# DIETARY ESSENTIAL AMINO ACID SUPPLEMENTATIONS
## (In a Sex and Growth-Phase Split Feedings in Pig)

**Suwarno[1], and S. K. Baidoo[2]**

**[1]Fakultas Peternakan Unsoed dan [2] Department of Animal Sci., the Faculty of Agricultural and Food Sciences University of Manitoba, Winnipeg, MB, Canada**

**ABSTRAK**

Penelitian ini bertujuan untuk menyelidiki pengaruh suplementasi ransum dasar (BD, ransum kontrol yg disusun menurut NRC, 1988) dengan asam amino esensial lysine, methionin, threonine (SD1 dan SD2, ransum perlakuan) terhadap konsumsi ransum dan kinerja pada ternak babi. Bahan utama ketiga ransum terdiri dari tepung barley, gandum, dan kedele. Masing-masing ransum mengandung kadar protein kasar (18% untuk grower dan 16,5% untuk finisher) dan enerji (14,2 MJ/kg). Ransum diberikan dengan cara dipecah (splitted) menurut periode pertumbuhan (grower dan finisher) dan jenis kelamin (jantan dan betina). Ransum BD dan SD1 dipecah menjadi 2 fase pemberian (grower: 20 – 60 kg berat badan (BB), dan finisher: 60 - 105 kg BB), ransum SD2 dipecah menjadi 4 fase pemberian (grower I: 20 – 40 kg, grower II: 40 – 60 kg, finisher I : 60 – 80 kg, dan finisher II: 80 – 105 kg BB). Babi dengan berat awal 20 kg sebanyak 72 ekor (36 jantan dan 36 betina) dikandangkan dg kondisi lingkungan yg serupa ($20^{O}$ C) selama penelitian. Suplementasi ransum dasar dengan asam amino esensial tidak mempengaruhi konsumsi ransum harian (2,49, 2,43, dan 2,36 kg masing-masing untuk BD, SD1 dan SD2, P > 0,05). Babi pada masa pertumbuhan finisher mengonsumsi ransum harian terbanyak (2,77 – 2,83 kg) dibanding masa pertumbuhan lainnya (P < 0,01). Babi jantan cenderung mengonsumsi ransum harian lebih banyak (P < 0,11) dibanding babi betina (2,49 kg vs. 2,36 kg). Babi yg diberi ransum yang diperkaya dengan asam amino tumbuh lebih cepat (0,93 dan 0,96 kg/hari untuk SD1 dan SD2) dibanding babi yang diberi ransum kontrol (0,82 kg/hari), P < 0,01. Pertumbuhan tercepat terjadi pada masa awal finisher (60 – 80 kg BB), yaitu 1,07 kg/hari, sedangkan kecepatan pertumbuhan pada masa pertumbuhan yang lain sebanding (0,85; 0,86; dan 0,83 kg/hari). Babi yang diberi ransum yang diperkaya dengan asam amino esensial dapat menggunakan ransum dengan lebih efisien (2,68 dan 2,58 kg ransum/kg PBB untuk SD1 dan SD2) dibanding babi yang diberi ransum kontrol (3,03 kg ransum/kg PBB), P < 0,01. Diantara masa pertumbuhan, awal masa pertumbuhan grower (20-40kg BB) mempunyai efisiensi penggunaan ransum tertinggi (2,16 kg ransum/kg PBB) dan akhir masa pertumbuhan finisher (80 – 105 kg BB) mempunyai nilai efisiensi terendah (3,55 kg ransum/kg PBB), P < 0,01. Babi jantan cenderung lebih efisien dalam menggunakan ransum dibanding babi betina (2,66 vs 2,87 kg ransum/kg PBB), P < 0,09.

**Kata kunci** : Ransum, suplementasi, asam amino, babi, konsumsi, kinerja.

## INTRODUCTION

Considerable attention has been given to the effect of amino acid supplementation in the diets on growth rate and carcass development in pig. Williams (1995) reported that amino acids are utilized for endogenous secretion and protein synthesis and transamination in gut tissue. Excess levels of amino acids may become a metabolic burden to the pigs (Stahly *et al.* 1979), and so does unfavourable environmental temperature. Stahly (1991) found out that in hot temperature pigs grew more slowly on a high-protein diet than on a low-protein diet. Therefore, accurate asssessment of amino acids for maintenance and growth and accurate supply of these amino acids in diet is essential to optimize growth and lean production.

To formulate the diets more economically it is important that the excess of amino acid content should be minimized (Lopez *et al.*, 1994). This can be done by preparing the diet on ideal protein basis, i.e. amino acids are provided in the exact proportions necessary for maintenance and protein accretion in a pattern in which every amino acid is equally limiting. Some experiments on the utilization of amino acids have been conducted, but most of the studies were performed with the younger growing animals (Yen *et al.*, 1986). Recommendation of lysine requirement was given by ARC (1967), but not for methionine and threonine , the other limiting amino acids. Yen *et al* (1986) reported the responds of pigs between 25-55 kg live weight to dietary lysine supplied as part of an ideal protein. The responds of the heavier live weight was rarely documented. Previous studies by Chiba (1994), Jongbloed and Lewis (1992), Campbell and Traverner (1988) have shown that pigs respond to higher levels of amino acids than those recommended by NRC (1988). The creation of new breeds of pigs that have genetic potential to grow faster and reach heavier finishing weight and more lean deposition relative to the older breeds, should require higher levels of amino acids in the diet. Within genotype, sex differences may result in alteration of growth performance (Baidoo *et al.*, 1995). This paper will review the study of essential amino acid supplementations for growing-finishing pigs based on split-sex and phase feeding on feed efficiency and pig performance and to compare the levels of dietary amino acids in this study with those as recommended by NRC (1988) on pig performance.

## RESEARCH METHODS

*Diets and experimental animals*

There were three dietary treatments in this study. Diet 1 was basal diet (BD) formulated to contain an average of 0.47 g lysine/MJDE, according to the recommendation of NRC (1988 ), diet 2 and diet 3 (SD1 and SD2) were supplemented with lysine, methionine and threonine, formulated to contain 0.79 g. lysine/MJDE. Basal diet and SD1 were split into 2 different phase feedings; for grower (20-60 kg body weigh, G), and finisher (60-105 kg body weigh, F). Diet 3 was split into 4 phase fedings; for grower I (20-40 kg, GI), grower II (40-60 kg, GII), finisher I (60-80 kg, FI) and finisher II (80-105 kg, FII), respectively. Diet 1 for grower was formulated to contain 0.55 g lysine/MJDE, diet 1 for finisher 0.47 g lysine/MJDE. Diet two for grower was formulated to contain 0.88 g lysine/MJDE and for finisher to contain 0.70 g lysine/MJDE. Diet 3 for grower I was to contain 0.92 g lysine/MJDE, for grower II was to contain 0.84 g lysine/MJDE, for finisher I was to contain 0.74 g lysine/MJDE and for finisher II was to contain 0.66 g lysine/MJDE, respectively. The basal diet was based on barley-wheat-soybean meal as shown in Table 1. To reach the required lysine levels as in diet 2 and 3, synthetic amino acids (lysine, methionine and threonine) were supplemented (Table 2).

The ingredients were thoroughly mixed with a feed mixer and sub-sampled for nutrient analyses, the results were shown in Table 2. The diets were fed ad-libitum

Table 1. Percentage Composition of Basal Diet

| Ingredients | Grower | Finisher |
|---|---|---|
| Barley | 51.7 | 55.6 |
| Wheat | 20 | 20 |
| Soybean meal | 8 | 6 |
| Canola meal | 10 | 8 |
| Canola oil | 5 | 5 |

Table 2. Amino Acid Supplementation (%, DM Basis) and Analyzed Composition of Basal and Supplemented Diets.

| | BD | | SD1 | | SD2 | | | |
|---|---|---|---|---|---|---|---|---|
| | GB | FB | GS1 | FS1 | GS2I | GS2II | FS2I | FS2II |
| *Supplementation* | | | | | | | | |
| Lysine | 0 | 0 | 0.47 | 0.24 | 0.56 | 0.35 | 0.31 | 0.11 |
| Methionine | 0 | 0 | 0.27 | 0.09 | 0.34 | 0.20 | 0.16 | 0.03 |
| Threonine | 0 | 0 | 0.24 | 0.06 | 0.30 | 0.17 | 0.13 | 0.00 |
| *Analyzed composition* | | | | | | | | |
| CP, % * | 18.6 | 16.8 | 18.0 | 16.4 | 18.2 | 18.0 | 16.3 | 16.5 |
| DE, MJ/kg DM. | 14.1 | 14.5 | 14.1 | 14.4 | 14.1 | 14.2 | 14.3 | 14.3 |
| Lysine, % * | 0.75 | 0.66 | 0.96 | 0.90 | 1.12 | 0.88 | 1.00 | 0.80 |
| Met & Cys , % * | 0.52 | 0.49 | 0.78 | 0.58 | 0.84 | 0.71 | 0.65 | 0.52 |
| Threonine, % * | 0.57 | 0.54 | 0.80 | 0.60 | 0.74 | 0.54 | 0.67 | 0.54 |

* Dry matter (DM) basis.

Seventy-two pigs, 36 gilts and 36 castrated males of the same breed and average initial body weight of 20.0 kg were used. There were twelve gilts and twelve barrows in each diet treatment.

There were 6 pens in each diet treatment as replicates, each of which contains 4 animals of the same sex, therefore, there were 3 pens that contained gilts and 3 pens that contained barrows in each diet treatment. The average initial body weights among pens were treated in such that they were to be similar. Each pen (3m X 1.2m) with solid concrete floor, equipped with a single-hole feeder and a nipple waterer) was supposed to be an experimental unit. Pens were placed in 3 rooms of similar environmental condition with an average temperature of $20^{0}$ C. There were 6 pens in each room, 3 pens for males and 3 pens for female. Animals were weighed from the start of the study and then every 7 days to determine the change in diet given (from grower to finisher), daily body weight gain and feed efficiency. Animals went off diets after they reached 105 kg body weight.

***Chemical analysis of feed***

Feed dry matter was determined at $105^{0}$ C in ovens. Samples then were ground through a 1-mm screen and stored in plastic bags for further analysis. Crude protein determinations were analyzed using a macro-Kjeldahl procedure (Association of Official Analytical Chemist, 1984). Amino acid concentration were determined by means of protein hydrolysis and amino acid assay using an Amino Acid Analyzer, Model 6300, Beckman Instruments, Palo Alto, CA. Assesment of energy was conducted using an Adiabatic Calorymeter.

*Statistical analysis*

The effect of inclusion of different levels of amino acids in the diets on feed intake, amino acid intake, daily gain and feed convertion ratio were determined by one-way analysis of variance using the general linear model (GLM) procedure of the Statistical Analysis System (SAS) Institute Inc., 1985. The design used was split split-plot. The Orthogonal Contrast test was used for all mean comparisons.

## RESULTS AND DISCUSSION

*Feed intake and feed convertion ratio*

Although all the three diets contained similar percentages of crude protein and digestible energy, as a result of amino acid supplementations, diets 2 and 3 contained higher percentage of the three amino acids relative to diet 1 (Table 2). No major differences were detected in daily feed intake due to amino acid supplementation in the diet (P>0.05, Table 3).

Table 3. Statistical Significance Differences among Treatment, Growth Pase, and Sex.

| Variable | Trt | Pha | Sex | Trt*Pha | Trt*Sex | Pha*Sex | Trt*Pha*Sex |
|---|---|---|---|---|---|---|---|
| Daily feed intake | NS | <0.01 | <0.11 | <0.05 | <0.16 | NS | NS |
| Daily lysine intake | <0.01 | <0.01 | NS | NS | NS | NS | NS |
| Daily methionine intake | <0.01 | <0.01 | NS | <0.01 | NS | NS | NS |
| Daily threonine intake | <0.01 | <0.01 | NS | <0.01 | NS | NS | NS |
| Days to 05 kg body weight | <0.01 | - | <0.01 | - | NS | NS | - |
| Average daily gain (ADG) | <0.01 | <0.01 | <0.01 | NS | NS | <0.06 | NS |
| Feed efficiency | <0.05 | <0.01 | NS | NS | NS | <0.09 | NS |

Table 4. Feed Intake and Animal Performance When Fed The Experimental Diets.

| | BD | SD1 | SD2 | SEM |
|---|---|---|---|---|
| Feed intake, kg/d | 2.49 a | 2.43 a | 2.36 a | 0.05 |
| Lysine intake, g/d | 17.35 b | 22.49 a | 21.96 a | 0.53 |
| Methionine intake, g/d | 12.50 b | 16.22 a | 15.51 a | 0.39 |
| Threonine intake, g/d | 13.74 b | 16.70 a | 16.08 a | 0.41 |
| *Animal Performance* | | | | |
| Days to 105 kg body weight | 105.70 a | 93.50 b | 92.90b | 2.10 |
| ADG, kg | 0.82 a | 0.93 b | 0.96 b | 0.01 |
| Feed efficiency, kg /kg gain | 3.03 a | 2.68 b | 2.58 b | 0.09 |

Means in the same row with different letters are significantly different ($P < 0.05$).
SEM: Standard Error of Means.

This finding was supported by the finding of Hansen *et al.*, (1993) who found no significant difference in daily feed intake of 20-50 kg pigs (2.14 kg vs. 2.05 kg) fed either 0.71% or 0.86% lysine levels in a 12% CP, sorghum-soybean meal diet. In all cases, the pigs in our study consumed about 2.4 kg to 2.5 kg feed per day (Table 4). However, Johnston et al., (1993) and Goodband *et al.*, (1993) found a linear decrease in daily feed intake ($P<0.01$) when dietary lysine levels of corn-soybean meal diet were increased from 0.8 to 1.4% and fed to 59-127 kg pigs (3.37kg/d vs. 3.17 kg/d and 2.92 kg/d vs 2.77 kg/d, respectively). In this case, Johnston *et al.*, (1993) and Goodband *et al.*, (1993) increased the lysine levels by changing the ratios between corn and soybean meals in the diets (increasing soybean concentration), which resulted in higher crude protein contents and also the amino acid contents in the higher lysine diets. The excess of this protein in the high lysine diet might become a metabolic burden to the pigs, with the result that pigs wanted to lighten the burden by decreasing their feed intake. The injection of porcine somatothropine to enhance the growth of the pig in their studies failed to depress the decrease in feed consumption in the high lysine diets. In our study, the increase in lysine levels was not accompanied by the increase in crude protein, with the consequence that the nutrients could be digested more efficiently without sacrificing feed intake. Effect of phase and treatment - phase interaction on daily feed intake were detected. Male pigs tended ($P<0.11$) to eat more feed compared to that of female pigs. Average daily feed consumption of barrows was 2.49 kg and that of gilts was 2.33 kg, respectively. In the range of 20-40 kg body weight pigs consumed less feed (1.82 kg) relative to that of 40-60 kg body weigh pigs (2.28 kg, $P<0.05$). In the range of 60-80 kg and 80-105 kg body weigh, daily consumption were similar (2.77 kg vs. 2.83 kg, $P>0.05$). These daily feed intakes were slightly lower compared to those reported by Henry *et al.*, (1992) that daily intake of 42-101 kg pigs fed .55 % and .65% lysine of 15.4 % dietary crude protein feed was 3.14 kg and 3.34 kg, respectively. While the daily consumption of diet 1 (0.47 g lysine/MJDE) and diet 3 (0.79 g lysine /MJDE) increased from about 1.74 kg to 2.95 kg during the entire growth period, that was not the case for diet 2 (0.79 g lysine/MJDE). At the beginning of the trial pigs ate more feed of diet 2 (1.95 kg), relative to those of diet 1 or diet 3 (1.74 kg). In the 60-80 kg body weight, the daily consumption of diet 2 became intermediate (2.86 kg) between those of diet 1 (2.92 kg) and diet 3 (2.53 kg), and the consumption of diet 2 dropped to about 2.60 kg when the animals reached 80 kg to 105 kg body weighs. It seemed that this pattern of intake might have relationship with the body weight (growth phase,) and concentration of amino acids (at least lysine) in the diet. When the concentration is too low or too high (diet 1 and 3 in the early grower) pigs ate less feed. The drastic increase of daily feed consumption of diet 1 among the growth phases may be due to the demand for amino acids by the animals for maintenance and body protein synthesis cannot be met by the concentration of amino acids in the diet. As a result the animals ate as much feed as possible in order to satisfy the requirement of these amino acids. Although there was no difference in feed intake among treatments, because the density of lysine, methionine and threonine were higher in diets 2 and 3 relative to diet 1, higher amount of these amino acids were also consumed from these diets ($P<0.01$) as shown in Table 4. Daily lysine intake was 17.35 g for the control diet and 22.49 g and 21.96 g respectively for diet 2 and diet 3. Johnston *et al.*, (1993) found similar results with this study with the increase of daily lysine intake from 26.9 g to 44.3 g with the increase in dietary lysine level from 0.8 % to 1.4%. Growth phases also affected daily amino acid intakes ($P<0.01$). Pigs of 20 - 40 body weight consumed 17.17 g, which was lower ($P<0.05$) relative to that of 40-60 kg, 60-80 kg or 80-105 kg body weigh groups (19.63 g, 23.44 g and 22.16 g, respectively). These daily intakes were similar with the estimated dietary lysine requirements recommended by Stahly (1991) for the high lean growth genotype type of pigs (15.5 to 23.1 g/d), but in some cases lower intakes compared to the estimated requirements recommended by Kerr (1993), who reported that the requirements ranged from 17.9 g/d (grower) to 25.2 g/d (finisher). In this case, the recommendation of Stahly was based on daily lean deposition (>340 g/d) while that of Kerr was based on daily protein deposition (150 g/d). No significant effects of sex or treatment x phase interaction on daily lysine intake were identified as shown in Table 3 ($P>0.05$). Similar results with those of daily lysine intake were identified in methionine and threonine for treatment and phase effects, $P<0.01$. Pigs fed diet 1 (control) consumed significantly lower methionine (12.50 g/d, $P<0.05$), compared to those of diet 2 (16.22 g/d) or diet 3 (15.51 g/d). Pigs fed diet 1 also consumed lower threonine (13.74 g/d, $P<0.05$) compared to those of diet 2 (16.70 g/d) or diet 3 (16.08 g/d). In the 20-40 kg body weigh range, pigs consumed lower methionine (13.02 g/d, $P<0.05$) compared to those of 40-60 kg, 60-80 kg or 80-105 kg body weigh pigs (15.22 g/d, 15.78 g/d and 14.95 g/d respectively). For the consumption of threonine the groups of pigs consumed 13.62, 15.98, 16.62 and 15.81 g/d respectively, in similar manner of those for daily methionine consumption. The interaction between treatment and growth phase for daily methionine and threonine consumption indicated that there were increased intakes of methionine and threonine for diet 1 and 3 during the trial, but that was not the case for diet 2, which decreased after the pigs reached 40-60 kg body weight. These patterns of methionine and threonine intakes were similar with that in the interaction of phase x treatment for daily feed intake (Figure 1). The inclusion of amino acid improved the efficiency of the diet ($P<0.05$). The growth phase also influenced the efficiency of the diets ($P<0.01$), but not for the interaction as shown in Figure 8 ($P>0.05$). The feed convertion ratio for diet 1 (3.03) was significantly higher ($P<0.05$) compared to those of diet 2 (2.68) or diet 3 (2.58) which indicated that feed was used less efficiently in diet 1 compared to those in diet 2 or diet 3. Stahly *et al.* (1988) found that increased percentages of dietary lysine (0.50 % vs 0.95 %) fed to high-lean type pigs from 22 to 107 kg body weight decreased feed convertion ratio from 3.48 to 3.08, while the increasing levels of lysine from 0.65 % to 0.95 % gave no effect. In this study, increased dietary lysine level from 0.70 %

(diet 1) to 0.93% (diet 2 and 3) resulted in a decrease of feed convertion ratio (improved feed efficiency), which was different with the findings of Stahly *et al* (1988). Although Hansen et al. (1993) found a tendency of improving feed efficiency with the increasing lysine level from 0.71 to 0.86% in a 12% dietary crude protein of the corn-soybean meal diet, Johnston *et al.* (1993) found no effect of the increasing lysine level on feed efficiency when the increase in lysine levels were accompanied by dietary crude protein levels. Other dietary factors such as differences in the sources of protein and amino acids (differences in the feedstuffs used), concentration of dietary digestible energy, ratio of the other amino acids to lysine might influence the differences between the findings of Stahly *et al.* (1988) and Johnston et al. (1993) with those in this study. The early phase of grower (20-40 kg body weight) in this study showed the best ($P<0.05$) in feed utilization (feed convertion ratio=2.15) compared to the other later growth phases. The later phase of grower (40-60 kg body weight) had similar ($P>0.05$) feed utilization compared to that of the early phase of finisher (60-80 kg body weight, feed convertion ratios of 2.69 and 2.66 respectively). The later phase of finisher (80-105 kg body weight) had the worst feed utilization with feed convertion ratio of 3.55. Females tended to use the feed less efficiently ($P<0.09$) compared to that of males, with the average feed convertion ratios of 2.87 and 2.66, respectively. Conversely Hahn *et al.*, (1995) found that gilts of the early finisher (50-95 kg) and late finisher (90-110 kg) fed 11% and 10% respectively of dietary crude protein of corn-soybean meal supplemented with tryptophan, threonine, methionine, valine and isoleucine, were able to use the diet more efficient compared to that of barrows (346 g gain/kg feed vs 313 g gain/kg feed and 301 g gain/kg feed vs 283 g gain/kg feed respectively for early finisher and late finisher). Differences in the source (quality) and concentration of crude protein as well as differences in amino acid concentrations might, at least in part, account for the differences between our findings with those of Hahn's. *et al.* (1995).

*Animal performances*

Inclusion of amino acid in the diet affected the time pigs reached finishing weight (105 kg). Pigs fed diet 1 required longer time (105.7 days, $P<0.05$) compared to those of diet 2 (93.5 days), or diet 3 (92.9 days), as shown in Table 4. Female pigs required longer time compared to those of male pigs (103.7 vs 91.0 days, $P<0.05$) to reach 105 kg body weigh.

As expected, the inclusion of amino acids in the diet increased daily gains in pigs. This was in accordance with the report of Whittemore (1996) that for fast lean growers, the diet should have high essential amino acid to energy ratio. Similar results with this study were also reported by Sharda *et al.*, (1976) when a 16% dietary CP of corn-soybean meal diet supplemented with lysine and threonine was fed to the pigs, or 12% dietary CP of corn-soybean meal diets were fortified with lysine and tryptophan (Corley and Easter, 1980), or with lysine, tryptophan and threonine (Russell *et al.*, 1986). Johnston *et al.*, (1993) found no effect of increasing dietary lysine levels on daily gain, when the increase in lysine levels were accompanied with the increase in intact dietary crude protein. Hansen *et al*., (1993) also found that the increasing dietary lysine levels from 0.71% to 0.86% in a 12% CP of sorghum-soybean meal diet although did not affect daily gain, it improved ($P<0.07$) feed efficiency. Growth phases and sex also affected daily gain, and there is a tendency of the growth phase x sex interaction ($P<0.06$). Average daily gain of pigs fed diet 1 was 0.82 kg that was lower ($P<0.05$) compared to those of pigs fed diets 2 or 3 (0.93 and 0.96 kg respectively, Table 4). The greatest average daily gain (1.07 kg) was achieved in the early phase of finisher (60-80 kg body weight), while the average daily gain in the other phases of growth being similar (0.85, 0.86, and 0.83 kg respectively for early grower, later grower and later finisher. Male pigs grew faster compared to that of females (0.97 kg/d vs. 0.84 kg/d, respectively, $P<0.01$). In the early grower (20-40 kg), male and female pigs had similar daily gain (0.88 kg vs. 0.82 kg, respetively). In the late grower (40-60 kg) male pigs began to grow faster (0.93 kg/d) relative to female pigs (0.79 kg/d, $P<0.05$), and the discrepancy of daily gain between male and female pigs culminated at the early finisher (1.17 kg/d vs. 0.96 kg/d, respectively). In the late finisher (80-105 kg) the daily gain of male and female pigs became similar again (0.88 kg/d vs. 0.79 kg/d, $P>0.05$). This finding was supported by Hahn et al., (1995) who reported a greater daily gain in male, 50-110 kg pigs, compared to that of females (0.961 kg to 1.150 kg vs 0.875 kg to 0.976 kg, respectively). Although the way the amino acid-supplemented feed was given to the pigs (diet 2 vs diet 3) gave no significant effect on daily gain and feed efficiency, Baidoo and Liu (1996) identified a cheaper cost when pigs were fed 4-split feedings during the grower-finisher phases rather than 2-split feedings ($ 0.40/kg gain vs. $ 0.43/kg. gain, respectively).

## CONCLUSION

The results of this study concluded that fast lean grower genotype of pigs require dietary essential amino acid density greater than those recommended by NRC (1988). The inclusion of amino acid into basal diet also improved feed efficiency. The 4-split feedings during the grower-finisher period was more beneficial than non-split feeding. Phase feeding therefore improves utilization of nutrients.

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