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# EFFECTS OF FIBRE AND PROTEIN LEVELS ON GROWTH AND CARCASS CHARACTERISTICS OF PIGS

H.K. ONG* and R.I. HUTAGALUNG**

*Keywords:* Fibre, Protein, Performance, Carcass quality, Pigs, Malaysia.

## RINGKASAN

Satu percubaan telah dijalankan untuk mengkaji kesan aras gentian dan protein pada tumbesaran dan ciri-ciri karkas khinzir. Percubaan ini menggunakan sembilan rumusan makanan yang mengandungi tiga aras gentian iaitu 10%, 15% dan 20% 'neutral detergent fibre' serta tiga aras protein pada purata 14.6%, 17.6% dan 20.6% N x 6.25. Rumusan makanan tersebut telah diberikan kepada 90 ekor khinzir (sepuluh ekor bagi tiap-tiap perlakuan). Gentian dalam makanan didapati mengurangkan purata pertambahan berat (ADG) dengan bererti ($P<0.01$) iaitu sebanyak 753, 676 dan 559 g masing-masing bagi khinzir yang memakan makanan bergentian rendah, sederhana dan tinggi. Khinzir yang diberi makanan bergentian tinggi menunjukkan purata pengambilan makanan yang lebih rendah ($P<0.05$). Kecekapan penukaran makanan didapati merosot apabila kandungan gentian bertambah, sebanyak 3.12, 3.40 dan 3.92 masing-masing bagi khinzir yang diberi makanan bergentian rendah, sederhana dan tinggi. Peratus daging selepas dilapah didapati lebih rendah ($P<0.01$) manakala saluran pencernaan bertambah besar berikutan dengan pertambahan aras gentian. Khinzir yang memakan makanan bergentian tinggi menghasilkan lebih banyak ($P<0.01$) daging tanpa lemak dan lemak belakang yang lebih nipis ($P<0.01$). Makanan yang mengandungi aras protein yang rendah didapati mengurangkan ADG. Walau bagaimanapun, ADG bagi khinzir yang diberi makanan berprotein sederhana dan tinggi tidak berbeza dengan bererti. Pada amnya, ciri-ciri karkas tidak berbeza dengan bererti antara perlakuan. Hanya makanan yang mengandungi aras protein yang rendah menghasilkan karkas yang mempunyai lemak belakang yang lebih tebal.

## INTRODUCTION

It has been emphasized that there should be increased livestock production using materials which are non-competitive between human and livestock in terms of food resources utilization. This points to the fact that there should be increased use of agricultural and industrial by-products as feeds. However, in Malaysia, these types of feedstuffs or potential feedstuffs such as palm oil effluent, cocoa pods and brewers dried grains tend to be fibrous.

Early work on pigs has demonstrated the adverse effect of fibre on digestibility (NORDFELDT, 1954; CUNNINGHAM, FRIEND and NICHOLSON, 1962) and growth (AXELSSON and ERICKSSON, 1953; CRAMPTON, ASHTON and LLOYD, 1954; TEAQUE and HANSON, 1954). More recent studies, however, showed that dietary fibre levels had no effect on growth performance if the energy density was constant (COLE, DUCKWORTH and HOLMES, 1967; BAIRD, MCCAMPBELL and ALLISON, 1970). Studies carried out under Malaysian conditions using different fibre sources have shown that the digestibility of protein decreased with increased levels of fibre (ONG and HUTAGALUNG, 1984; 1985). This experiment was conducted to study whether there was a need to increase dietary protein with increased dietary fibre, and whether fibre and/or protein levels would affect carcass characteristics.

## MATERIALS AND METHODS

A 3 x 3 factorial experiment with three levels each of dietary fibre and protein, using 90 pigs averaging 25 kg, was conducted. Nine diets were formulated to comprise three levels of fibre (averaging 10%, 15% and 20% NDF) and three levels of protein (averaging 14.6%, 17.6% and 20.6% of N x

*Livestock Research Division, MARDI, Serdang, Selangor, Malaysia.
**Dept. of Animal Sciences, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia.

6.25). These levels were categorised as low, medium and high fibre or protein respectively. The compositions of diets with calculated constituents are shown in *Table 1*. When the pigs reached 45 kg liveweight, their diets were reformulated *(Table 2)*. The two main fibre sources used were a leaf meal imported from China (CLM) and local brewers dried grains.

The pigs were housed in concrete-floored individual pens with individual feed troughs and water push-nipples. Individual feed bin with cover was provided for each pig. The animals were fed twice daily with frequent inspection for necessary addition between feedings so as to simulate *ad libitum* feedings. Feed refuse was weighed daily. Liveweight gains were recorded at weekly intervals.

Pigs that were reared to about 80 kg liveweight on the experimental diets were fasted for 12 hours before slaughter. Warm carcasses were weighed and chilled at 4°C for 16 hours. Full and empty digestive tracts of each pig were weighed. Chilled carcasses were weighed and the following records were taken: backfat thickness, loin eye area, weights of loin, ham, belly, picnic and boston butt. Lean cuts were taken as the sum of skinned ham, picnic and boston butt.

The statistical model to which data were applied, was $Y_{ijk} = U + B_i + T_j + (BT)_{ij} + E_{(ij)k}$ where $U$ is the overall mean; $B_i$, the effect of the $i^{th}$ block; $T_j$, the effect of the $j^{th}$ treatment; $(BT)_{ij}$, the interaction of the $i^{th}$ block with the $j^{th}$ treatment and $E_{(ij)k}$, the error term. Data were subjected to analysis of variance and the difference

Table 1. Composition of diets (25–45 kg liveweight)

| Composition | LF | | | MF | | | HF | | |
|---|---|---|---|---|---|---|---|---|---|
| | LP | MP | HP | LP | MP | HP | LP | MP | HP |
| Ingredient (%) | | | | | | | | | |
| Maize meal | 75.65 | 67.50 | 59.60 | 62.75 | 54.00 | 45.25 | 40.60 | 31.90 | 23.50 |
| Soybean meal | 17.25 | 25.75 | 34.00 | 11.75 | 20.50 | 29.00 | 8.20 | 17.00 | 25.25 |
| Leaf meal, China | – | – | – | 15.00 | 15.00 | 15.00 | 32.00 | 32.00 | 32.00 |
| Brewers dried grains | – | – | – | 5.00 | 5.00 | 5.00 | 8.00 | 8.00 | 8.00 |
| Palm oil | – | – | – | 2.90 | 3.00 | 3.25 | 9.00 | 9.00 | 9.25 |
| Salt | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Dicalcium phosphate | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 |
| Limestone | 1.00 | 1.00 | 1.00 | 0.50 | 0.50 | 0.50 | – | – | – |
| *DL*-methionine | 0.10 | – | – | 0.10 | – | – | 0.20 | 0.10 | – |
| Vitamin-mineral premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Koalin | 4.00 | 3.75 | 3.40 | – | – | – | – | – | – |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Calculated content | | | | | | | | | |
| Digestible energy (MJ/kg) | 13.54 | 13.51 | 13.49 | 13.57 | 13.53 | 13.49 | 13.57 | 13.51 | 13.49 |
| Protein (N x 6.25) (%) | 14.02 | 17.07 | 20.03 | 14.59 | 17.70 | 20.69 | 15.09 | 18.22 | 21.14 |
| Methionine + cystine (%) | 0.63 | 0.62 | 0.70 | 0.59 | 0.58 | 0.66 | 0.62 | 0.61 | 0.62 |
| Lysine (%) | 0.70 | 0.92 | 1.14 | 0.70 | 0.93 | 0.15 | 0.73 | 0.96 | 1.18 |
| Neutral detergent fibre (%) | 9.64 | 9.84 | 10.04 | 15.20 | 15.37 | 15.52 | 20.26 | 20.44 | 20.59 |
| Calcium (%) | 0.73 | 0.75 | 0.77 | 0.75 | 0.77 | 0.79 | 0.80 | 0.82 | 0.83 |
| Phosphorus (%) | 0.60 | 0.62 | 0.65 | 0.59 | 0.61 | 0.64 | 0.56 | 0.58 | 0.61 |

LF = Low fibre, MF = Medium fibre, HF = High fibre.
LP = Low protein, MP = Medium protein, HP = High protein.

Table 2. Composition of diets (45–80 kg liveweight)

| Composition | LF | | | MF | | | HF | | |
|---|---|---|---|---|---|---|---|---|---|
| | LP | MP | HP | LP | MP | HP | LP | MP | HP |
| Ingredient (%) | | | | | | | | | |
| Maize meal | 80.05 | 71.90 | 63.65 | 67.05 | 58.40 | 49.75 | 45.10 | 36.30 | 27.90 |
| Soybean meal | 12.75 | 21.25 | 29.75 | 7.25 | 16.00 | 24.50 | 3.70 | 12.50 | 20.75 |
| Leaf meal, China | – | – | – | 15.00 | 15.00 | 15.00 | 32.00 | 32.00 | 32.00 |
| Brewers dried grains | – | – | – | 5.00 | 5.00 | 5.00 | 8.00 | 8.00 | 8.00 |
| Palm oil | – | – | – | 2.90 | 3.00 | 3.25 | 8.90 | 9.10 | 9.35 |
| Salt | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Dicalcium phosphate | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 |
| Limestone | 1.00 | 1.00 | 1.00 | 0.50 | 0.50 | 0.50 | – | – | – |
| *DL*-methionine | 0.10 | – | – | 0.20 | 0.10 | – | 0.20 | 0.10 | – |
| *L*-Lysine | 0.10 | – | – | 0.10 | – | – | 0.10 | – | – |
| Vitamin-mineral premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Koalin | 4.00 | 3.80 | 3.60 | – | – | – | – | – | – |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Calculated content | | | | | | | | | |
| Digestible energy (MJ/kg) | 13.55 | 13.55 | 13.50 | 13.59 | 13.55 | 13.53 | 13.59 | 13.57 | 13.55 |
| Protein (N x 6.25) (%) | 12.41 | 15.46 | 18.50 | 12.97 | 16.09 | 19.09 | 13.49 | 16.62 | 19.53 |
| Methionine + cystine (%) | 0.59 | 0.57 | 0.66 | 0.64 | 0.63 | 0.61 | 0.57 | 0.56 | 0.54 |
| Lysine (%) | 0.68 | 0.80 | 1.02 | 0.68 | 0.81 | 1.03 | 0.71 | 0.84 | 1.06 |
| Neutral detergent fibre (%) | 9.54 | 9.74 | 9.94 | 15.09 | 15.27 | 15.43 | 20.17 | 20.34 | 20.49 |
| Calcium (%) | 0.72 | 0.74 | 0.76 | 0.74 | 0.76 | 0.78 | 0.79 | 0.81 | 0.82 |
| Phosphorus (%) | 0.58 | 0.61 | 0.64 | 0.57 | 0.60 | 0.62 | 0.54 | 0.57 | 0.59 |

Table 3. Performance and carcass traits of pigs fed various levels of dietary fibre and protein

| Variable | LF | | | MF | | | HF | | | C.V. |
|---|---|---|---|---|---|---|---|---|---|---|
| | LP | MP | HP | LP | MP | HP | LP | MP | HP | |
| Performance | | | | | | | | | | |
| Av. daily gain (g)[a,b] | 736 | 747 | 775 | 654 | 677 | 697 | 515 | 567 | 595 | 9.0 |
| Av. daily intake (kg)[a] | 2.41 | 2.27 | 2.35 | 2.31 | 2.27 | 2.24 | 2.11 | 2.27 | 2.18 | 8.6 |
| Feed/gain ratio[a,b] | 3.18 | 3.15 | 3.04 | 3.53 | 3.36 | 3.30 | 4.10 | 3.88 | 3.78 | 6.4 |
| Carcass | | | | | | | | | | |
| Dressing percentage[+] (%)[a] | 69.08 | 68.85 | 69.16 | 68.35 | 67.36 | 66.97 | 65.81 | 67.05 | 67.03 | 2.5 |
| Full digestive tract (% slaughter wt.)[a] | 9.27 | 9.09 | 9.55 | 10.26 | 10.63 | 10.60 | 12.11 | 12.46 | 12.43 | 9.2 |
| Empty digestive tract (% carcass wt.)[a] | 4.54 | 4.75 | 4.61 | 5.28 | 5.32 | 5.28 | 6.20 | 6.13 | 6.12 | 6.0 |
| Backfat thickness (cm)[a,b] | 3.09 | 2.96 | 2.87 | 2.56 | 2.53 | 2.55 | 2.33 | 2.15 | 2.13 | 7.3 |
| *L. dorsi* area ($cm^2$)[c] | 27.57 | 28.04 | 28.06 | 27.64 | 28.14 | 28.13 | 28.38 | 28.52 | 28.83 | 7.0 |
| Lean cuts (% carcass wt.)[a] | 40.56 | 39.97 | 41.48 | 39.92 | 40.98 | 42.54 | 42.78 | 42.89 | 42.94 | 6.7 |

[+]Based on chilled carcass without heads
[a]Significant (P<0.01) for fibre
[b]Significant (P<0.01) for protein
[c]Not significant (P>0.05) for both fibre and protein

between means was determined by Duncan's new multiple range test (STEEL and TORRIE, 1960).

## RESULTS

The performance and carcass traits of pigs fed various levels of fibre and protein are presented in *Table 3*. The effect of fibre was significant (P<0.01) on average daily gain (ADG), average daily intake (ADI), feed/gain ratio, dressing percentage, digestive tract percentage, backfat thickness and lean cuts. Similarly, significant effect (P<0.01) of protein was found on ADG, feed/gain ratio and backfat thickness. There were no significant effects (P>0.05) of both fibre and protein on *Longissimus dorsi* area. The interactive effects of fibre and protein were not significant.

Results on the effects of dietary fibre levels on the performance and carcass traits are presented in *Table 4*. Dietary fibre significantly (P<0.01) reduced ADG, *i.e.*, 753, 676 and 559 g respectively for pigs consuming low, medium and high fibre diets. Pigs fed the high fibre diet had significantly (P<0.05) lower ADI compared with those of the low fibre diet. The efficiency of feed conversion was adversely affected as the dietary fibre increased, *i.e.*, 3.12, 3.40 and 3.92 in pigs fed low, medium and high fibre diets respectively. Dressing percentage was significantly (P<0.01) reduced while both the full and empty digestive tracts were significantly (P<0.01) larger as the level of fibre in the diet increased. Backfat thickness was reduced in pigs fed medium and high fibre diets, but there were no significant differences in *L. dorsi* area at different levels of dietary fibre.

Data on the effects of dietary protein levels on the performance and carcass characteristics of pigs are shown in *Table 5*. Pigs fed low protein diet showed lower (P<0.01) ADG than those receiving medium and high protein diets. However, the ADG of pigs consuming medium and high protein diets did not differ significantly. There were also no significant differences in ADI of pigs consuming the three diets. Pigs fed low protein diet exhibited poorer (P<0.01) feed conversion efficiency than those consuming medium and high protein diets, the feed/gain ratio of the latter two being statistically non-significant. There were no significant differences in carcass traits except that pigs fed with low protein diet had thicker backfat than those consuming medium or high protein diet.

Table 4. Effects of dietary fibre levels on the performance and carcass traits of pigs

| Variable | Fibre level | | | Significance level |
|---|---|---|---|---|
| | Low | Medium | High | |
| Performance | | | | |
| Av. daily gain (g) | 753a | 676b | 559c | ** |
| Av. daily intake (kg) | 2.34a | 2.27ab | 2.18b | * |
| Feed/gain ratio | 3.12a | 3.40b | 3.92c | ** |
| Carcass | | | | |
| Dressing percentage$^+$ (%) | 69.03a | 67.56b | 66.61c | ** |
| Full digestive tract (% slaughter wt.) | 9.30a | 10.50b | 12.33c | ** |
| Empty digestive tract (% carcass wt.) | 4.63a | 5.29b | 6.15c | ** |
| Backfat thickness (cm) | 2.97a | 2.55b | 2.21c | ** |
| *L. dorsi* area ($cm^2$) | 27.89 | 27.97 | 28.58 | N.S. |
| Lean cuts (% carcass wt.) | 40.67a | 41.15b | 42.87b | ** |

$^+$Based on chilled carcass without heads
**Significant (P<0.01)
*Significant (P<0.05)
N.S. = Not significant
Means in the same row with different subscripts are different according to stated level of significance.

Table 5. Effects of dietary protein levels on the performance and carcass traits of pigs

| Variable | Protein level | | | Significance level |
|---|---|---|---|---|
| | Low | Medium | High | |
| Performance | | | | |
| Av. daily gain (g) | 635a | 667b | 689b | ** |
| Av. daily intake (kg) | 2.28 | 2.27 | 2.26 | N.S. |
| Feed/gain ratio | 3.61a | 3.45b | 3.37b | ** |
| Carcass | | | | |
| Dressing percentage+ (%) | 67.75 | 67.78 | 67.72 | N.S. |
| Full digestive tract (% slaughter wt.) | 10.55 | 10.67 | 10.86 | N.S. |
| Empty digestive tract (% carcass wt.) | 5.34 | 5.37 | 5.34 | N.S. |
| Backfat thickness (cm) | 2.66a | 2.56b | 2.51b | ** |
| *L. dorsi* area ($cm^2$) | 27.87 | 28.22 | 28.34 | N.S. |
| Lean cuts (% carcass wt.) | 41.09 | 41.23 | 42.32 | N.S. |

+Based on chilled carcass without heads
**Significant (P<0.01)
N.S. = Not significant
Means in the same row with different subscripts are different according to stated level of significance.

## DISCUSSION

The reduction in growth performance with increased fibre level could be attributed to decreased digestibility and reduced intake. The reduction in ADI could be caused by the high wet and dry bulk of the fibre sources (ONG and HUTAGALUNG, 1984; 1985). Poor palatability of CLM is also suspected as bitter compounds could be formed in leaf meals through caramelization reaction during the drying process (MYER and CHEEKE, 1975). In addition, it might contain inhibitors such as saponins (CHEEKE, PEDERSEN and ENGLAND, 1978). LEAMASTER and CHEEKE (1979) demonstrated that if given the choice, growing pigs would select an alfalfa-free diet rather than diets containing alfalfa meal. It may also be said that the modern pig has been indirectly selected against fibre utilization, as it has been intensively bred for superior performance based on high density diets.

The reduction in dressing percentage caused by increased dietary fibre seemed to be related to heavier gut fill. A decrease in backfat thickness is attributed to reduced digestible energy intake caused by decreased ADI. Reduction in fat deposition with increased fibre led to the higher percentage of lean cuts obtained. This is contrary to the report of BAIRD *et al.* (1975) who found that feeding a low-fibre diet resulted in more lean cuts than did a high-fibre diet. On the other hand, KENNELLY and AHERNE (1980) reported that fibre level in the diet did not significantly influence any carcass measurement. The conflicting results could be due to differences in breeds, degree of digestibility caused by unequal amount of carbohydrates in the diet (IMOTO and NAMIOKA, 1978) and differential fibre utilization caused by environmental temperature (STAHLY and CROMWELL, 1981).

Results on the effect of protein level showed that a dietary protein level of 17%–15% during the growing-finishing period gave better ADG than the 14%–12% dietary protein. BABATUNDE, OLOMU and OYENUGA (1972) also found that a dietary protein level of 14% was inadequate for optimal performance of growing pigs in the tropics. PHUAH and HUTAGALUNG (1979) suggested that a protein sequence of 15%–12% was adequate for optimal performance in the tropical environment. The results from this study indicate that there is no advantage in feeding a protein sequence of more than 17%–15% during the growing-finishing period. Similarly, WOO and CHEN (1984) found that there was no significant difference in growth rate of growing pigs fed

18% or 16% protein diet under tropical Singapore conditions.

It was found that decreasing the dietary protein level resulted in a linear increase in protein digestibility, showing a more complete digestion and use of protein when present at low level in the diet (PHUAH and HUTAGALUNG, 1979). However, in a more recent report by HARDY, BICHARD, COOKE and CURRAN (1982) on four genotypes of growing pigs kept under temperate condition, the ADG significantly increased with increased dietary protein (16%–24%) in all the four genotypes. It would seem that environmental temperature might affect use of protein. Nevertheless, it was acknowledged that protein requirement was met by digestible amino acids rather than digestible protein. The value of digestible protein, as a measure of available amino acids in the diet, depends on the relationship of individual amino acids digestibility with that of crude protein. This would mean that use of protein is complicated by the composition of the diet, as the availability of amino acids differs in different feed ingredients.

Reduced ADG in pigs fed lower protein diets could be due to reduced protein synthesis caused by lowered protein intake. REEDS, FULLER, CADENHEAD, LOBLEY and MCDONALD (1981) showed that there was a highly significant correlation between total protein intake and total protein synthesis in growing pigs. The failure of pigs fed high protein to show a significantly improved performance could be due to an inaccurate balance in amino acids. It was noted in this experiment that the level of methionine plus cystine was kept constant at about 0.6% of the diet. Where supplies from ingredients were lacking, *DL*–methionine was supplemented. However, owing to the different proportions of ingredients used, the level of lysine increased as the protein level increased. Thus, during the growing period, the levels of lysine were approximately 0.7%, 0.9% and 1.1% in the low, medium and high protein diets respectively. It is possible that pigs fed high-protein diets respond unfavourably because other essential amino acids are not elevated proportionally. It had been found that as dietary protein concentration decreased, the requirement for lysine also decreased (KLAY, 1964; BAKER, KATZ and EASTER 1975; EASTER and BAKER, 1975).

The carcass yield, digestive tract percentage, cross-sectional area of *L. dorsi*, and per cent lean were unaffected by dietary protein level. This was similar to the findings of PHUAH and HUTAGALUNG (1979). However, carcasses of pigs fed low protein diets had significantly thicker backfat which was contrary to the results obtained by PHUAH and HUTAGALUNG (1979). But, this result was similar to that of DAVIDICH and CANOPE (1978) who found that backfat thickness of pigs kept in a tropical environment decreased linearly with increasing supply of protein. This could be explained by the relative proportion of protein and non-protein energy in the diets (REEDS *et al.*, 1981). Although the digestible energy of the experimental diets was kept approximately constant, the energy was contributed by different proportions of protein, carbohydrates and oil. REEDS *et al.* (1981) showed that the rate of amino acid catabolism was significantly increased in pigs fed high protein diets. With increased catabolism, nitrogen excretion would represent an energetic cost to the pig (HOLMES, CARR and PEARSON 1980). An increase in dietary protein concentration would cause a decrease in the proportion of digestible energy that was metabolized as well as in the proportion of the metabolizable energy retained by the pig.

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## ABSTRACT

An experiment was conducted to study the effects of different levels of fibre and protein on the growth and carcass characteristics of pigs. Nine diets were formulated to comprise three levels of fibre averaging 10%, 15% and 20% of neutral detergent fibre and three levels of protein averaging 14.6%, 17.6% and 20.6% of N x 6.25. These diets were fed to 90 pigs (ten pigs per treatment). Dietary fibre significantly ($P<0.01$) reduced average daily gain (ADG) to 753, 676 and 559 g for pigs consuming low, medium and high fibre diets respectively. Pigs fed high fibre diet had significantly ($P<0.05$) lower average daily intake. Feed conversion efficiency was adversely affected as the dietary fibre increased, *i.e.*, 3.12, 3.40 and 3.92 in pigs fed low, medium and high fibre diets respectively. Dressing percentage was significantly ($P<0.01$) reduced while the digestive tracts were significantly ($P<0.01$) larger as the level of fibre increased. Pigs fed higher dietary fibre had significantly ($P<0.01$) thinner backfat and tended to yield more lean cuts. Pigs fed low protein diet showed lower ADG than those receiving medium and high protein diets. However, the ADG of pigs fed medium and high protein diets did not differ significantly. There were no significant differences in carcass traits except that pigs fed the low protein diet had thicker backfat compared with those consuming medium or high protein diets.


## REFERENCES


AXELSSON, J. and ERIKSSON, S. (1953). The optimum crude fibre level in rations of grazing pigs. *J. Anim. Sci.* ***12***, 881–91.

BABATUNDE, G.M., OLOMU, M.J. and OYENUGA, V.A. (1972). Determination of the optimum crude protein requirement of pigs in a tropical environment. *Anim. Prod.* ***14***, 56–67.

BAIRD, D.M., MCCAMPBELL, H.C. and ALLISON, J.R. (1970). Levels of crude fibre with constant energy levels for growing-finishing swine using computerized rations. *J. Anim. Sci.* ***31***, 518–25.

______ (1975). Effect of levels of crude fibre, protein and bulk in finishing hogs. *J. Anim. Sci.* ***41***, 1039–47.

BAKER, D.H., KATZ, R.S. and EASTER, R.A. (1975). Lysine requirement of growing pigs at two levels of dietary protein. *J. Anim. Sci.* ***40***, 851–6.

CHEEKE, P.R., PEDERSEN, M.W. and ENGLAND, D.C. (1978). Responses of rats and swine to alfalfa saponins. *Can. J. Anim. Sci.* ***58***, 783–9.

COLE, D.J.A., DUCKWORTH, J.E. and HOLMES, W. (1967). Factors affecting voluntary feed intake in pig. 1. The effect of digestible energy content of the diet on the intake of castrated male pigs housed in holding pens and in metabolism crates. *Anim. Prod.* ***9***, 141–8.

CRAMPTON, E.W., ASHTON, G.C. and LLOYD, L.E. (1954). Improvement of bacon carcass quality by the introduction of fibrous feed into the hog finishing ration. *J. Anim. Sci.* ***13***, 321–6.

CUNNINGHAM, H.M., FRIEND, D.W. and NICHOLSON, J.W.G. (1962). The effect of age, body weight, feed intake and adaptability of pigs on the digestibility and nutritive value of cellulose. *Can. J. Anim. Sci.* ***42***, 167–75.

DAVIDICH, J. LE. and CANOPE, I. (1978). Effect of protein content of the feed on performance of growing and finishing pigs in a tropical environment. *Nouvelles Agronomigues des Antilles et de la Guyane* ***4***, 19–31. In *Pig News and Info.* ***1***, p. 112 *(abstr.)*.

EASTER, R.A. and BAKER, D.H. (1975). Evaluation of lysine levels for growing-finishing pigs fed corn-soybean meal diets. *J. Anim. Sci.* ***41***, 312 *(abstr.)*.

HARDY, B., BICHARD, M., COOKE, B. and CURRAN, M.K. (1982). Response of four genotypes of growing pigs to dietary protein and energy input. *Paper (No. 23) presented at Br. Soc. Anim. Prod. Winter Meeting, 1982.*

HOLMES, C.W., CARR, J.R. and PEARSON, G. (1980). Some aspects of the energy and nitrogen metabolism of boars, gilts and barrows given diets containing different concentrations of protein. *Anim. Prod.* ***31***, 279–89.

IMOTO, S. and NAMIOKA, S. (1978). VFA production in the pig large intestine. *J. Anim. Sci.* ***47***, 467–73.

KENNELLY, J.J. and AHERNE, F.X. (1980). The effect of fibre addition to diets formulated to contain different levels of energy and protein on growth and carcass quality of swine. *Can. J. Anim. Sci.* ***60***, 385–93.

KLAY, R.F. (1964). The lysine requirement for growth of the pig at four protein levels. *J. Anim. Sci.* ***23***, 881 *(abstr.)*.

LEAMASTER, B.R. and CHEEKE, P.R. (1979). Feed preferences of swine : alfalfa meal, high and low saponin alfalfa, and quinine sulfate. *Can. J. Anim. Sci.* ***59***, 467–9.

MYER, R.O. and CHEEKE, P.R. (1975). Utilization of alfalfa meal and alfalfa protein concentrate by rats. *J. Anim. Sci.* ***40***, 500–8.

NORDFELDT, S. (1954). Digestibility experiments with pigs. *Kungl. Lantbrukshogsk Ann.* ***21***, 1–29. Cited by KIDDER and MANNERS (1978) in *Digestion in the Pig* p. 195. Bristol : Scientechnica.

ONG, H.K. and HUTAGALUNG, R.I. (1984). Evaluation of brewers dried grains as feed for pigs. Paper presented at *8th Annual Conf. Malays. Soc. Anim. Prod.,* Genting Highlands, 1984.

______ (1985). Effects of fibre levels on digestibility, growth performance and carcass traits of growing-finishing pigs. *Proc. 3rd AAAP Anim. Sci. Congress (Efficient Animal Production for Asian Welfare),* Seoul, 1985, p. 592–4.

PHUAH, C.H. and HUTAGALUNG, R.I. (1979). Effects of varying dietary energy and protein levels on performance, nutrient digestibility and carcass characteristics of pigs. *MARDI Res. Bull.* ***7***, 116–26.

REEDS, P.J., FULLER, M.F., CADENHEAD, A., LOBLEY, G.E. and McDONALD, J.D. (1981). Effects of changes in the intake of protein and non-protein energy on whole-body protein turn-over in growing pigs. *Br. J. Nutr.* ***45***, 539–46.

STAHLY, T.S. and CROMWELL, G.L. (1981). Interactive effects of dietary fibre level and environmental temperature on pig performance. *J. Anim. Sci.* ***53*** (Suppl. 1), 92.

STEEL, R.D.G. and TORRIE, J.H. (1960). *Principles and Procedure of Statistics* pp. 107–9. New York : McGraw-Hill Book Co.

TEAQUE, H.S. and HANSON, L.E. (1954). The effect of feeding different levels of a cellulosic material to swine. *J. Anim. Sci.* ***13***, 206–14.

WOO, K.K. and CHEN, T.W. (1984). Protein and energy requirements of growing pigs in tropical Singapore. I. Crude protein requirement. *Singapore J. Primary Ind.* ***12***, 78–87.

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