AJINOMOTO

AJINOMOTO ANIMAL NUTRITION

AJINOMOTO HEARTLAND, INC.

SWINE RESEARCH REPORT 13

Reducing Nitrogen Output in Pig Production

Introduction

The nitrogen (N) component of farm waste arises as a consequence of what the animal eats.

Nitrogen In → Nitrogen Retained (Meat, Milk) → Nitrogen Waste Excreted

Monogastrics are fed proteins to supply the necessary building blocks (amino acids) which are needed in precise amounts to produce meat, etc. Commercial diets normally oversupply amino acids (protein) in order to satisfy the demand for limiting amino acids. The most limiting amino acids for the pig fed corn-soybean meal based diets are lysine, threonine, tryptophan and methionine. With commercially available feed grade amino acids (lysine, threonine, tryptophan and methionine), there exists the potential to reduce dietary protein levels, hence reducing nitrogen excretion but still providing balanced (AA) diets.

Discussion

Prior to the advent of industrial fertilizers, manure (nutrients) from domestic animals provided the sole fertilizer input for arable land. Through the specialization and concentration of animal production, it has now become a troublesome waste disposal problem in areas of limited available land. Today there is regional excess of nitrogen and phosphorus (P) from domestic animal production.

Many proposed solutions do not focus on the origin of the excess nitrogen problem which is the transformation of nutrients by the animal (Aumuller, 1991).

1. *Phase feeding*

In some cases, simplification of management has reduced the number of feeds fed to the pig. Protein levels of these feeds would be adjusted high enough for the phase with the highest requirement thus leading to oversupply and enhanced nitrogen excretion during part of the production cycle. Phase feeding to provide a number of rations closely matched to the pig's requirement could reduce N and P excretion by 5 to 15% depending on the animal species (Aumuller, 1991).

2. *Dietary Protein Levels/Nitrogen Excretion*

The most efficient method to reduce nitrogen excretion is to decrease dietary protein levels. Pigs have a requirement for essential amino acids plus a minimum of nonessential nitrogen, but not for protein as such. Through the use of feed grade amino acids, protein levels of the feed may be reduced without a loss in performance, thereby reducing nitrogen output by as much as 40-50% (Hall *et al*., 1988). Quality of a dietary protein fed is dependent upon its essential amino acid pattern coinciding with the animal's needs, such that maximum nitrogen retention may not be achieved with poor dietary proteins (Boorman, 1980). For a growing animal, the primary determinant of the required pattern of amino acids will be the pattern deposited during the body's weight gain (predominantly muscle), thus amino acid patterns of the muscles and diet should be well correlated ("Ideal Protein"). Dietary energy will also influence nitrogen retention since insufficient levels will result in protein being used as an energy source, thereby limiting nitrogen retention.

As the dietary amino acid balance is improved due to supplementation of the first limiting amino acid (e.g. lysine), protein synthesis is increased and excesses of non-limiting amino acids reduced (Brown and Cline, 1974). Therefore, less of the non-limiting amino acids are catabolized and the amount of urea synthesized and excreted is reduced. Similar results were observed for pigs when graded levels of tryptophan were added to a diet known to be first limiting in tryptophan. These researchers suggested that total urinary excretion levels could be used as an indicator of protein quality and to possibly assess the amino acid requirements of swine.

Fecal and urine nitrogen output of female growing pigs (Figures 1 & 2) irrespective of live weight (35 or 55 kg), can be reduced by decreasing dietary levels of soybean meal and utilizing commercially available crystalline amino acids (Hall *et al*, 1988).

The degree of retained nitrogen, irregardless of live weight, changed very little when SBM level of the diet was reduced. Thus indicating the reduction of dietary protein (due to reduced SBM usage) did not adversely affect nitrogen retention, provided amino acid requirements were met. Raising the dietary level of digestible lysine at each weight range improved the level of retained nitrogen in female growing pigs.

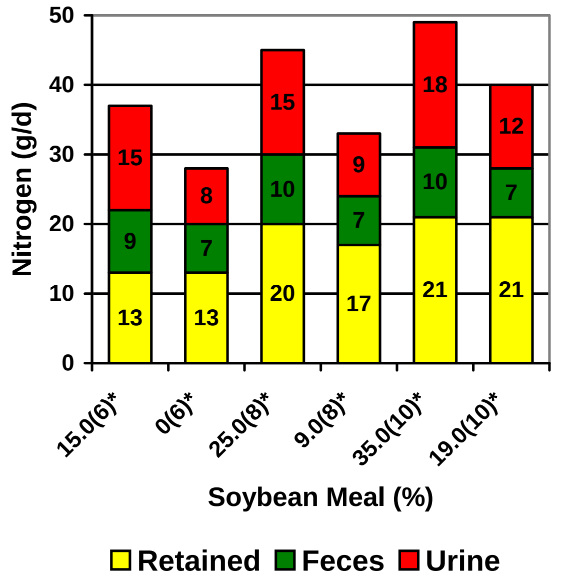
Barley and SBM were utilized to provide the desired lysine levels. The desired threonine:lysine ratios were achieved by reducing the dietary SBM content (-5% crude protein) and supplementing with crystalline lysine and threonine. The optimum level of dietary threonine to lysine content for growing pigs was determined to be 65%. A methionine:lysine ratio of 0.35 was provided in all diets with the use of supplemental methionine. Feeding experiments with these same diets containing crystalline amino acids resulted in equal growth and improved feed:gain (Table 1) compared to the high protein control diets (Treatments 1, 5, 9; Madsen *et al*, 1988).

Table 1. Daily gain, feed efficiency and carcass quality (4 females and 4 castrates per pen)*

	Treatments											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
20-50 kg (g,dig. Lys/FEs)	(6)				(8)				(10)			
50-90 kg (g,dig. Lys/FEs)	(5)				(7)				(9)			
Threonine:Lysine	K	0.50	0.65	0.80	K	0.50	0.65	0.80	K	0.50	0.65	0.80
Number of Pigs	96	96	96	96	96	96	96	96	96	96	96	96
Beginning Weight	25.2	25.4	25.2	25.2	25.2	25.2	25.1	25.1	25.3	25.1	25.1	25.2
End Weight	90.5	89.7	90.5	90.8	91.0	91.1	90.7	90.8	90.5	90.7	90.4	90.7
25-50 kg												
FEs/day	1.74	1.75	1.72	1.72	1.73	1.73	1.71	1.71	1.72	1.72	1.70	1.71
Daily gain, g	612	476	569	583	672	605	674	674	688	687	731	707
FEs/kg, gain	2.85	3.71	3.04	2.96	2.58	2.87	2.54	2.54	2.52	2.51	2.34	2.43
50-90 kg												
FEs/day	2.62	2.51	2.63	2.62	2.62	2.63	2.63	2.62	2.63	2.62	2.63	2.63
Daily gain, g	753	629	720	740	808	810	828	834	804	849	831	862
FEs/kg, gain	3.49	4.03	3.68	3.54	3.25	3.27	3.18	3.15	3.29	3.11	3.17	3.08
Total (20-90 kg)												
FEs/day	2.24	2.15	2.22	2.22	2.24	2.22	2.23	2.23	2.25	2.23	2.25	2.24
Daily gain, g	687	559	652	674	749	717	763	764	753	780	788	790
FEs/kg, gain	3.26	3.89	3.42	3.30	3.00	3.11	2.93	2.92	3.00	2.87	2.86	2.84
% muscle	54.3	53.0	53.8	53.9	55.8	54.8	54.9	55.2	56.5	56.1	55.8	56.3
Days to 90 kg	95.6	118.8	100.7	97.4	87.8	91.6	86.1	85.9	87.2	84.3	83.4	83.4
g Dig. protein/FEs	117	82	82	82	142	105	105	105	165	130	130	130
g Dig. lysine/FEs	5.3	5.5	5.5	5.5	7.1	7.2	7.2	7.1	8.8	8.9	8.9	8.9
g Dig. threonine/FEs	4.1	2.6	3.6	4.4	5.1	3.6	4.6	5.8	6.0	4.6	5.7	7.0
g dig. methionine/FEs	1.8	1.9	1.9	1.9	2.3	2.4	2.4	2.4	2.8	3.0	3.0	3.0
Soybean meal (kg)	25.8	--	--	--	40.5	16.3	15.4	15.3	56.6	31.1	30.9	30.8
Barley (kg)	179.5	247.8	217.9	210.3	146.5	179.9	169.7	168.9	128.5	148.6	147.8	147.2
L-Lysine HCl, g	--	868	756	729	--	682	644	640	--	624	619	617
L-Threonine, g	--	--	206	380	--	--	196	410	--	--	199	450
DL-Methionine, g	--	122	106	102	52	151	143	142	96	194	192	192
Mineral/Vit. Mix, kg	5.5	6.9	6.0	5.9	4.9	5.4	5.1	5.1	4.6	4.8	4.8	4.7
Total FEs intake	214	255	224	216	197	203	192	191	196	188	187	186

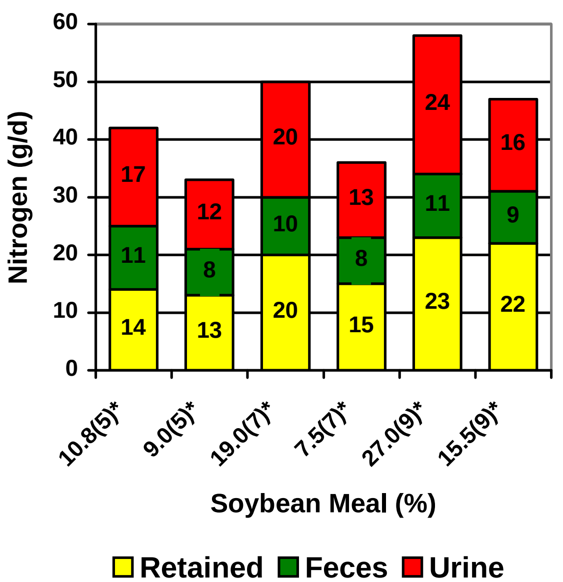
*Madsen et al., (1988)
FE – Danish Feed Unit (net energy system)

Figure 1. Nitrogen - Meabolism (Pig Weight 35 kg)



*Value in parentheses represent digestible lysine (g/feed unite)

Figure 2. Nitrogen - Meabolism (Pig Weight 55 kg)



*Value in parentheses represent digestible lysine (g/feed unit)

Nitrogen digestibility, urinary nitrogen excretion, total nitrogen excretion and retained nitrogen were highest for female crossbred (Lacombe x Yorkshire) pigs fed a 24.7% protein diets. However these levels decreased with decreasing dietary protein (Thacker *et al*, 1982). Urea pool size, entry rate and excretion rate also decreased with decreasing protein levels. When expressed as a percentage of total entry rate, significantly higher percentage of urea was recycled in pigs fed the low protein versus those fed the higher protein diet. The three corn-SBM diets used represented deficient (8.4% CP), adequate (15.8% CP) and excess requirements (24.7% CP) diets with no crystalline amino acid supplementation. These diets were fed to 41 kg pigs until a weight of approximately 65 kg at the end of the study. The amount of total nitrogen excreted was 17.4, 21.7 and 30.8 g/d for the 8.4, 15.8 and 24.7% dietary protein, respectively. Feeding the higher protein diet thus provided a greater imbalance of amino acids, leading to the higher nitrogen excretion rates observed.

3. Economical Aspects

At present there is no economical incentive in the U.S. to reduce nitrogen output from livestock. Dutch studies on the nationwide cost of nitrogen/phosphorus control indicated situations which reduce emissions via feeding are less expensive than solutions relying to a large extent on transport or industrial treatment (Aumuller, 1991).

Conclusion

Effective reduction of nitrogen excretion in swine production requires an examination of the origin of the problem, namely nitrogen (protein) intake. Nitrogen excretion in pigs may be reduced by:

1. Phase feeding to provide a series of diets closely matching the pig's requirements.
2. Utilization of commercially available amino acids combined with reduced protein levels to provide better balanced diets. Formulating diets based on ideal protein concept would be useful.
3. Reducing nitrogen excretion via nutritional means may provide a less expensive solution on a long term basis.

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