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Influence of High Crystalline Amino Acid Inclusion on Poultry Diet Formulation and Pellet Quality

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Cover Page Footnote

Appreciation is expressed to CJ America Bio for partial financial support of this study.

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Influence of High Crystalline Amino Acid Inclusion on Poultry Diet Formulation and Pellet Quality[1]

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Summary

A total of 3 broiler diets were pelleted to determine the effects of diet formulation on pellet quality. Dietary treatments consisted of corn and soybean meal (SBM)-based control, the control with crystalline Val, and the control with crystalline Val and Ile. As crystalline amino acids (AA) increased in the diets, corn concentrations increased as SBM and choice white grease (CWG) were removed to balance for nitrogen-corrected metabolizable energy (MEn). Diets contained 54.2, 56.4, and 57.5% corn; 39.1, 37.1, and 36.2% SBM; and 2.5, 2.1, and 1.9% CWG in the control, Val, and Val + Ile diets, respectively. Corn was ground to approximately 1,000 µm and used to mix 1,100 lb of feed per treatment. There were 3 replicates per treatment with time of processing as a blocking factor and treatment order randomized within each block. Diets were pelleted via steam conditioning (10 × 55 in., Wenger twin staff preconditioner, Model 150) using a pellet mill (CPM Model PM 1012-2 HD) equipped with a 3/16 × 1 ¼ in. pellet die. The target conditioning temperature was 185°F for 30 s at a 34 lb/min production rate. Pellet samples were collected and cooled in an experimental counterflow cooler for 15 min to determine percent fines, standard pellet durability index (PDI; ASABE S269.4, 2007), modified PDI (three 19-mm hex nuts) and Holmen NHP100 for 60 s. Hot pellet temperature decreased ($P < 0.01$) in the control diet compared to Val and Val + Ile diets, which were 184.5, 185.1, and 185.088°F, respectively. Pellet mill kilowatts (kW) were 9.1, 8.9, and 10.3 for control, Val, and Val + Ile diets, respectively. Pellet mill kW increased ($P < 0.05$) in pelleted Val + Ile diets compared to the control and Val diets. Percent fines decreased ($P < 0.01$) and PDI increased ($P < 0.01$) as crystalline AA increased and added fat decreased in the diet. For the control, Val and Val + Ile diets, PDIs were 66.5, 73.6, and 76.6% for the standard; 37.1, 46.9, and 52.8% for the modified; and 53.4, 67.8, and 73.7% for the Holmen NHP100 for 60 s methods, respectively. In conclusion, diets with increasing crystalline AA, Val, and Val + Ile, led to improved pellet quality, which can be explained by the 0.4% or 0.6% reduction in added fat with increasing crystalline AA and balancing for MEn in the diet.

Introduction

It is well established that pellet quality can be influenced by several factors including ingredient quality and diet formulation, which can impact broiler performance.

[1] Appreciation is expressed to CJ America Bio for partial financial support of this study.

[2] CJ America Bio, Downers Grove, IL.

Commercial broiler diet formulation has been affected by the increasing use of crystalline amino acids (AA). Increasing crystalline AA influences diet formulation by removing soybean meal and fat, and increasing corn to balance for energy (MEn). Therefore, the objective of this study was to determine the effects of poultry diet formulation with crystalline Val and Ile on pellet quality.

Materials and Methods

Diet manufacture

Feed was manufactured in accordance with CGMPs at the Kansas State University O.H. Kruse Feed Technology Innovation Center (Manhattan, KS). A total of 3 diets were pelleted to determine the effects of poultry diet formulation with crystalline valine and isoluecine on pellet quality. Dietary treatments consisted of a corn and soybean meal-based control, the control formulated with crystalline valine, and the control formulated to include crystalline valine and isoluecine. Diets were formulated to be isocaloric and balanced for lysine concentration (Table 1). As crystalline amino acids (AA) increased in the diets, corn concentrations increased as SBM and choice white grease (CWG) were removed to balance for nitrogen-corrected metabolizable energy (MEn). Diets contained 54.2, 56.4, and 57.5% corn; 39.1, 37.1, and 36.2% SBM; and 2.5, 2.1, and 1.9% CWG in the control, Val, and Val + Ile diets, respectively. Corn was ground with a three-high roller mill (RMS Model 924) to approximately 1,000 µm. All ingredients were weighed on certified scales, lot numbers recorded, and amounts verified by the feed manufacturing investigator. A total of 1,100 lb of poultry feed per treatment was mixed in a 1-ton Hayes & Stolz double ribbon mixer. Each 1,100-lb batch per treatment was divided into three batches for pelleting. Each treatment was pelleted in 350-lb batches during 3 separate periods in order to provide 3 replicates per treatment. Time of processing served as a blocking factor and order of pelleting each treatment was randomized within each block. Prior to pelleting dietary treatments, the pellet mill was warmed up with 1,000 lb of basal feed which included holding the conditioning temperature for a minimum of 15 minutes. Each treatment run was approximately 10 min per replication. Diets were steam conditioned (10 × 55 in. length Wenger twin staff pre-conditioner, Model 150) to a target conditioning temperature of 185°F for approximately 30 s and pelleted on a 1-ton 30-horsepower pellet mill (1012-2 HD Master Model, California Pellet Mill) equipped with a 3/16 × 1 ¼ in pellet die (L:D 6.67). The feeder was set at a constant rate to achieve approximately 1-ton per hour. Pellet samples were taken at the die and cooled in an experimental counterflow cooler for 15 min. Hot pellet temperatures and production rates were collected at three time points during the pelleting process. Samples of the cool pellets were collected for determination of pellet quality.

Sample collection

Three 10-lb samples were collected from the cooler during each replication for analysis of pellet fines and PDI. Pellet durability index was determined using the standard and modified tumble box method as well as the Holmen NHP100 model for 60 seconds as explained below.

Pellet durability

For the standard method, a sample of cool pellets was taken and the fines sifted off by using the corresponding sieve stack.[2] Sifted pellets were split using a riffle divider and

1.1-lb sample was weighed for analysis. The 1.1-lb sample was placed in the designated chamber of the tumble box and run for 10 minutes. After tumbling, the sample was collected from the compartment and sifted using the same sieve as used previously. The remaining sifted pellets were weighed with PDI being calculated by dividing this final sample weight by the 1.1-lb initial sample weight.

For the modified method, a sample of cool pellets was taken and the fines sifted off by using the corresponding sieve stack.[2] Sifted pellets were split using a riffle divider and 1.1-lb samples were weighed for analysis. The 1.1-lb sample was placed in the designated chamber of the tumble box with the addition of three ¾-inch hex nuts. The sample along with the hex nuts were tumbled for 10 minutes. After tumbling, the sample was collected from the compartment and sifted using the same sieve as used previously. The hex nuts were removed and the remaining sifted pellets were weighed, with PDI being calculated by dividing this final sample weight by the 1.1-lb initial sample weight.

For the Holmen method, a sample of cool pellets was taken and the fines sifted off by using the corresponding sieve stack.[3] Sifted pellets were split using a riffle divider and 100 g weighed for analysis. The 0.2-lb sample was placed into the hopper of the Holmen NHP100 and the desired run time selected (60 seconds). Once completed, the sample was removed from the hopper and weighed. The PDI was calculated by dividing this final sample weight by the 0.2-lb initial sample weight.

Data were analyzed using the PROC MIXED procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC). The experimental unit was pelleting run treatment with a random effect of pelleting period. Results were considered significant if $P \leq 0.05$.

Results and Discussion

Diets were formulated to be isocaloric and isonitrogenous, therefore added fat was removed as synthetic amino acids increased in the diets (Table 1). Hot pellet temperature decreased ($P < 0.01$) in the control diet compared to valine and valine + isoleucine diets. Pellet mill kilowatts (kW) increased ($P < 0.05$) in pelleted valine + isoleucine diets compared to the control and valine diets (Table 2). The Val + Ile diet had a higher hot pellet temperature because of the decrease in added fat from 2.5% in the control diet to 2.1 and 1.9% in the Val and Val + Ile diets, respectively. Therefore, diets pelleted with 1.9% added fat and greater die friction had increased kW compared to those pelleted with 2.5 and 2.1% added fat.

Percent fines decreased ($P < 0.01$) as synthetic amino acids increased and added fat decreased in the diet. Pellet durability index for the standard, modified and Holmen NHP100 (60 s) methods increased ($P < 0.01$) as crystalline amino acids increased and added fat decreased in the diet (Table 3). In conclusion, diets with increasing synthetic amino acids, valine, and valine + isoleucine, led to improved pellet quality. These improvements in pellet quality can be explained by the reduction in added fat with increasing synthetic amino acids in the diet. Therefore, decreasing added fat by 0.6% led to a 10.1, 15.7, and 20.3% increase in PDI for standard, modified, and Holmen methods, respectively.

[3] Schofield, Eileen K, and American Feed Industry Association. Feed Manufacturing Technology V. (pg. 631). American Feed Industry Association, 2005.

In conclusion, diets with increasing crystalline amino acids, valine, and valine + isoleucine, led to improved pellet quality. These improvements in pellet quality can be explained by the 0.4 or 0.6% reduction in added fat with increasing crystalline amino acids and balancing for MEn in the diet.

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Table 1. Diet composition[1,2]

Item, %	Control	Val	Val + Ile
Corn	54.20	56.44	57.48
Soybean meal (46.5% CP)	39.12	37.13	36.16
Choice white grease	2.52	2.11	1.92
Limestone	1.11	1.12	1.12
Dicalcium phosphate	1.81	1.83	1.84
Salt	0.34	0.35	0.35
Copper sulfate	0.05	0.05	0.05
L-Lysine-HCL	0.15	0.22	0.24
L-Methionine	0.31	0.32	0.33
L-Threonine	0.10	0.12	0.14
L-Valine	---	0.03	0.05
L-Isoleucine	---	---	0.02
Choline chloride	0.05	0.05	0.05
Mineral-vitamin premix	0.25	0.25	0.25
Total	100	100	100
Calculated nutrient analysis			
MEn, kcal/lb	1,380	1,380	1,380
Crude protein, %	24.43	23.73	23.40
Crude fat, %	4.95	4.60	4.44
Ca, %	0.96	0.96	0.96
Available P, %	0.48	0.48	0.48
Total lysine, %	1.41	1.41	1.41

[1]A starter poultry diet composed of corn (ground to 1000 μm) and soybean meal with added synthetic amino acids was mixed in a 1-ton Hayes & Stolz horizontal counterpoise mixer. Diets were steam pelleted (10 × 55 in. length Wenger twin staff preconditioner, Model 150) for approximately 30 s at 185°F targeted conditioning temperature on a 1 ton 30-horsepower pellet mill (1012-2 HD Master Model, California Pellet Mill) with a 3/16 × 1 ¼ in. pellet die (L:D 6.67).

[2]Diets were formulated to be isocaloric and isonitrogenous.

Table 2. Pellet mill production data[1,2,3]

Item[4]	Control	Val	Val + Ile	SEM	Probability, *P* <
Production rate, lb/min	34.0	34.2	34.1	---	---
Conditioning temperature, °F	184.5	185.1	185.0	---	---
Hot pellet temperature, °F	189.1[a]	189.8[b]	190.1[b]	0.237	0.01
kW	9.1[a]	8.9[a]	10.3[b]	0.392	0.05

[1]A starter poultry diet composed of corn (1000 µm) and soybean meal with added synthetic amino acids was mixed in a 1-ton Hayes & Stolz horizontal counterpoise mixer. Diets were steam pelleted (10 × 55 in. length Wenger twin staff preconditioner, Model 150) for approximately 30 s at 185°F targeted conditioning temperature on a 1 ton 30-horsepower pellet mill (1012-2 HD Master Model, California Pellet Mill) with a 3/16 × 1 ¼ in. pellet die (L:D 6.67).
[2]Pelleting order in each time period consisted of control, valine isoleucine; valine, isoleucine, control; and isoleucine, control, and valine for time 1, 2, and 3, respectively.
[3]An average initial mash temperature among the 3 treatments was 69.3°F.
[4]Reported values represent an average of 3 collected samples for each treatment.

Table 3. Effects of including valine and isoleucine in poultry diets on pellet quality[1]

Item, %	Control	Val	Val + Ile	SEM	Probability, *P* <
Pellet fines[2]	14.2[a]	12.1[b]	10.1[c]	0.154	0.01
Standard method[3]	66.5[a]	73.6[b]	76.6[c]	0.327	0.01
Modified method[3]	37.1[a]	46.9[b]	52.8[c]	0.501	0.01
Holmen NHP100 method (60 s)[3]	53.4[a]	67.8[b]	73.7[c]	0.967	0.01

[1]A starter poultry diet composed of corn (1000 µm) and soybean meal with added synthetic amino acids was mixed in a 1-ton Hayes & Stolz horizontal counterpoise mixer. Diets were steam pelleted (10 × 55 in. length Wenger twin staff preconditioner, Model 150) for approximately 30 s at 185°F targeted conditioning temperature on a 1 ton 30-horsepower pellet mill (1012-2 HD Master Model, California Pellet Mill) with a 3/16 × 1 ¼ in. pellet die (L:D 6.67).
[2]Reported values represent entire collected sample sifted (#5 screen).
[3]Pellet durability index methods were run in duplicate on the 3 collected samples for each treatment.