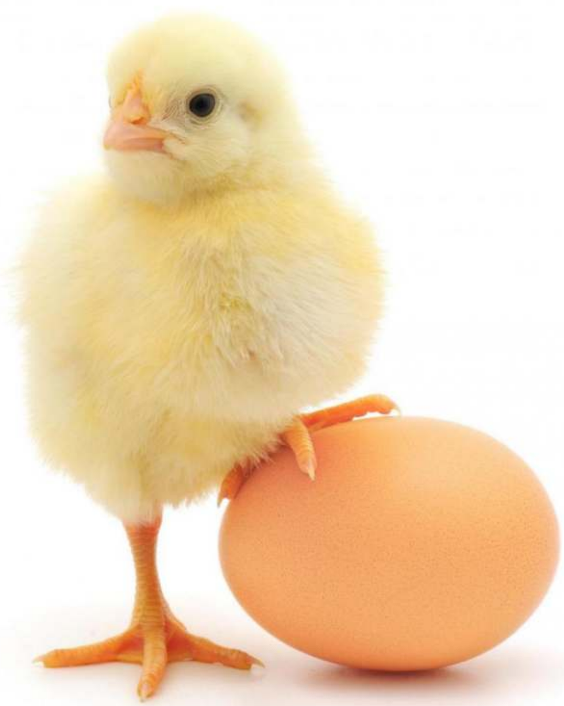
ISSN 1682-8356
ansinet.org/ijps



INTERNATIONAL JOURNAL OF
POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 12 (12): 698-704, 2013
ISSN 1682-8356

Evaluation of a Rice/Soy Fermentate on Performance and Volatilization of Odorants from Fresh Fecal Material When Included in Broiler Diets

M.P. Williams[1], C. Coufal[1], E. Caraway[2], R. Carpenter[3] and J.T. Lee[1]
[1]Department of Poultry Science, Texas A&M University, College Station, TX-77843, USA
[2]Olfactometry Laboratory, West Texas A&M University, Canyon, TX-79015, USA
[3]BiOWiSH Technologies, Chicago, IL-60601, USA

Abstract: Two experiments were conducted to evaluate the effectiveness of two fermented rice/soy products (A and B) on fecal odor compound volatilization and performance parameters when included in broiler diets. In Experiment 1 the addition of fermentate B at 900 g/ton increased ($p<0.05$) d 21 body weight. The inclusion of both fermentates resulted in significant decreases ($p<0.05$) in multiple volatile organic compounds which are associated with odor related to poultry. In Experiment 2, the addition of fermentate B at 900 g/ton resulted in a significant increase ($p<0.05$) in d 14 body weight. Inclusion of both rice/soy fermentates (A and B) significantly increased ($p<0.05$) carcass weights. Additionally, significant reductions ($p<0.05$) were observed on d 21 and 42 fecal pH with both fermentates (A and B). Taken in totality, these data demonstrate the ability of a rice/soy fermentate to alter the intestinal environment by reduced digest pH, reduced odorant volatilization and increased early bird weight.

Key words: Broiler, ammonia, odor, performance

INTRODUCTION

Poultry litter is a valuable fertilizer resource containing high levels of phosphorous (P), potassium (K), nitrogen (N) and trace minerals that provides required nutrients for crop growth (Kelleher *et al*., 2002). However, agricultural producers in the United States are increasingly concerned with odors and gases generated and emitted from their operations. Ammonia (NH_3) and odor volatilization from poultry litter are perceived as indicators of airborne pollutants. Emissions can originate from a variety of sources including poultry production facilities, manure/litter storage units and the land application of manure/litter (Choi *et al*., 2010). Due to increasing concerns regarding emissions, the implementation of improved waste management methodologies is a priority for the sustainable use of poultry litter and manure as a fertilizer and soil amendment (Cook *et al*., 2011).

Odors are generated by anaerobic decomposition of livestock and poultry waste such as manure. Odor production is attributed to absorption and metabolism of digesta nutrients by microorganisms in the gastrointestinal tract or manure following excretion (Chavez *et al*., 2004a; Chavez *et al*., 2004b; Chavez *et al*., 2004c). In anaerobic environments, the decomposition of organic compounds results in odorous volatile compounds that are metabolic intermediates or end products from the decomposition of manure. As manure decomposes, as many as 80 to 200 odorous compounds can be produced. Some of the principle classes of odorous compounds include amines, sulfides, volatile fatty acids, indoles, skatoles, mercaptans, alcohols and carbonyls (Choi *et al*., 2010). The breakdown of protein proceeds to proteoses, peptones, peptides, amino acids and finally, to NH_3 and volatile organic acids such as formic, acetic, propionic and butyric acids. Carbohydrates in animal waste include sugars, starch and cellulose. Starch and cellulose are broken into glucose units as the first step of decomposition. Under anaerobic conditions, these glucose units are fragmented into alcohols, aldehydes, ketones and organic acids. Lipids are esters of the tri-hydroxy alcohol called glycerol. Bacteria use fats as a source of energy, hydrolyzing them first to long-chain fatty acids and alcohols. These acids undergo further breakdown in which acetic acid is cleaved from the original acid. Kreis (1978) identified 17 different volatile compounds associated with odor from poultry waste which result from the partial decomposition of manure.

Since poultry is the initial source of nutrient excretion, diet manipulation or addition of additives could be a feasible solution to control excess nutrient excretions and odor emissions, thereby minimizing the potential for environmental issues (Sutton *et al*., 2002). The alteration of odors from broiler manure has been demonstrated through the supplementation of various methionine sources (Chavez *et al*., 2004a; Chavez *et al*., 2004b; Chavez *et al*., 2004c) and NH_3 reduction has been achieved with the inclusion of dried distillers grains plus solubles (Wu-haan *et al*., 2010), wheat middlings and

Corresponding Author: J.T. Lee, Departmento f Poultry Science, Texas A&M University, College Station, TX 77843-2472, USA

soybean hulls (Roberts *et al*., 2007). In the current study, two microbial biocatalysts produced through a rice/soy fermentation process that contain a consortium of naturally occurring yeast and bacteria were utilized. The objective of this research was to determine the effect of two rice/soy fermentates when included in broiler diets on broiler performance and odorant volatilization.

MATERIALS AND METHODS

Two experiments were conducted to evaluate the effectiveness of two fermented rice/soy products (A^2 and B^3) on volatilization of odor compounds from fresh fecal material and growth performance when included in broiler diets. For each of the following experiments, broiler chicks were provided age appropriate supplemental heat and given access to feed and water *ad libitum*. All animal care procedures were conducted in accordance with an Animal Use Protocol approved by the Texas A and M University (TAMU) laboratory animal care committee (IACUC). Prior to chick placement, battery units in Experiment 1 were thoroughly cleaned and disinfected. In Experiment 2, grow-out facilities utilized a combination of fresh pine shavings and used litter at a 50:50 ratio for bedding material to mimic industry conditions. Grow-out pens were equipped with one 14 kg tube feeder and nipple drinkers.

Experiment 1: This experiment was designed to determine the effect of feeding one of two rice/soy fermentates to broilers on early performance and odorant volatilization from fresh broiler fecal material. This experiment consisted of 360 1-d old Cobb 500 male chicks that were weighed and allotted to battery pens and dietary treatment based on body weight to assure statistically equivalent initial body weights across treatments. The basal starter diet was corn and soybean meal-based (Table 1) and was separated into five equal batches prior to treatments being added.

The rice/soy fermentates were added at four specified treatment levels to one of the five batches to obtain four experimental treatments and a control. The four experimental treatment groups contained the inclusion of two different rice/soy fermentate products at 300, 600 and 900 g/ton for fermentate A and 900 g/ton for fermentate B. Each of the five treatments consisted of six replicate pens with each replicate containing 12 birds. Average broiler body weight and feed consumption were determined on d 7, 14 and 21.

On d 12, manure pans were thoroughly cleaned and NH_3 volatilization evaluated following a 48 h collection period on d 14. On d 14, pans were removed and 1 kg of fecal material was placed under a static chamber for 20 min at which time the NH_3 concentration in the chamber headspace was determined using a Drager CMS gas analyzer with NH_3 chips that range from 2 to 50 ppm. On d 20, manure pans in the batteries were again thoroughly cleaned and manure was collected for 24 h. After 24 h (on d 21 of age), manure pans were moved to a clean, well-ventilated area for odorant assessment via lateral flow wind tunnel method. The top of the lateral flow wind tunnel had a 0.63 cm thick acrylic sheet with four 0.95 cm holes for air outlet near one end where air samples were collected. The flush gas inlet on the opposite end from the outlet holes was a 5.08×5.08 cm steel tube with ten 0.32 cm holes spaced 2.54 cm apart. Compressed breathing air was used as the flush gas at a flow rate of 8 L/min. Odor samples were collected by sorbent tubes and transported to West Texas A and M University (WTAMU) Olfactometry Laboratory for analysis via gas chromatography/mass spectrometry (GC/MS). Thermal desorption tube samples are analyzed using a PAL® autosampler and an Agilent® 6890 GC/MS. The GC is equipped with forte BP5 5% Phenyl/95% dimethyl polysiloxane 0.53 mm ID×30 m and a forte BP20 (polar) Polyethylene Glycol 0.53 mm ID×25 m. Samples were automatically desorbed at 280°C and injected into the GC/MS. The column oven was ramped from 40 to 240°C at 8°C/min for a total run time of 38 min.

Table 1: Dietary formulation and calculated nutrient concentrations of male broilers fed non-medicated diets with the inclusion of one of two different rice/soy fermentates

Ingredient	Starter diet (%)
Basal experimental diets	
Corn	58.38
Soybean Meal	34.50
Fat Blended	2.81
Limestone	1.57
Salt	0.46
Bifos 16/21p	1.56
Lysine HCL	0.17
DL-Met 98	0.26
Vitamins[1]	0.25
Trace Min[2]	0.05
Calculated nutrient concentration	
Protein	22.00
Calcium	0.95
Phosphorus	0.70
Available Phos.	0.45
Methionine	0.59
TSAA	0.95
Threonine	0.82
Crude Fat	5.36
Lysine	1.30
Sodium	0.20

[1]Vitamin premix added at this rate yields 11,023 IU vitamin A, 3,858 IU vitamin D_3, 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 thiamine, 0.55 mg biotin per kg diet. The carrier is ground rice hulls

[2]Trace mineral premix added at this rate yields 149.6 mg manganese, 125.1 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

Following odor sampling, the same fecal material was placed in a static chamber for NH_3 volatilization evaluation following a 20 min period. Ammonia concentration in the static chamber was determined using a SAM IV MAX gas monitor (OI Analytical, College Station, TX). Hydrogen sulfide (H_2S) was also measured following the 20 min period in the static chamber using a Jerome meter. Following NH_3 and H_2S concentration measurement, two 12 g fecal samples per replicate pen were diluted in 60 mL of distilled water for pH determination. Moisture, carbon (C) and nitrogen (N) content were also determined from the fecal samples collected on d 21. Triplicate 10 g samples of fresh fecal material were weighed into aluminum pans and dried at 100°C for 24 h for moisture analysis. All three dried samples were combined and ground using a Wiley mill equipped with an 80 mesh screen. Ground samples were then analyzed for C and N content on a dry matter basis by combustion method using a Vario Max analyzer (Elementar, Hanau, Germany).

Experiment 2: This experiment was designed to determine the effect of dietary inclusion of rice/soy fermentates on broiler growth performance, fecal pH and odorant volatilization from fresh broiler fecal material during a 41 d grow-out. This experiment consisted of 1,020 d-old straight-run Cobb 500 chicks that were weighed and allotted to floor pens and dietary treatment based on body weight as in Experiment 1. The basal starter, grower and finisher diets were corn and soybean meal-based (Table 2). Each dietary phase was mixed as one large basal diet and separated into three equal batches. The inclusion of the two fermentate products was added at a rate of 900 g/ton to one of the three batches to obtain two experimental treatments and a control.

Each treatment consisted of ten replicate pens with each pen containing 34 birds at placement. Broilers were reared on a 50:50 ratio of recycled litter and fresh pine shavings. The diets did not contain any medications throughout the trial; therefore birds were vaccinated with a coccidiosis vaccine (Coccivac®-B) on day of age as a coccidiosis preventative. The dietary program consisted of three dietary phases, starter (1 to 14 d), grower (15 to 28 d) and finisher (29 to 41 d). Body weights and pen feed consumptions were determined on days of dietary changes on d 14, 28 and 41. On d 42, 5 male and 5 female broilers per replicate (300 total birds) were subjected to an 8 h feed withdrawal period and processed at the TAMU processing facility to obtain carcass weights and carcass yield data.

On d 20, 3 male broilers per floor pen were placed in grower battery units to collect fresh fecal material for a period of 24 h. Then on d 40, 2 male broilers per floor pen were placed in grower battery units to collect fresh fecal material for a period of 24 h. After the collection period, manure pans were moved to a clean, well-ventilated area for volatilized odorant collection from 500 g of fecal material via flux chamber method as previously described. Following odor collection, two 5 g samples per replicate pen were diluted in 25 mL of distilled water for pH determination in duplicate.

Table 2: Dietary formulation and calculated nutrient concentrations of straight-run market broilers fed non-medicated diets with the inclusion of one of two different rice/soy fermentates

Ingredient	Starter (%)	Grower (%)	Finisher (%)
Basal experimental diets			
Corn	58.35	65.21	68.48
Soybean Meal	34.50	29.22	24.68
Fat Blended	2.84	1.93	2.90
Limestone	1.57	1.41	1.59
Salt	0.46	0.33	0.22
Bifos 16/21p	1.56	1.40	1.29
Sodium Bicarbonate	--	0.11	0.26
Lysine HCL	0.16	0.15	0.12
DL-Met 98	0.26	0.24	0.16
Vitamins[1]	0.25	0.25	0.25
Trace Min[2]	0.05	0.05	0.05
Calculated nutrient concentration			
Protein	22.00	20.00	18.00
Calcium	0.95	0.85	0.89
Phosphorus	0.70	0.66	0.62
Available Phos	0.45	0.41	0.38
Methionine	0.59	0.54	0.44
Lysine	1.30	1.15	1.00
TSAA	0.95	0.88	0.75
Threonine	0.82	0.62	0.67
Crude Fat	5.38	4.69	5.73
Sodium	0.20	0.18	0.18

[1]Vitamin premix added at this rate yields 11,023 IU vitamin A, 3,858 IU vitamin D_3, 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 thiamine, 0.55 mg biotin per kg diet. The carrier is ground rice hulls

[2]Trace mineral premix added at this rate yields 149.6 mg manganese, 125.1 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

Statistical analysis: For both experiments, all data were analyzed via a One-way Analysis of Variance using the General Linear Model. Means were deemed significantly different at p = 0.05 and separated using a Duncan's Multiple Range Test.

RESULTS

Experiment 1: The addition of fermentate B at 900 g/ton resulted in an increased body weight beginning as early as d 7 with a 3.5% increase. Increased body weight gain continued throughout the remainder of the experiment with a significant increase (p = 0.05) in d 21 body weight with a 5% increase (Table 3). The inclusion of both fermentates (A and B) resulted in lower (p = 0.05) concentrations of several odor compounds evaluated including 4-ethyl phenol, para-cresol, indole, skatole, valeric acid and hexanoic acid (Table 4). Isovaleric acid, one of the less offensive odorants has a descriptor of

Table 3: Average body weights (BW), mortality corrected feed conversion ratio (FCR) and feed consumption of battery reared male broilers fed one of two rice/soy fermentates (A[1] and B[2]) at varying dietary concentrations in Experiment 1

		BW (g)			FCR (Feed:Gain)			Feed consumption (g/bird/day)		
Ingredient	C (g/ton)	d 1-7	d 1-14	d 1-21	d 1-7	d 1-14	d 1-21	d 1-7	d 1-14	d 1-21
Control	0	161.0	450.8	909.7[b]	1.29	1.29	1.36	21.6	37.4	55.8
A	300	161.9	456.5	906.2[b]	1.22	1.26	1.36	21.0	37.2	55.5
A	600	159.2	452.7	908.6[b]	1.26	1.28	1.36	21.1	37.1	55.6
A	900	162.3	454.6	908.7[b]	1.25	1.27	1.33	20.8	36.0	53.3
B	900	167.2	470.4	946.4[a]	1.22	1.26	1.35	21.3	37.6	56.5
SEM		1.2	3.0	5.2	0.01	0.01	0.01	0.2	0.3	0.4

[a,b]Means in columns with different superscripts differ significantly at p = 0.05, C: Concentration

[1]BiOWiSH Odor-BiOWiSH Technologies, Naperville, IL, 60563

[2]BiOWiSH Aqua-BiOWiSH Technologies, Naperville, IL, 60563

Table 4: Profile of odor compounds (µg/m³) collected from fresh fecal material from 21 day old battery reared male broilers fed one of two rice/soy fermentates (A[1] and B[2]) at varying dietary concentrations in Experiment 1

Ingredient	Control	A	A	A	B	SEM
Selected odorants (µg/m³)						
Concentration (g/ton)	0	300.00	600.00	900.00	900.00	
Acetic acid	106.40	80.96	76.75	85.83	69.40	7.17
Propionic acid	8.99	14.50	5.70	3.76	14.74	2.04
Isobutyric acid	47.53	10.18	37.51	26.81	65.85	6.99
Butyric acid	132.80	75.06	84.82	74.65	120.30	9.17
Isovaleric acid	24.02	16.29	6.30	13.79	15.72	2.02
Valeric acid	68.68[a]	22.99[b]	18.74[b]	26.62[b]	29.35[b]	4.83
Hexanoic acid	260.40[a]	104.20[b]	124.80[b]	103.60[b]	162.10[b]	14.05
Phenol	9.17	7.24	7.59	9.47	6.93	0.51
Para-cresol	4.94[a]	1.70[b]	2.55[b]	2.65[b]	1.96[b]	0.26
4-ethyl-phenol	13.52[a]	1.65[c]	2.15[bc]	4.10[b]	1.70[c]	0.95
Indole	0.08[a]	0.02[b]	0.04[b]	0.02[b]	0.02[b]	0.01
Skatole	0.15[a]	0.07[b]	0.06[b]	0.04[b]	0.04[b]	0.01
ppm						
Hydrogen sulfide (Day 21)	0.14	0.19	0.18	0.30	0.16	0.02
Ammonia						
Day 14	45.60	32.30	20.30	44.80	27.00	5.25
Day 21	26.50	31.70	31.20	29.00	25.80	3.94

[a-c]Means in columns with different superscripts differ significantly at p = 0.05

[1]BiOWiSH Odor-BiOWiSH Technologies, Naperville, IL, 60563

[2]BiOWiSH Aqua-BiOWiSH Technologies, Naperville, IL, 60563

Table 5: Fecal characteristics of 21 day old battery reared male broilers fed one of two rice/soy fermentates (A[1] and B[2]) at varying dietary concentrations in Experiment 1

Ingredient	Conc. (g/ton)	pH	Moisture (%)	Nitrogen content	Carbon content	C:N
Control	0	6.58	69.65	4.35	41.02	9.45
A	300	6.48	69.14	4.44	40.73	9.26
A	600	6.58	68.48	4.28	40.83	9.59
A	900	6.38	68.25	4.52	40.73	9.04
B	900	6.33	69.12	4.42	40.98	9.35
SEM		0.06	0.32	0.03	0.05	0.08

[1]BiOWiSH Odor-BiOWiSH Technologies, Naperville, IL, 60563

[2]BiOWiSH Aqua-BiOWiSH Technologies, Naperville, IL, 60563

buttery and sweet; however, reductions were also observed in more offensive odorants including 4-ethyl phenol, para-cresol, indole, skatole, valeric acid and hexanoic acid which have descriptors of horse manure, barnyard, mothball, outhouse, foul and goat-like odor, respectively. No differences were observed with regard to feed conversion ratio, feed consumption, mortality, fecal pH, fecal moisture content, NH_3 and H_2S volatilization, or fecal N and C content (Table 3-5); however, multiple observations including reduced fecal pH and numerical decreases in feed conversion indicate support for further investigation with a larger sample size. These data suggest the ability of a rice/soy fermentate included in the diet to reduce odorant volatilization from fresh fecal material and increase early body weight, supporting the idea of further investigation into performance and odor profiles in a full- scale grow-out trial to market age.

Experiment 2: The addition of fermentate B at 900 g/ton resulted in a significant increase (p = 0.05) in d 14 body weight (Table 6). At the conclusion of the trial, inclusion of fermentate B did result in the highest average body weight although did not test to be statistically significant. The inclusion of the fermentates did not result in an observed difference in feed conversion during the starter or finisher period of the trial. However, during the grower period of the trial, inclusion of the

Table 6: Average body weight and mortality corrected feed conversion ratio (FCR) of straight-run market broilers fed non-medicated diets with the inclusion of one of two different rice/soy fermentates (A[1] and B[2]) in Experiment 2

	BW (kg)			FCR Feed:Gain				
Diet	d 14	d 28	d 41	Starter	Grower	Finisher	d 1-28	d 1-41
Control	0.390[b]	1.25	2.35	1.46	1.69[b]	2.24	1.62[b]	1.89
A	0.400[b]	1.25	2.37	1.47	1.73[a]	2.25	1.65[a]	1.92
B	0.410[a]	1.27	2.38	1.44	1.75[a]	2.21	1.65[a]	1.90
SEM	0.002	0.01	0.01	0.01	0.01	0.01	0.01	0.01

[a,b]Means in columns with different superscripts differ significantly at p = 0.05
[1]BiOWiSH Odor-BiOWiSH Technologies, Naperville, IL, 60563
[2]BiOWiSH Aqua-BiOWiSH Technologies, Naperville, IL, 60563

Table 7: Processing parameters and fecal pH of straight-run market broilers fed non-medicated diets with the inclusion of one of two different rice/soy fermentates (A[1] and B[2]) in Experiment 2

	Processing data			Fecal pH	
Diet	Live Wt (g)	Carcass Wt (g)	Carcass Yield (%)	day 21	day 42
Control	2383[b]	1745[b]	73.3	6.04[a]	6.70[a]
A	2452[a]	1796[a]	72.6	5.24[b]	6.00[ab]
B	2447[a]	1790[a]	73.1	5.47[b]	5.25[b]
SEM	16	12	0.2	0.12	0.21

[a,b]Means in columns with different superscripts differ significantly at $p<0.05$
[1]BiOWiSH Odor-BiOWiSH Technologies, Naperville, IL, 60563
[2]BiOWiSH Aqua-BiOWiSH Technologies, Naperville, IL, 60563

Table 8: Profile of odor compounds (μg/m³) collected fresh fecal material from 21 day old broilers fed one of two rice/soy fermentates (A[1] and B[2]) in Experiment 2

Ingredient	Control	A	B	SEM
Selected odorants (μg/m³)				
Concentration	0.0	900.0	900.0	--
Acetic Acid	479.6	576.1	445.0	55.3
Propionic Acid	79.9	29.6	30.2	18.6
Isobutyric Acid	98.8	59.6	412.4	121.8
Butyric Acid	12.9	33.3	44.6	11.1
Isovaleric Acid	13.0	6.0	10.9	2.7
Valeric Acid	24.7	20.1	18.4	3.5
Hexanoic Acid	3.9	4.7	7.7	1.6
Phenol	24.1	39.5	42.4	5.8
Para-cresol	23.8	52.2	42.2	5.8
4-ethyl-phenol	5.8	15.7	4.0	2.1
Indole	4.8	7.5	5.1	1.0
Skatole	3.4	3.8	3.8	0.5

[1]BiOWiSH Odor-BiOWiSH Technologies, Naperville, IL, 60563
[2]BiOWiSH Aqua-BiOWiSH Technologies, Naperville, IL, 60563

fermentates did increase feed conversion ratio compared to the control, although no difference was observed at the conclusion of the trial in cumulative feed conversion ratio. Following feed withdrawal, broilers fed the inclusion of both rice/soy fermentates (A and B) exhibited greater (p = 0.05) individual live weights and carcass weights; however, no difference was observed with regards to carcass yield percentage (Table 7). Fecal pH on d 21 was significantly lower with the inclusion of both fermentate products (A and B) when compared to the pH of the control (Table 7). Day 41 fecal pH was also lower (p = 0.05) with the inclusion of fermentate B when compared to the control. No significant differences were observed in odorant concentrations on d 21 or d 41 with the inclusion of either rice/soy fermentate product (Tables 8 and 9).

Table 9: Profile of odor compounds (μg/m³) collected from fresh fecal material from 42 day old broilers fed one of two rice/soy fermentates (A[1] and B[2]) in Experiment 2

Ingredient	Control	A	B	SEM
Selected odorants (μ/m³)				
Concentration	0.0	900.0	900.0	--
Acetic Acid	637.8	1160.2	1409.3	154.2
Propionic Acid	163.2	213.1	587.1	83.0
Isobutyric Acid	24.9	22.2	68.2	11.1
Butyric Acid	232.0	484.8	568.8	92.1
Isovaleric Acid	69.7	21.2	24.7	18.5
Valeric Acid	71.4	48.8	52.8	16.0
Hexanoic Acid	138.5	68.0	58.5	30.1
Phenol	59.6	65.9	61.0	2.5
Para-cresol	90.8	84.7	86.4	6.4
4-ethyl-phenol	49.9	42.3	37.0	3.6
Indole	19.2	15.9	13.9	2.1
Skatole	18.6	2.2	2.1	4.1

[1]BiOWiSH Odor-BiOWiSH Technologies, Naperville, IL, 60563
[2]BiOWiSH Aqua-BiOWiSH Technologies, Naperville, IL, 60563

DISCUSSION

The composition of freshly excreted manure is directly related to the original composition of the diet; therefore, diet manipulation is a potential strategy to reduce fecal odorants in poultry production. Odor volatilization is attributed to the microbial degradation of manure components by microorganisms in the gastrointestinal tract. This microbial growth and degradation is affected by temperature, pH, moisture, nutrient availability and atmospheric conditions. In Experiment 1, the inclusion of both fermentates (A and B) decreased (p = 0.05) multiple odorants. In Experiment 2, the inclusion of both rice/soy fermentate products in broiler diets reduced fecal pH at d 21 and d 42. A reduced gut pH is beneficial in improving energy and nutrient utilization (Gonzalez-Alvarado *et al*., 2007). In addition, pathogenic bacteria entering the gastrointestinal tract via the feed have a greater chance of being inactivated by a highly acidic environment (Naughton and Jenson, 2001). Studies have shown in monogastrics that a stomach pH below 5 results in an increased activity of proteolytic enzymes, improving protein digestibility and inhibits the proliferation of pathogenic bacteria in the gastointestinal tract (Partanen and Mroz, 1999).

The contrasting results of the two experiments may be due to the different rearing environments. In Experiment 1, male broilers were reared in batteries, whereas in

Experiment 2 straight-run broilers were reared in floor pens containing recycled litter. Torok *et al.* (2009) used microbial profiling to investigate changes in cecal bacterial communities associated with litter material and age to determine if litter type influences gut microbiota and performance in broilers. At both ages evaluated, the microbiota of chickens raised on used litter was significantly different from that of chickens raised on any other litter materials, except on softwood shavings at d 28 of age. This suggests that the type of litter material can influence colonization and development of cecal microbiota in chickens. Broilers in Experiment 2 could have potentially had a different microbial population because they were reared on used litter, thus preventing the rice/soy fermentate products from having the same effect on odorant production as in Experiment 1. It may be necessary to adjust dietary concentration to account for the exposure to environmental bacteria based on rearing conditions in order to observe the desired effect of the rice/soy fermentates. Supplementing water, feed or litter with biologicals enhances or alters microbial population with the goal of preventing the formation of toxic compounds, improving feed efficiency and competitively excluding undesirable microorganisms (Cole *et al.*, 2006; Patterson and Burkholder, 2003; Shah *et al.*, 2007). In Experiment 1, the addition of fermentate B at 900 g/ton resulted in a significant increase ($p = 0.05$) in d 21 body weight with a 5% increase. In Experiment 2, the addition of same fermentate at an equivalent inclusion rate (900 g/ton) resulted in a similar increase ($p = 0.05$) in early body weight; however, the observed difference was not significant on d 28 or 42, though an increase in live weight following feed withdrawal and carcass weight was observed in the sample of processed broilers. The inclusion of fermentate B at 900 g/ton in both experiments resulted in significant increases in body weight at the early stages of growth, possibly indicating a pobiotic type effect. Combined, the results of these two experiments indicate the ability of a microbial biocatalyst produced through a rice/soy fermentation process that contains a consortium of naturally occurring yeast and bacteria to increase early broiler body weight, alter digesta pH and reduce odorant volatilization from fresh fecal material through the alteration of the microbial populations that are responsible for the degradation of digesta.

REFERENCES

Chavez, C., C.D. Coufal, P.L. Niemeyer, J.B. Carey, R.E. Lacey, R.K. Miller and R.C. Beier, 2004a. Impact of dietary supplemental methionine sources on sensory measurement of odor-related compounds in broiler excreta. Poult. Sci., 83: 1655-1662.

Chavez, C., C.D. Coufal, J.B. Carey, R.E. Lacey, 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.

Chavez, C., C.D. Coufal, R.E. Lacey and J.B. Carey, 2004c. The impact of methionine source on poultry fecal matter odor volatiles. Poult. Sci., 83: 359-364.

Choi, I.H., J.H. Choi, S.H. Ko and P.A. Jr Moore, 2010. Reducing ammonia emissions and volatile fatty acids in poultry litter with liquid aluminum chloride. J. Environmental Sci. and Health, Part B, 46: 432-435.

Cole, K., M.B. Farnell, A.M. Donoghue, N.J. Stern, E.A. Svetoch, B.N. Eruslanov, L.I. Volodina, Y.N. Kovalev, V.V. Perelygin, E.V. Mitsevich, I.P. Mitsevich, V.P. Levchuk, V.D. Pokhilenko, V.N. Borzenkov, O.E. Svetoch, T.Y. Kudryavtseva, I. Reyes-Herrera, P.J. Blore, F. Solis De Los Santos and D.J. Donoghue, 2006. Bacteriocins reduce campylobacter colonization and alter gut morphology in turkey poults. Poult. Sci., 85: 1570-1575.

Cook, K.L., M.J.Jr. Rothrock, M.A. Eiteman, N. Lovanh and K. Sistani, 2011. Evaluation of nitrogen retention and microbial populations in poultry litter treated with chemical, biological or adsorbent amendments. J. Environmental Manage., 92: 1760-1766.

Gonzalez-Alvarado, J.M., E. Jimenez-Moreno, R. Lazaro and G.G. Mateos, 2007. Effect of type of cereal, heat processing of the cereal and the inclusion of fiber in the diet on productive performance and digestive traits of broiler. Poult. Sci., 86: 1705-1715.

Kelleher, B.P., J.J. Leahy, A.M. Henihan, T.F. O'Dwyer, D. Sutton and M.J. Leahy, 2002. Advances in poultry litter disposal technology-a review. Biodegrad Tech., 83: 27-36.

Kreis, R.D., 1978. Control of animal production odors: the state-of-the art. EPA Environmental Protection Technology Series; EPA-600/2-78-083; Ada, OK: Environmental Protection Agency. Office of Research and Development.

Naughton, P.J. and B.B. Jensen, 2001. A bioreactor system to study survival of *Salmonella* Typhimurium in pig gut content. Berl. Munch. Tierarztl Wochenschr, 114: 1-4.

Partanen, H.K. and Z. Mroz, 1999. Organic acids for performance enhancement in pig diets. Nutr. Res. Rev., 12: 117-145.

Patterson, J.A. and K.M. Burkholder, 2003. Application of prebiotics and probiotics in poultry production. Poult. Sci., 82: 627-631.

Roberts, S.A., H. Xin, B.J. Kerr, J.R. Russell and K. Bregendahl, 2007. Effects of dietary fiber and reduced crude protein on ammonia emission from laying-hen manure. Poult. Sci., 86: 1625-1632.

Shah, S.B., C.L. Baird and J.M. Rice, 2007. Effect of a metabolic stimulant on ammonia volatilization from broiler litter. J. Appl. Poult. Res., 16: 240-247.

Sutton, A., T. Applegate, S. Hankins, B. Hill, G. Allee, W. Greene, R. Kohn, D. Meyer, W. Powers and T. Van Kempen, 2002. 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.

Torok, V.A., R.J. Hughes, K. Ophel-Keller, M. Ali and R. MacAlpine, 2009. Influence of different litter materials on cecal microbiota colonization in broiler chickens. Poult. Sci., 88: 2474-2481.

Wu-haan, W., W. Powers, R. Angel and T.J. Applegate, 2010. The use of distillers dried grains plus solubles as a feed ingredient on air emissions and performance from laying hens. Poult. Sci., 89: 1355-1359.

[2]BiOWiSH™ Odor, BiOWiSH Technologies, Naperville, IL, 60563
[3]BiOWiSH™ Aqua, BiOWiSH Technologies, Naperville, IL, 60563