The effects of different dietary crude protein level on faecal crude protein and amino acid flow and digestibility in growing pigs

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1. Introduction

Amino acid (AA) plays a very important role in animal nutrition and physiology (Li et al. 2009). Animal diets are designed with little or no consideration of the AA excretion of nitrogen nutrition, hence excess nitrogen (N) excretes with animal manure (NRC 1998). Growing concerns about environmental pollution arising from intensive swine production had forced researchers to study protein and AA nutrition of the pig beyond their requirements for maximal growth and performance (NRC 2012).

In the last 10 years, animal husbandry workers did their best to find effective ways to reduce excessive emissions of nitrogen in the pig production, such as the use of essential AA (EAA) with diet, the decrease in the level of dietary protein, the use of amino acid synthesis, the application of ‘ideal protein’, the implementation stage and the high digestibility of protein feed raw materials (Rotz 2004). Reducing N excretion in swine manure could be effectively accomplished by decreasing dietary CP intake. However, the decreasing protein concentration in diets containing no supplemental crystalline AA decreased apparent and standardized ileal AA digestibility (Stein 1998). Protein-bound AA absorption might be reduced in complete diets containing low protein concentrations and might contribute to impaired growth performance.

The decomposition and synthesis of N and AA in intestinal microflora are very active. Lysine, arginine, histidine, threonine, glutamic acid and aspartic acid in human gut microbial belonged to the rapid fermentation AA (Smith & Macfarlane 1997) and Clostridium, Bacteriodes and Prepfooc are the main AA fermentation bacteria in the large intestine of human (Smith & Macfarlane 1998). After fermentable carbohydrates added to the culture system, amines was decreased because the decarboxylation of AAs bacteria was reduced (Smith & Macfarlane 1996). Branched chain amino acids, phenylalanine and lysine synthesized by intestinal bacteria in pig with intestinal fistula could be absorbed in small and large intestines (van Goudoever et al. 2000, Metges 2000, Torrallardona et al. 2003a, 2003b).

It was unknown whether digestibility of both protein-bound non-essential AA (NEAA) and EAA and microbial AA composition of ileum and faeces would be affected when four crystalline EAs are supplemented to reduced CP diets. So our experiment design was that four crystalline indispensable AAs were provided for a corn–soybean meal-based diet reduced dietary CP concentration to meet pig’s dispensable AA need. Thus the ratio of EAA to NEAA decreased while dietary CP concentrations increased. Our objective was to test the effects of faecal CP and AA flow, faecal CP and AA digestibility, and faecal ileal microbial AA composition in 60–90 kg growing pigs.

2. Materials and methods

2.1. Animals, experimental design and diets

Eighteen Duroc × Landrace × Yorkshire barrows (60 ± 1.43 kg) were obtained from a local commercial swine farm. The pigs were randomly divided into three groups with 6 barrows in each group: L-CP, M-CP and H-CP. The L-CP group had dietary CP concentration of 10% of CP in the maize–soybean meal-based diet reduced dietary CP concentration –0.05). Faecal microbial N and AA in the L-CP group was the highest in three groups. Pigs fed a corn–soybean meal-based diet reduced in protein concentration have lower faecal N flow.
were kept singly in steel metabolism crates, in a room maintained at 24 ± 1°C, at the Key Laboratory for Agro-ecological Processes in Subtropical Region, Institute of Subtropical Agriculture, the Chinese Academy of Sciences, Hunan, China. Approval for the study was granted by the Chinese Academy of Sciences Animal Ethics Committee.

The animals were randomly divided into three groups according to the three CP levels of diet (10%, 13% and 16%). Each group had 18 piglets and each repeat had one piglet. The test lasted 30 d.

All piglets were fed a diet formulated according to the NRC (2012) recommendations for various nutrients. The diet ingredients and the nutritional level of diets were given in Table 1. The piglets were kept in individual pens (1.5 m length × 0.5 m width × 0.8 m depth) in a mechanically ventilated and temperature-controlled room (22 ± 1.2°C). Feed and water were allowed on an ad libitum basis.

2.2. Measurements and sampling

The faeces of 6 piglets in each group were collected from d 25 to d 30, and then the piglets were anaesthetized with an intravenous injection of sodium pentobarbital (50 mg/kg BW) and bled by exsanguinations. Digesta of terminal ileum were collected into polythene bags. The digesta and faecal samples for microbe separation were stored at 4°C for less than 2 h. Briefly, the pooled digesta or faeces were centrifuged first at 250 RCF for 15 min at 4°C, giving a fraction expected to contain food particles and porcine cells, then at 14,500 RCF for 30 min at 4°C, to give a precipitate expected to contain microbial cells. A summary of the centrifugation protocol is given in Figure 1. The samples for chemical analysis were stored at −20°C.

2.3. Chemical analyses

Dry matter (DM) was measured by drying to a constant mass in a forced air oven at 105°C. Other digesta samples were fractionated by differential centrifugation using the method of Metges et al. (1999) and Warren et al. (2009). Total N was determined by the Leco total combustion method (AOAC 968.06 2000), a variation of the Dumas method. Amino acid compositions were determined using the procedure outlined by Hodgkinson and Moughan (2003).

2.4. Statistical analysis

The endogenous indicator acid-insoluble ash (AIA) was determined to calculate the apparent digestibility of DM, CP and TAA, the formula was as follows: 1-bc/ad, where a is the concentration of DM, CP or AA in diets (%); b is the concentration of DM, CP or AA in faecal samples (%); c is the concentration of AIA in diet (%); and d is the concentration of AIA in faecal (%). Amino acid compositions were the content of single AA in TAA.

All data were presented as means and standard error of mean (SEM). All data were subjected to one-way analysis of variance using the general linear model (GLM) procedure of SAS statistical software (SAS Institute, Inc. Cary, NC, USA) according to a completely randomized one-factorial design. The Student–Newman–Keuls (SNK) test was performed to identify differences among groups. Significance was set at P < 0.05.

Table 1. Ingredient composition of experimental diets in growing pigs (as-fed basis).

| Ingredients        | 10%CP | 13%CP | 16%CP |
|--------------------|-------|-------|-------|
| Corn               | 87.40 | 78.36 | 67.00 |
| Soybean meal       | 5.50  | 15.00 | 23.76 |
| Wheat bran         | 2.00  | 3.00  | 6.00  |
| Soybean oil        | 1.71  | 0.90  | 0.88  |
| L-Lys-HCl          | 0.55  | 0.27  | 0.01  |
| DL-Met             | 0.09  | 0.00  | 0.00  |
| L-Thr              | 0.19  | 0.06  | 0.00  |
| L-Trp              | 0.06  | 0.01  | 0.00  |
| Monocalcium phosphate | 0.65 | 0.55 | 0.50 |
| Limestone          | 0.55  | 0.55  | 0.55  |
| Salt               | 0.30  | 0.30  | 0.30  |
| Premix             | 1.00  | 1.00  | 1.00  |
| Total              | 100.00| 100.00| 100.00|

Nutritional level (based on chemical analysis)

| Nutrient | 10%CP | 13%CP | 16%CP |
|----------|-------|-------|-------|
| DM (MJ/kg) | 14.20 | 14.20 | 14.20 |
| CP       | 10.26 | 13.17 | 16.30 |
| Lys     | 0.73  | 0.72  | 0.72  |
| Met + Cys | 0.43 | 0.42  | 0.50  |
| Thr     | 0.49  | 0.50  | 0.56  |
| Trp     | 0.13  | 0.13  | 0.17  |
| Arg     | 0.44  | 0.70  | 0.94  |
| His     | 0.22  | 0.31  | 0.39  |
| Ile     | 0.30  | 0.45  | 0.60  |
| Leu     | 0.91  | 1.13  | 1.32  |
| Phe     | 0.41  | 0.57  | 0.71  |
| Val     | 0.36  | 0.50  | 0.61  |
| Ca, %   | 0.51  | 0.50  | 0.52  |
| Available P, % | 0.38 | 0.40 | 0.45 |
| EAA     | 4.23  | 5.24  | 6.29  |
| NEAA    | 5.36  | 7.10  | 8.76  |
| EAA/NEAA | 0.78 | 0.74  | 0.70  |

Figure 1. Schematic diagram of the processing of the digesta samples.
3. Results

3.1. Nitrogen and crude protein flow and digestibility

As shown in Table 2, faecal apparent DM, CP, total N and protein N digestibility were different among the three treatments ($P < 0.01$), that is, greater in the LCP group than in the MCP and HCP groups ($P < 0.05$). Faecal apparent non-protein N digestibility was different among the three treatments ($P < 0.01$), that is, greater in the MCP and HCP groups than in the LCP group ($P < 0.05$). The CP, total N, protein N and total microbial N flow of faeces in pigs were different among the three treatments ($P < 0.01$), that is, greater in the LCP group than in the MCP and HCP groups ($P < 0.05$). Faecal non-protein N flow and the percentage of protein N flow in total N flow in pigs were different among the three treatments ($P < 0.01$), that is, the greatest in the LCP group and the lowest in the MCP group ($P < 0.05$). Faecal protein N flow of pigs in MCP and HCP groups was higher than that in the MCP group. There are no significant differences in faecal microbial non-protein N among the three treatments ($P = 0.14$).

3.2. Faecal TAA, NEAA, EAA flows and apparent TAA digestibility with or without microbial

Table 3 shows that faecal TAA, NEAA and EAA flows with or without microbial in pigs was affected by the treatments ($P < 0.01$), that is, greater in the MCP and HCP groups than in the LCP group ($P < 0.05$). Faecal TAA, NEAA and EAA digestibility with or without microbial in pigs was affected by the treatments ($P < 0.01$), that is, greater in the MCP and HCP groups than in the LCP group ($P < 0.05$). Faecal EAA/NEAA flow with or without microbial in pigs was affected by the treatments ($P < 0.01$), that is, greater in the MCP group than in the LCP group. However, there were no significant differences in faecal microbial non-protein N among the three treatments ($P = 0.14$).

3.3. The 17 amino acids flow in the faeces

As shown in Table 4, faecal Asp, Cys, His and Arg flows were different among the three treatments ($P < 0.01$), that is, greater in the HCP group than in the MCP and LCP groups ($P < 0.05$). There were no significant differences in faecal Asp, Gly, Cys, His and Arg flows of pigs between the MCP and LCP groups ($P > 0.05$). Faecal Ser and Gly flows were different among the three treatments ($P < 0.01$), that is, greater in the MCP group than in the LCP group ($P < 0.05$). There were no significant differences in faecal Ser and Gly flows of pigs between the LCP and HCP groups ($P > 0.05$). There were no significant differences in faecal Tyr, Met, Ile and Phe flows of pigs among the three groups ($P > 0.05$). Faecal Glu, Ala, Pro, Val, Leu and Lys flows were different among the three treatments ($P < 0.01$). Faecal microbial Glu, Ala and EAA flows of pigs were different among the three treatments ($P < 0.01$), that is, greater in the MCP and HCP groups than in the LCP group ($P < 0.05$). There were no significant differences in faecal microbial Thr, Val, Met, Ile and Phe flows in growing pigs among the three treatments ($P > 0.05$). The faecal microbial Ile flow was different among the three treatments ($P < 0.01$), that is, greater in the HCP and LCP groups than in the MCP group ($P < 0.05$). There were no significant differences in faecal microbial Ser, Pro, Tyr, Cys, His and Arg flows of pigs between the MCP and LCP groups ($P > 0.05$). There were no significant differences in faecal microbial Thr, Val, Met, Phe and Lys flows in growing pigs among the three treatments ($P > 0.05$). There were no significant differences in faecal microbial Tyr, Cys, His and Arg flows of pigs between the MCP and LCP groups ($P > 0.05$). There were no significant differences in faecal microbial Thr, Val, Met, Phe and Lys flows in growing pigs among the three treatments ($P > 0.05$).

As shown in Table 4, faecal microbial Asp, Gly, Ala and EAA flows were different among the three treatments ($P < 0.01$), that is, greater in the HCP group than in the MCP and LCP groups ($P < 0.05$). Faecal microbial Asp, Gly, Ala and EAA flows of pigs were different among the three treatments ($P < 0.01$), that is, greater in the MCP and HCP groups than in the LCP group ($P < 0.05$). There were no significant differences in faecal microbial Glu, Ala and EAA flows of pigs between the MCP and LCP groups ($P > 0.05$). Faecal microbial Glu, Ala and EAA flows of pigs were different among the three treatments ($P < 0.01$), that is, greater in the HCP group than in the MCP and LCP groups ($P < 0.05$). There were no significant differences in faecal microbial Glu, Ala and EAA flows of pigs between the MCP and LCP groups ($P > 0.05$). There were no significant differences in faecal microbial Glu, Ala and EAA flows of pigs between the MCP and LCP groups ($P > 0.05$).

Table 2. The effects of dietary different CP levels on faecal CP and nitrogen (N) flow and apparent DM, CP and N digestibility in growing pigs.

|                  | L-CP | M-CP | H-CP | SEM | P-value |
|------------------|------|------|------|-----|---------|
| Faeces apparent digestibility (%) |      |      |      |     |         |
| DM               | 95.2a| 89.8b| 88.5b| 0.43| <0.01   |
| CP               | 91.4a| 85.9b| 86.0b| 0.37| <0.01   |
| Total N          | 91.4a| 85.9b| 86.0b| 0.37| <0.01   |
| Protein N        | 98.8a| 98.0b| 98.0b| 0.77| <0.01   |
| Non-protein N    | 71.7b| 78.1a| 80.4a| 1.16| <0.01   |
| CP and N flow in faeces (mg/g DM) |      |      |      |     |         |
| CP               | 170.3b| 173.7b| 196.2a| 5.1 | <0.01   |
| Total N          | 27.3b| 27.8b| 31.4a| 0.82| <0.01   |
| Protein N        | 23.9b| 24.4b| 27.7a| 0.87| <0.01   |
| Non-protein N    | 3.99a| 3.33c| 3.68b| 0.24| <0.01   |
| Total microbial N| 3.59b| 3.75b| 4.06a| 0.07| <0.01   |
| Microbial protein N| 3.10c| 3.43b| 3.70a| 0.07| <0.01   |
| Microbial non-protein N| 0.48| 0.32| 0.36| 0.01| 0.14    |
| The percentage of protein N flow in total N flow | 13.2a| 13.5a| 11.8b| 1.32| <0.01   |
| The percentage of protein N flow in total N flow | 85.3b| 87.8a| 88.2a| 3.21| <0.01   |

Table 3. The effects of dietary different CP levels on faeces TAA, NEAA and EAA flow (mg/g DM) and apparent TAA, EAA and NEAA digestibility (%) with or without microbial in growing pigs.

|                  | L-CP | M-CP | H-CP | SEM | P-value |
|------------------|------|------|------|-----|---------|
| Faeces with microbial |      |      |      |     |         |
| TAA flow         | 119.5b| 138.9a| 142.9a| 3.8 | <0.01   |
| NEAA flow        | 62.4b | 71.0a | 73.1a | 1.87| <0.01   |
| NEAA digestibility| 57.1b| 67.9a| 69.9a| 2.1 | <0.01   |
| EAA flow         | 89.2a | 90.1a| 84.3b| 0.43| <0.01   |
| EAA digestibility| 90.9a| 92.1a| 87.0b| 0.4 | <0.01   |
| EAA/NEAA         | 1.09a| 1.05b| 1.05b| 0.02| 0.06   |
| Faeces without microbial |      |      |      |     |         |
| TAA flow         | 100.1b| 117.4a| 119.7a| 3.65| <0.01   |
| NEAA flow        | 52.25b| 60.25a| 61.40a| 1.79| <0.01   |
| NEAA digestibility| 47.82b| 57.83a| 58.86a| 2.00| <0.01   |
| EAA/NEAA         | 1.09a| 1.04b| 1.04b| 0.02| 0.03   |
3.4. The 17 amino acids digestibility

As shown in Table 5, faecal Asp, Glu, Ile, Phe and His digestibility were different among the three treatments (P < 0.01), that is, the greatest in the MCP group and lowest in the HCP group (P < 0.05). There were no significant differences in faecal Ser digestibility of pigs among the three treatments (P > 0.05). Faecal Gly, Ala, Pro, Cys, Val, Met, Leu, Lys and Arg digestibility were different among the three treatments (P < 0.01), that is, greater in the MCP and LCP groups than the HCP group (P < 0.05). There were no significant differences in faecal Gly, Ala, Pro, Cys, Val, Met, Leu, Lys and Arg digestibility of pigs between the MCP and LCP groups (P > 0.05). Faecal Tyr digestibility was different among the three treatments (P < 0.01), that is, greater in the MCP and LCP groups than the HCP group (P < 0.05). There were no significant differences in faecal Tyr digestibility of pigs between the MCP and LCP groups (P > 0.05). Faecal Thr digestibility of pigs in the LCP and HCP groups is higher than that in the MCP group (P < 0.05), while there were no significant differences in faecal Ala and Val digestibility of pigs between the LCP and HCP groups (P > 0.05).

Table 5. The effects of dietary different CP levels on faecal apparent AA digestibility in growing pigs.

| L-CP | M-CP | H-CP | SEM | P-value |
|------|------|------|-----|--------|
| Asp  | 87.7b | 91.7a | 83.6c | 0.35   | <0.01  |
| Ser  | 96.5  | 94.5  | 94.9  | 0.57   | 0.06   |
| Glu  | 92.3b | 93.9a | 87.6c | 0.48   | <0.01  |
| Gly  | 85.0a | 85.3a | 81.9b | 0.73   | <0.01  |
| Ala  | 86.4a | 87.4a | 82.6b | 0.66   | <0.01  |
| Pro  | 93.1a | 92.8a | 88.7b | 0.48   | <0.01  |
| Thr  | 87.1b | 89.6a | 86.5b | 58     | <0.01  |
| Cys  | 93.2a | 90.6b | 93.0a | 0.64   | 0.02   |
| Val  | 88.1a | 87.4a | 75.9b | 0.61   | <0.01  |
| Met  | 87.0a | 86.5a | 84.6b | 0.54   | 0.02   |
| Ile  | 85.6b | 88.3a | 82.3c | 0.78   | <0.01  |
| Leu  | 90.9a | 91.5a | 86b   | 0.53   | <0.01  |
| Phe  | 85.3b | 89.5a | 79.8c | 0.79   | <0.01  |
| Lys  | 88.8a | 88.1a | 85.1b | 0.47   | <0.01  |
| His  | 88.1b | 91.2a | 82.4c | 0.46   | <0.01  |
| Arg  | 96.6a | 97.1a | 94.5b | 0.16   | <0.01  |

3.5. The microbial amino acid composition in faecal and ileal digesta

As shown in Table 6, faecal microbial Asp, Ile, Phe, Lys, Arg, EAA and EAA/NEAA percentages in 17 AAs were different among the three treatments (P > 0.05). Faecal NEAA and EAA/NEAA percentages in 17 AAs were different among the three treatments (P < 0.01). There were no significant differences in faecal Gly, Ala, Pro, Cys, Val, Met, Leu, Lys and Arg digestibility of pigs between the MCP and LCP groups (P > 0.05). Faecal Thr digestibility of pigs in the LCP and HCP groups is higher than that in the MCP group (P < 0.05), while there were no significant differences in faecal Ala and Val digestibility of pigs between the LCP and HCP groups (P > 0.05).
3 treatments (P < 0.01), that is, greater in the LCP group than in the MCP and HCP groups (P < 0.05). There were no significant differences in faecal microbial Asp, Ileu, Phe, Lys, Arg, EAA and EAA/NEAA percentages in 17 AAs between the MCP and HCP groups (P > 0.05). Faecal microbial Ser percentage in 17 AAs was different among the 3 treatments (P < 0.01), that is, the greatest in the MCP group and the lowest in the LCP group (P < 0.05). Faecal microbial Glu, Cys and Leu percentages in 17 AAs were different among the 3 treatments (P < 0.01), that is, greater in the MCP and HCP groups than in the LCP group (P < 0.05). There were no significant differences in faecal microbial Glu, Cys and Leu percentages of 17 AAs between the MCP and HCP groups (P > 0.05). There were no significant differences in faecal microbial Gly, Ala, Tyr, Thr, Val, Met and His percentages of 17 AAs among the 3 treatments (P > 0.05). Faecal microbial Pro percentage of 17 AAs was different among 3 treatments (P < 0.01), that is, greater in the MCP group than in the LCP and HCP groups (P < 0.05). There were no significant differences in faecal microbial Pro percentage of 17 AAs between the HCP and MCP groups (P > 0.05). There were no significant differences in faecal microbial Gly, Ala, Tyr, Thr, Val, Met and His percentages of 17 AAs among the 3 treatments (P > 0.05). Faecal microbial Glu percentage of 17 AAs between the HCP and MCP groups (P < 0.01), that is, greater in the HCP group than in the MCP and LCP groups (P < 0.05). The ileal digesta microbial Ser, EAA, EAA/NEAA percentages of 17 AAs were different among the 3 treatments (P < 0.01), that is, greater in the LCP group and lowest in the HCP group (P < 0.05). The ileal digesta microbial Glu percentage of 17 AAs was different among the 3 treatments (P < 0.01), that is, greater in the MCP group than in the HCP and LCP groups (P < 0.05). There were no significant differences in ileal digesta microbial Asp, Ala and Arg percentages of 17 AAs were different among the 3 treatments (P < 0.01), that is, greater in the HCP group than in the MCP and LCP groups (P < 0.05). There were no significant differences in ileal digesta microbial Val, Leu, Phe and His percentages of 17 AAs among the 3 treatments (P > 0.05). The ileal digesta microbial Ser, EAA, EAA/NEAA percentages of 17 AAs were different among the 3 treatments (P < 0.01), that is, greatest in the LCP group and lowest in the HCP group (P < 0.05). The ileal digesta microbial Glu percentage of 17 AAs was different among 3 treatments (P < 0.01), that is, greater in the MCP group than in the HCP and LCP groups (P < 0.05). There were no significant differences in ileal digesta microbial Val, Leu, Phe and His percentages of 17 AAs among the 3 treatments (P > 0.05). The ileal digesta microbial Glu percentage of 17 AAs between the HCP and MCP groups (P > 0.05). There were no significant differences in ileal digesta microbial Gly and Cys percentages of 17 AAs between the HCP and MCP groups (P > 0.05). The ileal digesta microbial Pro percentage of 17 AAs was different among the 3 treatments (P < 0.01), that is, the greatest in the HCP group and the lowest in the LCP group (P < 0.05). The ileal digesta microbial Tyr percentage of 17 AAs was different among 3 treatments (P < 0.01), that is, the greatest in the MCP group and the lowest in the LCP group (P < 0.05). The ileal digesta microbial Thr, Ile and Lys percentages of 17 AAs were different among the 3 treatments (P < 0.01), that is, greater in the MCP and LCP groups than in the HCP group (P < 0.05). There were no significant differences in ileal digesta microbial Thr, Ile and Lys percentages of 17 AAs between the MCP and LCP groups (P > 0.05). The ileal digesta microbial Met percentage of 17 AAs was different among the 3 treatments (P < 0.01), that is, greater in the HCP and LCP groups than in the MCP group (P < 0.05). There were no significant differences in ileal digesta microbial Met percentage of 17 AAs between the HCP and LCP groups (P > 0.05). The ileal digesta microbial NEAA percentage of 17 AAs was different among the 3 treatments (P < 0.01), that is, the greatest in the HCP group and the lowest in the MCP group (P < 0.05). As shown in Figure 2, the AA composition similarity between ileal microbia and faecal microbia was more than 90%.

4. Discussion

4.1. Faecal nitrogen excretion

Faecal N losses decreased (P < 0.05) by 11.0%, 12.3% when feeding the 10%, 13% CP diet, respectively, compared with feeding the 16% CP diet (Table 2). Our values are lower than previously reported, where N excretion in growing pigs was reduced by 10% and 40% when dietary CP concentration was decreased from 15% to 6% (Otto et al. 2003), from 16% to 14% (Hobbs et al. 1996) and from 17% to 11% (Kephart & Sherritt 1990), respectively, but are very close to an average as reviewed by Kerr et al. (2003). The largest contribution to reduction in faecal N losses when decreasing CP concentration from 16% to 10% was of protein N origin in this study. Faecal microbial N did not differ among the 10%, 13% and 16% CP diets; hence, faecal microbial N (represented 18.6%, 18.1% and 14.4% of the total N losses, respectively) was not a major contributor to reducing total N losses. Bacterial nitrogen, combined with ammonia and urea nitrogen, represented nearly
61% of the total N losses in pig fed a casein diet or free protein diet (Warren et al. 2009).

Dietary manipulation to reduce NH₃ emission appears to be a realistic and efficient practice for reducing NH₃ emission at each step of the chain from feeding the animal to spreading the manure (Portejoiea et al. 2004). Decreasing the CP level is an effective method to reduce ammonia emitted from pig houses (Michael et al. 2014).

4.2. Amino acid digestibility

Reducing dietary CP and providing indispensable crystalline AA can improve AA digestibility and reduce AA excretion. Reducing dietary CP and providing indispensable crystalline AA may offer a better balance of AA for uptake across the gut by reducing competition for AA transport by enterocytes (Otto et al. 2003). Amino acids themselves are inducers of AA transport systems (Diamond & Karasov 1987) and pancreatic peptides (Johnson 2001). It is unknown whether an interaction occurs for gut absorption between crystalline AA and protein-bound AA. Amino acid transport systems interact with multiple AAs. For example, it has been established that L-methionine and L-lysine share transport systems with cationic and neutral AA in the intestine of chickens. Inhibition or competition for uptake in the presence of other AAs occurs between L-methionine and L-lysine (Torras Llort 1996; Soriano Garcia et al. 1999). Thus the presence of readily available AA of crystalline origin may increase the absorption rate of peptide- and protein-bound AA.

4.3. Microbial amino acid composition

Microbial NEAA and EAA composition in faeces was not influenced by dietary AA composition in this study. However, microbial NEAA and EAA composition in ileum was influenced by dietary AA composition in this study.

This study demonstrated the effect of dietary N substrates on microbial AA composition in ileum was more significant than faeces. The reason was related to the different microbiome composition from anterior to posterior ( Isaacs on and Kim 2012). In previous studies, limited data were reported about microbial AA composition in pigs. Discharge of faecal N in pigs is mainly in the organic N (about 85–88%) form, and the radio percentage of microbial N in faecal N was about 11–13% in this study. Faecal N in pigs come from diet N which not digested and absorbed by host and endogenous proteins secreted by salivary, gastric, hepatic, pancreatic and intestinal secretory cells and bacterial protein. Bacterial protein was commonly included in the estimations of endogenous materials (Moughan et al. 2005) and might be the largest single contributor to the nitrogen of terminal ileal digesta (Caine et al. 1999). The AA composition similarity between ileal microbia and faecal microbia was more than 90%. His, Tyr, Met, Cys and Ser percentages in the 17 AAs in ileal microbia or faecal microbia were lower than the average level, while Phe, Leu, Pro, Ala, Glu and Asp percentages were higher than the average level. More than half of AAs in ileal microbial or faecal microbial showed significant response to the protein level. This study, which showed that the dietary AAs as the intestinal microbial substrates of intestinal microflora had a significant impact on microbial AA composition and excretion from faeces, would provide the reference meaning for the pig production.

5. Conclusion

It is concluded that pigs fed a corn–soybean meal-based diet reduced in protein concentration have lower faecal N flow. Reducing dietary CP and providing indispensable crystalline AA can improve AA digestibility and reduce AA excretion. The effect of dietary N substrates on microbial AA composition in ileum was more significant than faeces. The AA composition similarity between ileal microbia and faecal microbia was more than 90%.

Disclosure statement

No potential conflict of interest was reported by the authors.

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