EFFECTS OF FERMENTED SLAUGHTERHOUSE RESIDUUM PELLET CONTAINING BLOOD MEAL AND GROUND FRESH PIG BONE ON PORK QUALITY

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SUMMARY
Efficient utilization of slaughter by-products is a problem of great importance for resources use and also for waste management. A study on utilization of slaughterhouse residuum and other slaughter by-products for pig feed has been implemented with the following four experiments. 1) Chemical composition and palatability of the pellet feed made from slaughter by-products, 2) Meat productivity, 3) Health and nutritional condition and, 4) Meat quality of pigs which were given the pellet feed made from slaughter by-products. The pellet feed was made from 90% of fermented slaughterhouse residuum (FSR), 5% of blood meal and 5% of ground fresh pig bone and was mixed with formula feed in 20 to 80 proportion. This feed was given for the trial group (12 head of pigs), while the control group (12 head) were given only the formular feed. The feeding program was carried out for 56 days followed by slaughtering the pigs, all at 194 days of age. The carcass was used in the performance tests on meat production. A sample of loin was analyzed for determination of physicochemical characteristics. The chemical composition and processing quality of the meat were investigated. Sensory evaluation was also performed. The results obtained were as follows; 1) The palatability of the shortest size pellet, length of which was 0.74cm, was excellent. The FSR pellet contained high percentage of crude fat (22.9%) and high crude fiber (26.0%). 2) The trial group had higher daily weight gain and lower conversion ratio than the control group. 3) The health and nutritional condition were found to be normal. 4) Any undesirable effect of the FSR pellet on carcass, meat and processing quality was hardly observed.

INTRODUCTION
One of the biggest problem of livestock industry in Japan is how treat the slaughter by-products which used to have the connection with environmental pollution. A study on utilization of slaughterhouse residuum and other slaughter by-products for pig feed have been implemented for resources use and waste management. The slaughterhouse residuum (SR) is comprised of two kind of materials. The largest material in SR is partially undigested feeds in digestive organs such as rice straw and formula feed.

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These are main constituents in SR (Oshida et al., 1985a). The other materials are by-products in narrow sense such as blood, digestive juice, intestinal tissue, meat, feather and skin. All these materials are possibility usable as a feed source (Oshida et al., 1985a). In Japan, 19,120,000 heads of pig and 1,480,000 heads of cattle were slaughtered in 1992, according to a statistic report (1993). From their remains, about 58,300 tons of residuum were burned or utilized as compost. We have investigated the possibility of converting residuum into pig feed by fermentation under aerobic conditions (Oshida et al., 1985b). In order to make clear the possibility of using slaughter by-products for a source of pig feed, the present study was made on the chemical composition and the palatability of FSR pellet, productivity, health and nutritional condition, carcass and meat quality of fattening pigs fed the FSR pellet.

MATERIALS AND METHODS

1. Pelleting of the FSR

The FSR pellet was made from 90% fermented slaughterhouse residuum, 5% blood meal and 5% ground fresh pig bone and gluing agent. These materials were obtained as follows.

1) Fermented slaughterhouse residuum: SR was obtained from a local meat corporation. The fermentation of SR processed by adjusting the aeration volume to 0.1 ℓ/min/kg SR. This volume was determined on the basis of changes in temperature of SR and bacterial growth occurring within SR. The number of coliform bacilli and Salmonella decreased by fermentation due to the self-heating of growing thermophiles.

2) Blood meal and ground fresh pig bone: Blood meal were spared by Atsugi Meat Bureau. Ground fresh pig bone, residuum of deboned pork (call it demeat bone) which contained a large amount of marrow were spared by a local meat packer.

3) Gluing agent: Stan guard S (Pfizer Co, Ltd.) was used.

2. Palatability of the FSR pellet

To evaluate the palatability of the 4 different types of pellet feed in pellet length were provided. Each type pellet was mixed with the formula feed in a 20 to 80 proportion by weight. The palatability was calculated from the proportion of remained feed.

3. Feeding trial for fattening

The experiments of feeding trial consisted of productivity, health and nutritional condition of pigs.

1) Feeding trial:Twenty four piglets (body weight about 69 kg) were divided into the trial and the control group; the trial group was given 20% of the FSR pellet and 80% of the formula feed by weight and the control group were given only the formula feed. The feeding program was carried out for 56 days by slaughtering the pigs, all at 194 days of age.

2) Health and nutritional condition: During the feeding trial, blood was collected from each pig every week and analyzed for total protein, glucose, total-cholesterol, hemoglobin, hematocrit, serum iron, etc.

4. Quality of pork

The experiments of the pork quality consisted of carcass quality and meat quality including sensory evaluation.

1) Carcass quality: The left side of each carcass was used in the performance tests to determine carcass quality, such as dressing percent, carcass length and rib eye area.

2) Meat quality: A sample of loin meat was analyzed for determination of physicochemical characteristics such as pH, color and chemical composition of the meat. Analysis of the chemical composition and processing quality of the meat were carried out using a cooked cured loin roll. Sensory evaluation was also performed according to the method of Scheffé (1952). The panel consisted of 30 girl students, aged 19.5. The panel tried loin meat as table meat and loin roll. The loin meat, after dipping in boiling water for 10-15 seconds (traditional cooking in Japan, called Shabushabu), as well as the loin rolls of both groups were compared for color, odor, tenderness, flavor and total point evaluations.

3) Preparation of loin roll: Loin roll (24 hr postmortem) was cured with pickle for 2 weeks (Table 1), smoked for 5 hr and cooked at an internal temperature of 63℃ or above.

Table 1 Formulation of pickle for loinroll

Additives	Percent of pickle
Salt	7.0
Sugar	4.0
Color developing agent*	0.3
Chemical seasoning	0.4
Spice	0.7
Phosphate	0.6

*Trade name:Syosei(7% $NaNO_2$, 10% KNO_3, 83% NaCl)

Table 2 General composition of FSR, blood meal, demeat bone[1], pellet, trial and control feed (DM%)

	C.[2] protein	C. fat	C. fiber	C. ash	NFE
FSR	17.4	25.4	24.5	4.6	28.1
Blood meal	60.1	0.5	0.6	1.7	37.1
Demeat bone	18.1	13.3	0.8	46.7	20.6
Pellet	13.9	22.9	26.0	7.7	29.5
Trial feed	20.6	4.9	8.2	5.1	61.2
Control feed	15.1	3.6	6.6	4.7	70.0

[1] ground fresh bone [2] Crude

RESULTS and DISCUSSION

1. Chemical composition and palatability of the FSR pellet Table 2 shows the chemical composition of FSR, blood meal, demeat bone and the pellet feed. The FSR contains high crude protein, crude fat and crude fiber. Blood meal contains high crude protein, and demeat bone contains high crude protein and crude fat (1988). These composition of the FSR and blood meal were essentially the same as that of customary report. Table 3 shows the characteristics of each type pellet. Table 4 shows the palatability of each type pellet feed. Pellet type D of which pellet length was 0.74cm had none of remaining pellet, indicating high palatability (1988).

Table 3 Characteristics of each pellet type

Pellet type	Pellet length (cm)	Powder ratio (%)	Hardness (kg/cm^2)	Volume weight (g/ℓ)	Moisture (%)
A	3.59	0.8	10.8	285	2.9
B	1.76	1.1	8.5	328	7.6
C	1.07	1.9	8.2	318	7.7
D	0.74	2.3	7.3	280	6.7

Table 4 Palatability of each pellet feed type

Pellet type	Feed intake (kg)	Remaining feed (kg)[1]	Remaining pellet (kg)[1]	Rate of remaining pellet (%)[2]
A	7.5	1.0	0.89	89.0
B	7.5	0.8	0.60	75.0
C	7.5	0.4	0.20	50.0
D	7.5	0.1	0	0

[1] remaining feed and pellet were average of two groups (each 5 pigs)
[2] Remaining pellet(kg)/Remaining feed(kg) ×100

2. Productivity of fattening pig
The data for productive performance are shown in Table 5. Increment of body weight of the trial and the control group was 39.0 kg and 34.8 kg, respectively. The daily weight gain of the trial and the control, was 696g and 621g, respectively. The feed conversion ratio of the trial and the control was 3.95 and 4.64, respectively. Thus it was indicated that productivity of the trial group was higher than the control.

Table 5 Productivity of experimental pigs

Group	Initial body weight (kg)	Final body weight (kg)	Daily weight gain (g/day)	Feed conversion	Feed efficiency
Trial	68.8	107.8	696	3.95	0.25
Control	69.4	104.2	621	4.64	0.22

3. Blood constituents

Changes in certain blood constituents of the trial and the control are shown in Table 6. The blood constituents of two groups did not change during experiment, and were essentially the same for both groups. All the pigs were in good health condition according to clinical observation and blood testing results.

Table 6 Changes in blood constituents with health and nutritional conditions of pigs during experiment

Checking item and unit	0		2		4		6		8 (weeks)	
	Trial	Control	Trial	Control	Trial	Control	Trial	Control	Trial	Control
Body weight(kg)	68.8	69.4	78.4	78.0	89.6	87.6	96.8	96.1	107.8	104.2
TP(g/dl)	7.2	7.7	7.1	7.6	6.7	7.4	6.8	7.5	6.8	7.7
Glc(mg/dl)	83	86	94	89	85	93	75	75	88	85
T-cho(mg/dl)	111	117	88	85	84	78	72	85	100	110
Hb(g/dl)	16.9	14.2	14.3	13.9	14.3	15.0	13.5	14.7	14.3	14.5
Ht(%)	40.9	38.5	40.2	41.8	38.9	40.0	38.7	41.4	39.9	38.6
Fe(μg/dl)	150	166	141	154	185	152	153	170	163	158
GOT(Karmen unit)	29	29	26	24	27	28	23	21	23	24
GPT(Karmen unit)	25	25	21	25	23	27	17	20	20	17
ALP(King-armstrog unit)	12	13	12	14	13	16	12	17	11	12
LDH(Wróblewski unit)	980	950	1030	900	1110	1100	1080	1020	1030	880
BUN(mg/dl)	9.4	11.4	11.5	16.3	15.4	19.9	14.2	17.8	15.6	17.1

4. Carcass quality

Macrofindings showed the carcasses of all the experimental pigs were normal. Their quality was within the normal range in all cases as presented in Table 7. There was no significant difference between the trial and the control group, all carcasses being basically the same.

5. Physicochemical characteristics of the meat

The visual color score based on the Pork Color Standard of Japan (1975), Hunter value and total heme content did not differ significantly between two groups. The results are shown in Table 8 which also indicates the chemical composition of loin meat. The chemical composition of the meat in both groups were similar, all values being in the normal range.

6. Processing quality of the meat

The results of the processing quality analysis of cooked cured loin roll are shown in Table 9. No significant differences in color were evident between the two groups. The pinkish color characteristic of meat products was of passing quality in all samples examined. It was found that the chemical composition of the meat products was not affected by the FSR pellet.

Table 7 Carcass quality of experimental pigs

Items	Trial group	Control group
Final weight (kg)	104.4	102.4
Carcass weight(kg)	71.4	70.9
Dressing percent(%)	68.4	69.2
Weight ratio(%)		
Front	33.7	33.1
Center	36.2	36.3
Back	30.2	30.6
Carcass temp.(℃)	2.7	2.3
Carcass lenght[1](cm)	97.4	98.0
Carcass width(cm)	35.4	35.2
Loin length[2](cm)	71.8	71.8
Rib length(cm)	57.8	57.9
Rib eye area(cm^2)	24.6	24.0
Rib eye volume(cm^3)	1423.0	1385.7
Back fat thickness(cm)	2.6	2.7

1) First cervial ～ publis
2) First lib ～ last lumber

Table 8 Meat quality of the experimental pigs

Items	Trial group	Control group
Visual color score[1]		
Meat	2.7	3.1
Fat	2.0	1.8
Hunter values		
L	47.6	43.2
a	18.8	20.1
b	9.1	8.0
b/a	0.48	0.40
Total heme pigments[2]	5.23	5.67
pH	5.40	5.44
Water holding capacity(%)	73.8	70.7
Cooking loss(%)[3]	18.9	19.3
Moisture(%)	72.9	74.6
Crude protein(%)	18.7	19.5
Crude fat(%)	4.6	5.9
Crude ash(%)	1.1	1.2
Melting point of fat(℃)		
Back	32.2	32.5
Abdominal	43.9	43.2

1) Evaluated with Pork Color Standerd (1975)
2) μ moles/100g meat, Determined by the method of Okayama and Nagata (1979)
3) Determined by the method of Sakata et al. (1984)

Table 9 Quality of loin roll made from the expermental pigs

Items	Trial group	Control group
Hunter values		
L	62.1	61.6
a	12.8	13.1
b	6.1	6.1
b/a	0.48	0.47
Color-forming ratio(%)*	79.0	75.6
pH	5.86	5.86
Residual NO^-_2 (ppm)	0.11	0.21
Moisture(%)	67.7	69.2
Crude protein(%)	19.7	18.2
Crude fat (%)	5.5	4.6
Crude ash (%)	2.6	2.6

*Determined by the method of Sakata et al. (1981)

7. Sensory evaluation

The odor of Shabushabu in items of sensory evaluation, are shown in Table 10 and 11. Significant difference in odor was evident between two groups. The other items of sensory evaluation in Shabushabu and loin rolls were analyzed in the same way as Shabushabu in odor (another data were not shown). In all results of sensory evaluation, no significant difference was found between the two groups.

Table 10 Distribution of score for sensory evaluation by paired comparison (Shabushabu:odor)

Comb.* \ Score	-3	-2	-1	0	+1	+2	+3	Total
A → B	0	1	6	1	4	3	0	2
B → A	0	1	2	5	7	0	0	3
Total	0	2	8	6	11	3	0	

*Combination
Symbol(→) means tasting order (ex. A→B:panel members taste the sample A and then taste the sample B)

Table 11 Analysis of variance for sensory evaluation by paired comparisons

Source	S[1]	df[2]	MS[3]	F value
Main effects	0.42	1	0.41	0.32
Comb[4]. effects	0.42	0	0	0
Order effects	1.77	1	1.77	1.37
Error	36.40	28	1.29	
Total	39.01	30		

[1] Sum of squares [2] Number of degrees of freedom [3] Mean square [4] Combination

CONCLUSION

1) The fermented slaughterhouse residuum, blood meal and demeat bone contained crude protein 17.4%, 60.1

% and 18.1%, respectively; 2) The trial group had significantly higher body weight gain than the control group; 3) All the pigs in feeding trial were in good health according to clinical observation and blood test, and 4) The meat quality of the trial pigs given fermented slaughterhouse residuum pellet was found quite comparable to that of a pigs given only conventional formula feed. It is concluded from these results that there is the possibility using slaughterhouse residuum and some by-products as a source of pig feed.

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