EFFECT OF SUPPLEMENTATION OF SHRIMP WASTE ON BODY WEIGHT GAIN, NUTRIENT DIGESTIBILITY AND NITROGEN BALANCE IN CROSSBRED PIGS

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ABSTRACT

A study was conducted to determine the effects of supplementation of shrimp waste containing chitosan on the growth performance, digestibility of nutrients and nitrogen balance in crossbred pigs. There was a significant ($P<0.01$) increase in average body weight gain, increase in digestibility ($P<0.01$) of major nutrients and increase in nitrogen retention ($P<0.05$) due to shrimp waste supplementation. The results of the study indicated that supplementation of shrimp waste containing chitosan could improve growth in pig, and the underlying mechanism is increase in digestibility of major nutrients.

Key words: Shrimp waste, growth performance, digestibility, nitrogen balance.

INTRODUCTION

Demand for animal protein for human consumption is rising globally at an unprecedented pace. Use of antibiotics as growth promoters or to control diseases (Yang *et al.,* 2015) in swine production contribute to the spread of drug-resistant pathogens in both livestock and humans posing a significant public health threat (Gois *et al*., 2016). Moreover with the ban of antibiotic growth promoters by several countries (Simon *et al.,* 2003), extensive research has become a continuous process leading to the identification of many potential alternative growth promoters such as acidifiers, probiotics, prebiotics to reduce or eliminate the use of antibiotics in animal feeds. Recent research with dietary inclusion of Chito-oligosaccharides (COS) in pig rations suggested that COS provide a potential alternative to antibiotic feed supplements. Hence, the present study was carried out to study the effect of supplementation of shrimp waste containing chitosan (COS) as a source of prebiotic on the growth performance, digestibility of nutrients and nitrogen balance in crossbred pigs.

MATERIALS AND METHOD

Fresh shrimp waste was procured from a shrimp processing factory near Nellore. It contained 30 % dry matter (DM) and was sundried for 3 days to about 90% DM and subjected to grinding in a hammer mill and sterilized in an autoclave for 10 min at 121˚C and 15 psi pressure. The chemical composition of shrimp waste is 39.5 (CP), 4.8 (EE), 8.7 (CF), 24.8 (TA), 22.2 (NFE), 55.70 (NDF), 53.26 (ADF), 1.29

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(Cellulose), 0.82 (ADL), 6.92 (Silica), 15.5 (Chitosan), 7.18 (Ca) and 3.45 (P) on DM basis.

Forty weaned piglets (42 days) were assigned at random to 5 dietary treatments and fed grower (15 to 35 kg body wt.) and finisher ration (35 to 70 kg body wt.). The control ration (T1) was supplemented with chlortetracyclin (T2) while shrimp waste was included at 2.5 (T3), 5.0 (T4) and 7.5% (T5) as a source of chitosan (Tables 1 and 2). The body weight gain at weekly intervals and the daily feed consumed were recorded.

A metabolism trial was conducted using six animals in each treatment during the finisher phase. The pigs were individually placed in metabolic cages and had free access to water and feed. The pigs were acclimatized to the cages for 3 days followed by a collection period of 5 days. During the collection period, faeces and urine were collected daily from each pig. The daily feed intake, faeces and urine voided were recorded. About 50 ml of Sulphuric acid (laboratory grade) was added to the urine container to prevent nitrogen loss. An aliquot of $1/10^{th}$ of the total faeces voided and $1/100^{th}$ of the total urine output were preserved for N, Ca and P estimation.The data were subjected to one –way analysis of variance (Snedecor and Cochran, 1989) and the means were tested by least significant difference.

RESULTS AND DISCUSSION

The shrimp waste was a rich source of protein (39.5%), Ca (7.18), P (3.45%) and Chitosan (15.5%). The grower and finisher rations (Table 1 and 2) were isonitrogenous and isocaloric with 18% CP and 3100 kcal DE/kg during grower and 16% CP and 3100 kcal DE/kg during finisher phase. The growth performance of pigs during grower phase (15 to 35 kg) is presented in Table 3. The initial weight, final weight and weight gain (kg) were comparable among treatments. The number of days taken to attain the final body weight during grower phase was lowest (55 days) ($P<0.01$) in T4 fed pigs when compared to pigs fed control diet (72 days). The average daily gain was highest ($P<0.01$) in T4 fed pigs and was in the order of T4>T5>T3>T2 and T1 fed pigs. The average daily feed intake (ADFI) was significantly higher ($P<0.01$) in T4 and T5 fed pigs and comparable among T1, T2 and T3. The feed per kg gain and cost of feed per kg gain (Rs.) were highest ($P<0.01$) in T1 fed pigs than in T2 to T5 fed pigs.

The results of present study were in agreement with earlier studies of Yan and Kim (2011) and Xu *et al.* (2013) who showed beneficial effects of supplementing chito-oligosaccharides in promoting higher ($P<0.01$) growth rate and feed efficiency in growing pigs. The increased growth rate may be attributed to increased digestibility of nutrients, apart from increasing feed intake, which were in line with findings of Yuan and Chen (2012). During finisher phase (Table 4), the initial weight, final weight and weight gain (kg) were not significantly different among treatments. Similar to the trend observed in grower phase, the pigs fed T4 had taken less number of days (72 days) than in other treatments and the pigs fed control diet have taken maximum number of days (104 days) to reach the target weight. The ADG (g) was significantly higher (P<0.01) in T4 followed by T5 than in other treatments. The feed/ kg gain was lowest (P<0.01) in pigs fed T4 diets followed by T5, T3 and T2 than T1leading to lower cost of feed per kg gain in pigs fed T4 diet and the cost of feed per kg gain was in order of T4<T5<T3<T2<T1 fed pigs.

In the current study, the digestibility of major nutrients except Ether extract was increased (Table 5) when pigs were offered diets supplemented with shrimp waste meal. The digestibility of DM of in pigs fed T4 and T5 rations was significantly higher (P<0.05) than in those fed T1, T2 and T3 rations. The CP, CF and NFE digestibility was significantly higher (P<0.01) in T4 fed pigs than in other treatments while the digestibility of EE was significantly lower (P<0.01) in pigs fed T4 and T5 rations than those fed T1, T2 and T3 rations.

Walsh *et al.* (2013) reported that Chitosan which differs from other dietary fibres because of its cationic characteristics can reduce fat absorption and interrupt enterohepatic bile acid circulation by electrostatic and hydrophobic forces. Chitosan might also increase the viscosity of the intestinal contents and the anti-fatty effects of chitosan originate from its unique fat binding properties. Zhong *et al.* (2008) reported that dietary chitosan dissolves in the stomach, emulsifies fat and forms a gel, which binds with the fat in the intestine, increasing the viscosity of the intestinal contents and the unstirred layer in the intestine and slows down nutrient diffusion, leading to effective increase in the excretion of fat . Therefore, the inhibitory effect of chitosan on lipase activity may be attributed to the viscosity of chitosan which restricted the access of the pancreatic lipase to the lipids within the droplets and the reduction of bile acid concentration in the intestinal tract. Chitosan has profound impact on circulating adipocytokines (e.g. leptin, resistin, IL-6, and C-reactive protein, etc.) which significantly suppress appetite, regulate energy metabolism and prevent lipid accumulation in peripheral tissues and therefore chitosan can lower fat mass, regulate the level of circulating triglycerides, and reduce the accumulation of lipids both in the liver and in the muscle tissue.

The findings in the present study were in agreement with the previous studies of Hou and Gao. (2001); Wang *et al*. (2009); Yan and Kim. (2011); Xu *et al.* (2014) and Swiatkiewicz *et al.* (2015) which indicated that dietary supplementation of chitosan was effective in increasing digestibility of nutrients in pigs and other farm animals and the improved nutrient digestibility was due to improvement in gut health, stimulation of the secretion of digestive enzymes from the stomach, pancreas, and intestinal mucosa. Though the mechanism of action of chitosan is still not clear, Kong *et al.* (2010) reported that ionic interactions between positively charged surface chitosan amino group and negatively charged surface of bacteria, resulting in alteration of membrane permeability and causes improved digestibility.

The nitrogen balance of pigs fed experimental diets is presented in Table 6. The nitrogen intake (g/d) was higher (P<0.01) in pigs fed T1 than in other treatments and was lowest in pigs fed T4 and it might be due to differences in feed intake during metabolism trail. Total nitrogen (g/d) loss was highest ($P<0.01$) in T1 fed pigs than T2, T3, T4 and T5 fed pigs and it could be attributed to the higher CP digestibility in pigs fed experimental diets than control diets. The nitrogen retention (g/d) was lowest ($P<0.05$) in pigs fed T1 than in the other experimental diets, depends on the amount fed in relation to the requirements and other diet constituents (Whittemore, 1992). The nitrogen (% absorbed) was comparable among the treatments and there was no significant difference among the treatments.

CONCLUSION

It is concluded that shrimp waste meal at 5% of diet may be an effective alternative to antibiotic growth promoters in crossbred pig production.

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Table 1: Ingredient and chemical composition (%) of experimental grower diets

Ingredient	T1 (NC)	T2 (PC)	T3	T4	T5
Maize	55.0	55.0	55.0	55.0	55.0
Deioled Rice Bran	17.5	17.5	16.0	16.5	16.0
Soybean meal	25.0	25.0	24.0	21.0	19.0
Shrimp shell meal	-	-	2.5	5.0	7.5
Mineral Mixture	2.0	2.0	2.0	2.0	2.0
Salt	0.5	0.5	0.5	0.5	0.5
	100	**100**	**100**	**100**	**100**
Chlorotetracycline	-	0.080	-	-	-
Lysine	0.76	0.76	0.78	0.81	0.85
Methionine	0.32	0.32	0.41	0.44	0.48
AB_2D_3	0.02	0.02	0.02	0.02	0.02
Cost per 100 kg (Rs)	22.50	22.50	20.98	20.14	19.0
Proximate composition (%) [a]					
DM	89.16	89.23	90.19	90.34	90.45
OM	88.98	88.99	87.76	87.14	87.04
CP	18.05	18.05	18.41	18.12	18.16
TA	11.02	11.01	12.24	12.86	12.96
EE	1.85	1.85	2.03	2.21	2.54
CF	6.91	6.87	9.12	10.45	11.02
NFE	62.17	62.22	58.20	56.36	55.32
Calcium	0.64	0.64	0.66	0.68	0.70
Total phosphorus	0.72	0.72	0.74	0.74	0.74
Available phosphorus	0.14	0.14	0.16	0.18	0.22
DE (kcal/kg)*	3100	3100	3100	3100	3100

[a] on dry matter basis except for DM, * Calculated

Table 2: Ingredient and chemical composition (%) of experimental finisher diets

Ingredient	T1	T2	T3	T4	T5
Maize	58.75	58.75	58.0	61.00	60.0
Deioled Rice Bran	20.00	20.00	20.25	16.75	17.50
Soybean meal	19.00	19.00	17.00	15.00	12.75
Mineral Mixture	2.0	2.0	2.0	2.0	2.0
Salt	0.25	0.25	0.25	0.25	0.25
Shrimp shell meal	-	-	2.50	5.0	7.5
	100	**100**	**100**	**100**	**100**
Chlorotetracycline	-	0.080	-	-	-
Lysine	0.67	0.67	0.72	0.75	0.76
Methionine	0.24	0.24	0.26	0.28	0.31
AB_2D_3	0.02	0.02	0.02	0.02	0.02
Cost per 100 kg (Rs)	20.50	20.75	19.30	18.45	17.75
Proximate composition (%) [a]					
DM	89.62	89.61	89.89	90.18	90.36
OM	88.31	88.31	87.98	87.52	87.04
CP	16.05	16.05	16.11	16.05	16.04
TA	11.69	11.69	12.02	12.48	12.96
EE	1.09	1.09	1.69	1.92	1.97
CF	10.21	10.21	11.05	12.12	12.32
NFE	60.96	60.96	59.13	57.43	56.74
Calcium	0.64	0.64	0.66	0.68	0.71
Total phosphorus	0.72	0.72	0.74	0.74	0.76
Available phosphorus	0.15	0.15	0.16	0.16	0.16
DE (kcal/kg)*	3100	3100	3100	3100	3100

[a] on dry matter basis except for DM , * Calculated

Table 3: Effect of dietary treatments on growth performance of crossbred pigs during grower phase (15 to 35 kg body weight)

Parameter	T1	T2	T3	T4	T5
Initial weight (kg)^{NS}	15.77±0.23	15.76±0.18	15.73±0.28	15.78±0.16	15.75±0.20
Final weight (kg) ^{NS}	35.12±0.65	35.12±0.29	35.25±0.67	35.25±0.72	35.81±0.36
Weight gain (kg) ^{NS}	19.35±0.69	19.36±0.23	19.51±0.58	19.46±0.65	20.06±0.35
No. of days**	72.25^{a}±0.67	63.75^{b}±0.36	62.75^{bc}±0.36	55.87^{d}±0.71	61.75^{c}±0.25
ADG (g)**	267.24^{d}±7.40	303.76^{c}±3.62	310.70^{bc}±7.82	348.24^{a}±0.58	324.84^{b}±5.21
ADFI (kg)**	0.73^{b}±0.01	0.75^{b}±0.01	0.75^{b}±0.01	0.78^{a}±0.01	0.80^{a}±0.01
Feed / kg gain**	2.77^{a}±0.11	2.47^{b}±0.04	2.42^{b}±0.06	2.26^{b}±0.08	2.46^{b}±0.04
Cost of feed/kg gain (Rs.)**	61.24^{a}±2.46	54.47^{b}±0.98	53.46^{b}±1.37	49.84^{b}±1.82	54.40^{b}±0.91

^{abcd} values in a row not sharing common superscripts differ significantly **(P<0.01)

^{NS} Not significant

Table 4 : Effect of dietary treatments on growth performance of crossbred pigs during finisher phase (35 to 70 kg body weight)

Parameter	T1	T2	T3	T4	T5
Initial weight (kg)^{NS}	35.50±0.81	35.08±0.30	35.91±0.70	35.75±0.88	035.75±0.30
Final weight (kg) ^{NS}	70.75±0.25	70.66±0.42	71.33±0.33	70.91±0.30	71.41±0.20
Weight gain (kg) ^{NS}	35.25±0.97	35.58±0.49	35.41±0.71	35.16±0.99	35.66±0.40
No. of days**	104.16^{a}±1.53	90.66^{b}±1.40	80.66^{c}±1.47	72.50^{d}±1.11	79.16^{c}±1.53
ADG (g)**	338.16^{d}±5.70	393.20^{c}±10.43	439.60^{b}±10.72	485.00^{a}±10.89	451.02^{b}±6.34
ADFI (kg) ^{NS}	2.13±0.05	2.12±0.04	2.05±0.03	2.03±0.06	2.05±0.03
Feed / kg gain**	6.28^{a}±0.15	5.39^{b}±0.10	4.67^{c}±0.07	4.19^{d}±0.98	4.55^{c}±0.10
Cost of feed/kg gain (Rs.)**	138.65^{a}±3.51	118.89^{b}±2.20	102.98^{c}±1.68	92.43^{d}±2.03	100.34^{c}±2.23

^{abcd} values in a row not sharing common superscripts differ significantly **(P<0.01)

^{NS} Not significant

Table 5 : Effect of dietary treatments on nutrient digestibility (%)

Digestibility (%)	T1	T2	T3	T4	T5
DM*	85.27^{ab}±0.58	85.84^{ab}±0.86	84.08^{b}±0.88	87.69^{a}±1.00	86.61^{a}±0.82
CP**	85.00^{b}±0.61	85.98^{b}±0.50	85.13^{b}±0.58	89.65^{a}±0.81	85.01^{b}±1.06
CF**	53.79^{b}±0.51	56.78^{b}±1.61	56.80^{b}±2.10	64.75^{a}±1.40	64.85^{a}±1.25
EE**	79.99^{a}±1.31	79.49^{a}±1.67	73.01^{b}±1.49	71.15^{b}±0.59	69.80^{b}±2.20
NFE*	90.37^{b}±0.59	90.91^{b}±0.76	90.76^{b}±0.87	93.22^{a}±0.81	93.15^{a}±0.74

^{ab} values in a row not sharing common superscripts differ significantly *(P<0.05),**(P<0.01)

Table 6 : Effect of dietary treatments on nitrogen balance

Nitrogen balance	T1	T2	T3	T4	T5
Intake (g/d) **	51.18^{a}±0.02	50.61^{ab}±0.06	50.69^{ab}±0.21	48.80^{c}±0.61	50.05^{b}±0.19
Outgo in faeces (g/d)**	7.82^{a}±0.34	7.09^{a}±0.24	7.65^{a}±0.37	5.04^{b}±0.39	7.33^{a}±0.30
Outgo in urine (g/d)*	9.12^{a}±0.43	6.54^{c}±0.61	7.67^{abc}±0.34	8.41^{b}±0.53	7.69^{abc}±0.55
Total loss (g/d)**	16.92^{a}±0.45	13.63^{b}±0.49	14.82^{b}±0.73	13.46^{b}±0.55	15.03^{b}±0.42
Retained (g/d)*	34.27^{c}±0.45	36.92^{a}±0.49	35.36^{abc}±0.38	35.34^{abc}±1.12	35.02^{b}±0.32
Retained (% of intake)**	66.93^{d}±0.89	71.61^{ab}±0.43	69.32^{bcd}±0.73	72.33^{a}±1.46	69.97^{bc}±0.76
Retained (% of absorbed)^{NS}	78.97±0.96	80.99±0.29	80.33±0.49	80.83±0.65	80.07±1.05

^{abcd} values in a row not sharing common superscripts differ significantly *(P<0.05), **(P<0.01)

^{NS} Not significant