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TEST REPORT

Benchmark Test of Silage-film Systems in Silage Bunkers

Topic:

Impact of different silage film-systems on fermentation characteristics, Feed hygiene and aerobic stability of grass silage in bunker-silos

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Introduction

Only with the sealing off of feedstuffs against the incursion of atmospheric oxygen can the fermentation process take place, and this also protects the silage from aerobic spoilage during storage (Gross & Riebe, 1974). The supply of oxygen thus has a significant influence on the living conditions of the micro-organisms and therefore on the type of fermentation. The desired lactic fermentation and the speed of acidification are closely connected to the rapid creation of conditions which are as low-oxygen (anaerobic) as possible. According to Bernardes et al (2012) plastic foils have different material properties with regard to their permeability depending on their composition. So-called barrier films (OB = oxygen barrier, EOB = enhanced oxygen barrier) can achieve a considerably lower permeability to oxygen (Borreani & Tabacco, 2008; Robinson & Swanepoel, 2016). According to Wilkinson & Fenlon (2014) the results of 51 silage tests with film comparisons showed the positive effects of OB foils compared with traditional polyethylene foils with regard to mass loss and aerobic stability.
BÖCK Silosysteme GmbH has an interest in improving silage conservation methods and in 2017 commissioned the HBLFA Raumberg-Gumpenstein to carry out silage trials under real conditions comparing different film systems. The aim was to evaluate the effects of 3 silage bunker film systems on the quality and stability of the conserved silage as well as the amount of work needed to install the film systems.

Material and Method

A comparative test of silage bunker film systems under real conditions requires a silo facility with several identical chambers which can be filled with the same feed material at the same time. In spring 2017 there were three chambers available at the HBLFA Raumberg-Gumpenstein for ensiling the 1st grassland growth and therefore a research agreement was drawn up between BÖCK and the HBLFA which laid down the project framework for the film comparative test (silage trial S-67). This framework (Table 1) stipulated the testing of two film systems against a standard procedure for silage bunkers as a reference control measure.

Table 1: Silage Trial S-67 / 2017

Bunker	Variant	Foil system	Foil thickness (µm)
1	Kombi2plus	Combi-system with underlay foil + silage foil on one roll	35 + 115
2	Super7	7 layer silage foil with oxygen barrier	85
3	control	Underlay foil and silage foil separate	40 + 150

The silage bunkers were 5.2 m wide and 33 m long. The walls of the three chambers used in the comparison test were renovated so that the conditions at the start were the same (illus. 1).

Illus. 1: Silage facility after walls renovated (12.5.17) I   Illus. 2: Installing the wall foils (26.05.17)

Before the silo bunkers were filled side-wall film were installed in the three bunkers to ensure impermeability at the edges. The white PE wall film was 110 µm thick and 2 m wide (illus. 2). Eight grassland fields at the HBLFA Raumberg-Gumpenstein formed the basis for the feed and these were mown on 26th May 12017 (Table 2) and allowed to wilt to 400 to 480 g DM/kg FM until 27th May. A short cut loader was used for the harvest (illus. 3). The forage was unloaded evenly and then distributed with a silage spreader. This was then compacted with two four-wheel drive tractors working in parallel (illus. 4). The forage quantity was sufficient to fill the three silage bunkers to a length of 27 m.

Illus. 3: Transporting with short cut loader (27.05.17)   Illus. 4: Distributing forage with silage spreader

Table 2: Forage source and fill quantities in silage trial S-67

Silage bunker No.:	**1**	**2**	**3**
Field name:		**Quantity of forage (t FM)**	
58	0.00	13.14	13.75
Stainacher Wiese	12.60	5.86	18.23
Goschwiese	6.90	7.02	7.18
Irdningerwiese	13.27	13.11	5.51
Thalhammerwiese	12.12	15.54	0.62
Spalt/Mirtl	0.00	2.25	0.00
Schulwiese	10.20	0.00	6.56
Haiglwiese	0.00	6.35	7.18
Total	**55.08**	**63.25**	**59.01**

The film systems were installed on 27th May 2017 from 15:10 to 16:20 (illus. 5 to 7)

Illus. 5: Installation of Kombi2plus film in silage bunker 1

Illus. 6: Installation of Super7 film in silage bunker 2

Illus. 7: Installation of control film in silage bunker 3

The amount of time needed for each film variant was recorded, meaning that the total time required for each system could be calculated. The time requirements for installation of the film included unrolling the film across the middle of the silage bunker, stretching it over the entire surface and finally sealing it by weighing it down with gravel bags. The time needed for the silo protection grids including weighing down all around with gravel bags was recorded separately in order to establish the average amount of time needed for this step as well.

After 39 days of fermentation (05.07.2017) samples were taken from the three silage bunkers for chemical and micro-biological analysis as well as for durability testing, because one silage bunker had already had to be opened due to the dairy cattle needing grass silage. The samples were taken in two places in the silage bunkers, at the edge and in the middle, using a silage sample borer (Illus. 8)

Illus. 8: Silage sample borer

The sampling area at the edge was 20 to 30 cm from the side of the silage bunker, and the sampling area in the middle was 200 cm from the wall. Both long sides of the silage bunker were sampled to a depth of 25 cm in several places, so that a total of 24 samples were taken from the edges and 20 samples from the middle. All the sample material for each foil variant was mixed and part of it was then packed tight in screw jars for laboratory analysis and sent cooled to the laboratory.
The chemical and micro-biological analysis was carried out in the Rosenau Forage Laboratory (Lower Austria). Chemical analysis was conducted using wet-chemical methods in line with VDLUFA* (1976), the micro-biological analysis was in line with VDLUFA (2007). For the durability testing the remaining sample material was packed into plastic containers and stored with air stress at room temperature for 7 days. Temperature sensors were installed in the core of the feed in each container (illus. 9) to make it possible to observe changes in relation to room temperature at intervals of 30 minutes. The data were saved in a data logger (Mikromec Multisens).

Illus. 9: Durability test S-67 and temperature recording using Micromec Multisens data logger

*VDLUFA = Verband deutscher landwirtschaftlicher Untersuchungs- und Forschungsanstalten = Association of German Agricultural Analysis and Research Institutes

Results and Discussion

The aim was for the analysis of the samples from the silage trial S-67 to enable a descriptive evaluation of differences between the film systems in the test but also of differences between the sides and the middle in each of the silage bunkers. By measuring the work time it will be possible to calculate the amount of time needed for each of the three film systems tested.

DM Content

The DM content is a central factor in fermentation. The DM content of the silage samples corrected in line with Weissbach & Strubelt (2008) lay between 406 and 487 g/kg FM (Table 3) and was thus above the guideline value of 300 to 400 g/kg FM. In the context of the trial this degree of wilting is a little high and increases the probability of reduced compaction or a higher bacterial count with yeasts and moulds. The control sample showed somewhat higher DM content than the test variants both on the sides and in the middle. The DM contents for Super 7 and the control sample were lower at the sides than in the middle. Nevertheless the DM contents of the variants can be described as broadly comparable.

Table 3: Contents, fermentation quality and micro-biological status of grass silages dependent on sampling site at the time of opening (Silage trial S-67/2017)

Silage film system			Kombi2plus		Super7		Control	
Sampling site Parameter	abbrev	unit	side	middle	side	middle	side	middle
Dry matter corrected	DM	g/kg/ FM	442	443	406	466	446	487
Raw protein	XP	g/kg/ DM	129	128	127	133	129	127
Usable raw protein	nXP	g/kg/ DM	136	138	136	138	136	136
Ruminal N balance	RNB	g/kg/ DM	-1	-2	-1	-1	-1	-2
Crude fat	XL	g/kg/ DM	25	26	27	26	28	27
Crude fibre	XF	g/kg/ DM	252	236	253	244	253	251
Crude ash	XA	g/kg/ DM	67	68	69	70	71	67
Sugar	XZ	g/kg/ DM	161	158	139	153	163	167
OM digestibility	dOM	%	75,2	76,6	75	75,8	75	75,3
Metabolic energy	ME	MJ/kg DM	10,68	10,88	10,65	10,76	10,63	10,7
Net energy lactation	NEL	MJ/kg DM	6,43	6,59	6,41	6,5	6,4	6,45
Lactic acid	Ms	g/kg DM	26,9	22,8	22,7	25,7	24,7	23,7
Acetic acid	Es	g/kg DM	5,3	5,8	3,9	5,8	6	6,8
Propionic acid	Ps	g/kg DM	0	0	0,2	0	0	0
Total acid	Gs	g/kg DM	34,1	29,2	31,5	33,7	32,7	31
Ethanol	Eth	g/kg DM	6,9	7,4	3,6	4,7	7	5,8
Ammonia content in total N	NH3	% of total N	3,3	303	3,3	2,8	2,6	2,7
pH value	pH		4,2	4,2	4,6	4,6	4,3	4,4
Smell		points	11	12	11	11	10	11
Structure		points	4	4	4	4	4	4
Colour		points	1	1	1	1	1	1
Sensory evaluation		points	16	17	16	16	15	16
Compaction at depth 25 cm	Density	kg DM/m³	118	138	103	134	132	132
Aerobic mesophilic bacteria	Bacteria	CFU/g FM	330000	10000	850000	20000	340000	20000
Yeasts	Yeasts	CFU/g FM	<1000	1000	<1000	<1000	<1000	<1000
Moulds	Mould	CFU/g FM	<1000	<1000	<1000	<1000	<1000	<1000

Nutrients and Feed Energy

With regard to the timing of the harvest the median crude fibre contents of 248 g/kg DM point to the phenological state of maturity of formation of ears/panicles, which is an optimal value for silage from permanent grassland in Austria. The crude ash content was very low at an average of 569 g/kg DM, which suggests an uncontaminated harvest. The sugar content in the silage was very high at 157 g/kg DM and the raw protein content of 129 g/kg DM lay significantly below the guideline value of 140 g/kg DM. In particular the high sugar and low protein contents suggest a good ensilability of the material. The small differences between the variants or the zones (sides/middle) show that the conditions for fermentation of the forage material were comparable across the whole cross-section of the silage bunker.
The digestibility of organic matter and the energy density (ME and NEL) were calculated in the Rosenau laboratory according to Gruber et al (1997) on the basis of ash-corrected crude fibre content. In general the energy level was at a high average of 6.45 MJ NEL/kg DM. The differences between the variants and bunker zones are small, but could not be statistically verified due to the nature of the trial.

Fermentation Quality

Experience shows that the intensity of fermentation is heavily dependent on the DM content of the feed material. The moister the feed, the more acid has to be formed to bring the pH value to a stable level. With the available DM contents the necessary reduction in pH was achieved in each variant after 39 days' fermentation, with variant Super7 having a pH of 4.6. significantly higher than the two variants with underlay film (Table 3). The composition of the fermentation products showed relatively well pronounced lactic acid fermentation, which was almost identical at the sides and in the middle of the bunker for all 3 films.

Sensory Evaluation of Fermentation Quality

The silage samples were given points with regard to smell, structure and colour according to the ÖAG* sensory evaluation scale (Buchgraber, 2002). With regard to the smell this was generally felt to be a bready, slightly sweet, pleasant fermentation smell. There were only slight signs of an acidic odour, without traces of butyric acid above all towards the edges. The structure was optimal in all samples and not affected by fermentation. The colour was characterised by a visible contrast between dark leaves and light stems. This type of colouring points to a fermentation at slightly increased temperatures and is very typical with grass silages in silage bunkers with DM contents above 400 g/kg FM. The silages scored between 15 and 17 points, which corresponds to a good fermentation quality. There were only marginal differences between the film variants.

Compaction

Compaction of the sampled surface layers of the silage bunkers was also recorded. Up to a depth of 25 cm the bulk density lay between 103 and 138 kg DM/m3 (Table 3). According to Honig (1987) grass silage with a DM content of 450 g/kg FM should have a density of 243 kg DM/m3 so that the low pore volume prevents rapid seepage of atmospheric oxygen after opening. In this test the bulk density achieved was far short of the required levels, meaning that pore volume at the surface was much too high. This leads to air seeping into the grass silage more quickly after the bunker is opened, which can cause accelerated spoilage of the silage.

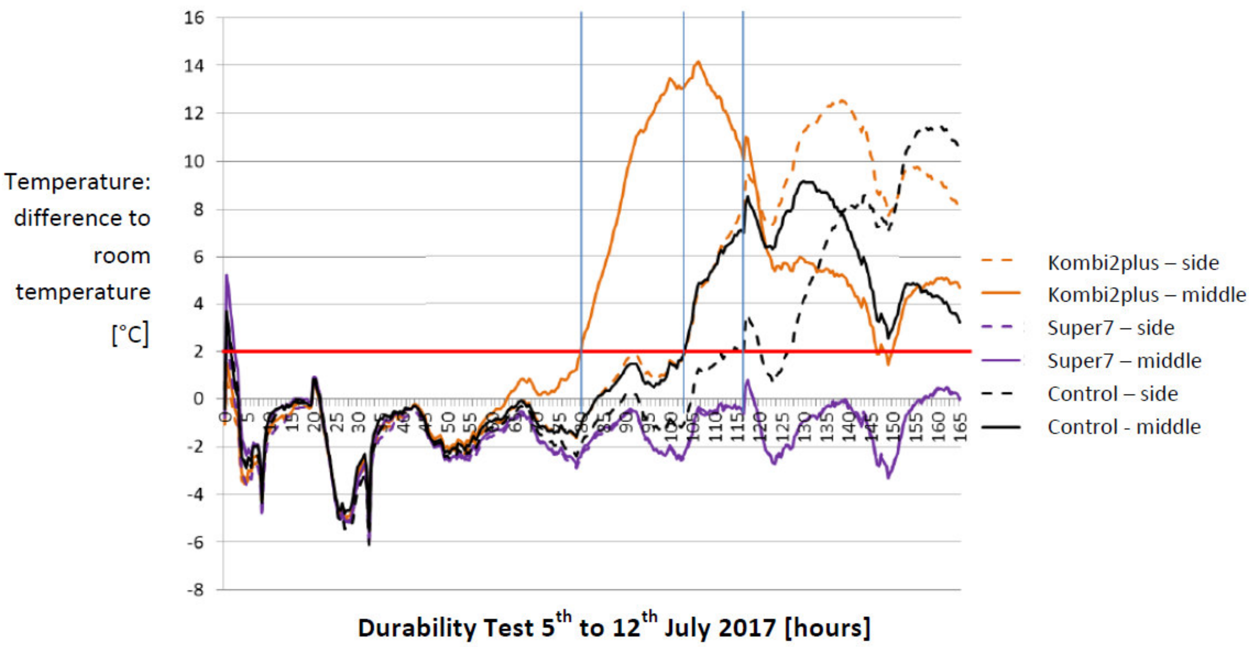
Micro-Biological Situation

When the silage bunkers were opened, micro-biological analysis showed that the levels of yeasts and moulds in the surface layer up to 25 cm depth reached a maximum of 1000 CFU/g FM. The bacterial count was thus far below the VDLUFA guideline values for feed spoilage, and so at impeccable levels of feed hygiene. With regard to aerobic mesophilic bacteria it was observed that the bacterial count at the edges was considerably higher than in the middle of the bunker (Table 3), although these levels were also in a harmless range.

Assessment of Aerobic Stability (ASTA) in Durability Test

Aerobic stability was assessed over 7 full days of storage from 5th to 11th July 2017. By tracking the silage temperature via in-built sensors it was possible to determine the point at which the silage temperature recorded a level 2°C above room temperature. Up to this point the grass silage can be regarded as stable.
In these silage trials the temperatures of the different variants did not diverge from each other until around 60 hours into the test. After this the temperature curves began to show differentiation (illus. 10). After 80 hours the variant Kombi2plus (middle of silage bunker) was the first to exceed +2°C above room temperature and then rose quickly to +14°C (max. 37.4°C). The Kombi2plus variant (side of bunker) and the control variant (middle of bunker) exceeded the critical temperature after 103 hours, while the control variant (side of bunker) did so after 116 hours. After more or less pronounced maximum temperatures of 32 to 34°C the temperatures of these two film variants gradually receded.

*ÖAG = Österreichische Arbeitsgemeinschaft für Grünland und Viehwirtschaft = Austrian Association of Grassland and Livestock Farming



Illus. 10: Temperature of grass silages in durability test dependent on sampling site and type of silage foil

The temperature course of the grass silage covered with the Super7 OB film was completely different. Throughout the entire 7 day period of the test there were only a few measurements recorded slightly above room temperature. There was also no noticeable difference in the temperature curves for the grass silage from the sides and from the middle of the bunker. The optimal temperatures recorded for the OB film confirm very good aerobic stability even after 165 hours of the test.
Meta-analysis of conventional silage bunker film systems and barrier film (Wilkinson & Fenlon, 2014) showed that the surface layer covered with OB film remains stable for longer (135 hours) than with conventional covers (75 hours). The HBLFA Raumberg-Gumpenstein tests were thus able to confirm these English results.

Sensory Evaluation of the Grass Silage after Durability Test

Evaluation after 7 days of air stress produced extremely different results. Irrespective of the sampling site (side or middle), the grass silages from the control variant and the Kombi2plus variant were completely spoilt by strong mould growth and in places the structure was greasy to slimy. The points total lay between -3 and 0 points, which can be regarded as totally spoilt and a very high deterioration in value. These grass silages were no longer at all suitable for livestock feed.

The grass silage with the Super7 OB film had two small patches of mould at the side, but otherwise the smell was bready, slightly roasty and pleasantly fermented. This grass silage was given 11 points due to the patches of mould, which represents a satisfactory silage quality. The sample for this film variant from the middle of the bunker had no patches of mould after 7 days of air stress and smelt just somewhat more intensely roasted and fermented. There was only a marginal loss of silage quality and it scored 15 points. This grass silage was perfectly acceptable from the point of view of feed hygiene.

Installation Times

In setting up the film comparison test the work time was measured in order to enable an evaluation of the effort needed in installing the covers with these three film systems. It was possible to establish that there were considerable time differences just for the installation of the film, without the time spent weighing down with gravel bags (Table 4). Since there were 2 people fewer working on the installation of the Kombi2plus variant, the results were mathematically adjusted to a uniform 10 workers. The total time for all workers showed that the Super7 OB film could be installed considerably more quickly than the two other variants, because the handling was clearly more straightforward. The conventional system with a separate underlay film and a silage film cover required the most time, with a total of 85 minutes. The combi-system with underlay and film cover on one roll needed 12 minutes less.

Table 4: Time required for installation of film covers on silage bunkers with three different film systems

Variant	Bunker	Clock times	Time needed (minutes)	People (number)	Total time (minutes)	Total time (hours)
Kombi2plus	1	15:10-15:19	9	9	81	1.35
Super7	2	15:38-15:41	3	11	33	0.55
Conventional	3	15:58-16:05	7	11	77	1.28
Kombi2plus	*1*			*10*	*73*	*1.22*
Super7	*2*			*10*	*36*	*0.61*
Conventional	*3*			*10*	*85*	*1.41*
		Relative deviation from control value (100)			%	
Kombi2plus	1				86	
Super7	2				42	
Conventional	3				100	

Normal font: exact figures from trial

Italic font: mathematically adjusted figures (same number of people)

Table 5: Time required for installation of film covers and weighing down with gravel bags on silage bunkers with three different film systems

Variant	Bunker	Clock times	Time needed (minutes)	People (number)	Total time (minutes)	Total time (hours)
Kombi2plus	1	15:10-15:28	18	9	162	2.70
Super7	2	15:38-15:47	9	11	99	1.65
Conventional	3	15:58-16:14	16	11	176	2.93
Kombi2plus	*1*			*10*	*150*	*2.50*
Super7	*2*			*10*	*113*	*1.88*
Conventional	*3*			*10*	*162*	*2.70*
		Relative deviation from control value (100)			%	
Kombi2plus	1				93	
Super7	2				70	
Conventional	3				100	

Normal font: exact figures from trial

Italic font: mathematically adjusted figures (same number of people) and average time for laying gravel bags

When the time needed for weighing down the sides of the bunker with gravel bags is included in the calculations the time needed for 10 people increased by an average of 77 minutes (Table 5). The time needed for the installation of the protection grid can be calculated as 95 minutes on average. The exact installation time calculations for the foil systems on silage bunkers in the silage trial S-67 are an important basis for discussion. Further exact measurements should be taken from working farms in order to extend the data pool and enable recommendations with regard to economics in practice to be substantiated.

Summary

In the silage trials S-67/2017 at the HBLFA Raumberg-Gumpenstein tests were conducted using three film systems (1: combi- film = underlay film + film cover on one roll; 2: oxygen barrier film; 3: control = separate underlay and cover films) for covering silage bunkers under comparable conditions (silage bunker, feed, harvesting and ensiling methods) with grass silage.
After 39 days the grass silages were analysed from the surface layer (up to 25 cm depth) at the sides and in the middle of the bunker in respect of DM, nutrients, fermentation quality and micro-biology. The compaction of the heavily wilted grass silage (DM 449 g/kg FM) at the surface was around 125 kg DM/m3, which is more than 100 kg below the required level, but the silage still exhibited a good to very good fermentation quality (70 to 100 points on the DLG scale). The Super7 OB film showed a considerably better aerobic stability in the durability test. After 165 hours of air stress the silage with the barrier film variant was still perfectly acceptable from a feed hygiene point of view, whereas the grass silages with the underlay film + silage film were completely mouldy. There was no improvement in quality with the combi- film compared with the control variant, neither when the bunker was opened nor in the durability test. From the labour perspective the barrier film proved itself as requiring considerably less work time compared with the control variant under the given conditions. The combi-film achieved a small time saving.
In the silage trial S-67 the example of the Super7 film showed that the new generation of oxygen barrier silage films has potential with regard to labour costs and improved aerobic stability in the surface layers. This represents progress when compared with the conventional underlay film and cover film for silage bunkers. Such benefits would be particularly attractive for larger silage bunkers.

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