# THE IMPACT OF METHIONINE SOURCE ON CHARACTERISTICS AND INTENSITY OF POULTRY EXCRETA ODOR.

**Dr. John B. Carey**
**Dept. of Poultry Science**
**Texas A&M University**
**2472 TAMU**
**College Station, TX 77843-2472**
**jcarey@poultry.tamu.edu**

## Introduction

Most odor nuisance reports concerning poultry farms are due to poultry manure. Before odor prevention and control can be implemented in poultry waste management the cause of the odor must be established (Mackie et al., 1998). O'Neill and Phillips (1992) have indicated that six of the ten compounds with the lowest odor thresholds in livestock manure contain sulfur, suggesting that these compounds may be the most likely associated with odor nuisance reports. The primary source of sulfur in broiler feces is dietary sulfur amino acids, with Met being the major dietary sulfur amino acid. Previous work in our laboratory (Chavez et al., 2001) using an electronic nose has shown that supplemental Met sources in poultry diets affects the production of odorants in broiler excreta. With the use of gas chromatography-mass spectrometry (GC/MS), individual volatile compounds (specifically sulfur volatile compounds) can be separated and identified in broiler excreta. A human olfactory panel utilizes the nose with the use of an instrument, which dilutes odor samples with odor-free air, defined as olfactometer.

The objectives of this study were to: (1) evaluate differences in volatile sulfur compound concentrations in broiler excreta with different Met treatments; (2) evaluate odor detection thresholds of broiler excreta air samples from the different treatment groups; (3) analyze excreta samples by a trained human descriptive aroma attribute sensory panel to determine offensiveness.

## Materials and Methods

The treatment groups were: 1) dry Met hydroxy analogue (Dry MetHA), 2) sodium methioninate aqueous solution (NaMet), 3) liquid Met hydroxy analogue (Liq MetHA), 40 D, L-Met and 5) no supplemental Met (control group). The Met activity of each Met source was 52, 45.9, 88, and 98%, respectively. Corn-soybean based diets were formulated to contain 3,135 Kcal ME/kg in the starter ration and 3,200 Kcal ME/kg in the grower ration. The starter and grower ration were formulated to contain 23% and 21% crude protein, respectively. For exp. 1, both starter and grower diets were formulated to contained 0.80% total Met activity except for the control group, which had 0.35% Met activity (Table 1). Analysis of the exp. 1 control diet for Met in trial one contained 0.26 and 0.20% for starter and grower diets, respectively. For exp. 2, both starter and grower diets were formulated to contain 0.50% and 0.38% Met activity except for the control group, which had 0.35% Met activity for both diets (Table 2). Analysis of the exp. 2 control diet for Met showed the diets contained 0.21 and 0.23% Met for starter and grower diets, respectively. Starter and grower diets for experiment 3 (trial 3A and 3B) were formulated to contain 0.50% and 0.38% Met activity (Table 3) except the control group (0.35% Met activity for both diets). The analysis of trial 3A control diets revealed 0.21 and 0.22% methionine for starter and grower diets, respectively. Trial 3B control diets contained 0.21 and 0.21% methionine for starter and grower diets, respectively. In experiment 4 ( trial 4A and 4B), in addition to the diet formulations used in experiment 3, starter and grower diets were also formulated to contain 0.80% total Met activity (Table 4). Thus the starter diets were formulated to contain high (0.80%) or low (0.50%) methionine activity and grower diets were likewise formulated to contain high (0.80%) or low (0.38%) methionine activity. Analyzed methionine content of trial 4A starter and grower control diets was 0.23 and 0.24%, respectively. Trial 4B starter and grower control diet methionine levels were 0.18 and 0.21%, respectively. This Met concentration was lower than the diet formulation was calculated to contain. This result could be attributed to variation in protein concentration in feed ingredients (corn and soybean meal) containing lower Met activity than was utilized in the computer program for diet formulations. All other nutrient requirements met or exceeded NRC recommendations (NRC, 1994). Diets were fed *ad libitum* from day 1 to 42, and all birds were weighed weekly.

In exp. 1, all poultry feces for all treatments were collected for 24 hours from broilers at six weeks of age for quantification of volatile sulfur compounds in poultry feces by GC/MS. In exp. 2, air samples were taken at week six to analyze for odor detection threshold by a sensory panel trained to evaluate odor detection threshold of air samples. Experiment 3 and 4 excreta samples were evaluated by a trained sensory panel for fourteen odor attributes to characterize broiler excreta odor (ammonia, dirty socks, wet poultry, fermented, rotten fruit, hay, musty wet, sharp, sour, urinous, rotten eggs, irritating, pungent, and nauseating). Panelist scored each attribute ranging from 0=none to 15=extremely intense using the universal Spectrum™ sensory scale.

## Results and Discussion

GC/MS analysis of broiler excreta was able to identify and quantify in the poultry fecal matter: 1) hydrogen sulfide, 2) carbonyl sulfide, 3) methyl mercaptan, 4) dimethyl disulfide, 5) dimethyl trisulfide (Table 5). For all five volatile sulfur compounds identified and quantified by GC/MS in the broiler excreta the control group never had the highest concentration for exp. 1 indicating that the four supplemental Met sources may play a role in odorant production in broiler excreta. This is very important because previous research (Chavez et al., 2001) in our laboratory indicated differences in odor volatiles in broiler excreta of different supplemental Met sources as detected by electronic nose readings. With the use of GC/MS it is clear that supplemental Met sources actually result in differences in volatile sulfur compounds in broiler excreta.

The odor detection threshold data of the sensory panel compares well with the electronic nose readings in exp. 2. The odor detection thresholds for the four supplemental Met treatment groups (Dry MetHA, D, L-Met, Liq MetHA, and NaMet) were significantly higher than the control group (Table 6). This would suggest that the four Met supplemental treatments had more odorant production than the control group.

In experiment 3, attributes of dirty socks, feathers/wet poultry, fermented, hay, sour fermented, rotten eggs, irritating, pungent, and nauseating did not differ across treatments (Table 7). 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 Na Meth or Liq MHA treatments. However, DL-Met excreta was higher in ammonia odor than excreta from Control and Dry MHA. There were no differences in ammonia odor of excreta from Control, Dry MHA, Na Meth, and Liq MHA treatments. 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. Musty wet attribute scores of the Control excreta did not differ from the DL-Met, Dry MHA and Na Met excreta. But, the control excreta musty wet attribute scores 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 to excreta from the DL-Met, Dry MHA and Na Met treatments. The DL-Met excreta did not differ in sharp odor from Dry MHA, Na Met, 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, Na Met, and Liq MHA groups. Excreta from the Liq MHA treatment had similar fermented rotten fruit odor to excreta from DL-Met or Na Met 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 to excreta from the DL-Met and Na Met treatments.

In summary of experiment 3, 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 methionine treatment groups but when significant differences existed, the control group excreta had consistently lower odor levels. This demonstrates that supplemental methionine sources may play a role in volatile odor composition of broiler excreta.

For Experiment 4, there were no significant differences in the sensory panel odor scores for the hay, musty wet and irritating odor attributes (Table 8). 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.

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. There were no differences in feathers/wet poultry 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. 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. Excreta from the High Dry MHA treatment had higher sour fermented odor than excreta from the Low Liq MHA treatment. Fermented (rotten) attribute scores for excreta from the High Dry MHA treatment was higher than those from all other treatments.

In summary for experiment 4, excreta from the Dry MHA treatment had higher intensity scores than some or all of the other treatments for nine of the fourteen 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 seven of the fourteen 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.

For further information on this research please refer to the following publications:

Chavez, C, C. D. Coufal, R. E. Lacey and J. B. Carey, 2004. The Impact of Methionine Sources on Poultry Fecal Matter Odor Volatiles. Poultry Science 83:359-364.

Chavez, C. C. D. Coufal, J. B. Carey, R. E. Lacey, R. K. Beier, and J. A. Zahn, 2004. The Impact of Supplemental Dietary Methionine Sources on Volatile Compound Concentrations in Broiler Excreta. Poultry Science 83:901-910.

Chavez, C., C. D. Coufal, P. L. Niemeyer, J. B. Carey, R. E. Lacey, R. K. Miller, and R. C. Beier, 2004. Impact of Dietary Supplemental Methionine Sources on Sensory Measurement of Odor Related Compounds in Broiler Excreta. Poultry Science 83:1655-1662.

**TABLE 1. Composition of Starter[1] and Grower[2] ration for Exp. 1.**

Starter Ration

| Feed Ingredient | Control[3] | D, L-Met[4] | Dry MetHA[4] | NaMet[4] | Liq MetHA[4] |
|---|---|---|---|---|---|
| | Percent of the Diet | | | | |
| 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 A&V 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 PO4 | 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 |
| Methionine Source Supplemental | 0 | 0.46 | 0.87 | 1.13 | 0.52 |

Grower Ration

| Feed Ingredient | Control[3] | D, L-Met[4] | Dry MetHA[4] | NaMet[4] | Liq MetHA[4] |
|---|---|---|---|---|---|
| | Percent of the Diet | | | | |
| 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 A&V Blend | 4.43 | 4.30 | 5.04 | 5.10 | 4.79 |
| Limestone Ground | 1.45 | 1.45 | 1.45 | 1.45 | 1.45 |
| Mono-dicalcium PO4 | 1.59 | 1.60 | 1.59 | 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 |
| Methionine Source Supplemental | 0 | 0.50 | 0.94 | 1.22 | 0.55 |

[1] Diet contains 3,135 Kcal ME/kg, and 23% crude protein.
[2] Diet contain 3,200 Kcal ME/kg, and 20% crude protein.
[3] Total Met activity in diet (0.35%).
[4] Total Met activity in diet (0.80%).
[5] Trace mineral premix added at this rate yields 149.6 mg manganese, 125.4 mg zinc, 16.5 mg iron, 1.7 mg copper, 1.05 mg iodine, 0.25 mg selenium, a minimum of 6.27 mg calcium, and a maximum of 8.69 mg calcium per kg of diet. The carrier is calcium carbonate and the premix contains less than 1% mineral oil.
[6] Vitamin premix added at this rate yields 11,023 IU Vitamin A, 3,858 IU Vitamin D, 46 IU Vitamin E, 0.0165 mg $B_{12}$, 5.845 mg riboflavin, 45.93 mg niacin, 20.21 mg d-pantothenic acid, 477.67 mg choline, 1.47 mg menadione, 1.75 mg folic acid, 7.17 mg pyroxidine, 2.94 mg thiamin, 0.55 mg biotin per kg diet. The carrier is ground rice hulls.

**TABLE 2. Composition of Starter[1] and Grower[2] ration for Exp. 2.**

Starter Ration

| Feed Ingredient | Control[3] | D, L-Met[4] | Dry MetHA[4] | NaMet[4] | Liq MetHA[4] |
|---|---|---|---|---|---|
| | Percent of the Diet | | | | |
| 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 A&V 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 PO4 | 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 |
| Methionine Source Supplemental | 0 | 0.18 | 0.34 | 0.44 | 0.20 |

Grower Ration

| Feed Ingredient | Control[3] | D, L-Met[5] | Dry MetHA[5] | NaMet[5] | Liq MetHA[5] |
|---|---|---|---|---|---|
| | Percent of the Diet | | | | |
| 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 A&V 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 PO4 | 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 |
| Methionine Source Supplemental | 0 | 0.07 | 0.13 | 0.17 | 0.08 |

[1] Diet contain 3,135 Kcal ME/kg, and 23% crude protein.
[2] Diet contain 3,200 Kcal ME/kg, and 20% crude protein.
[3] Total Met activity in diet (0.35%).
[4] Total Met activity in diet (0.50%).
[5] Total Met activity in diet (0.38%).
[6] Trace mineral premix added at this rate yields 149.6 mg manganese, 125.4 mg zinc, 16.5 mg iron, 1.7 mg copper, 1.05 mg iodine, 0.25 mg selenium, a minimum of 6.27 mg calcium, and a maximum of 8.69 mg calcium per kg of diet. The carrier is calcium carbonate and the premix contains less than 1% mineral oil.
[7] Vitamin premix added at this rate yields 11,023 IU Vitamin A, 3,858 IU Vitamin D, 46 IU Vitamin E, 0.0165 mg $B_{12}$, 5.845 mg riboflavin, 45.93 mg niacin, 20.21 mg d-pantothenic acid, 477.67 mg choline, 1.47 mg menadione, 1.75 mg folic acid, 7.17 mg pyroxidine, 2.94 mg thiamin, 0.55 mg biotin per kg diet. The carrier is ground rice hulls.

## TABLE 3. Composition of Starter[1] and Grower[2] Ration for Experiment 3.

Starter Ration

| Feed Ingredient | Control[3] | DL-Met[4] | Dry MHA[4] | Na Met[4] | Liq MHA[4] |
|---|---|---|---|---|---|
| | Percent of the Diet | | | | |
| 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 A&V 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 Methionine Source | 0 | 0.46 | 0.87 | 1.13 | 0.52 |

Grower Ration

| Feed Ingredient | Control[3] | DL-Met[4] | Dry MHA[4] | Na Met[4] | Liq MHA[4] |
|---|---|---|---|---|---|
| | Percent of the Diet | | | | |
| 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 A&V 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 Methionine Source | 0 | 0.50 | 0.94 | 1.22 | 0.55 |

[1] Diet contains 3,135 Kcal ME/kg, and 23% crude protein.
[2] Diet contain 3,200 Kcal ME/kg, and 20% crude protein.
[3] Total methionine activity in diet (0.35%).
[4] Total methionine activity in diet (0.80%).
[5] Trace mineral premix added at this rate yields 149.6 mg manganese, 125.4 mg zinc, 16.5 mg iron, 1.7 mg copper, 1.05 mg iodine, 0.25 mg selenium, a minimum of 6.27 mg calcium, and a maximum of 8.69 mg calcium per kg of diet. The carrier is calcium carbonate and the premix contains less than 1% mineral oil.
[6] Vitamin premix added at this rate yields 11,023 IU Vitamin A, 3,858 IU Vitamin D, 46 IU Vitamin E, 0.0165 mg $B_{12}$, 5.845 mg riboflavin, 45.93 mg niacin, 20.21 mg d-pantothenic acid, 477.67 mg choline, 1.47 mg menadione, 1.75 mg folic acid, 7.17 mg pyroxidine, 2.94 mg thiamin, 0.55 mg biotin per kg diet. The carrier is ground rice hulls.
[7] Analyses performed by Texas A&M University Protein Chemistry Laboratory (Cysteine and Tryptophan were not quantified in HCL hydrolysis assay).

**TABLE 4. Composition of Starter[1] and Grower[2] Ration for Experiment 4.**

Starter Ration

| Feed Ingredient | Control[3] | DL-Met[4] | Dry MHA[4] | Na Met[4] | Liq MHA[4] |
|---|---|---|---|---|---|
| | Percent of the Diet | | | | |
| 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 A&V 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 Methionine Source | 0 | 0.18 | 0.34 | 0.44 | 0.20 |

Grower Ration

| Feed Ingredient | Control[3] | DL-Met[5] | Dry MHA[5] | Na Met[5] | Liq MHA[5] |
|---|---|---|---|---|---|
| | Percent of the Diet | | | | |
| 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 A&V 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 Methionine Source | 0 | 0.07 | 0.13 | 0.17 | 0.08 |

[1] Diet contain 3,135 Kcal ME/kg, and 23% crude protein.
[2] Diet contain 3,200 Kcal ME/kg, and 20% crude protein.
[3] Total methionine activity in diet (0.35%).
[4] Total methionine activity in diet (0.50%).
[5] Total methionine activity in diet (0.38%).
[6] Trace mineral premix added at this rate yields 149.6 mg manganese, 125.4 mg zinc, 16.5 mg iron, 1.7 mg copper, 1.05 mg iodine, 0.25 mg selenium, a minimum of 6.27 mg calcium, and a maximum of 8.69 mg calcium per kg of diet. The carrier is calcium carbonate and the premix contains less than 1% mineral oil.
[7] Vitamin premix added at this rate yields 11,023 IU Vitamin A, 3,858 IU Vitamin D, 46 IU Vitamin E, 0.0165 mg $B_{12}$, 5.845 mg riboflavin, 45.93 mg niacin, 20.21 mg d-pantothenic acid, 477.67 mg choline, 1.47 mg menadione, 1.75 mg folic acid, 7.17 mg pyroxidine, 2.94 mg thiamin, 0.55 mg biotin per kg diet. The carrier is ground rice hulls.
[8] Analyses performed by Texas A&M University Protein Chemistry Laboratory (Cysteine and Tryptophan were not quantified in HCL hydrolysis assay).

**TABLE 5. GC/MS determination of sulfur compound concentrations[1] of broiler excreta for Exp. 1 at week 6.**

| Sample group | Analyte | | | | |
|---|---|---|---|---|---|
| | *Analyte concentration (ng/g feces)* | | | | |
| | Hydrogen sulfide | Carbonyl Sulfide | Methyl Mercaptan | Dimethyl disulfide | Dimethyl trisulfide |
| Control[2] | 49.6[b] | 37.4[b] | 9.4[d] | 5.6[c] | 2.9[d] |
| D, L-Met[2] | 26.6[d] | 30.6[c] | 36.1[b] | 6.3[b] | 7.8[a] |
| Dry MetHA[2] | 31.5 [c] | 43.9[b] | 41.7[a] | 6.8[b] | 5.6[b] |
| NaMet[2] | 224.4[a] | 176.1[a] | 29.2[c] | 11.5[a] | 3.6[c] |
| Lig MetHA[2] | 28.6[d] | 28.9[c] | 10.7[d] | 5.7[c] | 5.2[b] |
| SEM[3] | 1.64 | 1.86 | 0.71 | 0.10 | 0.13 |

[1] Total number of GC/MS analysis (Three injections per treatment).
[2] Treatment concentrations of sulfur compounds in broiler excreta are in (ng/g feces).
[3] Pooled standard error of the mean.
[abcd] Means within columns with no common superscript differ significantly ($P < 0.05$).

**TABLE 6. Detection threshold of odor in broiler excreta by olfactometry laboratory[1] for Exp. 2 at week 6.**

| Week | Odor sample group[2] | | | | |
|---|---|---|---|---|---|
| | Sample concentration (Odor units) | | | | |
| | Control[2] | D, L-Met[2] | Dry MetHA[2] | NaMet[2] | Liq MetHA[2] |
| Six | 350[b] | 526[a] | 568[a] | 493[a] | 496[a] |
| SEM[3] | 41.84 | 41.84 | 41.84 | 41.84 | 41.84 |

[1] Air samples were evaluated by a minimum of eight trained panelists (ISUOL) for odor detection threshold.
[2] Total number of air samples (Three per treatment, a set minimum of 8 liters were sampled in 10L tedlar odor sample bag).
[3] Pooled standard error of the mean.
[a] Means within rows with no common superscript differ significantly ($P<0.05$).

**Table 7. Broiler Excreta Sensory Panel[1] Odor Attribute Scores[2], Exp. 3**

| | Treatment | | | | |
|---|---|---|---|---|---|
| **Odor Attribute[3]** | **Control[4]** | **DL-Met** | **Dry MHA** | **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] |

[1] Sensory Panel consisted of 11 trained people.
[2] Universal Scaling System consisted of: 0 = none to 15 = extremely intense.
[3] Odor Attributes determined in a ballot development session.
[4] Panelist given 2 replications of each treatment group. One session per wk (10 samples/session). Total of five sessions. Means of scores from two trials, trial 1 sampled at wk 5, and 6, trial 2 sampled at wk 4, 5, and 6.
[a,b] Means within rows with no common superscript differ significantly ($P < 0.05$).

**Table 8. Broiler Excreta Sensory Panel[1] Odor Attribute Scores[2], Exp. 4**

| | Treatment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Odor Attribute[3]** | **Control** | **Low DL-Met** | **Low Dry MHA** | **Low Na Met** | **Low Liq MHA** | **High DL-Met** | **High Dry MHA** | **High Na Met** | **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] | .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] |

[1] Sensory Panel consisted of 5 trained people.
[2] Universal Scaling System consisted of: 0 = none to 15 = extremely intense.
[3] Odor Attributes determined in a ballot development session.
[4] Panelist given 2 replications of each treatment group. One session per wk (10 samples/session). Total of five sessions. Means of scores from two trials, trial 3 sampled at wk 5, and 6, trial 4 sampled at wk 4, 5, and 6.
[a,b,c] Means within rows with no common superscript differ significantly ($P < 0.05$).

**References**

Chavez, C, C. D. Coufal, R. E. Lacey and J. B. Carey, 2004. The Impact of Methionine Sources on Poultry Fecal Matter Odor Volatiles. Poultry Science 83:359-364.

Mackie, R. I., P. G. Stroot, and V. H. Varel. 1998. Biological identification and biological origin of key odor components in livestock waste. J. Anim. Sci. 76:1331-1342.

National Research Council, 1994. Nutrient requirements of poultry, 9th Revised Edition. 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. Agri. Eng. Res. 53:23-50.