Influence of Dietary Incorporation of Bloodmeal on Nursery Pig Manure Composition and Odor

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Summary and Implications

Specific dietary ingredients may have the potential to alter manure odor by altering digestive patterns or fermentation or by masking manure odorants. Inclusion of dietary bloodmeal (BM) into nursery pig diets resulted in a slight, but insignificant, increase in manure odor intensity. Electronic nose response to manure odor moderately mimicked human response.

Introduction

Manure odor is the result of the anaerobic decomposition of the organic matter present. By altering the composition of manure, as excreted, changes in the odor of decomposing manure may occur. Compositional alteration may occur by changing the dietary nutrient composition or by altering the use of these nutrients. Feed ingredients may contribute to manure odor due to their nutritional composition or inherent odor that may mask or counteract other manure odorants. Bloodmeal (BM) is one such ingredient that appears to alter manure odor. In a blind test, human panelists can distinguish between manures from dairy cows fed diets with and without dietary bloodmeal (Roger Nordstedt, personal communication).

Specific objectives of this work were to (1) determine whether manure odors differ when pigs are fed different levels of bloodmeal in the diet, (2) determine chemical composition of manures excreted from nursery pigs fed diets with and without dietary by-products, and (3) correlate chemical concentrations of manure odorants with organoleptic measures of manure samples. A fourth objective was to evaluate electronic nose technology as a means of discriminating between manure odors and emulating human response.

Materials and Methods

The feeding trial was conducted at an Iowa State University research facility. Four nursery rooms that each housed three or four weaned pigs (approximately 5 weeks old at the start of the feeding period) were used. Three treatment diets were formulated to be iso-nitrogenous and to contain 0, 1.5, or 3% bloodmeal (Tables 1 and 2). A new group of pigs was used for each of the two 4-week feeding periods. During both periods, all pigs in a room received the same diet and all diets were fed during each period. Additionally, during period 1, the 3% bloodmeal diet was fed in two of the four rooms; the 0% bloodmeal diet was fed in two rooms during period 2 (Table 3).

Table 1. Dietary treatment formulation and bloodmeal (BM) content.

Ingredient	Diet		
	0% BM	1.5% BM	3% BM
	--- kg per 1,000 kg feed fed ---		
Corn, yellow	657.40	680.00	705.20
Bloodmeal, spray dried	---	15.00	30.00
Soybean meal, dehulled	310.00	272.20	232.00
Lysine, synthetic	0.10	0.10	0.10
Dical phosphate	15.00	15.20	15.20
Limestone	8.80	8.80	8.80
Salt	4.20	4.20	4.20
Minerals	4.50	4.50	4.50

Table 2. Compositional analyses of dietary treatments containing 0%, 1.5%, or 3% dietary bloodmeal (BM).

Component	Diet		
	0% BM	1.5% BM	3% BM
Lysine (%)	1.12	1.12	1.12
Threonine (%)	0.77	0.76	0.75
Tryptophan (%)	0.25	0.24	0.23
Met + Cys (%)	0.67	0.66	0.64
ME (kcal/kg)	3271	3260	3252

Table 3. Assignment of treatments.

Period	Room			
	1	2	3	4
	---------- Diet, % bloodmeal ----------			
I	0	1.5	3	3
II	3	0	1.5	0

Manure and air samples were collected 2 days per week from each room during weeks 2 through 4. Manure samples were sent to laboratories at Iowa State University for chemical analyses that included wet chemistry measures (total Kjeldahl nitrogen [TKN, mg/g], chemical oxygen demand [COD, mg/g], total phosphorous [P, mg/g], potassium [K, mg/g], percent total solids [TS], and percentage of volatile solids [VS]).

Two 10-liter air samples were collected from each room twice weekly; samples were analyzed by organoleptic and instrumental methods within 8 hours of collection. A

human sensory panel conducted the organoleptic assessment by using dynamic dilution olfactometry. Instrumental assessment of odor intensity was conducted using a 32-sensor AromaScan electronic nose (AromaScan, Hollis, N.H.).

Statistical analyses. Data were analyzed using procedures by SAS (2, 3). Results for the human panel were skewed and so were transformed to normalize their distribution by using a natural logarithm function. Mixed model procedures were used to determine whether dietary treatment groups differed for odor intensity of resultant manure, electronic nose sensor values, and composition of manure, and to identify other factors that influenced these manure and odor measures. Many of the manure compositional values were highly correlated, thus six separate models were used to determine the effects of composition for odor intensities and electronic nose results. Random effects for all models were period of the trial, treatment × room, day of organoleptic assessment, and residual. All models included continuous linear terms for treatment, number of days that manure was stored in nursery rooms, the interaction term for treatment × days stored, and concentrations in manures of hydrogen sulfide and percentage of volatile solids. Four of the models included an additional linear term for (TKN, P, COD, or K). For the "best" model (model that described the largest percentage of variability for odor intensity), the linear term for concentration of total solids replaced the term for percentage of volatile solids. For terms that were included for all models, coefficients and P-values that are reported are those from the "best" model (model for which potassium concentration and percentage of volatile solids were linear compositional terms).

Principle component analyses were used to identify combinations of electronic nose sensor results that best explained variability of all sensor values. Principle component analyses of electronic nose sensor data identified a single combination of sensor values (principle component) that accounted for 94% of variability for these data. Thus, we used results from this component to compute a new variable for each observation that represented electronic nose results.

Correlations of olfactometer results with chemical and instrument data were Pearson correlations.

Results

Average daily gain among treatment groups was similar, 0.6 kg/d. Feed intake was not measured, and as a result, we were unable to determine feed efficiency for the groups.

Human panel response to odor represented a dilution ratio of the amount of 'odor-free' air required to dilute the odorous air sample until the smell was unable to be detected by the panelists. Thus, small intensities indicated that little odor free air was necessary to reach odor levels that were undetectable. Due to a very large daily variation in panelist response, two panelist responses were omitted. These panelists reported intensities of manure odor from pigs fed the control diet during period 1 that were more than 3 SD from mean response for other treatments during the first period.

Important factors for human assessment of odor included day of assessment, length of time that manure had been stored, and concentrations in manure of K and COD ($P < .10$, Table 4). AromaScan results were influenced by TKN, P, and marginally ($.2 < P < .1$) by VS and K (Table 5).

Treatment effects. No significant odor intensity differences were observed between manures from pigs fed the three treatment diets ($P = .26$); however, a strong trend towards increasing odor intensity with increasing dietary bloodmeal concentration was evident (Figure 1). No differences due to treatment were identified by studying instrument response, either.

Table 4. Effects for odor intensity (natural logarithm odor dilution ratio).

Component	Regression coefficient	*P*-value
Room air hydrogen sulfide, ppm	-0.022	0.51
Oxygen demand, mg/g	0.00087	0.05
Total Kjeldahl nitrogen, mg/g	0.024	0.27
Potassium, mg/g	0.092	<.0001
Phosphorus, mg/g	-0.027	0.27
Total solids, %	4.45	0.24
Volatile solids, %	5.92	0.16
Days stored	0.769	0.01
Treatment, % blood meal	0.121	0.26

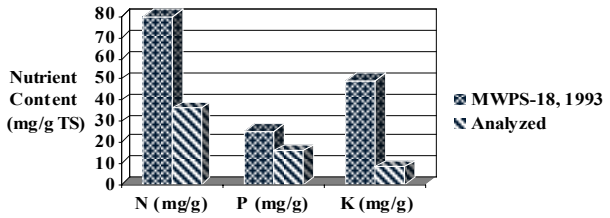
Manure storage time. Length of time manure had been stored in each room, 4 or 6 days, was important for manure odor intensity and instrumental (electronic nose) response. Longest storage time resulted in largest odor dilution ratio ($P < .01$). Manure composition and room hydrogen sulfide concentration were unaltered by storage time. Likewise, storage time did not affect odor differently for the three treatments (treatment × time).

Table 5. Effects for electronic nose results.

Component	Regression coefficient	*P*-value
Room air hydrogen sulfide, ppm	-0.002	0.97
Oxygen demand, mg/g	-0.0000044	0.99
Total Kjeldahl nitrogen, mg/g	-0.040	0.065
Potassium, mg/g	0.056	0.13
Phosphorus, mg/g	0.043	0.036
Total solids, %	-5.93	0.21
Volatile solids, %	-8.18	0.14
Days stored	0.272	0.04
Treatment, % blood meal	-0.044	0.83

Manure composition. When compared to industry-accepted tables (1) it is evident that pigs used in this study excreted considerably lower concentrations of N, P, and K than values reported for similar nursery pigs (Figure 1).

Figure 1. Comparison of experimental manure nutrient concentrations (analyzed) with industry-accepted table values (1).



Comparison of olfactometric and instrumental methods for odor assessment. Correlation of the log of human panel results and AromaScan responses was moderate (r = .27; P = .066; Table 6). It is important to note, that literature reported correlations between chemical analytes and olfactometry are typically not much larger (r=.4-.6). Low correlations may be due to the large daily variation in olfactometry response to treatments or inadequate training of the neural network within the AromaScan to the manure samples collected in our study.

Table 6. Pearson correlations of electronic nose results and sensory responses.

Sensory measure	Electronic nose	*P*-value
	— r —	
Dilution ratio	0.20	0.17
Dilution ratio, natural log.	0.27	0.066

Conclusions

We observed a strong trend for more intense manure odor when pigs were fed diet with largest concentrations of bloodmeal, however: due to large daily variation in panelist responses, this relationship was statistically unimportant. Further replication of the study is necessary to obtain additional results to verify those from the current study.

Correlation analysis indicated that the electronic nose mimicked panelist response only moderately. Small correlations probably are due to the wide daily variation in panelist response or inadequate training of algorithms in the AromaScan. For example, it is possible to select specific sensors to represent the response that may contribute to better correlation with human response. For the current study, however, all 32 sensors in the electronic nose were used.

Manure storage time influenced manure odor intensity with 6 days of storage resulting in a higher odor dilution ratio than 4 days storage. Manure composition was unaffected by storage time but COD content was affected by dietary treatment. Concentrations of N, P, and K in manure were considerably lower than reported values (1). Table values (1) report content on an as-excreted basis. For our study, the N content was lower, in part, due to volatilization of N as ammonia. Differences between our findings and standard table values, however, probably cannot be accounted for solely by ammonia volatilization; thus, it is probable that N concentrations of manure as-excreted were lower in this study than for studies reported previously.

For our study trained panelists were used; however, relative rankings of samples between panelists varied greatly within a given sampling day. To reduce the extraneous variability in results that were introduced by extremely variable panel responses, further replication of this study is needed to assess treatment effects on odor intensity.

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