EFFECT OF A SILO SEALING SYSTEM BASED ON AN OXYGEN BARRIER FILM ON COMPOSITION AND LOSSES FROM THE UPPER LAYER OF GRASS/CLOVER CROPS ENSILED IN FARM-SCALE SILOS

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Abstract. *Two experiments were conducted to investigate the extent to which a silo sealing system based on the oxygen barrier film 'Silostop' (S; 45 µm thickness) influenced the preservation quality of silage in the upper layer of the silo compared to a conventional sealing system comprising white-on-black polyethylene film (C; 150 µm thickness). Primary growth grass/clover crops were ensiled for 120 days in bunker silos split lengthways and covered with either S or C. Losses were estimated by burying bags beneath the top surface (Experiment 1) or by weighing inedible material (Experiment 2). Yeast counts were similar for the two crops at harvest, but the mould count was numerically higher in the crop at harvest in Experiment 2 than in Experiment 1, possibly reflecting wet weather. Silage in the upper 30 cm layer under S had higher concentrations of lactic acid than material stored under C ($P < 0.05$). In both experiments, counts of yeasts, moulds and clostridial spores were numerically lower for silage under S than for silage under C. Mycotoxins were not detected in silage samples. Losses of DM from the upper 30 cm layer in Experiment 1 averaged 5.0% and 2.5% for C and S, respectively. In Experiment 2, inedible silage fresh weight discarded from the top 30 cm layer was 1.7 tonnes (0.1%) and 100 tonnes (5.9% of total fresh weight ensiled) for S and C, respectively. Oxygen barrier film has the potential to reduce top spoilage and improve the microbiological quality of grass/clover silage.*[1]

Keywords: *Silage, silos, polyethylene film, oxygen barrier film, losses.*

Introduction

The upper layer of silage in bunker silos covered with conventional polyethylene film can deteriorate if oxygen ingress occurs by permeation through the top polyethylene film during the storage period. Bolsen (1995) estimated that over 25% of the silage mass is within the top 1 metre of a 1000-tonne bunker silo of 12 metres width, 32 metres length and 3.7 metres height. Waste silage near the top surface can therefore account for a significant proportion of the total mass in poorly sealed silos and farmers are advised to discard material adjudged to be inedible by livestock. Nevertheless, inedible material may be included accidentally with edible silage in the diet of livestock. Whitlock *et al*. (2000) recorded decreases in the intake of silage by cattle given increments of surface-spoiled maize silage in the diet with the first increment of spoiled silage, 5.4% of diet dry matter (DM), having the greatest detrimental effect. If mycotoxins are present in the spoiled material, there may be adverse effects on animal health (Wilkinson, 1999).

The development of co-extruded oxygen barrier (OB) film for use in forage conservation, in which polyethylene is combined with other polymers such as polyamide, introduces the possibility of restricting the ingress of oxygen through the top surface cover of the silo and into the upper layer of the ensiled crop. Wilkinson & Rimini (2002) observed no visible surface mould and lower losses of dry matter (DM) in ryegrass ensiled for 175 days in laboratory silos covered either with OB film of 45 µm thickness, compared with either double or single layers of conventional polyethylene film of 125 µm thickness. Silage adjudged visually to be inedible was significantly less for the material stored under OB (3.5% of total silage DM) compared to that stored under a double layer (14%) or under a single layer of conventional polyethylene film (20%).

In farm-scale silos, losses of silage from the upper layer of bunker silos tended to be lower when the silos were covered with OB film compared to a single layer of standard polyethylene film (Kuber *et al*., 2008; Rich *et al*., 2009; Basso *et al*., 2009). Borreani *et al*. (2007) found, with untreated maize silage stored in a split single farm-scale bunker silo under either OB film or under conventional film (C), that loss of DM from bags buried in the upper 40 cm layer was 37% and 10% for OB and C, respectively ($P < 0.05$). The reduction in loss of DM was attributed to a reduction in mould count and was also associated with a reduction in butyric acid spore count (Borreani & Tabacco, 2008).

The two studies described here were undertaken with grass/clover crops ensiled in farm-scale bunker silos to compare the effect, on the preservation of silage in the top 30 cm layer, of a silo sealing system based on OB film compared to a sealing system based on conventional polyethylene film.

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Materials and methods

Experiment 1 – Estonia

The experiment was conducted at Kehtna Cooperative Farm, 45 km from Saku, Estonia (Kehtna, 58° 55'N, 24° 54'E). A primary growth red clover-grass sward, in its second year from sowing, was mown with a rotary mower (Lely), harvested between 15 and 18 June 2009, and ensiled in a single bunker silo (39 m x 13 m x 3 m) of 1000 tonnes capacity with concrete walls and floor. The crop, comprising red clover at the start of flowering and a mixture of grass species at ear emergence, was harvested after a 2 to 3-hour wilting period in swaths, in dry weather, with a 'Pöttinger Jumbo' forage wagon. The crop was treated at harvest with an inoculant ('Sil-All', Alltech Inc.) at an application rate of 3 litres per tonne of crop fresh weight. The crop was packed into the silo as evenly as possible with a T-150K heavy tractor of 11 tonnes in weight. Both sides were compacted to the same average height of filled material of 2.5 metres.

One half of the top surface of the silo was covered lengthways with OB film ('Silostop', Industria Plastica Monregalese, Mondovi, Italy) of 45 µm thickness, on which was placed a woven polypropylene net to reduce exposure of the film to ultra-violet (UV) light (Treatment S). The other half of the top surface was covered with a single layer of conventional white-on-black plastic film of 150 µm thickness (Treatment C). The conventional film was protected by a single layer of car tyres. Divisions between sheets and the outer edges of the silo were weighted down with 20 kg bags of woven polypropylene containing gravel. Eight samples, each of 0.3 kg fresh weight, were taken from the upper 30 cm layer after filling was completed and bulked into two samples for microbiological and compositional analysis.

The storage period lasted for 120 days, after which four samples of the silage were taken by corer to a depth of 30 cm from the top surface of each side of the silo, avoiding the peripheral area, for chemical and microbiological analyses, and for assessment of aerobic stability.

Concentrations of volatile fatty acids (VFA), ethanol, ammonia N and the pH values of the silage samples were determined in silage liquor following homogenation of the samples in distilled water. Ammonia N was determined by using the Kjeldec 1030 Autosystem. Ethanol, VFA and butandiole were determined by gas chromatography (Faithfull, 2002). Concentrations of DM, crude protein (CP) crude fibre (CF) and ash were determined on dried and ground samples (AOAC, 1990). Water-soluble carbohydrates (WSC) were determined by the Bertran method (Thomas, 1977). Mycotoxins were determined in the silage samples by standard high-performance liquid chromatography. Aflatoxin was determined according to method EN-14123 (Estonian Centre for Standardisation (EVS), 2008), ochratoxin A by method EN-14132 (EVS, 2003), deoxynivalenol by method EN-15891 (European Committee for Standardisation, 2009) and T-2 toxin by the EC-IRMM method (European Commission, 2006). The limits of determination of toxins were: Aflatoxin B_1, 0.1 µg kg DM^{-1}; ochratoxin A (OTA), 0.9 µg kg DM^{-1}; deoxynivalenol (DON), 250 µg kg DM^{-1}; T2 toxin, 7.0 µg kg DM^{-1}.

Four gauze cloth bags (2.0 kg fresh weight) were filled with the same grass/clover crop during the silo filling period and placed within the top 30 cm of each side of the silo. The difference in the weight of the bags before and after the storage period was used to calculate loss of DM.

Four sub-samples of silage of 25 g fresh weight were taken from the 30-cm depth cores and placed in insulated polystyrene boxes for assessment of aerobic stability. Two separate boxes for each treatment were kept at a constant ambient temperature of 25°C. Aerobic stability was defined as the amount of elapsed time for the first colonies of mould to appear on the surface of silage. The total duration of the study was seven days (168 hours).

The data for chemical composition were statistically analyzed by the Tukey test. A single sub-sample was derived by mixing and pooling four sub-samples from each side of the silo for determination of microflora and mycotoxins; statistical analysis was therefore not possible on these data.

Experiment 2 – Latvia

The experiment was conducted at 'Kalnadambrani' Farm in the Viesites region of Latvia, 145 km from Riga (57° 4'N, 25° 65'E). A primary growth red clover-grass sward, in its third year from sowing, was mown with a Kverneland mower-conditioner and harvested by Claas forage harvester between 2 and 6 June 2009. The red clover was at the start of flowering and the grass, a mixture of species, was at ear emergence. The crop was harvested after a 24-hour wilting period in wet weather and a total of 1700 tonnes fresh weight was ensiled in a single bunker silo (42 m x 14 m x 4 m) with concrete walls and floor. The material was packed into the silo as evenly as possible with two tractors, a K-700 and a K-701 tractor, 14 and 12 tonnes in weight respectively, to a height of 3.5 metres on both sides of the silo,. An inoculant comprising *Lactobacillus plantarum* and *Propionobacterium* ('Kofasil Life', Proventus Farm Pluss, SIA) was added to the crop to provide about 10^6 colony forming units (CFU) per gram of fresh crop.

Half the silo was covered lengthways with OB film ('Silostop', treatment S) 45µm thickness, on which was placed a woven polypropylene anti-UV net. The other half of the top surface was covered with a single layer of conventional white-on-black plastic film (Treatment C, 150µm thickness). The conventional film was protected by car tyres (1 tyre per 2 m^{-2}). Divisions between sheets and the outer edges of the silo were weighted down with 20 kg bags of woven polypropylene containing gravel. Four samples were taken at random from the upper 30 cm layer of the crop at the end of the silo filling period for microbiological and compositional analysis of the crop at harvest.

The duration of the storage period was 120 days. On opening the silo for feed-out, six samples of silage each of 1.5 kg fresh weight were taken at random from each side of the silo, avoiding the peripheral area, to 30 cm depth from the top surface of each side of the silo by

corer for chemical and microbiological analyses and for assessment of aerobic stability. Each sample was divided into three equal sub-samples: One for chemical analysis, one for microbiological analysis and one for aerobic stability, which was assessed visually by exposing each sample to air at a constant ambient temperature of 27^{o} C for a total period of 8 days.

Concentrations of chemical components in the fresh crop at harvest and of the silage were determined by standard methods: DM by ISO 6496–1999 (International Organization for Standardization, 2010); ash by ISO 5984–2002; CP by LVS EN ISO 5983–1–2005 (Latvian National Standards Institute, 2010); WSC by GOST 26171–91 (Russian Federation National Classification of Standards, 2010), NDF and ADF by the FiberCap 2021/2023 system. Net energy for lactation (NEL) was calculated from total digestible nutrients (TDN, % of DM) as follows: TDN = 88.9 – (ADF x 0.779), NEL (MJ kg DM^{-1}) = (0.0245 x TDN – 0.12) x 4.184 (Beca, 2004). Concentrations of water-soluble nitrogen (WSN) and ammonia nitrogen (NH3-N) were determined by the method of Moisio and Heikonen (1989). Silage pH (GOST 26180–84) and concentrations of fermentation products were determined by standard methods (Russian Federation National Classification of Standards, 2010): Lactic acid (GOST 23638–90), acetic acid (GOST 23638–90), butyric acid, (GOST 23637–90) and ethanol (determined in silage liquor following homogenation of the samples in distilled water and then by gas chromatography (Faithfull, 2002)).

Total bacterial count was determined by method LVS EN ISO 4833:2003 A (Latvian National Standards Institute, 2010), yeast and mould count by LVS ISO 21527–2:2008 (Latvian National Standards Institute, 2010), Butyric acid bacteria spore count (*Clostridium tyrobutyricum*) by anaerobic cultivation on selective Bryant and Burkey broth (Biolab Zrt, Romania). The limit of detection for the counts of total bacteria, yeasts and moulds was 1 colony forming unit (cfu) x 10^{1}. Mycotoxins were determined as described in Experiment 1 with the same limits of detection.

Losses were calculated by weighing the harvested crop as it was ensiled and by weighing all the material removed from the silo during the feed-out period. The height of the filled silo (i.e. the distance from the floor to the top surface) and during the feed-out period was measured in six places on each side of the silo to assess the extent to which the two sides may have changed in height during the storage period.

The data for chemical composition were statistically analyzed by the Tukey test using Statistical Package for Social Sciences 17.0 for Windows (SPSS Inc. Chicago, IL, USA). Single pooled sub-samples of silage were analysed for microflora and mycotoxins and no statistical analyses were possible on these data.

Results and discussion

The use of farm-scale silos for the experiments had the advantage of being directly relevant to commercial practice in two European countries. However, by dividing a single silo at each location into two halves lengthways, there was the possibility that air might move from one side of the silo to the other during the storage period. To minimise the risk of air movement between the two sides of the silos, a continuous line of gravel bags was placed down the centre of each silo and there was a central overlap of the two films of about 1 metre at the centre which was not used for sampling. A weakness of the design was that the protective cover was not the same for the two films, although both the woven polypropylene and the car tyres would not be expected to have major inhibitory effects on oxygen ingress through the two plastic film covers. Nevertheless, the experiments were effectively a comparison of two contrasting systems of silo covering. The rationale for taking replicate samples at random from each side of the silos was to take account of possible variation in silage density in the upper layer of the silos.

The chemical composition of the crops at harvest is shown in Tables 1 and 2 for Experiments 1 and 2, respectively. The two grass/clover crops used in the two experiments were of similar composition with respect to DM, CP and WSC; both crops had relatively low concentrations of DM and WSC. The concentration of ash was somewhat higher in the crop harvested in Experiment 1 than in Experiment 2. The microbiological characteristics of the crops at harvest are in Table 3. Yeast counts were similar for the two crops, but the mould count of the crop harvested in Experiment 1 was lower (6.3 x 10^{4} cfu g^{-1}) than that of the crop harvested in Experiment 2 (8.85 x 10^{8} cfu g^{-1}). This may have been a consequence of wet weather during the field wilting and harvesting periods. Muck *et al*. (2003) noted that populations of moulds in crops after wilting are normally less than 10^{6} cfu g^{-1}, and Pahlow *et al*. (2003) stated that the typical population range of moulds on plants prior to ensiling was 10^{3} to 10^{5} cfu g^{-1} in fresh crop. The high mould count found in the crop harvested in Experiment 2 may have been a contributory factor to the poor fermentation quality of the material stored in the upper 30 cm layer under C (Table 2). No spores of *Clostridium tyrobutyricum* or mycotoxins were detected in the fresh crops.

Table 1. Experiment 1: Chemical composition of the crop at harvest and of the upper layer of silage covered with either conventional polyethylene (C) or oxygen barrier film (S)

	Crop at harvest	Silage			
Type of covering		C	S	s.e.d.	Sig.
Dry matter (DM, g kg $^{-1}$)	251	310	294	14.6	NS
pH	-	4.5	4.2	0.19	NS
Crude protein (CP, g kg DM^{-1})	152	151	156	3.60	NS
Ammonia – N (g kg total N^{-1})	-	59.0	48.0	3.20	P < 0.05
Crude fibre (CF, g kg DM^{-1})	262	254	256	6.12	NS
Ash (g kg DM^{-1})	96.0	95.0	97.0	2.30	NS
Water-soluble carbohydrates (g kg DM^{-1})	74.0	-	-		
Metabolizable energy (MJ kg DM^{-1})	10.0	-	-		
Lactic acid (g kg DM^{-1})	-	44.0	94.0	16.5	P < 0.05
Acetic acid (g kg DM^{-1})	-	17.5	19.5	2.24	NS
Propionic acid (g kg DM^{-1})	-	3.15	0.30	0.24	P < 0.05
Butyric acid (g kg DM^{-1})	-	6.20	0.45	2.70	P < 0.05
Ethanol (g kg DM^{-1})	-	0.85	1.35	0.62	NS
Butandiole (g kg DM^{-1})	-	1.60	0.45	0.16	P < 0.05

Table 2. Experiment 2: Chemical composition of the crop at harvest and of the upper layer of silage covered with either conventional polyethylene (C) or oxygen barrier film (S)

	Crop at harvest	Silage			
Type of covering		C	S	s.e.d.	Sig.
Dry matter (DM, g kg $^{-1}$)	220	207	221	17.2	NS
pH	-	8.5	3.7	2.37	P < 0.05
Crude protein (CP, g kg DM^{-1})	151	110	142	3.82	P < 0.05
Ammonia – N (g kg total N^{-1})	-	145.0	69.0	7.87	P < 0.05
Ash (g kg DM^{-1})	71.0	91.0	80.0	4.76	NS
NDF (g kg DM^{-1})	508	603	570	15.4	NS
ADF (g kg DM^{-1})	327	460	434	10.2	P < 0.05
Water-soluble carbohydrates (g kg DM^{-1})	75.0	9.9	14.5	2.80	P < 0.05
NEL (MJ kg DM^{-1})	6.0	4.8	5.2	0.34	NS
Lactic acid (g kg DM^{-1})	-	0.60	17.1	3.50	P < 0.05
Acetic acid (g kg DM^{-1})	-	3.10	12.6	2.72	P < 0.05
Butyric acid (g kg DM^{-1})	-	6.10	0.0	0.54	P < 0.05
Ethanol (g kg DM^{-1})	-	11.0	24.0	2.32	P < 0.05

The chemical composition of the upper surfaces of the silages (samples taken to 30 cm depth from the top surface of the silos) is shown in Tables 1 and 2 for Experiments 1 and 2, respectively. Differences due to type of covering in chemical parameters were generally small in Experiment 1. However, in Experiment 2 concentrations of CP and WSC were lower, and concentrations of ash and acid detergent fibre higher, in silage covered by treatment C compared to that covered by treatment S (Table 2).

In Experiment 1, concentrations of NH_3-N, butyric acid and butandiole were lower, while the concentration of lactic acid was higher for silage under S than for silage under C ($P < 0.05$). In Experiment 2, mean pH value and concentration of ammonia N were substantially higher high in samples taken from silage under C than from silage stored under S ($P < 0.05$). Concentrations of both lactic and acetic acids were lower for silage under C compared to the silage under S in Experiment 2 ($P < 0.05$).

In both experiments counts of yeasts and clostridial spores were numerically lower for silage stored under S than under C (Table 3). In Experiment 2, the total bacterial count was markedly higher for silage under C than under S. In Experiment 2, vegetative cells and spores of *Clostridium tyrobutyricum* were detected in silage under C but not in material stored under S. Counts of moulds were lower for the silages stored under S than under C in both experiments (Table 3), as Borreani *et al*. (2007) also found for untreated maize silage. Mycotoxins were not detected in any of the silage samples in either experiment.

Table 3. Experiments 1 and 2: Microbiological characteristics (cfu/g) of the crops at harvest upper layer of silages covered with either conventional polyethylene (C) or oxygen barrier film (S)

	Experiment 1			Experiment 2		
	Crop at harvest	Silage		Crop at harvest	Silage	
Type of covering		C	S		C	S
Yeasts (cfu g^{-1})	4.5 x 10^4	1.3 x 10^4	6.8 x 10^2	4 x 10^4	2.2 x 10^7	2 x 10^5
Moulds (cfu g^{-1})	6.3 x 10^5	6.2 x 10^3	4.4 x 10^2	8.85 x 10^8	8 x 10^4	4 x 10^2
Clostridium tyrobutyricum vegetative cells (cfu g^{-1})	-	-	-	Not detected	1.95 x 10^6	Not detected
Clostridium tyrobutyricum spores (g^{-1})	Not detected	1.8 x 10^4	6.8 x 10^2	Not detected	1 x 10^2	Not detected
Total bacterial count (cfu g^{-1})	-	-	-	-	1.15 x 10^{12}	4 x 10^8

cfu = colony forming units

The higher concentrations of lactic acid in the silages stored under S probably reflected restricted development during the storage period of lactic acid-utilising micro-organisms such as *C. tyrobutyricum*. The count of spores of *C. tyrobutyricum* was numerically higher for silage stored under C than under S (Table 3), in agreement with the findings of Borreani & Tabacco (2008). These authors found that the higher counts of butyric acid bacterial spores were associated with higher mould counts, possibly as a consequence of oxygen ingress through the conventional film. Kwella & Weissbach (1991) observed that clostridial sporulation can be encouraged in silage which is exposed to oxygen.

In Experiment 2, silage in the upper 30 cm stored under C showed evidence of substantial deterioration during the storage period. The total quantity of silage fresh weight discarded in Experiment 2 from the top 30 cm layer because it was adjudged visually to be inedible by livestock was 1.7 tonnes (0.1%) and 100 tonnes (5.9% of the total 1700 tonnes fresh weight ensiled) for S and C, respectively. This material had a high pH and high ammonia-N concentration, a low concentration of lactic acid (Table 2) and a relatively high count (1.95×10^6 cfu g^{-1}) of vegetative cells of *C. tyrobutyricum* (Table 3). The deterioration was probably the result of oxygen diffusion through the conventional silo sealing film, especially in the summer months. Borreani & Tabacco, (2008) noted that the rate of oxygen diffusion can increase to more than 3000 cm^{-3} m^{-2} per 24h through conventional polyethylene film (180 μm thickness) if the temperature of the film is increased to 50°C by hot weather. The number of tyres per square metre was probably inadequate to restrict oxygen ingress through the conventional film in Experiment 2. Bernades *et al*. (2009) found that the upper layer of maize silage stored in experimental silos of 500 litres capacity under conventional plastic film (150 μm thickness) which was covered with a layer of soil had lower pH and a lower count of yeasts compared to the same crop stored under the same film without a covering of soil. Silage stored without soil showed a marked elevation in temperature between 60 and 120 days of storage whilst that stored under soil or under an OB film did not. Losses of DM were 29.7% and 5.4% for the uncovered and soil-covered film treatments, respectively. Comparable loss of DM in the same experiment from silage sealed with OB film (125 μm thickness) without soil covering was 11.8%.

Losses of DM from bags buried in the top 30 cm of the silo in Experiment 1 averaged 5.0% and 2.5% for C and S, respectively, in agreement with previous work with ryegrass (Wilkinson & Rimini, 2002). Borreani *et al*. (2007) found that loss of DM from the upper 40 cm layer was 10% for maize ensiled with no additive treatment and covered with an OB film of 125 μm thickness under farm-scale conditions in Italy. Comparable loss of DM averaged 38% for the same crop ensiled under conventional polyethylene film of 180 μm thickness. In Experiment 2, there was no change in the mean height of settled silage under S; in contrast there was a mean decrease of 5 cm in height of settled silage for material stored under C during the storage period. Wilkinson & Rimini (2002) found that inedible silage was significantly lower, for ryegrass ensiled under C compared to material ensiled under S; they also observed that there was no visible top surface mould on the silos covered with S but the depth of visible mould in silage under C was 15.3 cm from the top surface.

In Experiment 1 there was no visible mould development in any of the silage samples during the entire 7-day period of exposure to air. In Experiment 2, samples of silage under S showed no visible mould development during the 8-day period of exposure to air, whilst three of the six samples of silage stored under C showed visible mould development after 7 days exposure to air.

In conclusion, these results and those of others illustrate that to achieve low losses of DM from the upper layer of silos and to maintain good silage hygienic quality, it is important to place an effective protective layer on top of conventional polyethylene film in order to restrict oxygen permeation through the film, or alternatively to use an oxygen barrier film.

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Erinevate silokatmissüsteemide mõju tranšeesilo pealmise kihi kvaliteedile

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Kokkuvõte

Selleks, et selgitada uudse kattekile süsteemi Silostop (S; paksusega 45 µm) efektiivsust võrreldes tavalise must/valge polüetuleenkilega (C; paksusega 150 µm), viidi läbi kaks sileerimiskatset. Eesmärk oli uurida katmisüsteemi mõju silo ülemiste kihtide käärimise kvaliteedile, mikrobioloogilisele koostisele ja söödakadudele. Värskelt lõigatud punase ristiku ja kõrreliste segu sileeriti tranžeesse ja kaeti pikuti pooleks vastavalt S ning C kilega. Siloproovid võeti 120 päeva pärast. Kuivainekaod määrati kontrollkotikeste abil silos (katse1). Söödakaod määrati söödamatu ja riknenud silo kaalumise teel (katse 2).

Pärmide arvukus koristamisel oli sarnane mõlemas katses, kuid hallitusete arvukus oli ilmselt vihmade tõttu tunduvalt kõrgem teises katses. Silo ülemiste kihtide piimhappesisaldus oli tunduvalt kõrgem S-variandis ($P < 0.05$). Mõlemas katses oli klostriidide eoste arv, pärmide ja hallituste arvukus väiksem S variandis. Mükotoksiine üheski variandis ei esinenud. Keskmised kuivainekaod esimeses katses olid C ja S variandis vastavalt 5.0% ja 2.5%. Söötmiskõlbmatu silo ülakihi hulk katses 2 oli 1.7 tonni (variant S) ja 100 tonni (variant C). Silostop silohoidla katmissüsteemil on suur potentsiaal, et silo pinnaosa riknemist vähendada ning silo mikroobset koosseisu ja käärimise kvaliteeti parandada.

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