Effects of Wet Feeding of Diets with or without Food Waste on Growth Performance and Carcass Characteristics in Finishing Pigs

J. S. Moon, I. K. Kwon and B. J. Chae*

College of Animal Resource Sciences, Kangwon National University, Chunchon 200-701, Korea

ABSTRACT : Two experiments were conducted. In expt. 1, a total of fifty-four pigs (L×Y×D, 56.14±1.7 kg) were used for a feeding trial to determine the effect of wet feeding of a commercial-type diet without food waste (FW). Treatments were dry (Control), wet (WF) and wet+dry feeding (WDF). For wet feeding, the diet was mixed with water at a ratio of 1:2.5 (feed:water). A wet feed was given during the whole experimental period for the WF group, but the dry feed was given during the finisher period for the WDF group. In expt. 2, a total of fifty-four pigs (L×Y×D, 55.7±1.8 kg) were used for a feeding trial to determine the effect of wet feeding of FW. Treatments were a commercial-type dry (Control), wet fermented food waste (WFFW) and WFFW+dry feeding (WFFW+DF). For wet feeding of fermented food waste, however, some ingredients (concentrate) were added to make nutrient contents comparable to the control diet. The FW collected was ground (≤5 mm), heated with a steam jacket (140±3°C) and fermented with probiotics for one day in a steel container at 30-40°C. For the WFFW group, the wet feed was given during the whole experimental period, but a dry feed was given during finisher period for the WFFW+DF group. In expt. 1, during the grower period, pigs fed wet feed showed higher average daily gain (ADG) and feed conversion ratio (FCR) than those fed only dry feed ($p<0.05$). During the finisher period, pigs in the WDF group showed better ADG and FCR than the control group. During the entire experimental period, pigs in the WDF group grew faster ($p<0.05$) than those in the control group, and the same trend was found in FCR. Also, dressing percentage, backfat thickness, lean %, and pork color were not affected by the wet feeding of diets in this study. In expt. 2, during the grower period, pigs fed diets containing FW showed lower ($p<0.05$) ADG than those fed the control diet. But FCR was better ($p<0.05$) in pigs fed FW than in the control group. During the finisher period, pigs in the WFFW+DF group grew faster ($p<0.05$) than those in the control and WFFW groups. During the entire experimental period, pigs fed the control diet showed better ADG ($p<0.05$) than those fed FW, but feed intake and FCR were vice versa. Dressing percentage was lower ($p<0.05$) in the WFFW than in the control group, but backfat was thinner in the WFFW group than in the control group. In summary, it can be concluded that wet feeding of formula feed can improve daily gain, however, feeding fermented wet food waste may reduce daily gain of finishing pigs, even though it was fermented and the nutrient was fortified with concentrates. In addition, dry feeding of a formula feed during the finishing period can improve daily gain in pigs fed a wet feed with or without food waste during the grower period. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 4 : 504-510)***

Key Words : Dry and Wet Feeding, Food Waste, Growth, Pig

INTRODUCTION

Weaning imposes nutritional problems on piglets due to abrupt change in diets from milk to solid feeds. Therefore, it is generally known that wet or liquid feeding is very effective for weaning pigs (Gill et al., 1991; Toplis, 1992; Geary et al., 1996; Kim, 1999; Yang et al., 2001).

For growing-finishing (G/F) pigs, however, less studies have been conducted, and growth response results were inconsistent when these pigs fed wet diets. Kneale (1972) and Smed (1994) reported improvements in daily gain of pigs, but Nielsen and Madsen (1978) reported no significant improvements. Even though the effects of wet feeding on growth is inconsistent in G/F pigs (Jensen and Mikkelsen, 1998), the major benefits of wet or wet/dry feeding include increased feed intake, improved growth rate, and better feed efficiency due to reduced feed wastage (Forbes and Walker, 1968; Maton and Daelemans, 1991; Payne, 1991; Partridge et al., 1992; Russell et al., 1996). Wet feeding has also been shown to enhance gut health and function by providing appropriate conditions for enzyme activity, digestion, nutrient absorption and microbial growth (Partridge et al., 1992).

On the other hand, well prepared food waste is one of the accepted feed resources used to reduce the feeding cost for pigs. Thus the feeding of food waste to pigs is a common practice in many countries (Boda, 1990). Most experiments with food waste, however, have been conducted with dried food waste for pigs (Myer et al., 1999; Yang, 1999; Chae et al., 2000). In this case, the drying of food waste to be used as feed adds extra cost and could be a financial burden.

As there is limited data on wet feeding of diets with or without food waste in G/F pigs, more studies are needed to understand the effects of wet feeding of diets. In this study, two experiments were conducted to evaluate the effects of wet feeding of diets without food waste (experiment 1) and with food waste (experiment 2) on growth performance and carcass characteristics in G/F pigs. An additional approach was added in both experiments in this study, that is, the effects on production traits of pigs fed a wet diet during

* Corresponding Author: B. J. Chae. Tel: +82-33-250-8616, Fax: +82-33-244-4946, E-mail: bjchae@kangwon.ac.kr
Received January 25, 2003; Accepted December 26, 2003

Table 1. Formula and chemical composition of experimental diets (as-fed)

	Control[1]	WFFW+concentrate
Ingredients (%)		
Wet fermented food waste[2]	-	86.58
Corn, grain	40.93	5.50
Rye, grain	5.00	-
SBM (44%)	24.60	6.00
Wheat bran	15.72	-
Rapeseed meal	2.50	-
Linseed meal	3.00	-
Molasses	3.00	0.80
Animal fat	2.90	0.96
DL-methionine (50%)	0.11	0.04
TCP	1.05	-
Vit-min. premix[3]	0.24	0.12
Calcium carbonate	0.95	-
Total	100.00	100.00
Chemical composition (%)[4]		
ME (kcal/kg)	3,268[5] (3,756)[6]	1,050 (3,750)
Crude protein	18.37 (21.11)	5.88 (21.00)
Lysine	0.93 (1.07)	0.28 (1.00)
Met+Cys	0.34 (0.39)	0.11 (0.39)
Calcium	0.95 (1.09)	0.78 (2.80)
Phosphorus	0.64 (0.74)	0.21 (0.75)

[1] Control diet was used for expt. 1 and 2.

[2] Fermented with probiotics (Unit/kg; 5.5×10^8 *Lactobacillus bulgaricus*, 2.5×106 *Micrococcus lactilyticus* 13×10^3 *Clostridium pasteurianum*, 7.5×10^6 *Saccharomyces sake*, 12×10^8 *Bacillus subtilis*)

[3] Contained per kg of premix: 3,000,000 IU vitamin A, 600,000 IU vitamin D_3, 16,000 IU vitamin E, 500 mg vitamin K, 500 mg thiamin, 3,000 mg riboflavin, 600 mg vitamin B_6, 10 mg vitamin B_{12}, 5,000 mg pantothenic acid, 10,000 mg niacin, 55 mg biotin, 1,000 mg folic acid, 4,500 mg Cu, 55,000 mg Fe, 10,000 mg Zn, 20,000 mg Mn, 250 mg I, 125 mg Co, 135 mg Se.

[4] Calculated. [5]As-fed basis (control : 87% DM, WFFW+Concentrate: 28% DM). [6] DM basis in all parenthesis.

grower period and a dry diet during finisher period were evaluated.

MATERIALS AND METHODS

Animals, feeds and feeding

Two experiments were conducted to evaluate the effects of wet feeding of diets, with and without food waste on growth performance and carcass characteristics in G/F pigs.

In expt. 1, a total of fifty-four growing pigs (Landrace×Yorkshire×Duroc, average initial body weight of 56.14±1.7 kg) were used for a feeding trial to determine the effect of wet feeding of a commercial-type diet without food waste. Treatments were dry feeding (Control: DF), wet feeding (WF) and wet+dry feeding (WDF). Pigs were allotted on the basis of sex and weight to the three treatments in a completely randomized block design (3 replicates, 6 pigs/replicate, 3 barrows and 3 gilts). Each pig's pen size was 2.0 m×2.5 m, and the floor was half slatted.

An experimental diet was formulated to contain 3,268 kcal ME/kg and 0.93% total lysine (Table 1). For wet feeding, the diet was mixed with drinking water at a ratio of 1:2.5 (feed:water). A nipple waterer was installed in each pen. Feed and water were offered for *ad libitum* consumption. The wet feed was given during the whole experimental period for the WF group, but the dry feed was given during the finisher (90-110 kg) period for the WDF group.

In expt. 2, a total of fifty-four growing pigs (Landrace×Yorkshire×Duroc, average initial body weight of 55.7±1.8 kg) were used for a feeding trial to determine the effect of wet feeding fermented food waste. Treatments were dry feeding with a commercial-type compound feed used in expt. 1 (Control: DF), wet-type fermented food waste (WFFW) and WFFW+dry feeding (WFFW+DF). Pigs were allotted on the basis of sex and weight to three treatments in a completely randomized block design (3 replicates, 6 pigs/replicate, 3 barrows and 3 gilts).

The food wastes were collected from the apartment areas of Wonjusi, Gangwondo, Korea. For wet feeding of fermented food waste, some ingredients (concentrate) were added to make nutrient contents comparable to the control diet as shown in Table 1. The food waste collected was ground (≤5 mm), heated with a steam jacket (140±3°C) and fermented with probiotics (Table 1) for one day in a steel container at 30-40°C. During fermentation, the initial temperature was about 40°C and the final temperature was 30°C. The concentrate was mixed with the fermented food waste before loading into a pump car. The diet was sent to a

Table 2. Media and culture of microbiological analysis in food waste (Expt. 2)

	Medium	Incubation	
		Temp (°C)	Time (h)
Total bacterial count	Standard plate count agar	32	48
Yeast count	Potato dextrose agar	32	48
Lactic acid bacterial count	MRS agar+NaN_3 0.02%	32	48
E. coli count	EC broth	44.5	24
	Violet red bile agar	37	24

Table 3. Effect of wet feeding on growth performance in growing-finishing pigs (Expt. 1)

Feeding method	Control (dry)	Wet	Wet+dry[1]	SE[2]
Grower (55-90 kg)				
ADG (g/d)	795[b]	875[a]	853[a]	43.00
ADFI (g/d)	2,704[b]	2,817[a]	2,648[c]	86.00
FCR (F/G)	3.40[a]	3.22[b]	3.09[b]	0.15
Finisher (90-110 kg)				
ADG (g/d)	810[b]	843[ab]	865[a]	33.00
ADFI (g/d)	2,707[b]	2,913[a]	2,826[a]	100.00
FCR (F/G)	3.38[a]	3.46[a]	3.26[b]	0.16
Overall (55-110 kg)				
ADG (g/d)	797[b]	862[a]	852[a]	34.00
ADFI (g/d)	2,703[b]	2,857[a]	2,702[b]	88.00
FCR (F/G)	3.38[a]	3.32[a]	3.16[b]	0.12

[a, b, c] Values with different superscripts in the same row are significantly different (p<0.05).
[1] 55-90 kg: wet feeding, 90-110 kg: dry feeding. [2] Pooled standard errors.

pig farm, where an insulated stainless steel container was installed for feeding.

Feed was delivered by an automatic feeding system to each pen for wet feeding groups. The pen size was 2.0 m×2.5 m and the floor was half slatted. A nipple waterer was installed in each pen. Feed and water were offered for *ad libitum* consumption. For the WFFW group, the wet feed was given during the whole experimental period, but dry feed was given during the finisher (90-110 kg) period for the WFFW+DF group.

Nutrient digestibilities of experimental feeds were measured. In expt 1, digestibility was compared in pigs fed a dry diet and those fed a wet diet. In expt 2, however, digestibilies were compared among 3 diets, dry feeding of the control diet, wet feeding of fermented food waste without concentrate and wet feeding of fermented food waste with concentrate. Additional 3 pens were prepared for the digestibility study of fermented food waste without concentrate.

Chromic oxide was added (0.25%) in the diets as an indigestible marker. On the 3rd week of the feeding trials, the marked diets were fed. Fecal samples were taken from 4 pigs in each pen and pooled by pen (3 samples per treatment) on the 4th day after feeding the marked diets. Feces were dried in an air forced drying oven at 60°C for 3 days for chemical analysis.

At the end of the experiment, barrows (3 per treatment), average body weight of 110.12±0.53 kg, were slaughtered to evaluate carcass characteristics such as dressing percentage and backfat thickness (last lib). Also, fat free lean index and pork color (*M. longgissimus dorsi*) were measured by the procedures of NPPC (1991).

Microbiological, chemical and statistical analyses

Proximate analyses of the feeds and feces were made according to the methods of AOAC (1990) and gross energy was measured with an adiabetic bomb calorimeter (Model 1241, Parr Instrument Co., Molin, IL). Chromium was measured with a spectrophotometer (Contron 942, Italy). Following acid hydrolysis in 6 N HCL at 105°C for 24 h, amino acid concentrations were determined, using a HPLC (Waters 486, USA).

For microbiological analysis, samples were diluted in 0.1% peptone solutions. Total bacterial counts (TBC), yeast counts (YC), lactic acid bacterial counts (LAB), and *E. coli* counts in samples were conducted before and after fermentation at 35-40°C. Media, incubation temperature and incubation periods are listed in Table 2.

The data was analyzed using the General Linear Model (GLM) Procedure of SAS (1985). The statistical model was that appropriate for a randomized complete block design.

RESULTS AND DISCUSSION

Expt. 1.

Growth performance as affected by wet feeding is shown in Table 3. During the grower period (55-90 kg), pigs fed wet feed showed higher average daily gain (ADG) and better feed conversion ratio (FCR) than those fed only dry feed (p<0.05). Feed intake was higher (p<0.05) in the

Table 4. Apparent fecal digestibility (%) of nutrients in the experimental diet as affected by feeding methods in finishing pigs[1] (Expt. 1)

Feeding method[2]	Control	Wet feeding	SE[3]
Dry matter	71.40	75.35	5.64
Gross energy	68.05	70.18	6.78
Crude protein	70.49	76.81	6.82
Crude fat	68.06	63.02	10.16
Calcium	56.73	62.57	12.93
Phosphorus	40.66	53.86	9.83

[1] Not significant (p<0.05).
[2] Control: dry feeding of formula feed, Wet feeding: feed and water (1:2.5). [3] Pooled standard errors.

WF group, but lower in the WDF group than in the DF group. During the finisher period (90-110 kg), pigs in the WDF group showed better ADG and FCR than the control group. During the entire experimental period, pigs in the WF and WDF group grew faster (p<0.05) than those in the control group, but FCR was better in WDF group only.

Unlike young pigs, reported growth response was inconsistent in G/F pigs when pigs were fed a liquid diet (Jensen and Mikkelsen, 1998), although meager studies have been conducted about the effects of wet feeding G/F pigs with freshly prepared wet feed.

In this study, ADG of pigs fed with wet feed grew faster than those fed with dry feed. This is in agreement with the reports of Kneale (1971) and Smed (1994). They reported that there were improvements in ADG, whereas Nielsen and Madsen (1978) demonstrated no significant improvement in ADG in G/F pigs. In a review, Jensen and Mikkelsen (1998) also concluded that feeding liquid feed to slaughter pigs seemed to improve the efficiency of feed utilization considerably (6.9±3.5%), whilst the effect on growth rate is questionable (4.4±5.4%).

Improved daily gain seemed to be the effect of increased feed intake. In the present study, feed intake was increased more in the WF compared to the DF group. This is similar to the result of Payne (1991), who reported that improvement of growth rate is largely related to the increase in voluntary feed intake in wet/dry feeders. Limited data, however, are available about the effect of wet feeding on feed intake.

Improved feed efficiency can be expected in G/F pigs by a reduction in feed wastage (Payne, 1991), as well as by improvements of the efficiency of feed utlization especially in fermented liquid feeds (Jensen and Mikkelsen, 1998). We mixed a dry diet with water before feeding, thus no fermentation occurred. In a report by Smith (1976), it was concluded that there appeared to be no advantage in offering fermented (soaked) as opposed to non-fermented (fresh prepared) wet feed to G/F pigs.

Nutrient digestibility was not improved by liquid feeding of diets in this study (Table 4). However, the wet-type diet showed a trend towards improved digestibilities of energy, protein, Ca and P, even though it was not significant (p>0.05). Unfortunately, very little is yet known about how wet feed affects nutrient digestibility in G/F pigs.

Table 5. Effects of wet feeding on carcass characteristics in finishing pigs[1] (Expt. 1)

Feeding method	Control (dry)	Wet	Wet+dry[2]	SE[3]
Dressing percentage (%)	74.40	73.65	73.57	0.46
Backfat thickness (last rib, cm)	2.16	2.10	2.32	0.08
Fat free lean (%)	53.21	53.40	52.47	0.49
Meat color	2.0	2.33	2.0	0.33

[1] Not significant (p>0.05). [2] 55-90 kg: wet feeding, 90-110 kg: dry feeding. [3] Pooled standard errors.

Table 6. Chemical composition of food waste during experiment[1] (DM-basis) (Expt. 2)

	July	August	September	Mean	SE[2]
GE (kcal/kg)	4,685	5,080	5,348	5,037	333.28
Crude protein (%)	22.63	25.26	26.03	24.64	1.78
Crude fat (%)	10.30	11.30	11.10	10.90	0.53
Calcium (%)	1.24	0.79	2.66	1.56	0.98
Phosphorus (%)	0.88	0.79	0.74	0.80	0.07
Salt (%)	1.30	1.30	1.33	1.31	0.02
Amino acids (%)					
Arg	2.16	3.51	5.03	3.57	1.44
Lys	1.56	2.12	3.27	2.32	0.87
His	0.92	2.67	2.99	2.19	1.11
Leu	2.91	3.95	5.63	4.16	1.37
Ile	1.56	1.88	3.19	2.21	0.86
Phe	2.36	0.32	3.71	2.13	1.71
Thr	2.12	3.59	4.11	3.27	1.03
Met	0.84	3.39	2.51	2.25	1.30
Val	1.24	3.11	3.87	2.74	1.35

[1] Each value is an average of 6 samples by month. [2] Pooled standard errors.

Table 7. pH and microbiological analysis of food waste (cfu/g) (Expt. 2)

	Fermentation		SE[2]
	Before	After	
PH	4.68±0.18	4.42±0.38	0.3
Total bacterial count	4.30^{b}±0.20	7.11^{a}±0.07	1.65
Yeast count	ND[1]	3.63±0.54	-
Lactic acid bacterial count	ND	6.59±0.02	-
E. coli count	ND	ND	-

a, b Value with different superscripts in the same column are significantly different ($p<0.05$).
[1] Not detected. [2] Pooled standard errors.

In addition, pigs in the WDF group showed better FCR than the control and WF groups. During the finisher period, we expected higher feed intake in WDF than in WF due to enlarged stomach capacity during the grower period, but there was no difference in feed intake between WF and WDF. This result is in agreement with the reports of Gill (1989) and Barber (1992). They pointed out that total volumetric feed intake will be comparable whether the same diet is fed in wet or dry form.

Also, dressing percentage, backfat thickness, lean %, and pork color were not affected by the wet feeding of diets in this study (Table 5). In the wet/dry feeder, several researchers reported that the improvement of growth rate due to the increase in voluntary feed intake could produce a poorer carcass and lower dressing percentage (Peet, 1989; Payne, 1991; Gadd, 1992). It was related to the larger gut fill for increased feed intake (Gadd, 1992).

In summary, it can be concluded that wet feeding can improve daily gain of slaughter pigs. Furthermore, dry feeding a formula feed during the finishing period can improve the efficiency of feed utilization in pigs fed the wet diet during the grower period.

Expt. 2.

Chemical and microbial compositions of the WFFW used in expt. 2 are listed in Table 6 and 7, respectively. As expected, there were great variations in nutrient contents in the food waste. In the case of gross energy and protein, the ranges were 4,685-5,348 kcal/kg and 22.63-26.03%, respectively. The ranges of lysine and methionine contents were 1.56-3.27% and 0.84-3.39%, respectively. The salt content was relatively constant (1.30-1.33%).

Great variations in chemical compositon of food waste were previously demonstrated by some researchers (Soliman et al., 1978; Lipstein, 1984; Chae et al., 2000), so Pond and Manner (1984) stated that the variation in nutrient contents is one of the problems in the use of food waste as a feed resource.

After heat treatment, there were little, if any, YC, LAB and *E. coli*. in the food waste (Table 7). It means that there is no problem in feeding the food waste to pigs in terms of hygiene. But the numbers of TBC, YC and LAB were markedly increased after fermentation, while pH was reduced. Generally, lactic acid bacteria and yeast species naturally occurring in feed ingredients proliferate and produce lactic acid, acetic acid and ethanol and reduce the pH in the wet condition (Brooks, 1994). In this study, we added some microorganisms listed in Table 1 for fermentation.

Table 8. Growth performance of finishing pigs as affected by feeding methods (Expt. 2)

Feeding method[1]	Control	WFFW	WFFW+DF	SE[2]
Grower (50-90 kg)				
ADG (g)	793^{a}	695^{b}	685^{b}	60
ADFI (g)	$2,424^{a}$	$1,785^{b}$	$1,806^{b}$	452
FCR (F/G)	3.06^{a}	2.57^{b}	2.64^{b}	0.59
Finisher (90-110 kg)				
ADG (g)	806^{b}	754^{b}	955^{a}	250
ADFI (g)	$2,441^{b}$	$2,130^{b}$	$3,266^{a}$	780
FCR (F/G)	3.03^{b}	2.82^{b}	3.42^{a}	0.34
Overall (50-110 kg)				
ADG (g)	799^{a}	719^{b}	764^{ab}	50
ADFI (g)	$2,433^{a}$	$1,914^{b}$	$2,269^{ab}$	300
FCR (F/G)	3.05^{a}	2.66^{b}	2.97^{ab}	0.33

a, b Value with different superscripts in the same column are significantly different ($p<0.05$).
[1] Control: dry feeding of formula feed, WFFW: wet feeding of food waste, WFFW+DF: wet feeding for grower and dry feeding for finisher. [2] Pooled standard errors.

Growth performance as affected by WFFW is shown in Table 8. During the grower period (50-90 kg), pigs fed diets containing food waste showed lower ($p<0.05$) ADG than those fed the control diet. But FCR was better ($p<0.05$) in pigs fed food waste than in the control group due to reduced feed intake ($p<0.05$). During the finisher period (90-110 kg), pigs in the WFFW+DF group grew faster ($p<0.05$) than those in the control and WFFW groups. The ADFI, however, was significantly higher ($p<0.05$) in the WFFW+DF than in the other groups, resulting in poor FCR ($p<0.05$). During the entire experimental period, pigs fed the control diet showed better ADG ($p<0.05$) than those fed food waste, but ADFI and FCR were vice versa. There were no differences in ADG, ADFI and FCR between the control and WFFW+DF groups.

In our previous study (Chae and Moon, 1997), market weight was delayed by 35 days in pigs fed fermented food waste (no concentrate) when it was fed to pigs from 50-110 kg body weight. So, we added some feed ingredients (concentrate) to make nutrient contents comparable to those of a commercial diet. In spite of fortified nutrient density, unlike our expectation, there was a gap in daily gain between pigs on the control diet and those on the WFFW diet. This might be related to reduced feed intake during the grower period ($p<0.05$). We do not know the reason for the reduced feed intake: palatability or stomach capacity. When feed intakes for the control (90% DM) and WFFW (25% DM) groups were calculated on as-fed basis, these were

Table 9. Apparent fecal digestibility of nutrients in experimental diets in finishing pigs (Expt. 2)

Feed[1]	Control	WFFW	WFFW+concentrate	SE[2]
Dry matter	70.42[a]	46.93[b]	70.21[a]	13.50
Gross energy	67.09[a]	52.99[b]	70.56[a]	9.31
Crude protein	68.46[a]	50.26[b]	72.28[a]	11.77
Crude fat	83.46[ab]	81.46[b]	86.51[a]	2.54
Calcium	56.13[a]	46.30[b]	52.48[a]	12.02
Phosphorus	45.50[a]	13.38[b]	43.62[a]	18.03
Amino acids				
Arg	64.64	61.43	64.40	1.79
Lys	77.42[a]	62.98[b]	78.53[a]	8.68
His	77.70[ab]	64.42[b]	80.80[a]	8.70
Leu	78.18[a]	61.65[b]	71.78[b]	8.33
Ile	76.85[a]	42.79[b]	69.34[b]	17.89
Phe	80.25[a]	64.19[c]	74.58[b]	8.14
Thr	69.21	56.19	68.18	7.24
Met	63.20	65.98	65.88	1.58
Val	75.99[a]	54.67[a]	69.97[a]	10.99

[a, b] Values with different superscripts in the same row are significantly different (p<0.05).
[1] Control: formula feed, WFFW: wet fermented food waste, WFFW+concentrate: wet fermented food waste+concentrate. [2] Pooled standard errors.

Table 10. Carcass characteristics of finishing pigs as affected by feeding methods (Expt. 2)

Feeding methods[1]	Control	WFFW	WFFW+DF	SE[3]
Dressing percentage	75.18[a]	74.04[b]	74.68[ab]	2.35
Back fat thickness (last rib, cm)	2.16[ab]	1.92[b]	2.27[a]	0.18
Fat free lean (%)	53.23[b]	54.36[a]	52.65[c]	0.87
Meat color	1.67[b]	2.67[a]	2.67[a]	0.58

[a, b, c] Value with different superscripts in the same row are significantly different (p<0.05).
[1] Control: dry feeding of formula feed, WFFW: wet feeding of food waste, WFFW+DF: wet feeding for grower and dry feeding for finisher.
[2] Pooled standard errors.

2,693 and 7,140 kg/pig/day, respectively. Bulkiness may have reduced the dry matter intake in the food waste group. Pigs consumed additional water by a nipple waterer due to high salt contents in the food waste.

But FCR was improved when pigs were fed WFFW, probably due to less feed waste or higher nutrient digestibility compared to the mash diet. As shown in Table 9, the digestibilities of DM, energy, protein, fat, Ca, P and some essential amino acids (lysine, histidine, leucine, isoleucine, phenylalanine, valine) were lower (p<0.05) in food waste than the control diet. However, when it was fermented and the concentrate was added, the digestibilities of DM, energy, protein, fat, Ca, P and amino acids except leucine, isoleucine and phenylalanine were improved (p<0.05).

Basically, nutrient digestibility in food waste is low, as shown in this study and in our previous study (Chae et al., 2000). But the digestibility can be improved through fermentation. As stated by Jensen and Mikkelsen (1998), improved feed efficiency can be obtained by feeding fermented liquid feed due to changes in GIT environment; reduced pH in the stomach and the number of enterobacteria. Even though we added the concentrate after 1 day fermentation of food waste, it was stored for 3-4 days at the farm in an insulated stainless container before being used, suggesting further fermentation of the feed.

When pigs were fed the control diet during the finisher period in the WFFW+DF group, ADG and ADFI were higher than in other groups, but FCR was poor. The improved daily gain was due to increased feed intake. This result is similar to the result obtained in expt. 1. It appears that enlarged gut capacity enabled pigs to consume more feed compared to pigs fed the dry diet.

In the carcass characteristics, dressing percentage was lower (p<0.05) in the WFFW group than in the control group. But backfat was thinner in the WFFW group than in the control group (Table 10). When pigs were fed the control diet during the finisher period (WFFD+DF), backfat was thicker than for the pigs fed food waste throughout the experimental period (WFFW), thus fat free lean was lowered (p<0.05). Pork color was better (p<0.05) in pigs fed WFFW than those fed the control diet. It appeared that higher energy intake during the finisher period resulted in thicker backfat.

In summary, it can be concluded that feeding wet food waste may reduce daily gain of slaughter pigs, even though it has been fermented and the nutrient density fortified with concentrate. However, feeding a formula feed during the finishing period can compensate the retarded growth rate in pigs fed food waste during the grower period.

REFERENCES

AOAC. 1990. Official methods of analysis (15th ed.). Association of Official Analytical Chemists. Arlington, VA.

Barber, J. 1992. The rationalisation of drinking water supplies for pig housing. Ph. D. thesis. Polytehnic South West, UK.

Boda, K. 1990. Domestic refuse. In: Nonconventional Feedstuffs in the Nutrition of Farm Animals (Ed. K. Boda). Developments in Animal and Veterinary Sciences. 23. Elsevier. Amsterdam. pp. 182-185.

Brooks, P. H. 1994. Water-forgotten nutrient and novel delivery system. In: Biotechnology in the Feed Industry (Ed. T. P. Lyons and K. A. Jacques). Proceedings of Alltech's Tenth Annual symposium. Nottingham University Press. pp. 211-234.

Chae, B. J. and J. S. Moon. 1997. Feeding wet fermented food waste in finishing pigs. Unpublished.

Chae, B. J., S. C. Choi, Y. G. Kim, C. H. Kim and K. S. Sohn. 2000. Effects of feeding dried food waste on growth and nutrient digestibility in growing-finishing pigs. Asian-Aust. J. Anim. Sci. 13:1304-1308.

Forbes, T. J. and N. Walker. 1968. The utilization of wet feed by bacon pigs with special reference to pipe line feedings. J. Agric. Sci. 71:145-151.

Gadd, J. 1992. Effect of wet feeding on performance of finishing pigs. In: Theory and practice in swine production. (Ed. J. Gadd). Swine Research Publt. Seoul. p. 348.

Geary, T. M., P. H. Brooks, D. T. Morgan, A. Campbell and P. J. Russell. 1996. Performance of weaner pigs fed at libitum with liquid feed at different dry matter concentrations. J. Sci. Food Agric. 72:17-24.

Gill, B. P., P. H. Brooks and J. L. Carpenter. 1991. The effects of water and creep feed provision on the performance of suckling piglets. Anim. Prod. 52:599.

Gill, B. P. 1989. Water use by pigs managed under various conditions of housing, feeding and nutrition. Ph. D. Thesis. Plymouth Polytechnic, Plymouth, UK.

Jensen, B. B. and L. L. Mikkelsen. 1998. Feeding liquid diets to pigs. In: Recent advances in animal nutrition (Ed. P. C. Garnsworthy and J. Wiseman). Nottingham University Press. UK. pp. 107-126.

Kim, J. H. 1999. Liquid feeding for pigs: Impact on growth, protein deposition and days market weight. Ph. D. Dissertation. Seoul National University, Suwon, Korea.

Kneale, W. A. 1972. A comparison of commercial wet and dry feeding systems for fattening bacon pigs. Experimental Husbandry, 21:51-59.

Lipstein, B. 1984. Evaluation of nutritional value of treated kitchen waste in broiler diets. Proc. of the 17th World Poultry Science Congress. Helsinki, pp. 372-374.

Maton, A. and J. Daelemans. 1991. Study of the wet-feed hopper versus the dry-feed hopper for finishing pigs. Revue de L'Agriculture, 44:763.

Myer, R. O., J. H. Brendemuhl and D. D. Johnson. 1999. Evaluation of dehydrated food waste products as feedstuffs for finishing pigs. J. Anim. Sci. 77:685-692.

Nielsen, E. K. and A. Madsen. 1978. Feeding strategy for slaughter pigs. 1. Dry or soaked feed in Danish. Publication No. 233. Meddelelse. National Institute of Animal Science, Denmark, Tjele.

NPPC. 1991. Procedures to evaluate market hogs (3rd ed.). National Pork Producers Council. Des Moines. IA.

Patridge, G. C., J. Fisher, H. Gerory and S. G. Prior. 1992. Automated wet feeding of weaner pigs vs. conventional dry diet feeding: effects on growth rate and food consumption. Anim. Prod. 54:484.

Payne, H. G. 1991. The evaluation of Single-space and wet-and-dry feeders for the Australian environment. In: Manipulating pig production III (Ed. E. S. Batterham). Austr. Pig Sci. Association, Nov. p. 158.

Peet, B. 1989. Single-space ad libitum feeders. No. 15. National Agricultural Center, Stoneleigh.

Pond, W. G. and J. H. Maner. 1984. Swine Production and Nutrition. AVI Publishing Co, Westport, CT.

Russel, P. J., T. M. Geary, P. H. Brooks and A. Campbell. 1966. Performance, water use and effluent output of weaner pigs fed *ad libitum* with either dry pellets or liquid feed and the role of microbial activity in the liquid feed. J. Sci. Food Agric. 72:8-16.

SAS. 1985. SAS User`s Guide; Statistics. Statistical Analysis system. Inst. Inc. Cary, NC.

Smed, A. F. 1994. Dry versus liquid feeding of female and entire male pigs in Danish. Publication No. 276. Meddelelse. The National Committee for pig Breeding, Health and Production. Denmark, Copenhagen.

Smith, P. 1976. A comparison of dry, wet and soaked meal for fattening bacon pigs. Exp. Husbandry. 30:87-94.

Soliman, A. A., S. Hamdy, A. A. Khaleel, M. A. Abaza, A. R. Akkada and K. Shazly. 1978. The use of restaurant food waste in poultry nutrition. 1. Effects on growing chicks. Alex. J. Agric. Res. 26(3):489-499.

Toplis, P. 1992. Feeding for 30kg in 60days. In: Advances in pork production (3rd ed.). University of Alberta, Edmonton, Canada. 13(1):22-46.

Yang, C. J. 1999. Use of food wastes in diets for animals. Proc. of a Symposium for Use of Food Waste in Animal Production. July. Livestock Experiment Station. Suweon, Korea. pp. 131-145.

Yang, J. S., J. H. Lee, T. G. Ko, T. B. Kim, B. J. Chae, Y. Y. Kim and In K. Han. 2001. Effects of wet feeding of processed diets on performance, morphological changes in the small intestine and nutrient digestibility in weaned pigs. Asian-Aust. J. Anim. Sci. 14(9):1308-1315.