

Impact of Dietary Supplemental Methionine Sources on Sensory Measurement of Odor-Related Compounds in Broiler Excreta

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ABSTRACT An experiment was conducted to detect differences in odor characteristics of broiler excreta due to utilization of different supplementary Met sources by a trained human descriptive aroma attribute sensory panel. The 5 treatment groups were no supplemental Met (control group), sodium methioninate aqueous solution, dry Met hydroxy analogue, liquid Met hydroxy analogue, and DL-Met. Two trials were conducted consisting of 5 treatment groups with 3 replications of 13 randomly distributed straight run broiler chicks per pen reared in battery cages. Starter and grower diets were formulated to contain 0.5 and 0.38% Met activity, respectively (except control group, 0.35% Met activity). Excreta were collected for 24 h in litter pans lined with aluminum foil at wk 4, 5, and 6 and analyzed by a trained sensory panel (7 people). Each panelist was given 25 g of manure heated at 27°C for 5 min for sensory analysis. The 13 odor attributes

used to determine differences in broiler excreta by the trained sensory panel were ammonia, dirty socks, wet poultry, fermented rotten fruit, hay, musty wet, sharp, sour, urinous, rotten eggs, irritating, pungent, and nauseating. Panelist marked intensities for each attribute ranging from 0 = none and 15 = extremely intense. Each panelist was given 2 replications of each treatment group in a random order each week (total of 10 samples per wk). All data were evaluated by ANOVA using the general linear model procedure of SAS software. No significant differences were observed in BW, feed consumption, or feed conversion among the treatments. The attributes of ammonia, wet poultry, rotten fruit, musty wet, sharp, and pungent differed ($P < 0.05$) across treatment groups. These findings demonstrate that supplemental Met sources significantly influence odor production in broiler excreta.

(Key words: broiler excreta, methionine, odor, sensory panel)

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INTRODUCTION

The composition of broiler excreta is related to the composition of the diet (Sutton et al., 2001). The conversion of various dietary nutrients to volatile odor gases is attributed to the absorption and metabolism by microorganisms of nonabsorbable byproducts in the intestinal tract or litter. This may affect odor production via the microbial metabolism of different chemical compounds causing the production of odor volatiles. Because the broiler is the initial source of nutrient excretion, diet manipulation could be a feasible method to control offensive odor emissions from broiler farms (Sutton et al., 2001).

Broilers are fed diets that contain about 23 to 17% CP throughout the 6-wk growout period. An efficient way to reduce nitrogen excretion in broilers is to reduce CP

and add supplemental synthetic amino acids in the diet. The addition of synthetic amino acids enables the producer to meet the amino acid requirement of the bird with less CP. Ferguson et al. (1998) showed that reducing CP from 215 to 196 g/kg causes a reduction in equilibrium ammonia concentration of 31% and litter nitrogen reduction of 16.5% on a dry matter basis. Elwinger and Svensson (1996) reported similar findings that increasing CP levels from 18 to 22% increases the loss of ammonia from litter.

Sutton et al. (1999) was able to reduce odorous sulfur-containing compounds in swine by reducing Met and mineral sulfates in the diet by 63 and 49%, respectively. Van Kempen and Van Heugten (2001) reported a reduction in odor sensation of 2.7 when pigs are fed limestone as a calcium source instead of calcium sulfate. Shurson et al. (1999) demonstrated that feeding high and low sulfur-containing swine diets causes differences in odor detec-

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Abbreviation Key: dry MHA = dry Met hydroxy analogue; Liq MHA = liquid Met hydroxy analogue; MHA = Met hydroxy analogue; NaMet = sodium methioninate aqueous solution.

tion and hydrogen sulfide levels. Odor levels and hydrogen sulfide levels were higher for the high sulfur containing diets when compared with the low treatment group for wk 3 to 5.

Odor reduction research has focused little on sulfur intake in the diet of broilers. Livestock manure has been identified to contain over 160 compounds (O'Neil and Phillips, 1992). Six of the 10 compounds with the lowest odor threshold contained sulfur, meaning that these compounds were most likely associated with odor nuisance reports. Most reports of odor nuisances have been described as a sulfury or "rotten eggs" smell (O'Neil and Phillips, 1992). These odor compounds originate in the feces (Clanton and Schmidt, 2000). A major dietary contributor of sulfur amino acids in the diet is the Met source. Commercial synthetic Met sources are available from several manufacturers in liquid or dry forms. There are 2 main types of synthetically produced Met for poultry diets: DL-Met and Met hydroxy analogue (MHA). Supplemental dietary Met sources may play a role in odor-related compounds in poultry manure.

Chavez et al. (2004a,b) indicated that supplemental Met sources play a role in broiler excreta odor volatile production. Chavez et al. (2004a) used an electronic nose to indicate that there are significant differences in volatiles in the broiler excreta for all treatment groups. Additional research (Chavez et al., 2004b) has used gas chromatography-mass spectrometry to determine that there are statistically significant differences among Met source treatments in broiler excreta concentration of 5 volatile sulfur compound concentrations (hydrogen sulfide, carbonyl sulfide, methyl mercaptan, dimethyl disulfide, and dimethyl trisulfide). They noted that the control group never had the highest concentration of any the 5 volatile sulfur compounds. This study also revealed a relationship between electronic nose readings and sensory panel measurements. Electronic nose readings revealed that the 4 supplemental Met treatment groups had significantly higher readings than the control group. The odor detection threshold of the treatment groups followed an identical pattern in that the 4 supplemental treatment groups had higher odor detection thresholds than the control. The higher electronic nose readings and higher odor detection threshold demonstrated more odor volatile production from the broiler excreta of the supplemental Met treatment groups. This research established that supplemental Met sources in broiler feeds play a role in odor volatile production in broiler excreta. However, none of the data suggested the role that supplementary Met sources play in odor volatile offensiveness of broiler excreta.

In the current study, broiler excreta will be analyzed by a trained human descriptive aroma attribute sensory panel to determine offensiveness. Broiler excreta were evaluated at wk 4, 5, and 6. This period is the most important for odor nuisance reports. It has been stated that odor problems originating from broiler farms peak during the last 2 wk of production (Farran, 2000), which is most

likely due to the fact that manure production is greater than the litter material can absorb during this time.

MATERIALS AND METHODS

Two experiments each with 2 trials were conducted using straight run broiler chicks raised in battery cages at Texas A&M University Poultry Science Center. All broiler chicks were randomly distributed into 3 replications of 5 treatment groups with 16 birds per pen. The treatment groups were dry Met hydroxy analogue (dry MHA), sodium methioninate aqueous solution (NaMet), liquid Met hydroxy analogue (Liq MHA), DL-Met, and no supplemental Met (control group). The Met activities of each Met source were 52, 45.9, 89, and 98%, respectively. Corn-soybean based diets (Table 1) were formulated to contain 3,135 kcal of ME/kg in the starter ration (fed 0 to 4 wk) and 3,200 kcal of ME/kg in the grower ration (fed 4 to 6 wk). The starter and grower rations were formulated to contain 23 and 21% CP, respectively. In both experiments, all other components met NRC nutrient requirements (National Research Council, 1994). Feed and water were available ad libitum, mortality was recorded daily, and BW were recorded weekly. Each pen contained an individual litter pan lined with aluminum foil.

Starter and grower diets for experiment 1 (trials 1 and 2) were formulated to contain 0.50 and 0.38% Met activity (Table 1) except the control group (0.35% Met activity for both diets). The analysis of control diets from trial 1 revealed 0.21 and 0.22% Met for the starter and grower diets, respectively (Table 2). Control diets from trial 2 contained 0.21 and 0.21% Met in the starter and grower diets, respectively (Table 2). A Met concentration lower than the diet formulation could be attributed to lower actual Met concentration in feed ingredients (corn and soybean meal) than was used in the computer program for diet formulations.

In experiment 2 (trials 3 and 4), in addition to the diet formulations used in experiment 1, starter and grower diets were also formulated to contain 0.80% total Met activity (Table 3). Thus the starter diets were formulated to contain high (0.80%) or low (0.50%) Met activity, and grower diets were likewise formulated to contain high (0.80%) or low (0.38%) Met activity. The low Met activity treatment groups were designated as low DL-Met, low dry MHA, low NaMet, and low Liq MHA. The high Met activity treatment groups were designated as high DL-Met, high dry MHA, high NaMet, and high Liq MHA. Analyzed Met contents of trial 3 starter and grower control diets were 0.23 and 0.24%, respectively (Table 4). The Met levels in trial 4 starter and grower control diets were 0.18 and 0.21%, respectively (Table 4). The lower Met concentration in the diet could be explained as previously described.

Experiment 1 excreta samples were collected over a 24-h period from each pen at wk 4, 5, and 6 (trial 1) and wk 5 and 6 (trial 2) for a total of 5 sampling periods. Experiment 2 excreta samples were collected as described for experiment 1 at wk 3, 4, 5, and 6 (trial 3) and wk 4,

TABLE 1. Composition of starter¹ and grower² rations for experiment 1

Feed ingredient	Control ³	DL-Met ⁴	Dry MHA ⁴	NaMet ⁴	Liq MHA ⁴
	(% of diet)				
Starter ration					
Corn	53.43	53.68	51.69	51.53	52.38
Soybean meal 48	38.06	37.45	38.36	38.39	38.24
Fat, animal and vegetable blend	4.63	4.51	5.19	5.24	4.97
Limestone, ground	1.68	1.68	1.68	1.68	1.68
Mono-dicalcium PO ₄	1.54	1.55	1.54	1.54	1.54
Salt	0.36	0.36	0.36	0.18	0.36
Trace minerals					
Premix ⁵	0.05	0.05	0.05	0.05	0.05
Vitamin premix ⁶	0.25	0.25	0.25	0.25	0.25
Supplemental Met source	0	0.46	0.87	1.13	0.52
Grower ration					
Corn	61.42	61.70	59.54	59.37	60.32
Soybean meal 48	30.47	29.82	30.80	30.83	30.66
Fat, animal and vegetable blend	4.43	4.30	5.04	5.10	4.79
Limestone, ground	1.45	1.45	5.04	1.45	1.45
Mono-dicalcium PO ₄	1.59	1.60	1.45	1.59	1.59
Salt	0.34	0.34	0.34	0.14	0.34
Trace minerals					
Premix ⁵	0.05	0.05	0.05	0.05	0.05
Vitamin premix ⁶	0.25	0.25	0.25	0.25	0.25
Supplemental Met source	0	0.50	0.94	1.22	0.55

Analyzed nutrients of control feed samples from trials 1 and 2

Analyzed nutrient ⁷	Trial 1		Trial 2	
	Starter	Grower	Starter	Grower
	(% of diet)			
Dry matter	89.00	87.97	89.06	89.30
Protein	19.09	19.13	19.48	19.65
Asx	1.03	1.83	0.61	0.67
Glx	4.75	3.72	5.33	5.46
Ser	0.98	1.08	1.06	1.17
His	0.45	0.49	0.43	0.46
Gly	0.73	0.73	0.79	0.83
Thr	0.72	0.72	0.74	0.78
Ala	0.95	1.02	1.01	1.03
Arg	1.58	1.57	1.61	1.61
Tyr	0.56	0.56	0.54	0.58
Val	0.92	0.97	0.99	0.89
Met	0.21	0.22	0.21	0.21
Phe	1.09	1.08	1.08	1.10
Ile	0.90	0.90	0.91	0.81
Leu	1.77	1.88	1.82	1.83
Lys	1.33	1.17	1.30	1.31
Pro	1.14	1.21	1.05	1.08

¹Diet contained 3,135 kcal of ME/kg, and 23% CP.

²Diet contained 3,200 kcal of ME/kg, and 20% CP.

³Total methionine activity in diet (0.35%).

⁴Total methionine activity in diet (0.80%). Dry MHA = dry Met hydroxy analogue; Liq MHA = liquid Met hydroxy analogue; NaMet = sodium methioninate aqueous solution.

⁵Trace mineral premix added at this rate yielded 149.6 mg of manganese, 125.4 mg of zinc, 16.5 mg of iron, 1.7 mg of copper, 1.05 mg of iodine, 0.25 mg of selenium, a minimum of 6.27 mg of calcium, and a maximum of 8.69 mg of calcium per kg of diet. The carrier was calcium carbonate, and the premix contained less than 1% mineral oil.

⁶Vitamin premix added at this rate yielded 11,023 IU of vitamin A, 3,858 IU of vitamin D, 46 IU of vitamin E, 0.0165 mg of vitamin B₁₂, 5.845 mg of riboflavin, 45.93 mg of niacin, 20.21 mg of D-pantothenic acid, 477.67 mg of choline, 1.47 mg of menadione, 1.75 mg of folic acid, 7.17 mg of pyridoxine, 2.94 mg of thiamin, 0.55 mg of biotin per kilogram of diet. The carrier was ground rice hulls.

⁷Analyses were performed by Texas A&M University Protein Chemistry Laboratory (cysteine and tryptophan were not quantified in the HCL hydrolysis assay).

5, and 6 (trial 4). Immediately following each sample collection period, excreta were pooled within treatment. Broiler excreta samples were evaluated for moisture con-

tent by oven drying at 100°C for 24 h. Sensory evaluation immediately followed sample collection in experiment 1 and in 2 sampling periods of experiment 2. The remaining

TABLE 2. Composition of starter¹ and grower² rations for experiment 2

Feed ingredient	Control ³	DL-Met ^{4,5}	Dry MHA ^{4,5}	NaMet ^{4,5}	Liq MHA ^{4,5}
	(% of diet)				
Starter ration					
Corn	53.43	53.53	52.76	52.69	53.04
Soybean meal 48	38.06	37.82	38.18	38.19	38.13
Fat, animal and vegetable blend	4.63	4.58	4.85	4.87	4.75
Limestone, ground	1.68	1.68	1.68	1.68	1.68
Mono-dicalcium PO ₄	1.54	1.54	1.54	1.54	1.54
Salt	0.36	0.36	0.36	0.29	0.36
Trace minerals					
Premix ⁶	0.05	0.05	0.05	0.05	0.05
Vitamin premix ⁷	0.25	0.25	0.25	0.25	0.25
Supplemental Met source	0	0.18	0.34	0.44	0.20
Grower ration					
Corn	61.42	62.01	61.71	61.69	61.82
Soybean meal 48	30.47	30.28	30.42	30.43	30.40
Fat animal and vegetable blend	4.43	4.23	4.34	4.34	4.30
Limestone, ground	1.45	1.65	1.65	1.65	1.65
Mono-dicalcium PO ₄	1.59	1.11	1.11	1.11	1.11
Salt	0.34	0.34	0.34	0.31	0.34
Trace minerals					
Premix ⁶	0.05	0.05	0.05	0.05	0.05
Vitamin premix ⁷	0.25	0.25	0.25	0.25	0.25
Supplemental Met source	0	0.07	0.13	0.17	0.08

Analyzed nutrients of control feed samples from trials 3 and 4

	Trial 3		Trial 4	
	Starter	Grower	Starter	Grower
	(% of diet)			
Analyzed nutrients ⁸				
Dry matter	89.12	88.53	88.91	89.37
Protein	21.72	16.59	15.93	16.94
Asx	0.24	1.79	0.19	0.38
Glx	6.47	3.15	4.85	4.84
Ser	1.17	0.86	0.94	1.00
His	0.44	0.53	0.25	0.34
Gly	0.87	0.70	0.64	0.69
Thr	0.82	0.63	0.63	0.66
Ala	1.07	0.83	0.85	0.92
Arg	1.82	1.34	1.25	1.36
Tyr	0.65	0.39	0.43	0.48
Val	1.07	0.84	0.72	0.75
Met	0.23	0.24	0.18	0.21
Phe	1.19	0.88	0.89	0.94
Ile	1.00	0.76	0.65	0.69
Leu	1.96	1.50	1.51	1.62
Lys	1.51	1.10	1.01	1.08
Pro	1.20	1.03	0.94	0.98

¹Diet contained 3,135 kcal of ME/kg, and 23% CP.²Diet contained 3,200 kcal of ME/kg, and 20% CP.³Total methionine activity in diet (0.35%).⁴Total methionine activity in the starter diet (0.50%). Dry MHA = dry Met hydroxy analogue; Liq MHA = liquid Met hydroxy analogue; NaMet = sodium methioninate aqueous solution.⁵Total methionine activity in the grower diet (0.38%).⁶Trace mineral premix added at this rate yielded 149.6 mg of manganese, 125.4 mg of zinc, 16.5 mg of iron, 1.7 mg of copper, 1.05 mg of iodine, 0.25 mg of selenium, a minimum of 6.27 mg of calcium, and a maximum of 8.69 mg of calcium per kilogram of diet. The carrier was calcium carbonate, and the premix contained less than 1% mineral oil.⁷Vitamin premix added at this rate yielded 11,023 IU of vitamin A, 3,858 IU of vitamin D, 46 IU of vitamin E, 0.0165 mg of vitamin B₁₂, 5.845 mg of riboflavin, 45.93 mg of niacin, 20.21 mg of D-pantothenic acid, 477.67 mg of choline, 1.47 mg of menadione, 1.75 mg of folic acid, 7.17 mg of pyroxidine, 2.94 mg of thiamin, and 0.55 mg of biotin per kilogram of diet. The carrier was ground rice hulls.⁸Analyses were performed by Texas A&M University Protein Chemistry Laboratory (cysteine and tryptophan were not quantified in the HCL hydrolysis assay).

5 sets of samples were held at -87°C until analyzed. Frozen samples were thawed in a 37°C water bath for 4 h prior to subsequent sensory analysis.

Samples of broiler excreta (25 g) were placed in glass custard cups with glass concave covers and heated at 27°C for 5 min immediately prior to sensory analysis.

TABLE 3. Broiler six-week body weights,¹ experiments 1 and 2

Treatment group ²	Experiment 1 (g)	Experiment 2 (g)
No Met	1,937 ^a	2,080 ^a
DL-Met	1,956 ^a	2,088 ^a
Dry MHA	1,985 ^a	2,119 ^a
NaMet	1,838 ^a	2,097 ^a
Liq MHA	1,955 ^a	2,109 ^a

^aMeans within columns with no common superscript differ significantly ($P < 0.05$).

¹Body weights of 5 broilers per pen (3 replications per treatment) at 42 d.

²Dry MHA = dry Met hydroxy analogue; Liq MHA = liquid Met hydroxy analogue; NaMet = sodium methioninate aqueous solution.

Fourteen odor attributes were used to characterize broiler excreta odor by the trained sensory panel (ammonia, dirty socks, wet poultry, fermented, rotten fruit, hay, musty wet, sharp, sour, urinous, rotten eggs, irritating, pungent, and nauseating). Odor attributes were determined in ballot development sessions in which untrained panelists were given samples of excreta and an attribute lexicon ballot to identify the 14 odor attributes they detected in the broiler excreta. Panelist were trained to identify each attribute and were scoring training samples similarly for each attribute prior to initiation of the study in a manner consistent with Meilgaard et al. (1991). To evaluate samples, panelists slightly uncovered the custard cups and sniffed. Panelist scored each attribute ranging from 0 = none to 15 = extremely intense using the universal Spectrum sensory scale. Panelists sniffed their skin on their lower arm between samples to reduce carryover between samples. For experiment 1, the panel consisted of 11 trained individuals. On each sampling day, panelists were given 2 replications of all treatments (10 samples per d). For experiment 2, 5 trained panelists were given 1 replication of each treatment plus an additional random sample (10 total samples per d). The first sample evaluated in every session was a control sample followed by other samples in random order. Panelists were seated in partitioned booths to minimize communication between panelists. Panelists were instructed to not drink, eat, or consume products 30 min prior to the evaluations.

All bird weights and excreta moisture content data from each trial were separately subjected to ANOVA using the GLM procedure of SAS software.² Mean differences were separated by the PDIFF option (pairwise *t*-tests).

Sensory panel data were subjected to ANOVA using the GLM procedure of the SAS software.² Sources of variation for experiment 1 included trial, week (trial), sample presentation order, treatment, panelist, and interactions among these factors. Data from experiment 2 were similarly analyzed with sample preparation (fresh or frozen) as an additional source of variation. Statistical significance for all data was considered at $P < 0.05$.

RESULTS AND DISCUSSION

Body weights (Table 3) and excreta moisture (Table 4) did not differ among the treatment groups for any of the trials in either experiment (excreta moisture data from trials 1, 3, and 4 not shown).

Statistical analysis of sensory data revealed a significant interaction between trial and week (trial). This finding could possibly be attributed to differences in broiler physiology among the trials, but a significant interaction did not exist between panelist and treatment. Therefore, panelists did not differ in their evaluation of attributes across treatments (Meilgaard et al., 1991), and the sensory data will be presented for treatment least squares means across sample dates within an experiment.

In experiment 1, attributes of dirty socks, feathers/wet poultry, fermented, hay, sour fermented, rotten eggs, irritating, pungent, and nauseating did not differ across treatments (Table 5). However, broiler excreta did differ in ammonia, urinous, musty wet, sharp, and fermented (rotten) fruit attributes (Table 5).

Broiler excreta were highest in ammonia odor. Researchers have indicated that ammonia was 1 of the 2 most commonly found odorous compounds in broiler operations (Jiang and Sands, 2000). Panelists indicated that excreta from the DL-Met treatment had the highest ammonia intensity of the treatment groups. DL-Met excreta did not differ in ammonia from excreta from the NaMet or Liq MHA treatments. However, DL-Met excreta were higher in ammonia odor than excreta from control and dry MHA. There were no differences in ammonia odor of excreta from control, dry MHA, NaMet, and Liq MHA treatments.

Urinous had the second highest intensity of the excreta odor attributes. Urinous has been described by Civille and Lyons (1996) to contain a combination of sour, somewhat sweet, and slight ammonia-like aromatics. Panelists indicated that DL-Met excreta had the highest intensity of urinous odor of the treatment groups. Panelists determined that DL-Met excreta had a higher urinous attribute score than excreta from the control group. DL-Met excreta did not differ in urinous odor of excreta from the dry MHA, Na Met, and Liq MHA treatments. These treatment groups were also not different in urinous odor from the control excreta.

The musty wet odor attribute was also influenced by treatments. Civille and Lyons (1996) describe musty wet as an aromatic characteristic of damp. Musty wet attribute scores of the control excreta did not differ from the DL-Met, dry MHA and NaMet excreta. The control excreta musty wet attribute scores, however, were higher than those of the excreta from the Liq MHA treatment group. The Liq MHA excreta did not differ in musty wet odor when compared with excreta from the DL-Met, dry MHA, and NaMet treatments.

Panelists detected differences among the treatments for sharp odor, described as the aromatic characterized by a clean, sour impression (Civille and Lyons, 1996). The DL-Met excreta did not differ in sharp odor from dry MHA,

²SAS Version 6.11, SAS Institute Inc., Cary, NC.

TABLE 4. Broiler excreta moisture,¹ experiment 1, trial 2

Week	Control	DL-Met	Dry MHA ²	NaMet	Liq MHA	SEM ³
	(% moisture)					
2	75.91 ^a	80.76 ^a	78.94 ^a	79.75 ^a	73.17 ^a	1.38
4	80.61 ^a	77.98 ^a	80.38 ^a	76.64 ^a	81.50 ^a	1.64
5	78.80 ^a	80.02 ^a	77.78 ^a	79.23 ^a	79.22 ^a	1.38
6	80.27 ^a	78.54 ^a	75.88 ^a	77.64 ^a	77.11 ^a	1.46

^aMeans within rows with no common superscript differ significantly ($P < 0.05$).

¹n = 6 samples per treatment, total of 30 per week.

²Dry MHA = dry Met hydroxy analogue; Liq MHA = liquid Met hydroxy analogue; NaMet = sodium methioninate aqueous solution.

³Pooled standard error of the mean.

NaMet, and Liq MHA groups, but the DL-Met excreta had higher sharp odor scores than excreta of the control group. The control group sharp odor scores were not different from sharp odor scores of excreta from the dry MHA, NaMet, and Liq MHA groups.

The fermented rotten fruit odor of excreta differed among the treatments. Fermented rotten fruit has been described to contain the aromatic associated with rotten fruit (Civille and Lyons, 1996). Excreta from the Liq MHA treatment had similar fermented rotten fruit odor to excreta from DL-Met or NaMet treatments. The Liq MHA excreta were higher in fermented rotten fruit odor than excreta from the control and dry MHA treatments. Control and dry MHA excreta did not differ in fermented rotten fruit odor compared with excreta from the DL-Met and NaMet treatments.

In summary of experiment 1, DL-Met excreta had the highest scores for ammonia, urinous, and sharp odor attributes. The control group excreta had the lowest scores for these same attributes. Control group excreta odor scores were not significantly lower than excreta odor scores from

all supplemental Met treatment groups, but when significant differences existed, the control group excreta had consistently lower odor levels. This finding demonstrates that supplemental Met sources may play a role in volatile odor composition of broiler excreta.

Experiment 2

There were no significant differences in the sensory panel odor scores for the hay, musty wet, and irritating odor attributes (Table 6). Panelists detected differences in ammonia, dirty socks, feathers/wet poultry, fermented, fermented (rotten) fruit, sharp, sour fermented, urinous, rotten eggs, pungent, and nauseating odor attributes in excreta across treatments.

Sensory panel scores for the ammonia attribute were similar to those observed in experiment 1. Excreta from control, low DL-Met, low NaMet, and high Liq MHA treatment groups had higher ammonia odor scores than did excreta from the high dry MHA treatment.

TABLE 5. Broiler excreta sensory panel¹ odor attribute scores,² experiment 1

Odor attribute ³	Treatment				
	Control ⁴	DL-Met	Dry MHA ⁵ 2	Na Met	Liq MHA
Ammonia	3.42 ^b	4.27 ^a	3.65 ^b	3.97 ^{ab}	3.80 ^{ab}
Dirty socks	1.78 ^a	1.88 ^a	1.53 ^a	1.50 ^a	1.41 ^a
Feathers/wet poultry	2.26 ^a	2.32 ^a	2.31 ^a	1.99 ^a	2.05 ^a
Fermented	0.53 ^a	0.58 ^a	0.49 ^a	0.40 ^a	0.60 ^a
Fermented (rotten) fruit	0.31 ^b	0.44 ^{ab}	0.30 ^b	0.43 ^{ab}	0.57 ^a
Hay	1.16 ^a	0.90 ^a	1.19 ^a	1.03 ^a	1.06 ^a
Musty wet	2.34 ^a	2.05 ^{ab}	2.15 ^{ab}	1.99 ^{ab}	1.83 ^b
Sharp	1.65 ^b	2.40 ^a	1.75 ^{ab}	2.11 ^{ab}	2.03 ^{ab}
Sour, fermented	3.68 ^a	3.46 ^a	3.73 ^a	3.37 ^a	3.73 ^a
Urinous	2.77 ^b	3.44 ^a	3.21 ^{ab}	3.17 ^{ab}	3.15 ^{ab}
Rotten eggs	0.14 ^a	0.10 ^a	0.05 ^a	0.11 ^a	0.06 ^a
Irritating	2.49 ^a	2.99 ^a	2.73 ^a	2.56 ^a	2.72 ^a
Pungent	0.34 ^a	0.39 ^a	0.21 ^a	0.29 ^a	0.12 ^a
Nauseating	0.21 ^a	0.31 ^a	0.28 ^a	0.25 ^a	0.27 ^a

^{a,b}Means within rows with no common superscript differ significantly ($P < 0.05$).

¹The sensory panel consisted of 11 trained people.

²Universal Scaling System consisted of 0 = none to 15 = extremely intense.

³Odor Attributes determined in a ballot development session.

⁴Panelist given 2 replications of each treatment group. One session per week (10 samples/session). Total of 5 sessions. Means of scores from 2 trials, trial 1 sampled at wk 5, and 6, trial 2 sampled at wk 4, 5, and 6.

⁵Dry MHA = dry Met hydroxy analogue; Liq MHA = liquid Met hydroxy analogue; NaMet = sodium methioninate aqueous solution.

TABLE 6. Broiler excreta sensory panel¹ odor attribute scores,² experiment 2

Odor attribute ³	Treatment ⁵								
	Control ⁴	Low DL-Met	Low dry MHA	Low Na Met	Low Liq MHA	High DL-Met	High dry MHA	High NaMet	High Liq MHA
Ammonia	3.10 ^a	2.73 ^a	2.68 ^{ab}	3.00 ^a	2.64 ^{ab}	2.66 ^{ab}	2.22 ^b	2.63 ^{ab}	2.88 ^a
Dirty Socks	1.14 ^c	1.06 ^c	1.06 ^c	1.26 ^{bc}	1.10 ^c	1.61 ^{ab}	1.80 ^a	0.96 ^c	1.56 ^{ab}
Feathers/wet poultry	1.62 ^{ab}	1.49 ^b	1.78 ^{ab}	1.76 ^{ab}	1.63 ^{ab}	1.84 ^{ab}	1.70 ^{ab}	1.85 ^{ab}	1.89 ^a
Fermented	1.12 ^{ab}	1.06 ^{abc}	1.05 ^{abc}	0.56 ^c	0.75 ^{bc}	0.69 ^{bc}	1.29 ^a	0.73 ^{bc}	0.89 ^{abc}
Fermented (rotten) fruit	0.48 ^b	0.70 ^b	0.56 ^b	0.66 ^b	0.76 ^b	0.62 ^b	1.98 ^a	0.60 ^b	0.85 ^b
Hay	0.92 ^a	1.00 ^a	0.89 ^a	0.76 ^a	0.82 ^a	0.71 ^a	1.07 ^a	0.69 ^a	0.77 ^a
Musty wet	1.64 ^a	1.59 ^a	1.44 ^a	1.66 ^a	1.46 ^a	1.75 ^a	1.59 ^a	1.65 ^a	1.46 ^a
Sharp	1.82 ^{ab}	1.40 ^b	1.50 ^{ab}	1.54 ^{ab}	1.66 ^{ab}	1.36 ^b	1.90 ^a	1.54 ^{ab}	1.98 ^a
Sour, fermented	2.64 ^{ab}	2.48 ^{ab}	2.53 ^{ab}	2.58 ^{ab}	2.36 ^b	2.50 ^{ab}	2.82 ^a	2.42 ^{ab}	2.62 ^{ab}
Urinous	1.86 ^{ab}	1.81 ^{ab}	1.58 ^b	1.90 ^{ab}	1.67 ^b	1.76 ^{ab}	1.52 ^b	1.54 ^b	2.21 ^a
Rotten eggs	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.30 ^a	0.00 ^b	0.00 ^b
Irritating	2.20 ^a	2.10 ^a	2.18 ^a	2.38 ^a	2.30 ^a	2.40 ^a	2.26 ^a	2.16 ^a	2.62 ^a
Pungent	0.00 ^b	0.00 ^b	0.08 ^b	0.00 ^b	0.00 ^b	0.05 ^b	0.33 ^a	0.00 ^b	0.00 ^b
Nauseating	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.36 ^a	0.00 ^b	0.00 ^b

^{a-c}Means within rows with no common superscript differ significantly ($P < 0.05$).

¹The sensory panel consisted of 5 trained people.

²Universal Scaling System consisted of: 0 = none to 15 = extremely intense.

³Odor attributes determined in a ballot development session.

⁴Panelist given 2 replications of each treatment group. One session per week (10 samples/session). Total of 5 sessions. Means of scores from 2 trials, trial 3 sampled at wk 5, and 6; trial 4 sampled at wk 4, 5, and 6.

⁵Dry MHA = dry Met hydroxy analogue; Liq MHA = liquid Met hydroxy analogue; NaMet = sodium methioninate aqueous solution.

Civille and Lyons (1996) described dirty socks as an aroma similar to old dirty socks or sour. High dry MHA, high DL-Met, and high Liq MHA excreta had higher dirty sock odor scores than those of the excreta from the control, low DL-Met, low dry MHA, low Liq MHA, and high NaMet treatments.

Feathers/wet poultry has been described as an aroma reminiscent of wet poultry feathers (Civille and Lyons, 1996). There were no differences in excreta odor scores among the treatment groups except that excreta from the high Liq MHA treatment had higher odor scores than excreta from the low DL-Met treatment.

Fermented has been described by Civille and Lyons (1996) to contain the aroma associated with fermented grains, vegetables, or fruits. Excreta from the high dry MHA treatment had higher intensity of fermented odor than the excreta from the low NaMet, low Liq MHA, high DL-Met, and high NaMet treatments.

Panelists determined that excreta from the high dry MHA and high Liq MHA treatments had higher levels of the sharp odor attribute than did excreta from the low DL-Met and high DL-Met treatments.

The high Liq MHA treatment had higher urinous odor scores than did excreta from low dry MHA, low Liq MHA, high dry MHA, and high NaMet treatments.

Sour fermented had the second highest odor intensity scores for all odor attributes. Civille and Lyons (1996) described sour fermented as an aroma associated with fermented vegetation. Panelists were able to demonstrate that there were differences between treatment groups except for excreta from high dry MHA and low Liq MHA treatments. Excreta from the high dry MHA treatment had higher sour fermented odor than excreta from the low Liq MHA treatment.

Differences were similar for fermented (rotten) fruit, rotten eggs, pungent, and nauseating odor attributes. Attribute scores for excreta from the high dry MHA treatment were higher than those from all other treatments.

Excreta from the dry MHA treatment had higher intensity scores than some or all of the other treatments for 9 of the 14 attributes (dirty socks, feathers/wet poultry, fermented, fermented (rotten) fruit, sharp, sour fermented, rotten eggs, pungent, and nauseating odor aromatics). However, there were differences among the treatment groups for 7 of the 14 attributes.

Individual attributes are difficult to discriminate due to complexity of the odor (Gostelow et al., 2001). Previous studies have determined that complex odors are more difficult to determine than single attribute characteristics due to synergistic effects (Laing et al., 1994; Livermore and Laing, 1998). In this study, ammonia had the highest concentration of all the odor attributes. This intensity of ammonia may have caused the other attributes not to have higher intensity rankings due to suppression or halo effects. Otto et al. (2003) demonstrated that pigs fed 15% CP compared with 6 or 9% CP had higher ammonia levels. However, the 6 and 9% CP diets resulted in more offensive odors than 15% CP. They stated that the higher ammonia levels might have scaled down the detection of other odor offensiveness attributes or otherwise masked odors in the 6 and 9% CP diets.

Panelists were also not able to detect differences among the treatments in hydrogen sulfide (rotten egg attribute). Dietary Met sources have been shown to affect hydrogen sulfide levels in broiler excreta (Chavez et al., 2004b). However, levels detected were between 0.005 to 0.009 ppm. These low levels might not have been detectable by panelist. Another possibility is that odorous sulfur

compounds emitted from livestock waste are unstable and are very reactive and quickly oxidized (Spolestra, 1980; O'Neil and Phillips, 1992). This would also reduce the quantity of hydrogen sulfide present at the time of sensory analysis. Even though panelists were not able to detect differences in the hydrogen sulfide related attribute (rotten eggs), they were able to detect significant differences in other offensive odor attributes.

The primary aim of this study was to determine if supplemental dietary Met sources played a role in odor offensiveness of broiler excreta utilizing a sensory panel. In both experiments, supplemental Met sources did produce significantly different odor attribute scores in broiler excreta. Further research is warranted to determine the potential for linking sensory and analytical measurements to correlate a common output related to offensive or nuisance odors.

REFERENCES

- Chavez, C., C. D. Coufal, R. E. Lacey, and J. B. Carey. 2004a. The impact of methionine source on poultry fecal matter odor volatiles. *Poult. Sci.* 83:359–364.
- Chavez, C., C. D. Coufal, J. B. Carey, R. C. Beier, and J. A. Zahn. 2004b. The impact of supplemental dietary methionine sources on volatile compound concentrations in broiler excreta. *Poult. Sci.* 83:901–910.
- Civille, G. V., and B. G. Lyons. 1996. Aroma and flavor lexicon for sensory evaluation: Terms, definitions, references, and examples. ASTM Data Series Publication 66:1–158.
- Clanton, C. J., and D. R. Schmidt. 2000. Sulfur compound in gases emitted from stored manure. *Trans. ASAE* 43:1229–1239.
- Elwinger, K., and L. Svensson. 1996. Effect of dietary protein content, litter and drinker type on ammonia emission from broiler houses. *J. Agric. Eng. Res.* 64:197–208.
- Farran, I. 2000. Managing odour emissions. *Aust. Poult. Dig.* 15:30–34, 46.
- Ferguson, N. S., R. S. Gates, J. L. Taraba, J. L., A. H. Cantor, A. J. Pescatore, M. J. Ford, and D. J. Burnham. 1998. The effect of dietary crude protein on growth, ammonia concentration, and litter composition in broilers. *Poult. Sci.* 77:1481–1487.
- Gostelow, P., S. A. Parsons, and R. M. Stuetz. 2001. Odour measurements for sewage treatment works. *Water Res.* 35:579–597.
- Jiang, J. K., and J. R. Sands. 2000. Odour and ammonia emissions from broiler farms. Publication 00/2. Rural Industries Research & Development Corporation, Sydney, Australia.
- Laing, D. G., A. Eddy, and D. J. Best. 1994. Perceptual characteristics of binary, trinary, and quaternary odor mixtures consisting of unpleasant constituents. *Physiol. Behav.* 56:81–93.
- Livermore, A., and D. G. Laing. 1998. The influence of chemical complexity on the perception of multicomponent odor mixtures. *Percept. Psychophys.* 60:650–661.
- Meilgaard, M., G. V. Civille, and B. T. Carr. 1991. *Sensory Evaluation Techniques*. 2nd ed. CRC Press, Inc., Boca Raton, FL.
- National Research Council. 1994. *Nutrient Requirements of Poultry*. 9th rev. ed. National Academy Press, Washington, DC.
- O'Neil, D. H., and V. R. Phillips. 1992. A review of the control of odor nuisance from livestock buildings: Part 3, properties of the odorous substances, which have been identified in livestock wastes or in the air around them. *J. Agric. Eng. Res.* 53:23–50.
- Otto, E. R., M. Yokoyama, S. Hengemuehle, R. D. von Bermuth, T. van Kempen, and N. L. Trottier. 2003. Ammonia, volatile fatty acids, phenolics, and odor offensiveness in manure from growing pigs fed diets reduced in protein concentration. *J. Anim. Sci.* 81:1754–1763.
- Shurson, J., M. Whitney, and R. Nicolai. 1999. Manipulating diets may reduce hydrogen sulfide emissions. *Feedstuffs* 71:12–17.
- Spolestra, S. F. 1980. Origin of objectionable odorous components in piggery wastes and the possibility of applying indicator components for studying odour development. *Agric. Environ.* 5:241–260.
- Sutton, A., T. Applegate, S. Hankins, B. Hill, G. Allee, W. Greene, R. Kohn, D. Meyer, W. Powers, and T. Van Kempen. 2001. Manipulation of animal diets to affect manure production, composition and odors: State of the science. The National Center for Manure and Animal Waste Management. White Papers CD-ROM. Midwest Plan Service, Ames, IA.
- Sutton, A. L., K. B. Kephart, M. W. A. Verstegen, T. T. Canh, and P. J. Hobbs. 1999. Potential for reduction of odorous compounds in swine manure through diet modification. *J. Anim. Sci.* 77:430–439.
- Van Kempen, T., and Van Heugten. 2001. The science of odor. *Swine News North Carolina Cooperative Extension Service.* 24:1–4.