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Full Length Research Paper

Effect of low protein diets and lysine supplementation on growth performance and carcass characteristics of growing pigs

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The present study was to assess the effect of feeding low protein diet with or without supplemental lysine to meet NRC (1998) requirement on growth performance, carcass trait, meat composition, and meat quality of pigs. An experiment of 126 days was conducted on 21 crossbred Landrace pigs (average weight 11.72 ± 0.57 kg, average age 7.59 ± 0.14 weeks). Animals were randomly assigned to three dietary treatment groups T_0, T_1 and T_2 each comprising 7 animals. A basal diet (T_0) was formulated as per NRC (1998). Basal diet (T_1) reduced crude protein by 10% with supplemental lysine identical in T_0; while without supplemental lysine in T_2 (that is, reduced protein by 10% and lysine by 15%). All the diets were iso-caloric and offered in phases according to change in body weight (10 to 20, 20 to 50, 50 to 80 and >80 kg). Growth performance, carcass parameters, meat composition and meat quality were evaluated at the end of the trial on four animals per group. The results show no significant difference on growth parameters and carcass and meat quality traits among the groups. Thus, it was concluded that the crude protein and lysine concentration can be reduced safely by 10 and 15%, respectively to that of NRC (1998) in diet of crossbred Landrace pigs without any compromise on performance during growing and fattening stage of production.

Key words: Carcass trait, low protein, lysine, meat quality, pigs.

INTRODUCTION

Proteins and amino acids play a crucial role in the formulation of least cost ration, as they are essential for the normal growth of body tissues, synthesis of macromolecules involved in structural, metabolic and functional activities, reproduction and disease resistance of animals (Kaur et al., 2006). The dietary provision of amino acids in correct amounts and proportions determines the adequacy of a dietary protein concentrate. Feeding and growing pigs with diets containing higher crude protein level is a metabolic and economically costly process. Lysine is the first limiting amino acid while methionine is the second limiting amino acid in corn-soybean meal diet for pigs. Lysine is the first limiting amino acid for pigs because of two main reasons. First, the concentration of lysine in muscles and other tissue is relatively high (about 7%) and second, many of the feedstuffs (Maize grain, Sorghum, Wheat bran and Barley) commonly fed to pigs are quite low in lysine (Cromwell, 1996). The different advantages of adding lysine in the diets of pigs are protein sparing effect in pig diets (reduction of dietary CP level by up to 55 g/kg in association with adequate amino acids supplementation does not affect the level of performance and body composition of piglets; Le Bellego and Noblet, 2002); environmental protection (decrease of nitrogen excretion

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by 15 to 20% with protein reduction of 2% on lysine supplementation; Shriver et al., 2003); reducing energy expenditure as less energy is diverted for protein metabolism and elimination of excess nitrogen in the form of urea; reduction of feed cost, increased immune-responsiveness, improved growth and feed efficiency and improved carcass trait and meat quality. Therefore, quantifying its requirement followed by its supplementation in diet through commercial synthetic source (L-lysine hydrochloride - 98.5%, pure L-lysine hydrochloride equivalent to 78.8% actual lysine) provides scope for reducing dietary protein supply. One of the major advantages of using low protein amino acid supplemented diet with lysine is the positive impact on environment. Reducing CP by 4% unit with the addition of amino acid markedly decreased total N excretion by 40% without influencing growth performance and carcass traits (Shriver et al., 2003). In addition, ammonia and other odorous nitrogenous emissions from manure are substantially reduced (Carter et al., 1996). The use of lysine supplementation is also economically viable and cost effective, giving higher income over feed costs (Main et al., 2008). Many experimental trials done in the past, showed positive influence of lysine supplement on growth performance. Average daily gain and gain: feed (G: F) ratio improves with increase in lysine to digestible energy (DE) ratio (Friesen et al., 1994; Szabo et al., 2001; Apple et al., 2004; Main et al., 2008). There are also some reports of improvement in immunity with feeding high lysine diets. The carcass trait and lean percentage of meat also improves with increase of lysine content in diet (Loughmiller et al., 1998; Witte et al., 2000; Szabo et al., 2001; Main et al., 2008). Therefore, the present research work was conducted to study the effect of feeding low protein diet with or without supplemental lysine to meet NRC (1998) requirement on carcass trait, meat composition, and meat quality of growing pigs.

MATERIALS AND METHODS

Experimental animal and diets

An experiment of 126 days was conducted on 21 (9 males and 12 females) cross-bred Landrace pigs (average weight 11.72 ± 0.57 kg, average age 7.59 ± 0.14 weeks) and were randomly assigned to three dietary groups (T_0, T_1 and T_2). A basal diet (T_0) was formulated (Table 1) incorporating conventional feedstuffs (maize grain, soyabean meal, and fish meal and wheat bran), salt, mineral and vitamin supplements as per NRC (1998) specifications. The crude protein (CP) content of the T_0 was reduced by 10% with supplemental lysine (as L-lysine hydrochloride) to meet the requirement in T_1; while without supplemental lysine in T_2 (that is, reduced protein by 10% and lysine by 15%). All the diets were iso-caloric (3400 kcal/kg DE) and offered in phases according to the change in body weight (10 to 20, 20 to 50, 50 to 80 and >80 kg) as per NRC (1998).

Carcass analysis

At the end of the experimental trial, 4 pigs (2 males and 2 females) per group were sacrificed to study the carcass traits and meat quality following standard procedure. All the animals were kept in liarage after arrival at the slaughter house and deprived of feed overnight but with free access to water. They were weighed immediately prior to slaughter and recorded as pre-slaughter live weight of pigs. The pigs were slaughtered after proper stunning at 70 V, 250 mA by electricity. Then, bleeding by heart puncturing with knife and wet scalding by hot water at 65°C for 5 to 6 min were performed followed by scrapping and removal of hairs. Singeing was done by blow lamp followed by evisceration and removal of gastrointestinal tract (GIT), the weight was recorded as carcass weight. The weight of hot carcass was expressed as percent of pre-slaughter live weight to arrive at dressing percentage. Carcass length was measured from the front of aitch bone to the middle of the front of first rib using a metal scale. Back fat thickness was measured at first rib, last rib and last lumbar using plastic measuring scale and average back fat thickness was determined by taking the mean of all the three values.

Meat composition and quality analysis

Samples of longissimus muscle were taken from the carcass after dissection, sealed in polythene bags and stored at -20°C for further analysis. Collected samples were analyzed for proximate principles after thawing. Moisture, fat, protein and ash contents of dissected longissmus muscles were determined as per the procedures of AOAC (1995). The pH of raw meat was determined as per the method described by Trout et al. (1992). Ten grams of sample were homogenized with 50 ml of distilled water for about a minute in Ultra Turrex T-18 tissue homogenizer (Janke and Kenkel, IKA Labor Technik, USA). The pH was recorded by immersing the combined glass electrode of digital pH meter (Elico, India, Model: L1 114) directly into the meat suspension. The water holding capacity (WHC) of raw meat was determined as per the method described by Wardlaw et al. (1973) with little modifications. Ten grams of finely minced meat sample was homogenized with 15 ml of 0.6 M NaCl in a polycarbonate centrifuge bottle for about one minute in Ultra Turrex T-18 tissue homogenizer. After holding for 15 min at 4°C in order to allow the 0.6 M NaCl to reach equilibrium, the meat slurry was again homogenized for 1 min and immediately centrifuged (REMI centrifuge, T23, Sl No. GGNC 338) at 5500 rpm for 10 min. The supernatant volume was measured and WHC was expressed as ml of 0.6 M NaCl retained by 100 g of meat. Cooked pork chunks (from meat curry) were cut into 1.25 cm^3 cubes. The cut piece was then sheared in a Warner-Bratzler Shear Press (Model: No. 81031307, G. R. Elect. Mfg. Co., USA). The shear force was recorded (in kg/cm^2) as per the method of Berry et al. (1980). Ten observations were recorded for each sample to get the average value of shear force.

Statistical analysis

Results obtained from the study were subjected to one way analysis of variance (ANOVA) as described by Snedecor and Cochran (1989) using statistical package for the social sciences, version 17(SPSS 17) software. The data were expressed as mean ± S.E., considering P<0.05 as significant.

RESULTS AND DISCUSSION

The body weight gain during the entire experimental period and average daily gain (ADG) are given in Table 2. There was no statistical difference in total body weight and average daily gain among the dietary treatments,

Table 1. Ingredients (% on as fed basis) and nutrient composition (as fed basis – 90.2%DM) of experimental diet as per NRC (1998) for growing pigs.

Ingredients%	10-20 kg			20-50 kg			50-80 kg			80-120 kg		
	T_0	T_1	T_2	T_0	T_1	T_2	T_0	T_1	T_2	T_0	T_1	T_2
Maize	51.19	58.51	57.70	59.10	65.50	64.60	66.79	72.10	71.40	72.90	77.40	76.90
Soyabean meal (DOC)	29.00	23.00	23.30	21.98	16.62	17.20	15.20	10.86	11.10	9.80	5.97	6.14
Wheat bran	13.90	12.40	13.10	14.00	12.80	13.30	13.10	12.00	12.60	13.38	12.60	13.03
Fish meal	4.00	4.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00	2.00	2.00	2.00
Limestone	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Lysine	0.01	0.19	0.00	0.02	0.18	0.00	0.01	0.14	0.00	0.02	0.13	0.03
Trace MM and Vit premix[a]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Total	100	100	100	100	100	100	100	100	100	100	100	100
Calculated nutrient composition												
DE (kcal/kg)	3399	3400	3399	3400	3399	3401	3400	3401	3400	3401	3400	3399
CP (%)	20.94	18.78	18.77	18.07	16.16	16.24	15.50	13.94	13.95	13.25	11.88	11.88
Lysine (%)	1.15	1.14	1.00	0.95	0.94	0.81	0.77	0.76	0.66	0.61	0.60	0.53
True ileal dig. Lys[b] (%)	1.01	1.01	0.87	0.83	0.83	0.70	0.66	0.66	0.56	0.52	0.52	0.44
True ileal dig. Met[b] (%)	0.31	0.29	0.29	0.27	0.25	0.25	0.25	0.23	0.23	0.21	0.20	0.20
Ca (%)	0.70	0.68	0.69	0.64	0.62	0.63	0.62	0.61	0.61	0.56	0.55	0.55
Total P (%)	0.63	0.59	0.60	0.58	0.54	0.55	0.54	0.51	0.52	0.49	0.47	0.47

[a]Trace min mix premix (0.1 kg) consisted of 10.8 g ZnO, 40 g $FeSO_4$, 1.2 g $MnSO_4$, 2 g $CuSO_4$, 0.03g KI mixed as per quintal of feed and Vit premix (0.1 kg) consisted of Vitablend AD_3 (A = 50,000 IU/g, D_3 = 5000 IU/g) and B complex vitamins. [b]True ileal dig. Lysine and methionine of different feed ingredient calculated by multiplying analyzed lysine and methionine to corresponding digestibility values of ingredient NRC (1998).

though, treatment T_2 showed the highest insignificant final body weight (89.38 kg) and body weight gain (77.65 kg). Similar results were obtained by Stahly et al. (1981) and Asche et al. (1985), who found that the growth rate of pigs fed to appetite, were not significantly affected by dietary protein or non-essential nitrogen content when the levels of essential amino acids were adequately maintained to meet the requirements. Moreno et al. (2008) also observed that the dietary lysine to NE ratio had no effect on the growth performance for late-finishing pigs. On the contrary, a positive linear effect of lysine: DE on ADG was observed by Friesen et al. (1994). More recently, Schneider et al. (2005) and Lenehan et al. (2004) reported a linear increase in ADG when diets were provided with 0.9 to 1.3% true ileal digestible lysine in exotic breed with higher growth rate. De la Llata et al. (2007) and Main et al. (2008) also found that the growth performance improved significantly with increase of dietary lysine to energy ratio. Average daily gain in respective groups were not in accordance with the present study as pigs used in the study were crossbred Landrace pigs with low growth potential and thus, had lower lysine requirement. The data obtained during the course of the carcass and meat study are presented in Table 2. The pre-slaughter live weight (kg) of pigs did not differ significantly among treatment groups. The hot carcass weights (kg) and length (cm) taken were comparable with highest insignificant values (64.07 kg and 79.25 cm) respectively for T1,

Table 2. Growth performance, carcass traits, meat composition and meat quality of growing pigs in different dietary treatments (T_0- Standard protein and lysine as per NRC, 1998, T_1- Reduced protein by 10% and standard lysine, T_2- Reduced protein by 10% and lysine by 15%).

Parameter	Treatment		
	T_0	**T_1**	**T_2**
Initial body weight (kg)	11.74 ± 1.21	11.73 ± 1.15	11.69 ± 0.71
Final body weight (kg)	85.55 ± 3.79	89.38 ± 3.72	81.87 ± 2.11
Total body weight gain (kg)	73.81 ± 3.43	77.65 ± 3.06	70.17 ± 2.05
Average Daily gain (kg)	0.59 ± 0.03	0.62 ± 0.02	0.56 ± 0.02
Average Daily feed intake (kg)	1.93 ± 0.11	1.99 ± 0.09	1.85 ± 0.05
Daily DMI (kg)	1.72 ± 0.10	1.76 ±0.08	1.64 ± 0.03
Feed : Gain	3.30 ± 0.11	3.23 ± 0.09	3.33 ±0.11
DMI : Gain	2.93 ± 0.09	2.85 ± 0.08	2.97±0.10
CPI : Gain*	0.55 ± 0.02^{a}	0.48 ± 0.01^{b}	0.49 ± 0.02^{b}
Carcass traits			
Pre slaughter live weight (kg)	93.63 ±1.34	92.88 ±2.11	89.00 ± 0.58
Hot Carcass weight (kg)	61.94 ±1.07	64.07±1.96	61.43 ±1.85
Hot Carcass length (cm)	74.00 ± 3.74	79.25 ± 1.70	74.5 ± 2.10
Average back fat thickness (cm)	2.48 ± 0.42	2.83 ± 0.34	2.82 ± 0.07
Leaf fat (kg)	1.25 ± 0.22	1.08 ± 0.17	1.49 ± 0.25
Dressing percentage	66.18±1.29	68.97±0.95	68.99±1.64
Meat composition %			
Moisture	74.00 ±1.10	72.00 ± 0.83	71.90 ± 0.24
CP (N x 6.25)	22.21 ±1.23	23.72 ± 0.31	23.94 ± 0.49
EE	2.70 ±1.09	3.22 ± 0.99	3.08 ± 0.47
Ash	1.08 ± 0.06	1.06 ± 0.22	1.08 ± 0.04
Meat quality			
pH	6.03 ± 0.17	6.3 ± 0.04	6.15 ± 0.03
Water holding capacity (ml/100 g)	32.5 ± 6.24	32.5 ± 4.79	27.5 ± 2.50
Shear force (kg/cm^2)	5.53 ± 0.05	5.5 ± 0.07	5.5 ± 0.04

^{ab} Values in a row bearing different superscripts differed significantly ($P<0.05$).* $P<0.05$.

irrespective of dietary treatments. The average back fat thickness (cm), leaf fat yield (kg) and dressing percentage also did not differ (P>0.05) due to the dietary treatments. These findings were in line with the observations of Knowles et al. (1998) and Shriver et al. (1999), who found similarity in carcass traits of pigs consuming low protein amino acid supplemented diet with those consuming the standard diet.

The chemical composition (as percent on fresh basis) of longissimus muscle sampled from each carcass is given in Table 2. The mean percent moisture, protein, EE and total ash content of longissimus muscle showed no significant difference (P>0.05) among the dietary treatments. Castell et al. (1994) and Cameron et al. (1999) also did not observe any changes in longissimus muscle moisture content with the increase of lysine: energy content in swine diets. However, Goerl et al. (1995) reported that the moisture content in the longissimus muscle actually increased in response to increasing lysine or CP content in the diet. The CP content of longissimus muscle did not differ due to different treatments. These findings were in contrast to the findings of Castell et al. (1994) and Grandhi and Cliplef (1997) who found that protein content in longissimus muscle increased with increasing dietary lysine level or CP (Cromwell et al., 1978; Goerl et al., 1995). Dietary energy and protein content play an important role in the fat and lean tissue deposition (NRC, 1998). The numerical difference in EE is quite evident between the different groups giving trend of increase in fat deposition with decrease in protein in the diet. This finding is in accordance to those observed by Castell et

Table 3. Absolute and relative weight (% BW) of trimmed lean cut & organs of pigs under different treatments (T_0- Standard protein and lysine as per NRC, 1998, T_1- Reduced protein by 10% and standard lysine, T_2- Reduced protein by 10% and lysine by 15%).

Parameter	Treatment		
	T_0	T_1	T_2
Pre-slaughter live weight (kg)	93.63±1.34	92.88±2.11	89.00±0.58
Carcass weight (%)	66.18±1.29	68.97±0.95	68.99±1.64
Trimmed lean cuts			
Head, kg	5.67±0.36	4.94±0.36	5.31±0.36
% BW [b]	6.06±0.38	5.32±0.13	5.97±0.15
Leg, kg	2.20±0.28	2.12±0.14	2.18±0.23
% BW	2.35±0.28	2.28±0.11	2.45±0.25
Jowl, kg	0.59±0.10	0.71±0.06	0.59±0.06
% BW	0.63±0.11	0.77±0.06	0.66±0.06
Butt, kg	4.05±0.70	4.02±0.41	4.03±0.76
% BW	4.31±0.69	4.36±0.54	4.55±0.88
Picnic, kg	4.37±0.34	4.39±0.19	4.05±0.44
% BW	4.68±0.40	4.73±0.13	4.55±0.47
Belly, kg	4.14±0.13	3.96±0.28	3.83±0.26
% BW	4.43±0.14	4.25±0.23	4.30±0.27
Ham, kg	7.21±0.34	6.95±0.09	7.00±0.37
% BW	7.69±0.31	7.50±0.25	7.87±0.41
Loin, kg	10.39±0.88	11.70±0.93	9.93±0.97
% BW	11.06±0.78	12.60±0.99	11.16±1.09
Organs			
Liver, kg	1.54±0.08	1.36±0.08	1.57±0.12
% BW	1.65±0.07	1.46±0.08	1.77±0.12
Heart, kg	0.32±0.03	0.30±0.02	0.33±0.01
% BW	0.34±0.03	0.33±0.02	0.37±0.01
Kidney, kg	0.34±0.03	0.39±0.07	0.37±0.02
% BW	0.37±0.02	0.42±0.07	0.42±0.02
Spleen, kg	0.23±0.03	0.20±0.01	0.21±0.02
% BW	0.25±0.03	0.22±0.02	0.24±0.02
Lung, kg	0.80±0.13	1.01±0.16	0.82±0.14
% BW	0.86±0.15	1.09±0.18	0.92±0.16
GIT full (%)	7.69±0.59	7.41±0.94	7.51±0.39
% BW	8.25±0.71	7.93±0.86	8.43±0.40

[b] Percent of pre-slaughter live body weight, ($P>0.05$).

al. (1994) and Blanchard et al. (1999). On the contrary, it has been reported that lean yield increased due to increase in lysine: energy ratio (Grandhi and Cliplef, 1997; Szabo et al., 2001), lysine level (Dourmad et al., 1996; Witte et al., 2000) and CP content (Cromwell et al., 1978) in pig. The findings related to ash contents were similar to the findings of Goerl et al. (1995), who stated that increasing dietary lysine or CP had no effect on the proportion of ash in the longissimus muscle.

The physico-chemical properties studied with longissimus muscle sampled from each carcass are given in Table 2. The pH, WHC (ml/100 g) and shear force (kg/cm^2) of the muscle samples ranged from 5.6 to 6.4, 20 to 50 and 5.3 to 5.6, respectively with no significant ($P>0.05$) difference recorded among dietary treatments. This finding is in accordance to earlier findings indicating no influence on ultimate muscle pH (Goerl et al., 1995; Witte et al., 2000; Szabo et al., 2001), water-holding capacity (Goerl et al., 1995) and firmness scores (Friesen et al., 1994; Grandhi and Cliplef, 1997) in pigs fed with diets formulating based on CP, lysine, or lysine: energy ratio. Absolute and relative weight (% BW) of trimmed lean cut and organs of pigs under different treatments are given in Table 3. Trimmed lean cut among different group did not differ significantly. The relative weights of visceral organs were also comparable. The body weight, carcass traits and yield of visceral organs were not affected by 10% reduced crude protein and 15% lysine comparable to NRC (1998). Therefore, the results indicate scope for reduction of protein and lysine in diets of crossbred Landrace pigs.

Conclusion

From the ongoing findings, it is concluded that the crude protein and lysine concentration can be reduced safely by 10 and 15% respectively to that of NRC (1998) without any compromise on performance of the crossbred Landrace pigs during growing and fattening stage of production.

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