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Lining bunker walls with oxygen barrier film reduces nutrient losses in corn silages

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ABSTRACT

The objective of this study was to evaluate 2 systems for covering corn silage in bunker silos. The first system consisted of a sheet of 45-μm-thick oxygen barrier film (OB, polyethylene + ethylene-vinyl alcohol) placed along the length of the sidewall before filling. After filling, the excess film was pulled over the wall on top of the silage, and a sheet of polyethylene was placed on top. The second system involved using a standard sheet (ST) of 180-μm-thick polyethylene film. Eight commercial bunker silos were divided into 2 parts lengthwise so that one-half of the silo was covered with OB and the other half with a ST system. During the filling, 3 net bags with chopped corn were buried in the central part (halfway between the top and bottom of the silo) of the bunkers (CCOR) in 3 sections 10 m apart. After filling, 18 net bags (9 per covering system) were buried 40 cm below the top surface of the 3 sections. These bags were placed at 3 distances from the bunker walls (0 to 50 cm, 51 to 100 cm, and 101 to 150 cm). During unloading, the bags were removed from the silos to determine the dry matter (DM) losses, fermentation end products, and nutritive value. The Milk2006 spreadsheet was used to estimate milk per tonne of DM. The model included the fixed effect of treatment (7 different locations in the bunker) and the random effect of the silo. Two contrasts were tested to compare silages in the top laterals (shoulders) with that in the CCOR (CCOR vs. OB and CCOR vs. ST). Three contrasts compared the corresponding distances of the silage covered by the 2 systems (OB50 vs. ST50, OB100 vs. ST100 and OB150 vs. ST150). Variables were analyzed with the PROC MIXED procedure of the SAS at the 5% level. The OB method produced well-fermented silages, which were similar to CCOR, whereas the OB system showed less lactic acid and greater pH and mold counts compared with CCOR. The ST method had 116.2 kg of milk/t less than the CCOR, as the OB system and the CCOR were similar (1,258.3 and 1,294.0 kg/t, respectively). Regarding the distances from the walls, the effects were more pronounced from 0 to 101 cm. The OB50 and OB100 silages had better quality and lower mold counts and DM losses than ST50 and ST100. The OB system reduced DM and nutrient losses at the shoulders in farm bunker corn silages compared with no sidewall plastic. The OB film should lap onto the crop for at least 200 cm so that 150 cm are covered outward from the wall.
Key words: aerobic deterioration, oxygen barrier film, maize silage, sidewall plastic

INTRODUCTION

The importance of corn silage to the dairy industry implies that spoilage in this feed can affect DMI (Gerlach et al., 2013) and it has fundamental implications for overall profitability of the industry (Kristensen et al., 2010). Furthermore, silage spoilage can risk the safety of operators on the farm and causes problems for consumers because of the potential transfer of microorganisms and mycotoxins from silage to milk (Cavallarin et al., 2011; Ogunade et al., 2016).

The bunker silo is widely used by livestock farms; however, this type of silo allows the corn silage to be more prone to deterioration (Bolsen et al., 1993), especially at the shoulders (Ashbell and Kashanchi, 1987; Honig, 1991; Chen and Weinberg, 2009). This can be explained by the variation of density within a bunker silo (Holmes, 2009). Silage density tends to decrease from the bottom to the peripheral layer (Muck and Huhnke, 1995). When only the upper layer is considered, density varies horizontally because the top center is denser than shoulder (D'Amours and Savoie, 2005; Borreani et al., 2008). Despite that, air can infiltrate between the wall and the cover plastic, and rain can run off the plastic and through the silage at the wall (Muck, 2011). Thus, avoiding or reducing spoilage at the shoulders of corn silages when they are stored in bunker silos becomes a key factor for commercial farms.

The management necessary to prevent aerobic deterioration in bunkers requires proper chop length, rapid

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filling, good packing, coverage with plastic, and a proper feed-out rate (Mahanna and Chase, 2003; Wilkinson and Davies, 2013). Among these alternatives, the quality of the plastic film and how well it is secured to the crop are considered keys to eliminating top spoilage (Muck, 2011). Oxygen barrier films (**OB**) have reduced oxygen permeability compared with standard polyethylene (**PE**) films (Borreani et al., 2007; Wilkinson and Fenlon, 2013). Currently, 2 types of oxygen barrier films are available on the market (Bernardes, 2016). The first one is a white-on-black sheet (130-µm-thick), which is composed by a layer of ethylene-vinyl alcohol (**EVOH**) between layers of PE (known as a 1-step system). A study demonstrated that corn silage quality in the upper part was improved when this plastic film was used to cover bunker silos (Borreani and Tabacco, 2014). The second OB film is a thin sheet (45-µm-thick PE + EVOH), which needs to be covered by a tarp or a second layer of PE during its application in practical conditions (2-step system). This procedure is necessary because it is not UV stabilized. Originally, the thin OB film was associated with a protective tarpaulin. However, tarpaulin cover is expensive for some producers, especially those with modest resource availability. Thus, to overcome this problem, a method that combines the thin OB film with a conventional PE sheet has been created for covering stack silos (Bernardes et al., 2009).

As the quality of film is not the full answer to preventing spoiled silage at the top because the film needs to be held to the forage (Muck, 2011) and the shoulders present a high risk of losses, we hypothesized that an effective way of reducing shoulder (top lateral) spoilage is to line bunker walls with the thin OB film before filling, overlap it onto the forage, and finally cover the entire silo using a PE sheet. Therefore, the aims of this study were to (1) evaluate the effect of a 2-step system on the fermentation end products, spoilage microorganisms, and nutrient losses of corn silage in dairy farm bunker silos; (2) determine how much OB film needed to be purchased for lining walls and protecting the top lateral by examining the effects of the 2-step system in different distances from the wall.

MATERIALS AND METHODS

Experimental Design, Treatments, and Sampling

Eight commercial bunker corn silages were sampled during a 2-yr period, 4 in 2014 and 4 in 2015. Bunker silos belonged to dairy farms located in the south of Minas Gerais state, which is the largest milk producer in Brazil. The width of the bunkers ranged from 4.9 to 6.5 m, the height from 2.5 to 3.3 m, and the length from 39 to 55 m. The average storage period and daily feed-out rate were 134 d (98–166 d) and 0.91 m (0.68–1.13 m), respectively. Whole-crop corn silages were harvested with both pull-type and self-propelled forage harvesters to a 12 to 15 mm theoretical length of cut. All corn silages were inoculated with 3.2×10^5 cfu of *Pediococcus acidilactic* and *Lactobacillus plantarum* (Kera, Farroupilha, Brazil) per gram of fresh matter. This product is very common among dairies in this region and the company recommended the dose applied.

Two methods to seal bunker silos were evaluated, as illustrated in the Figure 1. The first method involved a sheet of 45-µm-thick OB film (PE + EVOH) positioned along the length of the sidewall before filling, with approximately 2 m of excess draped over the wall. After the silo was filled, the excess film was overlapped onto the forage, and a sheet of PE was placed on top of the OB film. The second method involved using a standard sheet (**ST**) of 180-µm-thick PE film. This sheet protected the entire top of the silo (i.e., the OB film on

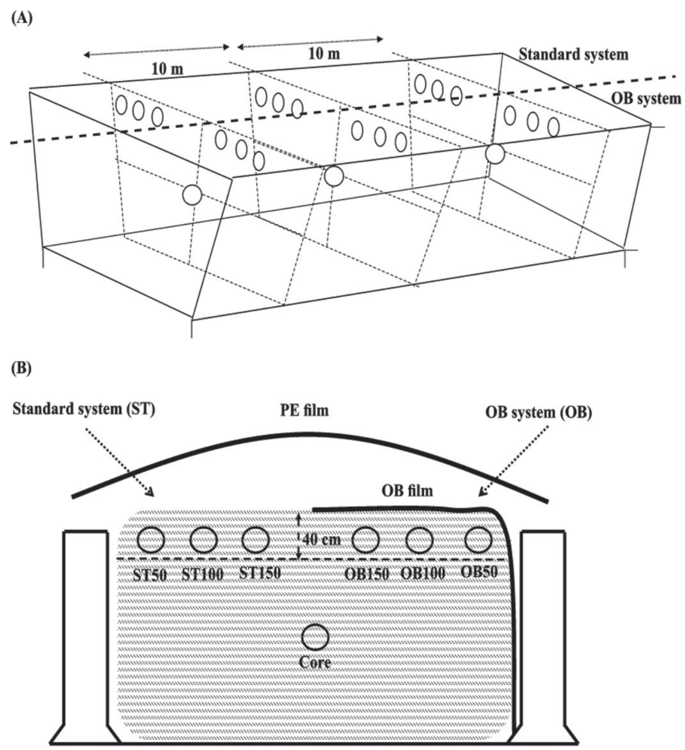

Figure 1. The 2 methods used to seal the bunker silos. (A) Bunker silos were longitudinally split into 2 parts to apply the 2 covering methods and transversally into 3 sections to bury the net bags. (B) A frontal view of the bunker showing the locations where the treatments were applied. Core = central core of the silo; OB50, OB100, and OB150 and ST50, ST100, and ST150 = 0 to 50, 51 to 100, and 101 to 150 cm from the bunker walls for oxygen barrier film (OB) on the walls and no wall film (ST), respectively. PE = polyethylene.