This is not a peer-reviewed paper.

The Society for engineering in agricultural, food, and biological systems

Paper Number: 01-2260
An ASAE Meeting Presentation

Evaluation of Fabric Swatch Types for Relative Odor Intensity at Beef Cattle Feedyards

Sean D. See, Graduate Student
Killgore Research Center
West Texas A&M University, Canyon, TX 79016
ssee@mail.wtamu.edu

David B. Parker, Assistant Professor
Killgore Research Center
West Texas A&M University, Canyon, TX 79016
dparker@mail.wtamu.edu

Brent W. Auvermann, Assistant Professor
Texas A&M Research and Extension Center
6500 Amarillo Blvd., West; Amarillo, TX 79106
b-auvermann@tamu.edu

Jacek Koziel, Assistant Professor
Texas A&M Research and Extension Center
6500 Amarillo Blvd., West; Amarillo, TX 79106
ja-koziel@tamu.edu

John Sweeten, Professor
Texas A&M Research and Extension Center
6500 Amarillo Blvd., West; Amarillo, TX 79106
j-sweeten@tamu.edu

Written for presentation at the
2001 ASAE Annual International Meeting
Sponsored by ASAE
Sacramento Convention Center
Sacramento, California, USA
July 30-August 1, 2001

Abstract. *A research project was conducted to determine which type of fabric swatch was best suited for on-site sampling of odor intensity at open-lot beef cattle feeding operations. Five different types of fabric were tested: cotton flannel, cotton muslin, acetate, polyester and polyester felt. Square swatches (20 ´ 20 cm) were suspended 1 m above the ground surface downwind of cattle pens for 24 hours. The swatches were placed in glass jars and presented to 8-10 human panelists who were asked to rank the swatches based on relative odor intensity. Five trials were conducted at 3 feedyards. Sums of ranks and Spearman rank correlation coefficients were used to evaluate the degree of closeness of association between panelists. Muslin had the highest sum of ranks in 3 of 5 trials. When the wind had been blowing and dust was visible on the swatches, the polyester felt had the most detectable odor. The wide variation in Spearman rank correlation coefficients, with about half of the correlation coefficients negative, indicates little consistency between panelists in ranking of fabric swatches. Experiments are currently being conducted to determine sources of uncertainties associated with odor assessment using fabric swatches.*

Keywords. odor, feedyards, feedlot, cattle, manure, swatch, fabric.

Introduction

The beef industry is an integral part of the Southern High Plains. Over 7 million head of cattle are fed annually in open-lot confined animal feeding operations (SPS, 1999). The dry climate and relatively low human population makes the region attractive to the development of cattle feeding. Although air quality in the region is generally good, cattle feedyards are known to emit dust and gases that contribute to odor and other localized conditions related to air quality. Nationally, however, nuisance odors are becoming more of a challenge and environmental problem (Miner, 1997). Air pollution within and from confined animal feeding operations (CAFOs), including cattle feedyards, has become one of the most challenging issues facing the livestock industry.

Odors can be evaluated by scentometers (Barnebey-Cheney, 1987), olfactometers (Jones et al., 1994; Hobbs et al., 1999; Watts et al., 1994; Ogink et al., 1997), use of chemical sensory arrays ("electronic noses") (Hobbs et al., 1995; Di Francesco et al., 2001; Hudon et al., 2000), or by measuring true chemical concentrations of some gases comprising odors (Hobbs et al., 1995). The latter can be achieved by the use of gas chromatography coupled with various detectors, e.g., mass spectrometer for identification of the chemical compounds, or by the use of gas-specific analyzers, e.g. ammonia or hydrogen sulfide analyzers (Heber et al., 2000). In olfactometry, the human nose is the primary instrument used to evaluate the odor in terms of non-chemical values. Correlation between odor intensity evaluated by olfactometry with true concentrations of main odorous gases is difficult (Zahn et al., 2001).

Odor strength can be measured by two different methods: dynamic and static (Wood et al., 2000). Dynamic olfactometry is where an odorous air source is directed toward a panelist's nose, whereas static olfactometry involves odorous air in an enclosed "static" space. Static olfactometry lends itself well to subjective measurement of odors, such as offensiveness and recognition of the odor. In most cases, static and dynamic olfactometry use a "spot" or "grab" air sample collected in a sampling bag at a given, short time. Such a sample is not always representative of odor, because of the possible odor variations over time. Given the low availability and high cost of dynamic olfactometers (over $30,000), a low cost, readily available method of odor measurement over a longer period of time would be desirable. One of the possible solutions is the use of odor-adsorbing fabric swatches, which could be exposed to odors for extended periods.

Miner and Licht (1981) experimented with cotton and wool swatches in livestock buildings to determine which would retain a representative odor. They used both wet and dry swatches of cotton and wool felts. When wet, both fabrics exuded their own odors (wet cotton and wet wool) with the wool being the strongest. Williams and Schiffman (1996) and Schiffman and Williams (1999) rated captured swine odors on fabric swatches on three 9-point scales. These scales included odor intensity, irritation intensity and hedonic tone. Wood et al. (2000) found that flannel worked well at retaining odors when exposed to a headspace of swine effluent samples that were stored inside glass jars. This was a reliable method of evaluating the offensiveness of swine effluent.

It is well-known fact that clothes take on the essence of the cattle feedyard after even a relatively short visit and exposure at the site. Thus, using this reasoning we tested the use of fabric swatches for assessment of feedyard odors. The goal of this research was to compare 5 fabric types for suitability as inexpensive odor swatches after being exposed to beef cattle feedyard odors under ambient weather conditions.

Materials and Methods

Selected Feedyards

Three different feedyards in the Texas Panhandle were chosen for the trials: two commercial feedyards and one research feedyard. The research feedyard (Feedyard A) held approximately 300 head of cattle, while one commercial feedyard (Feedyard B) had a 30,000 head capacity and the other commercial feedyard (Feedyard C) had a capacity of 80,000 head.

Trials 1, 2 and 3 were conducted at Feedyard A. (Table 1). Trials 1 and 2 were conducted to test the repeatability of the panelists. The swatches for Trials 1 and 2 were placed in the feedyard on July 24, 2000. The same swatches were used in Trials 1 and 2, but panelists were asked to rank the swatches on different days. Panelists were unaware that they were sniffing the same swatches as previously. Trial 3 was conducted on August 3, 2000 to assess variability at a single feedyard. At the time of trials 1-3, there were 300 head in the facility. The swatches were located at the northern end of a set of pens running north and south. This allowed the swatches to be on the downwind side of the pens. Typical for the Texas Panhandle, the wind at the time of sampling was out of the southwest.

Trial 4 was conducted at Feedyard B in March, 2001. The swatches were placed on the downwind side of a runoff storage pond. The pond was also downwind of several pens. The storage pond had a maximum depth of two meters. The swatches were located approximately 30 meters north of the pond edge. At both feedyard A and B, the swatches were placed in the early afternoon and collected the following afternoon, 24 hours later.

Trial 5 took place in at Feedyard C, the largest of the feedyards. This trial also took place in March, 2001. The swatches were located near the middle of the feedyard, next to a processing facility/hospital. There was a building to the immediate west and an enclosed crowding pen to the immediate south. Twenty meters to the north were a feed alley and pens, while about 10 meters to the east were more pens. These swatches were placed in the morning and collected the following morning, 24 hours later.

Fabrics

There were 5 different fabrics: cotton muslin, cotton flannel, polyester, polyester felt and acetate (from Walmart, Canyon, TX) (Table 2). In addition, a composite of all five fabrics was also used in Trials 4 and 5. Each fabric was cut into a swatch of 20×20 cm, except for the composite, which was comprised of five 4×20 cm strips. The swatches were placed along with pint glass canning jars (from Walmart, Canyon, TX) and their lids (rings and seals) in a drying oven at approximately 100° C for at least 1 hr to remove residual odors. In most cases, this was done within 24 hr prior to exposure. Upon removal from the drying oven, the swatches were then enclosed in the pint jars until exposed on site.

At the feedyards, the swatches were suspended about 1m above the ground for an approximate 24 hr period. Each swatch was transferred from the jar containing it to the cord where it was suspended with a plastic clothespin. Each swatch was collected individually and enclosed in the jar. At the time of collection, weather conditions were noted to help explain possible trends in the data. After all the swatches had been collected, they remained in the jars until they were presented to the panelists.

After the swatches were returned to the lab, the jars were wrapped in paper to prevent panelists from seeing the swatches, as swatch appearance may have biased the panelists. The jars containing the swatches were labeled A through E or F, depending on how many were used per panelist. Jars were labeled in a different order for each trial.

Panelists were chosen at random from students and staff that worked in the building (Table 3). There were a total of 22 panelists (15 men and 7 women), ranging in age from 21 to 50. Panelists did not undergo any formal training or selection process as is typical with some odor panels. Some panelists were familiar with livestock operations and others were not. Although panelists were picked at random, we tried to use each panelist in as many trials as possible.

Each panelist was asked to rank the swatches from weakest odor to strongest odor in a 5 to 6-tiered scale. Panelists were allowed to sniff each sample as many times as they felt necessary, with no time limit. When they sniffed the sample, panelists did not remove the swatch or look into the jar. After sniffing each sample, the panelist replaced the lid on the jar, thus allowing some of the odiferous air to remain inside. Some panelists ranked the swatches very quickly, while others spent more time deliberating how they would rank them. In several instances, panelists stated there were too little differences between the swatches to rank some swatches above others. Ties were allowed.

Data Analysis

Each panelist ranked the fabrics from 1 (weakest odor) to 5 or 6 (strongest odor).
For each trial, the sum of the ranks for each fabric was calculated. To evaluate the degree of closeness of association between panelists, the Spearman rank correlation coefficient was determined (Hoshmand, 1998). The Spearman rank correlation coefficient ranges in value from -1.0 to +1.0, with a value of -1.0 meaning a perfect negative correlation, and a value of +1.0 meaning a perfect positive correlation. A value of 0.0 implies no correlation between the two rankings. All statistics were performed using SPSS Version 10 software (SPSS, 2000).

Results and Discussion

In Trial 1, cotton muslin had the highest sum of ranks and therefore had the strongest odor (Table 4). It was distantly followed by polyester, polyester felt, cotton flannel and acetate, in that order. In Trial 2, cotton muslin again had the highest sum of ranks (and strongest odor). This time, however, acetate was the second strongest, followed by polyester, polyester felt and cotton flannel. In Trial 3, polyester felt had the highest sum of ranks, indicating the strongest odor, followed by polyester, muslin, acetate and cotton flannel. In Trial 4, cotton muslin and the composite tied for the highest sum of ranks. In Trial 5, polyester had the highest sum of ranks, followed by acetate, muslin, polyester felt, cotton flannel, and the composite. It is interesting that the polyester and composite samples switched places in the last two trials. The composite was tied for strongest odor in Trial 4, but had the weakest odor in trial 5 (Table 4).

Spearman rank correlation coefficients for each of the five trials are shown in Tables 5-9. The broad range of correlation coefficient values, with about half negative numbers, indicates little consistency between panelists. There was also little consistency in pairs of panelists between trials.

Some panelists would describe the odors as they sniffed, even though they were only required to rank the swatches. They did not always detect a “feedyard” odor. Sometimes panelists would state that the odor was similar to grain. One said he was reminded of detergent, while another compared the odor of one swatch to camphor.

Throughout the trials, panelists did not exhibit great correlation with the other panelists. However, when they were allowed to sniff the same swatches at a later date (comparing Trials 1 and 2), they achieved moderate repeatability (Table 10). Several panelists that ranked muslin highest in the Trial 1 also ranked it highest in the Trial 2. This suggests that the same panelist will likely rank swatches exposed to identical conditions in much the same way.

As indicated in the first two trials, there is a fairly good degree of repeatability when the same swatches are evaluated at different dates (Table 10). However, under different environmental conditions, the correlation between panelists decreased, as evident in Trial 3. The swatches in Trial 3 were covered with dust, indicating the possibility that a wind event had changed which fabric absorbed the most odor. Trial 3 was the only trial in which polyester felt was chosen as holding the strongest odor. Another possibility is that odorous gases were adsorbed to dust particles which were observed on the surface of some swatches. Differences in odor perception could be associated with the amount of dust collected and retained by each type of fabric. This hypothesis is currently being tested.

The switching of the top and bottom rankings in the last two trials is interesting and difficult to explain. Each trial was conducted on a different feedyard, both within a period of about three weeks. Although both feedyards were in the same geographic region, the locations of the swatches in the feedyard may have affected the odor characteristics. At Feedyard B, the swatches were located immediately downwind of a runoff storage pond, and the pond was located downwind of several pens. The swatches at Feedyard C were located directly downwind of the pens. There was more mud in the pens in Feedyard C than Feedyard B, thus a likely difference would be the moisture content of the pen surface.

There are several uncertainties associated with the fabric swatches method for odor assessment. The first is associated with the adsorption of odors to fabric fibers. Sampling reproducibility is likely affected by the various adsorptive capacities of different fabric and gases, gas-fiber partitioning and re-equilibration that follows variations in gas concentration, by the effects of competition between gases for the same adsorption sites, by the effects of environmental conditions (temperature, solar radiation, humidity), and others. The second uncertainty is associated with the fact that samples were open to laboratory air for various periods of time during which various amounts of gases adsorbed to fabric could be desorbed and lost to the ambient air before presented to another panelist. The third uncertainty is associated with the lack of background odor data for the fabric and glass jars. These and other uncertainties are currently being investigated.

Conclusions

Of the five fabrics, muslin had the highest sum of ranks in three of five trials, indicating it had the highest relative odor intensity. When dust was visible on the swatches, polyester felt had the highest sum of ranks. The wide variation in Spearman rank correlation coefficients, with about half of the correlation coefficients being negative, indicates little consistency between panelists in ranking of fabric swatches.

References

ASAE. 1999. Control of manure odors. ASAE Standard EP379.2. American Society of Agricultural Engineers:St. Joseph, MI.

Barnebey-Cheney. 1987. Scentometer: An Instrument for Field Odor Measurement. Bulletin T-748, Barnebey-Cheney Activated Carbon and Air Purification Equipment Co., Columbus, Ohio. January. 3 p.

Di Francesco F., B. Lazzarini, F. Marcelloni, and G. Pioggia. 2001. An electronic nose for odour annoyance assessment. Atmospheric Environment, 35:1225-1234.

Heber, A.J., J.Q. Ni, B.L.Haymore, R.K. Duggirala and K.M. Keener. Measurements of gas emissions from commercial swine buildings. *Transactions of the ASAE* (in press).

Hobbs, P. 1995. Measurement of Swine Odor Using Electronic Nose Technology. In: International Round Table on Swine Odor Control, pp. 36-39. Ames, Iowa, Iowa State University.

Hobbs, P.J., Misselbrook T.H., and Pain B.F., 1995. Assessment of Odours from Livestock Wastes by Photoionization Detector, and Electronic Nose, Olfactometry and Gas Chromatography-Mass Spectrometry. Journal of Agricultural Engineering Research, 60:137-144.

Hobbs PJ, Misselbrook TH, Cumby TR. 1999. Production and emission of odours and gases from aging pig waste. Journal of Agricultural Engineering Research 72(3):291-8.

Hoshmand, A. R.1998. *Statistical methods for environmental and agricultural sciences.* Boca Raton, FL: CRC Press.

Hudon G., C. Guy, and J. Hernia. 2000. Measurement of Odor Intensity by an Electronic Nose. Journal of the Air & Waste Management Association. 50:1750-1758.

Jones, M. P. J. Watts and R. J. Smith. 1994. A mobile dynamic olfactometer for feedlot odor studies. *Transactions of the ASAE* 10(3): 417-423.

Miner, J. R. 1997. Nuisance concerns and odor control. *Journal of Dairy Science.* 80(10): 2667-2672.

Miner, J. R. and M. Licht. 1980. Fabric swatches as an aid in livestock odor evaluations. In: *Livestock Waste: A Renewable Source; Proc. 4th International Symposium on Livestock Wastes.* Amarillo, TX, April 15-17. 302-305.

Ogink, N.W.M., C. van ter Beek, J.V. Klarenbeek. 1997. Odor emission from traditional and low-emitting swine housing systems: emission levels and their accuracy. St. Joseph, MI: American Society of Agricultural Engineers. ASAE Paper No. 97-4036.

Schiffman, S. S. and C. M. Williams. 1999. Evaluation of swine odor control products using human odor panels. In: Animal Waste Management Symposium. Raleigh, North Carolina State University. pp 110-118.

SPS. 2000. Cattle-feeding capital of the world, 2000 fed cattle survey. Southwestern Public Service Company, Amarillo, TX.

SPSS. 2000. SPSS Version 10 for Windows. Statistical Software. SPSS Inc., Chicago, IL.

Watts, P. J., M. Jones, S. C. Lott, R. W. Tucker, and R. J. Smith. 1994. Feedlot Odor Emissions Following Heavy Rainfall. Transactions of the American Society of Agricultural Engineers. 37(2):629-636.

Williams, C. M. and S. S. Schiffman. 1996. Effect of liquid swine manure additives on odor parameters. International Conference on Air Pollution from Agricultural Operations. Kansas City, MO. American Society of Agricultural Engineers. pp 409-412.

Wood, S. L., E. F. Wheeler and K. B. Kephart. 2000. Reliability of subjective odor quantification using the refined cloth swatch olfactometric technique. Presented at the 2000 ASAE International Meeting, Paper No. 004022. ASAE, 2950 Niles Road, St. Joseph, MI 49085-9659 USA.

Zahn J.A., A.A. DiSpirito, Y.S. Do, B.E. Brooks, E.E. Cooper and J.L. Hatfield. 2001. Correlation of Human Olfactometry Responses to Airborne Concentrations of Malodorous Volatile Organic Compounds Emitted from Swine Effluent. Journal of Environmental Quality. 30:624-634.

Table 1. Site selection and sample collection.

Trial number	Start Date	Sampling / Collection Time	Feedyard	Sample Location	Comments
1	7-24-00	24 hr / afternoon	A	Northern end of pens; downwind from open pens	Same swatches used in Trial 1 and 2
2	7-24-00	24 hr / afternoon	A	Northern end of pens; downwind from open pens	
3	8-03-00	24 hr / afternoon	A	Northern end of pens; downwind from open pens	
4	3-05-01	24 hr / afternoon	B	Downwind from a runoff storage pond, approx. 30 meters north of the pond edge (also generally downwind from of several cattle pens)	
5	3-21-01	24 hr / morning	C	Middle of the feedyard, next to a processing facility/hospital	

Table 2. Average mass per unit area of fabrics used in the experiment.

Fabric	Mass/area (g/m^2)*
Acetate	127
Polyester Felt	215
Cotton Flannel	159
Cotton Muslin	110
Polyester	65
Composite	135
* Average of 5 swatches.	

Table 3. Summary of panelists by gender and age.

Panelist Number	Gender	Age
101	M	35
202	F	33
103	M	40
104	M	37
205	F	29
106	M	26
107	M	22
208	F	23
109	M	32
210	F	27
211	F	25
112	M	24
113	M	37
114	M	23
115	M	26
116	M	24
117	M	23
118	M	51
119	M	36
220	F	34
121	M	21
222	F	48
F = female, M = male, average age = 31		

Table 4. Sum of ranks for each fabric. Overall ranks by column are presented in parenthesis.

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Acetate	20 (1)	24 (4)	19.5 (2)	47.5 (4)	42.5 (5)
Polyester Felt	22 (2.5)	21.5 (2)	36.5 (5)	44.5 (2)	29 (3)
Flannel	22 (2.5)	20.5 (1)	19 (1)	45 (3)	27 (2)
Muslin	33 (5)	32 (5)	28 (3)	59.5 (5.5)	41 (4)
Polyester	23 (4)	22 (3)	32 (4)	38 (1)	45.5 (6)
Composite	*	*	*	59.5 (5.5)	25 (1)

* Composite not used in Trials 1-3.
** Rankings are from weakest odor (low number) to strongest odor (high number).

Table 5. Spearman rank correlation coefficients for Trial 1.

Panelist	101	202	103	104	205	106	107	208
101	1.00							
202	-0.50	1.00						
103	0.30	-0.60	1.00					
104	0.60	0.30	-.100	1.00				
205	0.50	-0.50	0.40	-0.20	1.00			
106	-0.30	0.60	-0.20	0.50	-0.90*	1.00		
107	0.40	-0.80	0.90*	-0.30	0.70	-0.60	1.00	
208	0.30	-0.10	0.30	-0.10	0.90*	-0.70	0.50	1.00

* Correlation is significant at the 0.05 significance level (2-tailed)

Table 6. Spearman rank correlation coefficients for Trial 2.

Panelist	101	103	205	106	107	208	109	210
101	1.00							
103	0.98**	1.00						
205	0.36	0.40	1.00					
106	-0.20	-0.30	0.00	1.00				
107	0.46	0.60	0.80	-0.10	1.00			
208	0.82	0.90*	0.30	-0.10	0.70	1.00		
109	-0.56	-0.60	0.30	-0.10	-0.20	-0.80	1.00	
210	-0.46	-0.60	-0.80	0.10	-1.00	-0.70	0.20	1.00

* Correlation is significant at the 0.05 significance level (2-tailed)
** Correlation is significant at the 0.01 significance level (2-tailed)

Table 7. Spearman rank correlation coefficients for Trial 3.

Panelist	101	103	104	106	208	210	211	205
101	1.00							
103	-0.50	1.00						
104	-0.16	-0.21	1.00					
106	-0.36	-0.31	0.89*	1.00				
208	0.15	-0.82	0.70	0.79	1.00			
210	-0.20	-0.60	0.53	0.56	0.72	1.00		
211	0.00	-0.50	0.95*	0.87	0.87	0.70	1.00	
205	-0.30	0.60	0.58	0.41	-0.10	-0.30	0.30	1.00
* Correlation is significant at the 0.05 significance level (2-tailed)								

Table 8. Spearman rank correlation coefficients for Trial 4.

Panelist	101	202	104	210	112	113	114	115	116	117	118	119	220	221
101	1.00													
202	0.14	1.00												
104	-0.35	0.24	1.00											
210	0.54	-0.66	-0.50	1.00										
112	-0.49	-0.54	-0.26	0.37	1.00									
113	-0.43	-0.03	-0.44	0.03	0.77	1.00								
114	-0.77	-0.26	-0.03	-0.09	0.89*	0.77	1.00							
115	0.54	0.31	-0.06	0.03	-0.49	-0.54	-0.43	1.00						
116	-0.32	-0.64	0.19	0.12	0.17	-0.38	0.20	0.23	1.00					
117	0.71	0.14	-0.35	0.37	-0.37	-0.09	-0.66	-0.14	-0.70	1.00				
118	-0.20	-0.77	-0.59	0.60	0.77	0.60	0.49	-0.60	0.12	0.09	1.00			
119	0.37	0.31	-0.79	0.20	0.14	0.60	0.03	0.03	-0.70	0.49	0.26	1.00		
220	-0.32	-0.62	-0.44	0.53	0.97**	0.76	0.76	-0.50	0.10	-0.18	0.88	0.26	1.00	
121	0.09	-0.09	-0.76	0.43	0.66	0.83*	0.49	-0.14	-0.38	0.14	0.6	0.83	0.74	1.00

* Correlation is significant at 0.05 significance level (2-tailed)
** Correlation is significant at 0.01 significance level (2-tailed)

Table 9. Spearman rank correlation coefficients for Trial 5.

Panelist	101	104	109	112	113	114	115	116	117	222
101	1.00									
104	0.41	1.00								
109	0.20	0.79	1.00							
112	0.09	0.03	-0.31	1.00						
113	-0.09	0.35	0.14	0.83*	1.00					
114	0.14	-0.15	0.14	0.43	0.43	1.00				
115	0.60	0.35	0.66	-0.20	-0.03	-.60	1.00			
116	-0.55	-0.84*	-0.64	-0.23	-0.32	-0.12	-0.41	1.00		
117	0.21	-0.19	0.03	0.33	0.39	0.82*	0.58	0.18	1.00	
222	0.54	0.24	-0.09	0.77	0.49	0.43	0.14	-0.64	0.15	1.00
* Correlation is significant at 0.05 significance level (2-tailed)										

Table 10. Spearman rank correlation coefficients comparing panelists in Trial 1 and 2 to assess repeatability of panelists.

		Panelists in Trial 1					
		101	103	106	205	107	208
Panelists in Trial 2	101	**0.98****					
	103		**0.10**				
	106			**0.60**			
	205				**0.90***		
	107					**0.50**	
	208						**0.70**
* Correlation is significant at 0.05 significance level (2-tailed) ** Correlation is significant at 0.01 significance level (2-tailed)							