Effects of Feed Processing and Feeding Methods on Growth and Carcass Traits for Growing-Finishing Pigs

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ABSTRACT : The present experiment was conducted to evaluate the effects of feed processing and feeding methods on growth performance and carcass characteristics of growing-finishing pigs. A total of 72 pigs (LYD, 22.24 kg BW) were employed for a 90-d feeding trial. Treatments were 1) mash dry feeding (MD), 2) mash wet feeding (MW), 3) pellet dry feeding (PD), and 4) extruded pellet dry feeding (EPD). Corn, soybean meal and wheat bran in the basal diets were extruded before mixing and pelleting for EPD diet production. Ileal or fecal digestibility and carcass traits including lean meat percentage and weights of stomach, small and large intestines, and the degree of stomach ulcer were also examined. During the growing period, pigs fed PD showed improved ($p < 0.05$) average daily gain (ADG) and feed conversion (F/G) over those fed MD, whereas no significant differences in average daily feed intake (ADFI) were found among dietary treatments. Finisher pigs fed MD showed lower, but not significant, ADG and F/G than those fed MW, PD or EPD. For the overall period, pigs fed PD grew faster ($p < 0.05$) than those fed MD or EPD. Feed intake was different between the two feeding methods (MD vs MW), and between the two processed feeds (PD vs EPD). The digestibility of crude fat was higher ($p < 0.05$) in pigs fed EPD than in pigs fed mash feeds. NFE digestibility of EPD treatment was also higher ($p < 0.05$) than that of PD. Back fat (10th rib area) was thicker ($p < 0.05$) in pigs fed MD than in pigs fed EPD. Other carcass traits including incidence of esophagogastric ulcers were not different among treatments. In conclusion, pelleting appeared to be the desirable processing methods and wet feeding could also be recommended for growing-finishing pigs.

(Key Words : Pelleting, Extruding, Wet Feeding, Growth Performance, Nutrient Digestibility, Growing-Finishing Pigs)

INTRODUCTION

Feed processing can change the physical and chemical properties of feedstuffs. In addition, it can also improve the nutritional values of the feeds through various mechanism. Pelleting is used extensively in commercial swine feed production. Many researchers reported that pelleted diet improved average daily gain (Hanke et al., 1972; Baird, 1973; Wondra et al., 1992; Stark et al., 1993), and nutrient digestibility (Seerley et al., 1962; Skoch et al., 1983). Extrusion cooking also has been used to prepare swine feeds, resulting in improved growth rate and digestibility in early-weaned pigs (Noland et al., 1976; Fapojuwo et al., 1987; Sauer et al., 1990; Friesen et al., 1991), and growing-finishing pigs (Hancock et al., 1991). However, other researchers reported that no improvements were observed on performance or nutrient digestibility in pigs with pelleting (NCR-42 Committee on swine nutrition 1969; Baird, 1973; Skoch et al., 1983), and extruding (den Hartog et al., 1988; Herkelman et al., 1990; Rodhouse et al., 1992). Studies on carcass quality with pelleted or extruded feeds, however, are limited and inconsistent. In the case of pelleting, even though Braude and Rowell (1966) reported that pigs fed a pelleted diet were slightly fatter with a smaller loin muscle than those fed meal diet, others reported no differences in carcass traits due to pelleted diet (Baird, 1973).

Recently, on the other hand, a lot of interest is being given to wet feeding to reduce waste water. In addition to the approximate 30% water savings (Maton and Daelemans, 1991) with a modern single space wet and dry feeder (SSWD) for pigs, growth rates were also

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increased with both meal (Taylor and Clark, 1990; Walker, 1990) and a pelleted diet (Payne, 1991). But it can produce a poorer carcass with lower dressing percentage due to thicker backfat (Payne, 1991). However, the data in feed efficiency and carcass quality with SSWD feeders are inconsistent. Reduction in feed wastage was suggested as a possible reason for improved feed efficiency (Payne, 1991). Maton and Daelemans (1991) also reported that there was no difference in backfat thickness between dry and wet feeding of meal and pelleted feed, which is inconsistent with the report of Payne (1991).

Therefore, this experiment was conducted to evaluate the effects of both feed processing and feeding methods of diet (dry vs wet feeding) on the growth performance and carcass characteristics for growing-finishing pigs.

MATERIALS AND METHODS

Experimental design and feeds

A total of 72 pigs (L × Y × D, 22.24 kg BW) were alloted to 4 treatments with adjustments of sex and weight. Dietary treatments were 1) mash-dry feeding (MD), 2) mash-wet feeding (MW), 3) pellet-dry feeding (PD), and 4) extruded pellet-dry feeding (EPD). Diets were wet-fed by the built-in nipple waterer in the SSWD feeders, and dry-fed by separated feeders and waterers. Basal diets were formulated to contain 20% crude protein for growing period (20 to 60 kg), and 16% crude protein for finishing period (60 to 90 kg) (table 1).

Extrusion of corn, soybean meal and wheat bran was carried out by a semimoist extruder (Millbank®, Single Screw, New Zealand) with 3.0 ℓ/min of steam conditioning and 7.0 ℓ/min of water supply. The temperature reached 133℃ in the barrel. Diets for PD and EPD were steam pelleted with a pellet mill (CPM®, USA) using 4.6 mm die in diameter. Extruded products and pellets were cooled and the moisture content reduced to 11%, and the levels of fine were ≤ 2.2%. Particle sizes of corn were different between mash (5 mm for grower and 7 mm for finisher) and processed feeds (3 mm) to improve pellet quality. Digestibility trial was performed using chromic oxide as an indigestible marker during finishing periods (80 kg of body weight, 3 heads/treatment).

Carcass measurements

Carcass traits (10th rib area backfat, lean meat %, and loin eye area) of three gilts of each treatment were examined by the procedure of NPPC (1983), and individual wet weights of stomach and small and large intestines were determined after elimination of digesta. The score of stomach (esophagogastric) ulcer was rated according to the degree of severity from scores 1 (normal) to 4 (severe).

Table 1. Formula and chemical composition of experimental diets

	Grower	Finisher
Ingredient (%)		
Corn, yellow*	55.10	49.16
Soybean meal (44%)*	33.84	18.39
Tricalcium phosphate/limestone	1.48/–	0.25/0.47
Animal fat/molasses	4.25/4.00	2.00/4.00
Wheat bran*	–	24.35
Vit. premix[1]	0.2	0.2
Min. premix[2]	0.24	0.24
Choline chloride (25%)	0.22	–
Salt	0.30	0.30
Virginiamycin[3]	–	0.10
Lysine (98%)/methionine (50%)	–/0.02	0.04/–
Furazolidone[4]	0.10	–
Olaquindox[5]	0.10	–
Amafeed (enzymes + probiotic)	0.1	–
Sulfathiazol[6]	0.05	–
Total	100.00	100.00
Chemical composition[5];		
Crude protein (%)	19.88	16.00
ME (kcal/kg)	3,350	3,060
Lysine (%)	0.70	0.65
Methione + Cystine (%)	0.62	0.60
Calcium (%)	1.08	0.83
Phosphorus (%)	0.68	0.59

* Extruded for extruded pellet.
[1] Supplied per kg diet 8,000 IU vitamin A, 2,500 IU vitamin D_3, 30 IU vitamin E, 3 mg vitamin K, 1.5 mg thiamin, 10 mg riboflavin, 2 mg vitamin B_6, 40 μg vitamin B_{12}, 30 mg pantothenic acid, 60 mg niacin, 0.1 mg biotin, 0.5 mg folic acid.
[2] Supplied per kg diet 200 mg Cu, 100 mg Fe, 150 mg Zn, 60 mg Mn, 1 mg I, 0.5 mg Co, 0.3 mg Se.
[3] Virginiamycin: Virginiamycin 20 mg/kg.
[4] Furazolidone: Furazolidone 100 mg/kg.
[5] Olaquindox: Olaquindox 50 mg/kg.
[6] Sulfathiazol: Sulfathiazol 200 mg/kg.
[7] Calculated value.

Chemical and statistical analyses

Proximate nutrients in diets and feces were analyzed by the methods of AOAC (1990), and gross energy was measured by an adiabatic bomb calorimeter (Parr®, USA). Concentration of Cr was measured by an atomic absorption spectrophotometer (Shimadzu, AA625). Statistical analysis was carried out by comparing means according to Duncan's multiple range test (Duncan, 1955) using General Linear Model (GLM) procedure of SAS (1985) package program.

RESULTS AND DISCUSSION

Growth performance

During the growing period, as shown in table 2, pigs fed PD showed improved ($p < 0.05$) ADG and F/G over those fed MD. No significant differences in feed intake were found among dietary treatments. Differences in ADG, ADFI and F/G were not significant between feeding methods (MD vs MW), and processing methods (PD vs EPD). During the finishing period, even though there were no significant differences ($p > 0.05$) among treatments, pigs fed MD showed lower ADG and higher F/G to those fed MW, PD or EPD. For the overall period, pigs fed PD grew faster ($p < 0.05$) than those fed MD or EPD. Feed intake was different ($p < 0.05$) between the two feeding methods (dry vs wet), and between the two processed feeds (pellet vs extruded pellet). Pigs fed a MD diet exerted the poorest ($p < 0.05$) overall F/G compared to other treatments. There were also significant ($p < 0.05$) interactions, in ADG and F/G (MD × MW), and in ADG and ADFI (MD × processed feeds).

Table 2. Growth performance of pigs as affected by processing or feeding methods[1,2]

Treatment*	MD	MW	PD	EPD	SE
Growing (20-60 kg)					
ADG (g)	741^{b}	802^{ab}	846^{a}	771^{ab}	16.5
ADFI (g)	1,584	1,659	1,652	1,568	21.6
F/G	2.14^{a}	2.07^{ab}	1.96^{c}	2.04^{bc}	0.02
Finishing (60-90 kg)					
ADG (g)	763	858	859	839	17.9
ADFI (g)	2,312	2,371	2,351	2,317	17.5
F/G	3.04	2.77	2.74	2.76	0.06
Growing-finishing					
ADG (g)[3,4]	751^{c}	828^{ab}	852^{a}	802^{b}	12.7
ADFI (g)[4]	1,915^{bc}	1,983^{a}	1,970^{ab}	1,909^{c}	12.2
F/G[3]	2.55^{a}	2.40^{b}	2.31^{b}	2.38^{b}	0.03

* MD (mash dry feeding), MW (mash wet feeding), PD (pellet dry feeding), EPD (extruded pellet dry feeding).

[1] Average initial weight, 22.24 kg; 90-d experiment.

[2] Values on the same line without a common superscript differ ($p < 0.05$).

[3] MD vs MW ($p < 0.05$).

[4] MD vs Processed ($p < 0.05$).

Generally, there were several trends in growth performance of pigs when diets were fed to pigs by different physical forms and different feeding methods. In terms of ADG and F/G, pelleting of a diet showed the best result compared to meal or extruded pellet diets except for Sauer et al. (1990) in piglets. Between wet and dry feeding for a meal diet, great differences were observed in ADG, ADFI and F/G. Also, wet feeding of meal diet showed a similar growth performance compared to dry feeding of pelleted diet, even though the direct comparison of feeding methods (dry and wet) of a pelleted diet was not intended in this experiment. In terms of improved growth performance by feeding pelleted feed, this result is consistent with previous studies (Hanke et al., 1972; Baird, 1973; Wondra et al., 1992; Stark et al., 1993). Pigs fed PD showed 13.4 and 9.8% improvement in ADG and F/G as compared to those fed MD. This result is higher than the result reviewed by Van Schoubroek et al. (1971), who reported that pelleted feeds were 8% (average of 66 experiments published) more efficiently utilized by finishing pigs. Better performance by feeding pelleted feeds in the present study appears to be obtained from improved F/G and nutrient digestibility (tables 2 and 3). Nutrient digestibility was slightly improved in certain nutrients (crude protein and fat) in pigs given PD as compared to MD as shown in table 3. But, in the present study, when mash was pelleted, energy digestibility was not improved opposited to results of previous reports (Seerley et al., 1962; Meade et al., 1966; Skoch et al., 1983). For growth performance, pigs fed EPD was poorer than those fed PD, even though improvement was distinct as compared to MD. The main reason for reduced ADG by extruding was related to the reduced feed intake. During the growing period, however, there were no significant differences in ADG and F/G between the two processed feeds. Lower efficiency in EPD than in PD is in partially agreement with the results of Allee (1976) who reported that pelleting sorghum had better efficiency than extruding, and by Sauer et al. (1990) showing that repelleting of the extruded diet partially removed the beneficial effect of extrusion.

In addition to the difference due to feed processing methods, differences appear between feeding methods in the present study. Pigs fed a mash feed (MW) with a SSWD feeder which had a nipple inside the feeder, grew faster ($p < 0.05$) than those fed with a separated feeder and waterer (MD). Feed intake and feed efficiency were significantly ($p < 0.05$) increased when mash feed was given in a SSWD feeder. This result is in agreement with some previous reports. With modern SSWD feeders, growth rates were improved with both meal (Taylor and Clarke, 1990; Walker, 1990; Payne, 1991) and pelleted diets (Payne, 1991). The improvement of growth rate was largely related to the increase in voluntary feed intake, as indicated by Payne (1991). Feed efficiency was improved with a reduction of feed wastage in the present study, because there were no significant differences in nutrients digestibility between the two feeding methods (table 3).

Table 3. Effects of feed processing and feeding methods on the nutrient digestibilities in growing-finishing pigs

Treatment[1]	MD	MW	PD	EPD	SE
CP	67.50	68.25	69.58	74.10	1.37
CFat	56.83^{c}	60.01^{bc}	72.09^{ab}	79.85^{a}	3.34
NFE	78.75^{ab}	79.77^{ab}	77.16^{b}	84.77^{a}	1.18
TC[2]	74.25	75.18	74.05	76.20	1.35
GE	70.09	68.36	68.23	68.90	1.20
Contrast	CP	CF	NFE	TC	DE
MD vs Others	NS	0.024	NS	NS	NS
Dry vs Wet	NS	0.005	0.055	NS	NS
Mash vs Processed	NS	NS	NS	NS	NS

^{abc} Means with different superscripts in the same row differ ($p < 0.05$).
[1] Abbreviations: see table 2.
[2] Total carbohydrates.

Carcass characteristics

The effect of feed processing and feeding methods on carcass characteristics of marketed pigs was presented in table 4. There were no differences in gut weight (total weight of stomach, small and large intestines), % of lean meat, and loin eye area among treatments. But, back fat was significantly ($p < 0.05$) reduced when pigs were fed EPD as compared to those fed MD. This result is not in agreement with the finding of Hancock et al. (1991). They reported that last rib fat thickness was not affected by dietary treatment (extrusion), although pigs fed extruded grains exerted 2 percentage units higher than pigs fed ground grains. For pelleting, no differences were found in carcass quality in the present study, which is consistent with previous report by Baird (1973) according which no differences in carcass traits due to diet pelleting was observed. For wet feeding, it is reported that higher feed intake from SSWD feeders can lead to an increase in carcass back fat in the same genotypes of pigs to the extent that the benefits from growth efficiency are negated by loss in carcass value (Peet, 1989; Payne, 1991). But in the present study, there were no differences in backfat thickness between dry and wet feeding, which is consistent with the report of Maton and Daelemans (1991). Also, no incidences of esophagogastric ulcers were found when feed was pelleted or extruded in the present study, which is inconsistent with the published information on increased ulceration with fine grinding (Mahan et al., 1966; Maxwell et al., 1970) and pelleting (Chamberlain et al., 1967; Wondra et al., 1995). Reimann et al. (1968) and Maxwell et al. (1970) reported that smaller particle sizes increased the fluidity of stomach contents and increased the concentration of pepsin in the stomach, thus, pepsin and acid secretion were continuously in contact with the unprotected mucosa of the esophageal region of the stomach. The particle size of corn used for PD and EPD diets (3 mm) was not involved in the ulceration of stomach in the growing-finishing pigs .

In conclusion, pelleting rather than extruding appears to be a cheap recommedable processing method for growing-finishing swine feeds. Wet feeding also could be advisable upon feeding mash diet itself.

Table 4. Effects of feed processing and feeding methods on carcass characteristics of pigs[1]

Treatment[2]	Gut weight[3] (kg)	10th rib Back fat (mm)	LMP[4] (%)	LEA[5] (cm^2)	Ulcer[6]
MD	4.79	2.42[a]	54.31	41.05	1
MW	5.04	2.10[ab]	56.26	46.85	1
PD	5.18	2.10[ab]	57.17	49.33	1
EPD	4.68	2.06[b]	53.81	48.13	1
SE	0.15	0.06	1.81	1.91	
Contrast					
Pellet vs Non pellet	NS	NS	NS	NS	NS
Ex. vs No Ex.	NS	NS	NS	NS	NS
MD vs Others	NS	0.017	NS	NS	NS

[ab] Means with different superscript in the same column differ ($p < 0.05$).
[1] Average body wt. slaughtered (95.4 kg/head), adjusted (covariate analysis) to a common slaughter weight.
[2] Abbreviations : see table 2.
[3] Total wt. of stomach, small and large intestines.
[4] Lean meat percentage.
[5] Loin eye area.
[6] Score: normal (1) to severe (4).

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