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# The relationship between compost bedded pack performance, management, and bacterial counts

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## ABSTRACT

The objective of this study was to assess the relationships among temperature, moisture, carbon-to-nitrogen (C:N) ratio, space per cow, and bacterial counts from bedding material collected from compost bedded pack (CBP) barns. A field survey of 42 routinely aerated CBP barns was conducted in Kentucky between October 2010 and March 2011. Two bedding material samples of 1,064.7 $cm^3$ each were collected during a single site visit from 9 evenly distributed locations throughout each barn and thoroughly mixed to create a composite sample representative of the entire CBP. Bacterial counts were determined for coliforms, *Escherichia coli*, streptococci, staphylococci, and *Bacillus* spp. University of Kentucky Regulatory Services (Lexington) laboratory personnel performed nutrient analyses to determine moisture, carbon, and nitrogen contents. Surface and 10.2-cm pack depth temperatures were collected for each of the 9 evenly distributed locations and the mean calculated to produce a composite temperature. Space per cow was calculated as the total CBP area divided by number of cows housed on the CBP. The GLM procedure of SAS (SAS Institute Inc., Cary, NC) generated models to describe factors affecting bacterial counts. Bacterial counts were $6.3 \pm 0.6$, $6.0 \pm 0.6$, $7.2 \pm 0.7$, $7.9 \pm 0.5$, and $7.6 \pm 0.5$ $\log_{10}$ cfu/g of dry matter for coliform, *Escherichia coli*, streptococci, staphylococci, and *Bacillus* spp., respectively. Composite temperature, CBP moisture, C:N ratio, and space per cow had no effect on coliform counts. *Escherichia coli* reached a peak concentration when the C:N ratio was between 30:1 and 35:1. Staphylococci counts increased as ambient temperature increased. Streptococci counts decreased with increased space per cow and composite temperature and increased with increasing ambient temperature and moisture. Streptococci counts peaked at a C:N ratio ranging from 16:1 to 18:1. *Bacillus* spp. counts were reduced with increasing moisture, C:N ratio, and ambient temperature. Mastitis-causing bacteria thrive in similar conditions to that of composting bacteria and microbes, making elimination of these at higher temperatures (55 to 65°C) difficult in an active composting environment. Producers must use recommended milking procedures and other preventative practices to maintain low somatic cell count in herds with a CBP barn.
**Key words:** compost bedded pack barn, bacterial analysis, somatic cell count

## INTRODUCTION

Virginia dairy farmers developed the compost bedded pack (**CBP**) barn concept to improve cow comfort, increase cow longevity, and reduce initial barn costs (Barberg et al., 2007b) while potentially reducing the mastitis risks associated with the conventional bedded pack. Producers used the bedded pack system layout and incorporated composting methods. Compost bedded pack barns provide an open resting area free of stalls or partitions (Janni et al., 2007). Producers use fine wood shavings or sawdust as bedding (Janni et al., 2007). A cultivator or rototiller incorporates manure, urine, and air into the CBP typically during milking 2 or 3 times per day (Barberg et al., 2007a; Janni et al., 2007; Shane et al., 2010). Aeration increases metabolic heat production by aerobic microbes and bacteria (Suler and Finstein, 1977). Higher temperatures (55 to 65°C) promote pathogen destruction (Stentiford, 1996), which may be advantageous for mastitis-causing bacteria destruction. However, temperatures observed by Barberg et al. (2007a), Klaas et al. (2010), and Black et al. (2013) did not reach the level necessary for bedding sanitization. The lack of material sanitization during the microbial processes in the CBP indicates that the system is more of a semi-composting system that does not fully cycle through the entire composting process. Higher temperatures also increase moisture evaporation (NRAES, 1992). Manure, urine, and microbial activity

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moisture act as moisture sources in a CBP (Janni et al., 2007). The CBP should remain between 50 to 60% moisture for efficient composting (Gray et al., 1971; Suler and Finstein, 1977; NRAES, 1992).

Compost bedded pack barns do not have stalls or partitions and cows are allotted a given amount of space per cow. Wagner (2002) originally recommended 9.4 $m^2$/cow for CBP barns. However, to accommodate cow manure and urine output, Janni et al. (2007) recommended 7.4 $m^2$/cow for a 540-kg Holstein cow or 6.0 $m^2$/cow for a 410-kg Jersey cow. Overstocking the CBP barn may result in increased bedding needs or dirty cows. Proper cow hygiene management can reduce mastitis risk (Neave et al., 1969; Philpot, 1979; Schreiner and Ruegg, 2003; Reneau et al., 2005). Barberg et al. (2007b) observed a mean hygiene score of 2.66, where 1 = clean and 5 = very dirty (Reneau et al., 2005), for the 12 CBP barns visited, whereas Shane et al. (2010) observed a mean hygiene score of 3.1 for 6 CBP barns. A study comparing CBP barns, cross-ventilated (**C-V**) barns, and naturally ventilated (**N-V**) barns noted that cows housed in CBP barns had increased ($P < 0.05$) hygiene scores (3.18) compared with the C-V (2.83) and N-V (2.77) barns (Lobeck et al., 2011). Udder health, indicated by SCC, improved after moving cows into the CBP barn in a study by Barberg et al. (2007b), where the mastitis infection rate (cows with SCC ≥200,000 cells/mL) decreased from 35.4 to 27.7%. Klaas et al. (2010) observed SCC of 133,000, 214,000, and 229,000 cells/mL for the 3 barns in Israel operating CBP barns without additional bedding added.

A direct correlation exists between the bacteria load at the teat end and mastitis incidence (Neave et al., 1966). Bedding contributes to teat end bacterial load (Hogan et al., 1989; Hogan and Smith, 1997; Zdanowicz et al., 2004) and minimizing bedding bacterial counts is an important management strategy. Janni et al. (2007) recommended avoiding green or wet (from uncured wood) sawdust or shavings because of possible increased teat-end exposure to *Klebsiella* spp. (Newman and Kowalski, 1973; Bagley et al., 1978; Fairchild et al., 1982). Inorganic bedding, such as sand or crushed limestone, typically hinders bacterial growth within bedding material through a lack of nutrients compared with organic bedding materials (Fairchild et al., 1982; Hogan et al., 1989; Zdanowicz et al., 2004; LeJeune and Kauffman, 2005). However, composting microbes and bacteria require a carbon source to proliferate, making inorganic bedding an impractical choice for use in CBP barns. Reported ranges for bacterial counts in dairy sawdust bedding are highly variable [15.8 $\log_{10}$ cfu/g (Fairchild et al., 1982); 6.2 $\log_{10}$ cfu/g (Hogan et al., 1989); 17.8 $\log_{10}$ cfu/g (Rendos et al., 1975)] and *Klebsiella* spp. [15.0 $\log_{10}$ cfu/g (Fairchild et al., 1982); 4.8 $\log_{10}$ cfu/g (Hogan et al. 1989); 15.3 $\log_{10}$ cfu/g (Rendos et al., 1975)] and streptococci [7.1 $\log_{10}$ cfu/g (Hogan et al., 1989); 16.2 $\log_{10}$ cfu/g (Rendos et al., 1975)] in sawdust bedding have been reported in bedding used in dairy barns. Chopped straw contained similar coliform counts (7.1 $\log_{10}$ cfu/g), *Klebsiella* spp. (6.3 $\log_{10}$ cfu/g), and streptococci (7.8 $\log_{10}$ cfu/g) compared with sawdust (Hogan et al., 1989). The bacterial concentration in organic bedding makes it imperative to manage teat-end cleanliness.

A Minnesota study by Barberg et al. (2007a) reported total bacterial counts of 7.0 $\log_{10}$ cfu/g in 12 CBP barns, a content less than the 13.8 $\log_{10}$ cfu/g expected to increase risk for clinical mastitis (Jasper, 1980). Lobeck et al. (2012) determined that bedding in CBP, C-V, and N-V barns exhibited no difference ($P > 0.05$) in coliform, *Klebsiella* spp., environmental *Streptococcus*, or *Staphylococcus* species counts. However, CBP barns contained greater ($P < 0.05$) *Bacillus* levels (798,000 cfu/g) in the summer than N-V (366,000 cfu/g) and C-V barns (59,000 cfu/g) and lesser *Bacillus* spp. (800 cfu/g) in the winter than N-V barns (9,881,000 cfu/g). Bulk tank milk contained similar levels of *Staphylococcus aureus*, non-*agalactiae Streptococcus* spp., *Staphylococcus* spp., and coliforms for the 3 housing systems. The objectives of the current study were to define total bacteria populations of streptococci, staphylococci, *Bacillus* spp., coliforms, and *Escherichia coli* within the CBP barn system and evaluate management strategies for reducing CBP bacteria levels.

## MATERIALS AND METHODS

A field survey of 42 aerated CBP barns was conducted in Kentucky between October 2010 and March 2011. Each farm was visited once during the study period, with 2 to 3 different site visits per collection day. Of the 42 barns, 32 barns were used as the primary housing facility for lactating cows. The remaining 13 barns were used as supplemental housing for special needs cows (i.e., lame, old, and sick cows). A companion paper describes herd characteristics; management practices; producer perception of the CBP system; compost characteristics, including CBP temperature, moisture, and nutrient values; and herd performance, including lameness, hygiene, and production and reproductive performance (Black et al., 2013). Damasceno (2012) described structure characteristics for these barns, including building material, dimensions, and layout. Compost characteristics, including physical, bacterial, chemical, and thermal properties, observed in this study were also described previously (Damasceno, 2012).