FFECTS OF ENZYME FEED ADDITIVES ON PIG PRODUCTION FOR ENVIRONMENTAL ROTECTION IN LIVESTOCK INDUSTRY.

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UMMARY

he effects of enzyme feed additives on pig defecation (excrement volume and its characteristics) and production (growth, utility of feed, alth, nutritional conditions and quality of pork) were investigated. All trials were performed on Meicelase (MC), Delicase (DC) and Proctase (PT) in LWD pigs. The volume and characteristics of the excrement were recorded about 12 piglets (about 50.2 kg), which were divided to 3 oups: control group(only formula feed), MC group (formula feed with MC 800 u/g) and DC group (formula feed with MC 500 u/g and PT 50 u/g). These piglets were individually house and allowed to feed freely for 21 days. The growth and feed efficiency trial was performed ing 30 hogs and 30 gilts (about 7.4 kg), which were divided to 3 groups of 10 gilts and hogs each:control, MC and DC groups. These gs were individually housed and allowed to feed freely for 161 days (189 days after birth). During the feeding tests, the body weight and od intake were measured for investigation of the growth and utility of feed,i,e, feed conversion, feed efficiency and daily weight gain. The alth and nutritional conditions were evaluated by blood analysis. The quality of the pork was checked when each pig weighed approx.100 ed was slaughtered. The left side of the carcass was used to determine the carcass quality. The meat of the loin was analyzed for ysicochemical characteristics such as pH, color and moisture. The three groups were compared for color, odor, tenderness and flavor and en a total score for these sensory evaluations. The results are as follows; addition of enzyme to the feed decreased the excreted volume and proved the characteristics of excrement for animal waste management. In terms of the body weight gain during feeding trial, there were nificant differences between the test groups (MC and DC) and control group. All the pigs in the feeding trial were in good health according the clinical observation and blood test. The pork quality of the test pigs (MC and DC) was found to be comparable to that of the control s. It is concluded from those results that enzyme additives is useful for decrease and improve pig excrement, and increase production thout any troubles in health and nutritional conditions, and meat quality.

TRODUCTION

ne of the biggest problem of livestock industry in Japan is how to treat of animal excrement which used to have the connection with the vironmental pollution. In order to develop the technique which decrease the volume of animal excrement and improve the characteristics of crement, such as BOD and SS etc (OSHIDA et al.,1992), the authors have been studying about enzyme feed additives. At the same time dies have been carried out about effects of additives on growth and feed usability (OSHIDA and KONISHI,1990), health,nutritional dition (OSHIDA et al.,1990) of pig. There has been no report about the effects of enzyme additives on the pork quality. So far that we sent the outline of those studies including meat quality.

TERIALS and METHODS

zyme agents: All trials were performed with Meicelase (MC), Delicase (DC) and Proctase (PT). MC made from cellulase with *richoderma viride*. MC is situated complex type enzyme such as contained xylanase and pectinase etc. PT is anti-acidic protease made from *spergillus niger*. DC is made of MC and PT. All enzymes were produced by Meiji Seika Co. Ltd. in Japan.

perimental pigs: All trials were carried out using LWD (Large white X Duroc).

ume and characteristics of excrement: Twelve piglets (body weight is about 50.2 kg) were divided to 4 groups with 3 heads each; control oup, MC 8 group, MC 16 group and DC group. These piglets were controlled under free feeding and drinking with individual feeding thod for 21 days (feeding program is shown in Table 1). Excrement was collected from each of the pigs and analyzed for volume, isture, BOD, SS, particle size distribution and transmissivity of crement suspension with the following methods; Moisture: Drying thod for 24 hrs, BOD and SS: Excrement suspension was made th distilled water and it was analyzed according to the testing thods for sewage in Japan (1984a, 1984b), Particle size tribution: Excrement suspension was divided to 7 fractions by sieve and weighed according to the previous report (OSHIDA, 1976), Transmissivity of excrement suspension: The supernatant ht which made from excrement suspension was centrifuged at

Table 1 Feeding program for improvement of volume and characteristics in porcine excrement

Group	No.of head	Feed composition
Control	3	Formula feed
MC 8	3	Formula feed + MC 800u/g*
MC16	3	Formula feed + MC 1,600u/g
DC	3	Formula feed + MC 500u/g + PT 50u/g

MC:Meicelase DC:Delicase PT:Proctase
* u/g:unit/feed per gram

3,000 rpm for 15 min. measured at 660 nm by a spectrophotometer.

Growth and feed usability: 30 hogs and 30 gilts (28 days after birth, body weight is about 7.4 kg) were divided to 3 groups each 10 head hogs and gilts, control group, MC group and DC group. These piglets were controlled under free feeding and drinking with group feeding system during 161 days (189 days after birth), feeding program shown in Table 2. During feeding test,body weight and feed intake were measured for investigation of growth and feed usability such as feed conversion,feed efficiency and daily weight gain.

Table 2 Feeding program for feedig trial

Group	No.of head	Feed composition
Control	♂10 ♀10	Formula feed
MC	♂10 ♀10	Formula feed+MC 1,600u/g*
DC	♂10 ♀10	Formula feed+MC 500u/g+PT 50u/g

MC:Meicelase DC:Delicase PT:Proctase
* u/g:unit/feed per gram

Health and nutritional conditions: Blood was collected from each of the pigs every week during feeding test, and analyzed for Hb, T-
TP, Alb, Glu, GOT, GPT, ALP, BUN and Ca by auto analyzer (Fuji DRI-CHEM 5000, made in Japan).

Quality of pork: Pigs of which body weight were approximatley 100 kg was slaughtered. The left side of carcass was determined
quality. A sample of loin meat (*M.longissimus thoracis*, 24hr postmortem) was analyzed for checking some physicochemical
such as pH,color and moisture. Sensory evaluation was also performed according to the method of SCHEFÉ (1952). The panels
of 40 girl students. The loin meat, after dipping in boiling water for 10~15 seconds (traditional cooking in Japan, it is
Shabushabu). The loin rolls cured with pickle for 3 weeks, smoked for 6 hrs and cooked at an internal temperature of 75°C
investigated. Three groups were compared for color, odor, tenderness, flavor and given total point evaluations.

RESULTS and DISCUSSION

Volume and characteristics of excrement: Total feeding volume, excrement and characteristics of excrement are shown in Table 3 and
for excrement volume, there is significant difference ($p<0.05$) between control and DC group. Japanese Feeding Standard for
(NRCAFF,1975) describes that, feed which has high energy with poor fiber (TDN;75~85, crude fiber;2~3%) is effective to decrease
volume of excrement. Based on this information, it is supposed that decrease of excrement in the trial groups is connected
decomposition of crude fiber by the effect of enzyme additives. The moisture of excreta of trial groups have decreased significantly

Table 3 Feeding and excrement volume during experiment

Group	Feeding(a) (kg)	Excrement(b) (kg)	(b)/(a) (%)
Control	49.9	31.7	63.5(100)*
MC 8	49.2	28.9	58.7(92)
MC16	49.0	28.3	57.8(91)
DC	50.0	25.8	51.6(81)

*digit of inside parentheses mean index number

Table 4 Characteristics of excreta

Group	Moisture (%)	BOD (mg/1)	SS (mg/1)	Transmissivity (%)
Control	75.3 (100)	81,000 (100)	181,000 (100)	66.0
MC 8	70.8 (94.0)	72,300 (89.3)	179,600 (99.2)	57.0
MC16	70.5 (93.6)	70,300 (86.8)	160,830 (88.9)	52.6
DC	71.3 (94.7)	66,125 (81.6)	150,000 (82.9)	56.6

*digit of inside parentheses mean index number

with that of control group. The reason make decrease moisture of excreta is considered that polysaccharide such as glucan which is excreted without digestion into excrement has been decomposed by the effect of cellulase in digestive tract and loses its ability to keep moisture, and, as the results, the moisture which is kept in excrement becomes decrease (ANDERSON,1988). BOD and SS in excreta decreased in trial groups against control group. It is reported that BOD and SS of excreta have decreased when the feed of high energy with poor fiber is given to pigs (SUGAWARA et al.,1976). Above results are considered that decomposition of crude fiber in feed is promoted by the effect of cellulase in enzyme additives Particle size of distribution of excrement became fine with enzyme addition (Table 5). It is surmised that addition of enzyme additives has greatly participated to digest of crude fiber under consideration that the particle size distribution getting fine when digestibility of feed is

Table 5 Particle size distribution(%)

mesh	Control	MC 8	MC16	D
4	3.1	1.1	1.7	0.
8.6	46.7	38.9	35.4	34.
18	36.5	41.1	41.8	44.
42	11.3	14.4	11.0	13.
60	2.0	0.9	3.0	2.
83	0.3	1.1	2.5	1.
140	0.1	2.5	4.6	2.

ced (FURUHASHI et al.,1975). It is concluded that the enzyme additives ful for decrease and improvement of pig excrement.

th and feed usability: The data for productive performance are shown in e 6. There is significant difference in gain of body wight between trial (MC DC) and control groups. However, productivity of MC and DC groups are ially the same. According to NEUDOERFFER and SMITH (1969) g enzyme additives is effectual way to improve digestion, and increasing y weight and daily weight gain.

th and nutritional condi-tions: The items of anemia and nutritional ions (TP, Alb, Glu, T-chol, Hb), of hepatic and nephric functions (BUN, (GPT) and bone formation (ALP, Ca) were observed with growth. There no significant change for items between groups e 7). This indicates that is no special problem in items.

ity of pork: Macrofindings the carcasses of all the imental pigs showed to be mal. Their quality was within mal range in all cases (Table Physicochemical characteris- of the meat are shown in the le 9. The visual color score ed on the Pork Color Stan- of Japan (NAKAI et al,1975), Hunters value and total heme content (as oglobin %) did not differ significantly in the control and trial (MC and groups. Table 10 and 11 (Shabushabu) are shown as an operative of lysis for sensory evaluation. No significant difference in color were ent in the three groups. The other items of sensory evaluation in abushabu and loin rolls were analyzed in the same way as Shabushabu in er. In the results of sensory evaluation, no significant difference could d amongn the three groups.

Table 6 Productivity of pigs given enzyme agent

Items	Control	MC	DC
Initial BW(kg)	7.3	7.4	7.4
Final BW(kg)	101.5	108.5	108.0
Live weight gain(kg)	94.8	102.6	102.5
Daily gain(g/day)			
Former period	405	460	462
Middle period	656	724	719
Final period	642	652	647
All period	589	637	637
Feed conversion	2.56	2.42	2.42
Feed efficiency	0.39	0.41	0.41

Table 7 Changes in blood constituents with health and nutritional conditions of pigs during experiment

Items	3 month			4 month			5 month			6 month		
	Cont.	MC	DC	Cont.	MC	DC	Cont.	MC	DC	Cont.	MC	DC
TP(g/dl)	6.3	6.0	6.4	6.6	6.6	6.7	6.9	6.9	7.2	7.3	6.8	6.9
Alb(g/dl)	3.9	3.7	3.8	4.0	4.0	4.0	3.6	3.7	3.6	4.0	3.8	3.8
BUN(mg/dl)	14.6	15.5	16.2	15.4	16.6	15.6	15.3	16.0	15.2	16.9	15.1	16.4
Glu(mg/dl)	112	113	116	115	110	113	111	106	102	108	103	106
T-chol(mg/dl)	92	89	92	95	95	94	99	99	100	104	93	98
GOT(IU/L)	39	41	37	35	34	35	32	26	29	32	27	27
GPT(IU/L)	27	26	27	22	24	26	22	22	23	26	26	27
ALP(IU/L)	371	352	359	329	260	325	269	253	260	298	265	297
Hb(g/dl)	13.1	12.6	13.2	13.3	13.3	14.0	13.1	13.0	13.5	14.7	13.7	14.3
Ca(mg/dl)	10.2	9.7	10.0	10.6	9.7	10.1	11.7	11.3	11.5	11.8	11.2	11.5

Cont.:Control IU/L:International unit

Table 8 Carcass quality of pigs

Items	Control	MC	DC
Final body weight(kg)	101.5	108.5	108.0
Carcass weight(kg)	70.2	72.3	70.5
Dressing percent(%)	66.4	66.2	65.5
Eye muscle area(cm^2)	25.0	26.0	26.3
Back fat thickness(cm)	2.6	2.4	2.7

Table 9 Meat quality of pigs

Items	Control	MC	DC
inal color score	4.3	4.1	3.8
ter L value	43.1	43.7	42.4
a value	20.4	21.0	20.3
b value	8.3	9.1	8.1
al heme pigments(%)	0.088	0.095	0.091
H value	5.68	5.58	5.63
isture(%)	73.5	74.1	73.6
ter holding capacity(%)	79.5	78.3	79.1
ering point(℃)	42.0	42.3	43.1

Table 10 Distribution of score for sensory evaluation by paired comparisons [Shabushabu·color]

Score / Combination	-3	-2	-1	0	+1	+2	+3	Total
A→B		1	2	3	10			6
B→A		1	10	3	2			-10
C→D		1	6	1	7	1		1
D→C		3	2	1	8	2		4
E→F		1	6	4	3	2		-1
F→E	1	1	4	2	5	3		2
Total	1	8	30	14	35	8	0	

Control: B and E, MC:C and F, DC:A and D

CONCLUSIONS:

1) Addition of enzyme for feed qualified to decrease of excrement volume and improved the characteristics of excrement for animal waste management; 2) There were significant differences in body weight gain between groups of trial (MC and DC) and control; 3) All the pigs in feeding trial were in good health according to clinical observation and blood test, and 4) The quality of the pork from trial (MC and DC) pig was found quite comparable to that of a pig given only conventional formula feed.

Table 11 Analysis of variance for sensory evaluation by paired comparisons (Shabushabu·color)

Sources	Sum of squares	d.f.	Mean square	F value
Main effects	7.52	2	3.76	2.64
Combination effects	1.04	1	1.04	0.73
Order effects	1.31	3	0.44	0.31
Error	128.12	90	1.42	
Total	138	96		

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