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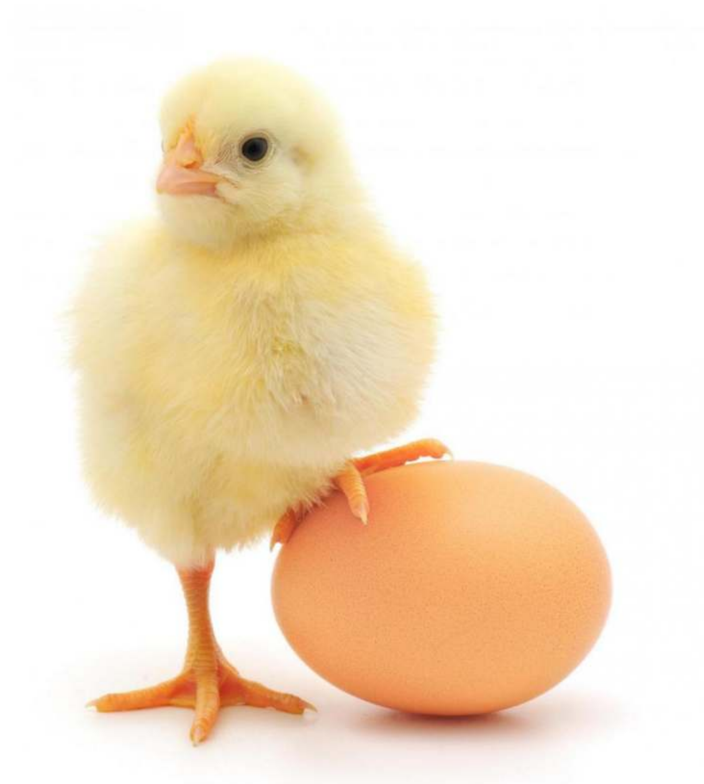

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Impact of Dietary Crude Protein, Synthetic Amino Acid and Keto Acid Formulation on Nitrogen Excretion

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Abstract: Nitrogen excretion from poultry facilities is one of the environment concerns. High levels of nitrogen excretion in poultry manure could cause eutrophication, nitrate or nitrite contamination in water, ammonia volatilization and acid deposition in the air. Therefore, minimizing nitrogen excretion in poultry manure is essential to maintain a clean environment. In order to minimize nitrogen excretion in manure, precise feed formulation to meet exact birds' nutrient requirements is critical. In this study, an empirical exercise was conducted to evaluate the possibilities of supplementing hydroxy-analogues or keto acids into low protein diets to minimize dietary nitrogen and reduce nitrogen excretion in poultry manure. The results showed that supplementing synthetic amino acids to the 16% CP diet greatly reduced N input (23.6% N) compared to a typical 23% CP corn and soybean meal diet supplemented with synthetic Met and Lys. Utilizing the three hydroxy-analogues with the 16% CP diet reduced nitrogen input further (approximately 3% more) compared to the 16% CP diet supplemented with synthetic amino acids. This empirical exercise showed the opportunities to reduce protein level and utilize synthetic amino acids, keto acids, or amino acid analogues to reduce nitrogen excretion.

Key words: Feed formulation, keto acid, synthetic amino acids, hydroxyl analogue

INTRODUCTION

The negative influence of intensive poultry production on the environment has been a major issue facing the poultry industry (Blair *et al*., 1999). High manure nitrogen excretion from poultry facilities could lead to eutrophication, nitrate/nitrite water contamination and ammonia emission and air pollution (Summers, 1993; Moore, 1998). Therefore, minimizing poultry manure nitrogen excretion is essential to maintain a clean environment. One of the strategies to reduce nitrogen excretion in poultry manure is minimizing excess protein and amino acid levels in diets. In this review, we discussed optimization of protein and amino acid input to meet the requirement using synthetic amino acids and keto-amino acids/hydroxyl-analogues.

Empirical exercise: Three CP levels (23, 19 and 16%) of corn and soybean meal diets were formulated using the Brill least cost feed formulation program. In all diets, dry matter was approximately 90%, metabolizable energy was 3, 200 kcal/kg, the minimum calcium was set at 1%, 0.45% available phosphorus and 1% linoleic acid. After formulation, levels of excess and limiting amino acids in the 23, 19 and 16% CP diets were compared with the amino acid requirements for broilers NRC (1994).

The composition of the diets are shown in Table 1-3, respectively and the amino acid profile compared to the NRC amino acid requirements (1994) for 0 to 3-wk-old broiler chicks are in Fig. 1-3, respectively. The most limiting amino acid in the 23% CP corn and soybean meal diet was Methionine (Met) and the second most limiting amino acid was Lysine (Lys) (Fig. 1). The diet with limiting amino acids should be supplemented with synthetic amino acids to maintain proper growth. However, there are several amino acids in excess compared to the NRC amino acid requirements (1994) for broilers (Fig. 1). The most excessive amino acid was Leucine (Leu) (170%) and the second most excessive amino acids were Glycine (Gly) and Serine (Ser) (157%) and Histidine (His) (153%). Phenylalanine (Phe) and Tyrosine (Tyr), Tryptophan (Trp), Valine (Val), Arginine (Arg), Isoleucine (Ile) and Threonine (Thr) were also greater than the NRC requirements (1994) for broilers. Parr and Summers (1991) also indicated that all essential amino acids except total sulfur amino acids of a 23% CP corn and soybean meal broiler diet were in excess of the NRC amino acid requirements (1994) for broilers. These excess amino acids in the diet cannot be utilized for muscle accretion but instead are used for energy and fat deposition. Eventually, they increase nitrogen excretion in the manure. To reduce nitrogen excretion, the excess amino acids beyond the bird's requirements should be minimized. One method to minimize the excess amino acids is reducing crude protein level and supplementing synthetic amino acids or analogues of amino acids to meet the amino acid requirements.

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Table 1: Composition of a 23% CP corn and soybean meal diet

		Amino acid composition	
Ingredient	%		%
Corn	60.291	Arginine	1.450
Soybean meal	23.926	Glycine	1.082
Corn gluten	3.813	Serine	0.883
Animal vegetable fat	3.574	Glycine+Serine	1.965
Animal protein	6.000	Histidine	0.537
Dicalcium phosphate	0.785	Isoleucine	0.881
Limestone	0.804	Leucine	2.042
Salt	0.300	Lysine	1.000
Vitamin premix	0.250	Methionine+Cystine	0.761
		Phenylalanine	1.082
Metabolizable		Phenylalanine+Tyrosine	1.946
Energy (kcal/kg)	3200	Threonine	0.810
Crude protein	23.00	Tryptophan	0.248
		Valine	1.055

Table 2: Composition of a 19% CP corn and soybean meal diet

		Amino acid composition	
Ingredient	%		%
Corn	69.840	Arginine	1.304
Soybean meal	19.270	Glycine	1.090
Animal vegetable fat	2.780	Serine	0.836
Animal protein	6.000	Glycine+Serine	1.926
Dicalcium phosphate	0.670	Histidine	0.448
Limestone	0.870	Isoleucine	0.880
Salt	0.300	Leucine	1.756
Vitamin premix	0.250	Lysine	0.944
		Methionine+Cystine	0.662
Metabolizable		Phenylalanine	0.885
Energy (kcal/kg)	3200	Phenylalanine+Tyrosine	1.586
Crude protein	19.00	Threonine	0.775
		Tryptophan	0.216
		Valine	1.082

Table 3: Composition of a 16% CP corn and soybean meal diet

		Amino acid composition	
Ingredient	%		%
Corn	75.158	Arginine	0.996
Soybean meal	16.316	Glycine	0.665
Animal vegetable fat	2.789	Serine	0.648
Animal protein	2.105	Glycine+Serine	1.313
Dicalcium phosphate	1.574	Histidine	0.384
Limestone	1.074	Isoleucine	0.591
Salt	0.300	Leucine	1.366
Vitamin premix	0.253	Lysine	0.679
		Methionine+Cystine	0.511
Metabolizable		Phenylalanine	0.750
Energy (kcal)	3200	Phenylalanine+Tyrosine	1.416
Crude protein	16.00	Threonine	0.552
		Tryptophan	0.185
		Valine	0.713

When the CP level was empirically reduced from 23 to 19%, the amount of excess amino acids in the diet was reduced (Fig. 2). The amino acids in greatest abundance were Gly and Ser (154%) and the second most excessive amino acid was Leu (146%). The percent amino acid concentrations of His, Val, Phe and Tyr, Ile, Trp and Arg were 128, 120, 118, 110, 108 and 104%, respectively, compared to the NRC amino acid requirements (1994). Three amino acids were limiting in the 19% corn and soybean meal diet compared to the NRC amino acid requirements (1994) for broilers: Met (74%), Lys (86%) and Thr (97%). Thus, these limiting amino acids could be supplemented with synthetic amino acids or keto acids.

When the CP level of a diet was reduced to 16%, levels of excess amino acids in the diet were considerably

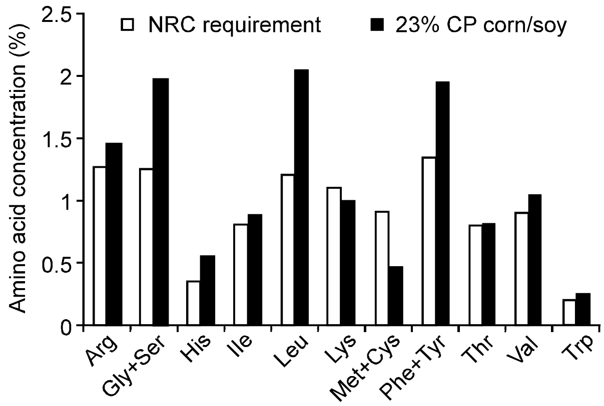

Fig. 1: Amino acid concentration of a 23% CP corn and soybean meal diet compared to the NRC amino acid requirements (1994) for broilers

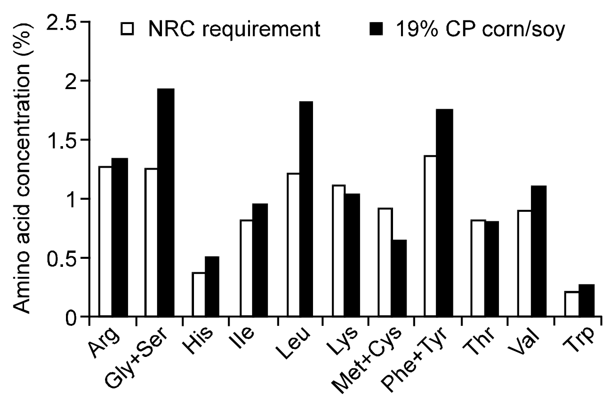

Fig. 2: Amino acid concentration of a 19% CP corn and soybean meal diet compared to the NRC amino acid requirements (1994) for broilers

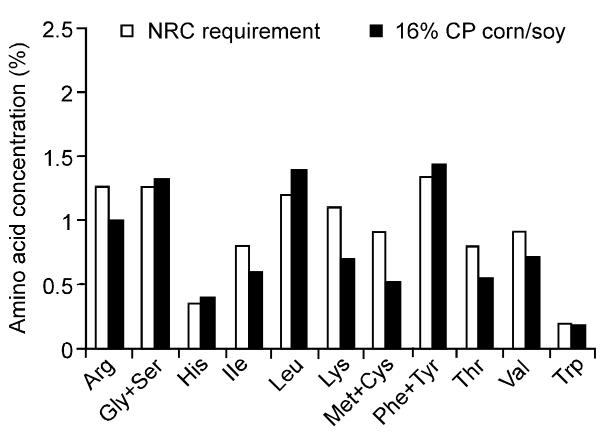

Fig. 3: Amino acid concentration of a 16% CP corn and soybean meal diet compared to the NRC amino acid requirements (1994) for broilers

reduced compared to either the 23 or 19% CP diets. In the 16% CP diet, there were not many amino acids in excess. The level of Leu that was the highest excessive amino acid (170%) in a 23% CP diet is now 114% of the NRC requirement (1994). The levels of His, Gly+Ser and Phe+Tyr are 110, 105 and 105%, respectively, compared to the NRC requirements (1994). These results suggest that the reduction of the CP level reduces excess amino acids, potentially decreasing nitrogen excretions in the manure. Furthermore, the reduction of CP level from 23 to 16% created deficiencies of some amino acids that could be corrected with hydroxy-analogues or keto acids to meet the exact bird's requirements. The levels of Met+Cys, Lys, Thr, Val, Ile, Arg and Trp in the 16% CP diet were all less than that recommended by the NRC (1994).

Although all the limiting amino acids in a 19 or 16% CP diet could be supplemented by synthetic amino acids, the Met in the 19% CP diet and Met, Ile and Val in the 16% CP diet could be provided by hydroxy-analogues or keto acids. Lys and Thr cannot be synthesized from hydroxy-analogues or keto acids because there are no aminotransferases. Furthermore, there are no reports on the metabolism and utilization of hydroxy-analogues or keto acids of Arg and Trp in poultry. Therefore, there is only a limited opportunity to supplement the keto acids or hydroxy-analogues in feed formulation even if CP levels are reduced to 16%.

However, hydroxy-analogues or keto acids of Met, Ile, or Val still can be supplemented in a 19 or 16% CP diet. Supplementing hydroxy-analogues or keto acids could reduce nitrogen excretion further compared to the 19 or 16% CP diet supplemented with only synthetic amino acids. The impact of hydroxy-analogue or keto acid supplementation on reducing N input in the diets was evaluated in Table 4 and 5. When the limiting amino acids, Met and Lys, in a 23% CP corn soybean meal diet were supplemented by synthetic amino acids, the total CP level was 23.2%. When the CP level was reduced to 19% and the limiting amino acids, Met, Lys and Thr, were supplemented with synthetic amino acids, the total CP level was reduced to 19.22%.

When methionine-hydroxy-analogue (MHA) and two synthetic amino acids (Lys and Thr) were supplemented to the 19% CP diet, the total CP level was approximately 19.2%. The 19% CP diet supplemented with synthetic amino acids reduced N input approximately 17.2% compared to the 23% CP diet supplemented with synthetic amino acids, whereas MHA supplementation in the 19% CP diet did not have much impact on reducing N input further.

When the dietary CP level was reduced to 16% and limiting amino acids were supplemented with synthetic amino acids to meet the NRC (1994) requirement, the final CP level was reduced to 17.72%. When hydroxy-analogues or keto acids of Met, Ile and Val and synthetic amino acids of the remaining limiting amino acids were supplemented to the 16% CP diet, the total CP level was further reduced to 17.21%. These results showed that

Table 4: Corn and soybean meal diets (23 and 19%) CP supplemented with synthetic amino acids and hydroxy-analogues to meet the NRC (1994) amino acid requirements for broilers

Analogue, keto acid or synthetic amino acid supplementations in diets	Supplementation level (%)		Total CP levels (%) after supplemented
After supplementing synthetic amino acids to the 23% CP diet			
		CP level of basal diet	23.000
DL-methionine	0.139	CP level of DL-Met	0.081
L-lysine	0.100	CP level of L-Lys	0.120
		Total CP level	23.201
After supplementing synthetic amino acids to the 19% CP diet			
		CP level of the basal diet	19.000
DL-methionine	0.238	CP level of DL-Met	0.019
L-lysine	0.156	CP level of L-Lys	0.187
L-threonine	0.025	CP level of L-Thr	0.018
		Total CP level	19.224
After supplementing analogues and synthetic amino acids to the 19% CP diet			
		CP level of the basal diet	19.000
MHA[1]	0.238	CP level of MHA	0.000
L-lysine	0.156	CP level of L-Lys	0.187
L-threonine	0.025	CP level of L-Thr	0.018
		Total CP level	19.205

[1]MHA: Methionine hydroxy-analogue has an equal efficiency to DL-Met

Table 5: Corn and soybean meal diets (16% CP) supplemented with hydroxy-analogues or keto acids and synthetic amino acids to meet the NRC (1994) amino acid requirements for broilers

Analogue, keto acid or synthetic amino acid supplementations in diets	Supplementation level (%)		Total CP levels (%) after supplemented
After supplementing synthetic amino acids to the 16% CP diet			
		CP level of the basal diet	16.000
DL-methionine	0.389	CP level of DL-Met	0.228
L-lysine	0.421	CP level of L-Lys	0.504
L-threonine	0.248	CP level of L-Thr	0.182
L-arginine	0.254	CP level of L-Arg	0.511
L-tryptophan	0.015	CP level of L-Trp	0.013
L-isoleucine	0.209	CP level of L-Ile	0.139
L-valine	0.187	CP level of L-Val	0.140
		Total CP level	17.720
After supplementing analogues and synthetic amino acids to the 16% CP diet			
		CP level of the basal diet	16.000
MHA[1]	0.389	CP level of MHA	0.000
L-lysine	0.421	CP level of L-Lys	0.504
L-threonine	0.248	CP level of L-Thr	0.182
L-arginine	0.254	CP level of L-Arg	0.511
L-tryptophan	0.015	CP level of L-Trp	0.013
HMV[2]	0.249	CP level of HMV	0.000
HIV[3]	0.228	CP level of HIV	0.000
		Total CP level	17.210
After supplementing analogues, keto acids and amino acids to the 16% CP diet			
		CP level of the basal diet	16.000
MHA	0.389	CP level of MHA	0.000
L-lysine	0.421	CP level of L-Lys	0.504
L-threonine	0.248	CP level of L-Thr	0.182
KGV[4]	0.254	CP level of L-Arg	0.385
Indole-3-pyruvate[5]	0.015	CP level of L-Trp	0.006
HMV	0.249	CP level of HMV	0.000
HIV	0.228	CP level of HIV	0.000
		Total CP level	17.080

[1]MHA: Methionine hydroxy-analogue has an equal efficiency to DL-Met

[2]HMV: α-hydroxy-β-methylvanleric acid, hydroxy analogue of isoleucine, has 84% efficiency relative to L-Ile

[3]HIV: α-hydroxy-isovaleric acid, hydroxy analogue of valine, has 82% efficiency relative to L-Val

[4]KGV: α-keto-δ-guanido-η-valeric acid, keto acid of arginine, is assumed to have an equal efficiency relative to L-Arg

[5]Indole-3-pyruvate: Keto acid of tryptophan is assumed to have an equal efficiency relative to L-Trp

Table 6: Total CP level of a 16% CP corn and soybean meal diet with supplemented synthetic amino acids to meet the digestible amino acid requirements based on the ideal protein ratio for broilers

Limiting amino acid in a 16% CP corn and soybean meal diet	Amino acid concentration	Average digestibility[1]	Digestible AA concentrations of limiting AA in the 16% CP diet	Digestible AA requirement based on ideal protein ratio
	------------------------	--------- % ---------	------------------------	
Methionine+Cystine	0.511	88	0.450	0.81
Lysine	0.679	88	0.598	1.12
Threonine	0.552	88	0.486	0.75
Arginine	0.996	93	0.926	1.18
Tryptophan	0.185	90	0.167	0.18
Isoleucine	0.591	90	0.532	0.75
Valine	0.713	90	0.642	0.86
After supplementing only synthetic amino acids to the 16% CP diet				
	(%)			(%)
			CP level of the basal diet	16.000
DL-methionine	0.360		CP level of DL-Met	0.211
L-lysine	0.522		CP level of L-Lys	0.625
L-threonine	0.264		CP level of L-Thr	0.194
L-arginine	0.254		CP level of L-Arg	0.510
L-tryptophan	0.001		CP level of L-Trp	0.001
L-isoleucine	0.218		CP level of L-Ile	0.146
L-valine	0.187		CP level of L-Val	0.140
			Total CP level	17.830

[1]Average true amino acid digestibility in a 22 to 23% CP corn-soybean meal diet (Parsons, 1991)

Table 7: Total CP level of a 16% CP corn and soybean meal diet with supplemented hydroxy-analogues and keto acids to meet the digestible amino acid requirements based on the ideal protein ratio for broilers

Limiting amino acid in a 16% CP corn and soybean meal diet	Amino acid concentration	Average digestibility[6]	Digestible AA concentrations of limiting AA in the 16% CP diet	Digestible AA requirement based on ideal protein ratio
	------------------------	--------- (%) ---------	------------------------	
After supplementing hydroxy-analogues and synthetic amino acids to the 16% CP diet				
		CP level of the basal diet	16.000	
MHA[1]	0.360	CP level of MHA	0.000	
L-lysine	0.522	CP level of L-Lys	0.625	
L-threonine	0.264	CP level of L-Thr	0.194	
L-arginine	0.254	CP level of L-Arg	0.510	
L-tryptophan	0.001	CP level of L-Trp	0.001	
HMV[2]	0.259	CP level of HMV	0.000	
HIV[3]	0.228	CP level of HIV	0.000	
		Total CP level	17.330	
After supplementing hydroxy-analogues, keto acids and synthetic amino acids to the 16% CP diet				
		CP level of the basal diet	16.000	
MHA	0.389	CP level of MHA	0.000	
L-lysine	0.421	CP level of L-Lys	0.625	
L-threonine	0.248	CP level of L-Thr	0.194	
KGV[4]	0.254	CP level of L-Arg	0.385	
Indole-3-pyruvate[5]	0.015	CP level of L-Trp	0.006	
HMV	0.259	CP level of HMV	0.000	
HIV	0.228	CP level of HIV	0.000	
		Total CP level	17.210	

[1]MHA: Methionine hydroxy-analogue has an equal efficiency to DL-Met
[2]HMV: α-hydroxy-β-methylvanleric acid, hydroxy analogue of isoleucine, has 84% efficiency relative to L-Ile
[3]HIV: α-hydroxy-isovaleric acid, hydroxy analogue of valine, has 82% efficiency relative to L-Val
[4]KGV: α-keto-δ-guanido-η-valeric acid, keto acid of arginine, is assumed to have an equal efficiency relative to L-Arg
[5]Indole-3-pyruvate: Keto acid of tryptophan is assumed to have an equal efficiency relative to L-Trp
[6]Average true amino acid digestibility in a 22 to 23% CP corn-soybean meal diet (Parsons, 1991)

supplementing synthetic amino acids to the 16% CP diet greatly reduced N input (23.6% N) compared to a typical 23% CP corn and soybean meal diet supplemented with synthetic Met and Lys. Utilizing the three hydroxy-analogues with the 16% CP diet reduced nitrogen input further (almost 3%) compared to the 16% CP diet supplemented with synthetic amino acids.

Although no actual studies have been conducted evaluating keto acid supplementation in reducing nitrogen excretion, several studies demonstrated that synthetic amino acid additions to low protein diets significantly reduced nitrogen excretion in poultry manure (Summers, 1993; Blair *et al*., 1999; Waldroup, 2000). Waldroup (2000) reported that the chicks fed either a 20.32 or 16.61% CP corn and soybean meal diet supplemented with synthetic amino acids excreted approximately 13.5 and 29.5% less nitrogen than those fed the 22.48% CP basal diet, respectively.

The present empirical exercise indicated that supplementation of synthetic amino acids and keto acids to low protein diets could have an impact on nitrogen excretion in poultry manure by reducing N input. Although no feeding trials have been conducted to evaluate the utilization of hydroxy-analogues or keto acids of Arg and Trp in poultry, their addition to low protein diets would reduce N input further if the hydroxy-analogues or keto acids are effectively converted to the corresponding amino acids. Some studies have been conducted to evaluate replacement of Arg and Trp by their corresponding hydroxy-analogues or keto acids in the diets of rats. Winitz *et al*. (1957) reported that rats fed an arginine-deficient diet supplemented with the keto acid of Arg, α-keto-δ-guanido-η-valeric acid, had higher weight gain than those fed the arginine-deficient diet. The efficiency of α-keto-δ-guanido-η-valeric acid was approximately 74% of L-Arg. Pond *et al*. (1964) indicated that the hydroxy-analogue (DL-3-indole lactic acid) of Trp promoted rat growth equal to that achieved with DL-Trp, whereas the keto acid (3-indole pyruvic acid) had approximately 80% efficiency relative to DL-Trp and 17% relative to L-Trp.

It is necessary to evaluate the transamination of the keto acids of Arg and Trp in poultry. If the keto acids of these amino acids are effectively transaminated, their addition to low protein diets could reduce N input further. Thus, the total CP level of the 16% CP diet supplemented with the hydroxy-analogues and keto acids was also estimated with the assumption of equal efficiencies of keto acids of Arg and Trp relative to L-Arg and L-Trp in Table 5. This reduced the final CP level further to approximately 17.1%.

Utilizing the Ideal Protein Ratio concept might reduce N input further because it makes a better amino acid balance and eliminates excesses of amino acids compared to the NRC (1994) amino acid requirements. Furthermore, the amino acid requirements based on the ideal protein ratio are digestible amino acid requirements rather than total amino acid requirements like the NRC (1994) requirements with intact protein. Thus, one can more precisely estimate the amount of amino acid deficiency in order to supplement with synthetic amino acids or keto acids. For instance, if limiting amino acids are supplemented with synthetic amino acids to meet the NRC (1994) amino acid requirements, the amount of synthetic amino acids added to the diet is higher than the actual bird's requirements because the digestibility of synthetic amino acids (100%) is higher than the amino acid digestibility (60 to 95%) of intact protein sources, such as soybean meal and corn. If we use the digestible amino acid requirements based on the ideal protein ratio, estimated levels of limiting amino acids are the exact levels needed by the birds and can be met by supplementing synthetic amino acids. Thus, using the digestible amino acid requirements based on the ideal protein ratio would be better than the NRC total amino acid requirements for supplementing synthetic amino acids or keto acids in low protein diets. An example of supplementing synthetic amino acids, keto acids and analogues based on the ideal protein ratio approach to a low CP diet is shown in Table 6 and 7.

Concentrations of amino acids in a 16% corn and soybean meal diet were converted to digestible amino acid levels based on average digestibility of each amino acid (Parson, 1991). Then, the digestible amino acid levels in the 16% CP diet were subtracted from the digestible amino acid requirement based on the ideal protein ratio in order to estimate the amount of synthetic amino acid or keto acid supplementation.

When limiting amino acids in the 16% CP diet were supplemented with only synthetic amino acids to meet the digestible amino acid requirements based on the ideal protein ratio, the total CP level was 17.83%. When the three hydroxy-analogues of Met, Ile and Val were supplemented instead of amino acids, the total CP level was reduced to 17.33%. When the three hydroxy-analogues and two keto acids of Arg and Trp were added to the 16% CP diet, the total CP level was reduced to 17.22%. However, each of these total CP levels was higher than those of the 16% CP diet supplemented with synthetic amino acids or keto acids based on the NRC (1994) amino acid requirements.

This result was contrary to what was expected. It was expected that supplementing synthetic amino acids or keto acids to the low protein diet to meet the digestible amino acid requirements based on the ideal protein ratio would reduce N input further compared to the NRC amino acid requirement basis. One of explanations for this is that the total requirements for key amino acids based on the ideal protein ratio are higher than the NRC amino acid requirements for broilers (1994). The total amino acid requirements which are converted from the digestible amino acid requirements based on the ideal protein ratio for Lys, Met+Cys, Thr, Val and Arg were 1.22, 0.92, 0.85, 0.96 and 1.26, respectively, whereas the NRC requirements of those amino acids were 1.10, 0.90, 0.80, 0.90 and 1.25, respectively. Thus, we have to add more synthetic amino acids or keto acids to meet the ideal amino acid requirements compared to the NRC (1994) amino acid requirement basis.

The ideal amino acid requirements may overestimate actual amino acid requirements for broilers in intact protein diets. Because the ideal amino acid requirements were made based on purified diets, application of the ideal amino acid requirements to intact protein feed formulations like corn and soybean meal diets might not be effective. Wang and Fuller (1990) also indicated that the ideal amino acid ratios developed using purified diets might not be applicable to practical intact protein diets. In purified diets, the changes of amino acid levels affect bird performances more sensitively than those in intact protein diets. Thus, using the ideal amino acid requirements for corn and soybean meal diet formulations might not be a good method to reduce N excretion by supplementing synthetic amino acids or keto acids in low protein diets. Therefore, the diet formulation based on the NRC (1994) amino acid requirements would be more effective for supplementing synthetic amino acids or keto acids to reduce N input.

Although lowering the CP level to 16% markedly reduced N input compared to the 23% CP diet, the 16% CP diet is too low to maintain proper growth even if all limiting amino acids are supplemented to the NRC requirement (1994). Edmonds *et al.* (1985) demonstrated that chicks fed a synthetic amino acid supplemented 16% CP corn and soybean meal diet significantly improved weight gain compared to those fed an unsupplemented 16% CP diet, but did not fully reach the weight of chicks fed a 24% CP diet. The authors reasoned the 16% CP diet did not contain enough nonessential amino acid nitrogen to maintain optimum muscle accretion. When they supplied 3% Glu to the 16% CP diet supplemented with synthetic essential amino acids, bird performance was further improved compared to the chicks just fed the 16% CP diet supplemented with synthetic essential amino acids. Therefore, the crude protein level should be higher than 16% to maintain optimum growth. Waldroup (2000) reported that the chicks fed a 20.32% CP diet supplemented with synthetic amino acids had similar body weights and significantly less manure N excretion (13.6% reduction) compared to those fed a 22.48% CP diet. However, if the crude protein level is higher than 16% in a corn and soybean diet, the opportunity for the supplementation of hydroxy-analogues or keto acids is further reduced.

Supplementing hydroxy-analogues or keto acids to low, 16% CP diets is currently not feasible for the poultry industry even though this feeding practice could markedly reduce nitrogen excretion in poultry manure. One of the reasons is because the poultry industry has no intention to lose optimum bird performance. Moreover, the cost of supplementing keto acids and synthetic amino acids into poultry diets is very expensive, e.g., the prices of soybean meal, synthetic valine and the reagent grade keto acid of valine are $ 0.23, 1.270 and 4.380/kg, respectively. A few synthetic amino acids can be supplemented into poultry diets on a cost-effective basis including Met, Lys, Thr and Trp (Waldroup, 2000). Only the hydroxy-analogue of Met can be supplemented into poultry diets in a cost effective manner today. Although the poultry industry will not use expensive keto acids and synthetic amino acids into poultry diets right now, it could be more feasible in the future when environmental regulations are more restrictive and fermentation technologies allow for less expensive keto acids and synthetic amino acids.

Conclusion: This empirical exercise showed the opportunities to reduce protein level and utilize synthetic amino acids, keto acids, or amino acid analogues to reduce nitrogen excretion. Actual feeding trials with poultry need to be conducted to evaluate the effect of keto acid and amino acid analogue supplementation into low protein diets on nitrogen excretion and growth performance of poultry.

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