04 mg vitamin B_{12}; 34.5 mg nicotinic acid; 26 mg pantothenic acid.