The effect of number of layers of silage bale film wrap on silage microbiological and chemical quality

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Caiff y Rhaglen Datblygu Defaid a Chig Eidion, a gaiff ei rhedeg gan Hybu Cig Cymru, ei rheoli gan Lywodraeth Cynulliad Cymru fel rhan o Cyswllt Ffermio.

The Sheep and Beef Development Programme, run by Hybu Cig Cymru, is managed by the Welsh Assembly Government as part of Farming Connect.

Experiment 1

Objectives
This experiment examined the effect of insufficient film wrapping on silage quality. To ensure full coverage of a round bale with 4 layers of film a bale must rotate 16 times on a single spool turntable wrapper. Fewer revolutions will result in only 2 layers of film being applied to parts of the bale leading to deterioration of the silage.

Materials and Methods
A 3 ha field of ryegrass/white clover was mown on the 29 June 2006. The grass was wilted for 24h, raked and baled using a Greenland 230 chopping baler. All bales were sampled for chemical analysis prior to wrapping. Thirty two experimental bales were produced with eight bales allocated to each experimental treatment as follows:-

Treatment 1	14 revolutions
Treatment 2	15 revolutions
Treatment 3	16 revolutions
Treatment 4	17 revolutions

All bales were film-wrapped with 25µm thick, 750mm wide Silotite film (bpi.agri, Leominster) on a McHale 911B wrapper. The bales were then stored in a single layer with a 250mm gap between each bale. A row of ‘guard’ bales were stored around the perimeter of the experimental bales. A net was placed over the bales for protection and the bales stored for 150 days.

After the 150 day storage period each bale was tested to evaluate effectiveness of film seal. Each bale was evacuated and the time taken for the vacuum to drop from 250kPa to 200kPa recorded.

The film wrap was then carefully cut away from each bale and the film stored. The film was then hung up to dry for a three week period before being dried in a force draught oven at 60^{o}C for three weeks.

Each bale was assessed for mould coverage immediately after unwrapping. A steel mesh grid (1m by 0.5m) with each grid of mesh 75mm square was used to quantify mould coverage. The score was then calculated as a percentage of the whole bale covered.

Two 50mm diameter cores were taken to a depth of 300mm from the top of the bale, before the bale was rotated 180^{o} and two similar samples were taken from the underside of the bale. The samples were immediately frozen to await chemical analysis for freeze dry matter, pH, nitrogen, ammonia nitrogen and lactate performed by standard wet chemistry methods. A further sample was analysed by Near Infra Red Spectroscopy to obtain predicted intake potential, LWG and ME. *Listeria* were enumerated from a bulked sample taken from 10 points from the surface of the bale using a standard spread plate enumeration technique with a *Listeria* enrichment medium.

Results

The dry matter of the grass at ensiling was 547 g/kg with crude protein content of 110 g/kg DM and a WSC content of 137 g/kg DM. Indicating a standard quality grass was ensiled that had sufficient sugar for a good fermentation and the ash content was very low at 58 g/kg DM indicating that soil contamination was minimal.

Table 1. Grass analysis at ensiling

	Mean	sd
Dry Matter (g/kg)	547	13.9
Nitrogen (g/kg DM)	17.7	0.77
Crude Protein (g/kg DM)	110.5	4.81
WSC (g/kg DM)	137.3	3.52
Ash (g/kg DM)	58.4	1.56

The bales were opened on the 27 November 2006.

The results for film weight, film seal, mould coverage, *Listeria* populations and losses are shown in table 2. Film weight was significantly different between treatments indicating that the number of revolutions of the wrapper turntable had resulted in different amounts of film being applied to the bales of silage as had been set out in the protocol. Surprisingly there were no significant differences in film seal, mould coverage or losses between treatments. In terms of film seal all bales had an adequate seal which is also reflected in the mould coverage and losses being low. Microbiological determinations by their very nature have large variability associated with them and hence the *Listeria* populations were not significantly different from each other. *Listeria* populations were similar and low on 15, 16 and 17 revolutions. However, *Listeria* numbers on the 14 revolution treatment were 30 times greater than the 15, 16 or 17 revolutions at 62,000 cfu/g FM indicating that livestock consuming this silage would be at a much greater risk of developing listeriosis than the other treatments.

Table 2. Weight of film wrap, film seal and visible mould cover, listeria and losses from silage after a 150 day ensiling period.

	14 rev	15 rev	16 rev	17 rev	sed	sig
Film Wt (g)	696 [a]	740 [ab]	766 [bc]	819 [c]	26.2	***
Film Seal (sec)	68	105	124	130	27.4	NS
Mould Cover (%)	0.99	0.17	0.08	0.06	0.361	NS
Listeria (cfu/g)	61894	1081	1978	688	38418	NS
Recovery (%)	98.1	104.6	107.7	108.6	3.84	NS

No significant differences were observed in the NIRS predicted values shown in table 3. The silage had an average ME value of *ca*. 10 which was predicted to supported average liveweight gains of 0.6 to 0.7 kg per day from silage alone. These values are representative of silage fed to beef cattle on Welsh farms.

Table 3. Silage evaluation by NIRS after a 150 day ensiling period

	14 rev	15 rev	16 rev	17 rev	sed	sig
Intake potential	101.1	102.5	103.4	107.2	2.78	NS
LWG (300kg steer)	0.59	0.67	0.62	0.58	0.031	NS
LWG (500kg steer)	0.63	0.71	0.67	0.63	0.033	NS
ME (mj/kg DM)	9.84	10.23	10.01	9.75	0.193	NS

The results of the silage chemical composition are shown in Table 4, in general the silages were very dry and so a limited fermentation had occurred in all bales indicated by the high pH (ranging from 4.93 to 5.26) and low lactic acid concentrations (ranging from 17.5 to 27.7). The dry matter content was significantly lower in the 14 revolution treatment compared to 16 and 17 revolutions. This treatment also had a significantly higher ammonia-N content and thus would suggest a poorer preservation had occurred in these bales than the bales with 16 and 17 revolutions of the wrapper. The 15 revolution treatment was intermediate. As expected the crude protein content was not significantly different between any of the bales indicating that each bale irrespective of treatment contained a representative sample of grass at the point of ensilage.

Table 4. Silage dry matter and chemical composition after a 150 day ensiling period (g/kg DM unless otherwise stated)

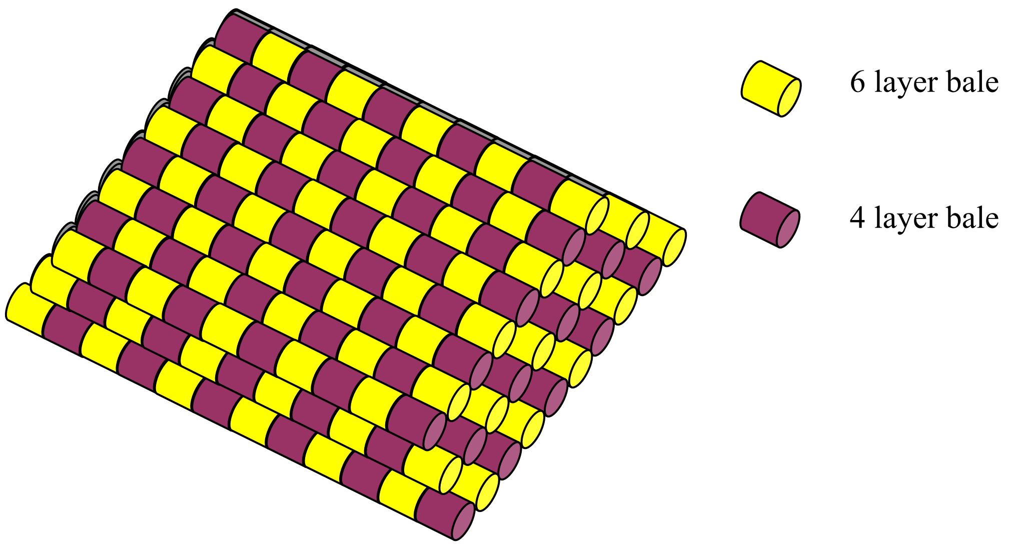
	14 rev	15 rev	16 rev	17 rev	sed	sig
Dry Matter (g/kg)	538 [a]	569 [ab]	593 [b]	606 [b]	23.29	*
pH	4.96 [a]	4.93 [a]	5.11 [ab]	5.26 [b]	0.099	*
Amm. N (g/kg N)	83.5 [a]	76.6 [ab]	69.4 [b]	69.1 [b]	3.9	**
Lactate	27.7 [a]	25.9 [a]	20.4 [b]	17.5 [b]	2.01	***
Crude Protein	124.6	128.9	126.2	128.6	4.9	NS

Experiment 2

Objectives
This experiment examined the effect of applying 4 layers of film to round bales (the UK standard) versus 6 layers of film. The trial was conducted under 'farm conditions' with bales being wrapped in the field followed by carting bales to the storage area which is common practice on most Welsh farms. This system tests the films ability to protect the silage to the full, with physical damage to the film very likely.

Materials and methods
Fifteen fields of hybrid ryegrass swards (second silage cut) were mown and wilted for 24 hours before raking and baling using a Greenland 130 round baler. Bales were wrapped in the field using either 4 layers or 6 layers of a 25µm thick 750mm wide Silotite film (bpi.agri, Leominster). This was achieved by ensuring that the bales received film with either 16 or 24 revolutions of the McHale 911B wrapping machine. All bales were labelled in the field to record the number of layers applied. The bales were then loaded onto trailers and carted to the storage area before being stacked in a single stack, 10 bales wide and 12 bales deep on the bottom layer and 3 bales high (see Fig. 1). A total of 299 bales were stacked.

Figure 1. Stack design and position of 4 and 6 layer treatments



During January and February 2007 (150 -200 days ensilage) bales were opened, one face at a time (27 bales per face).

Each bale was tested to evaluate the effectiveness of film seal. Each bale was evacuated and the time taken for the pressure to drop from 250kPa to 200kPa recorded.

A representative section of the film was cut from each bale, dried and weighed, to ensure that the correct number of layers was applied to each particular bale.

Each bale was assessed for mould coverage immediately after unwrapping. A steel mesh grid (1m by 0.5m) with each grid of mesh 75mm square was used to quantify mould coverage. The score was then calculated as a percentage of the whole bale covered.

Three 50mm diameter cores were taken to a depth of 300mm from the top of each bale. The samples were immediately frozen to await chemical analysis for freeze dry matter, pH, nitrogen, ammonia nitrogen and lactate. A further sample was analysed by Near Infra Red Spectroscopy to obtain predicted intake potential, LWG and ME. *Listeria* were enumerated from a bulked sample taken from 10 points from the surface of the bale using a standard spread plate enumeration technique with a *Listeria* enrichment medium.

Results

The mean dry matter of the grass at ensiling was 523g/kg which proves that weather conditions were very good during the 24 hr wilting period (see Table 5). WSC content of the grass at ensiling was high, with sufficient sugars available for fermentation. The DOMD of the grass was low at only 0.57g/g DM.

Fig. 2. Plan of bale stack

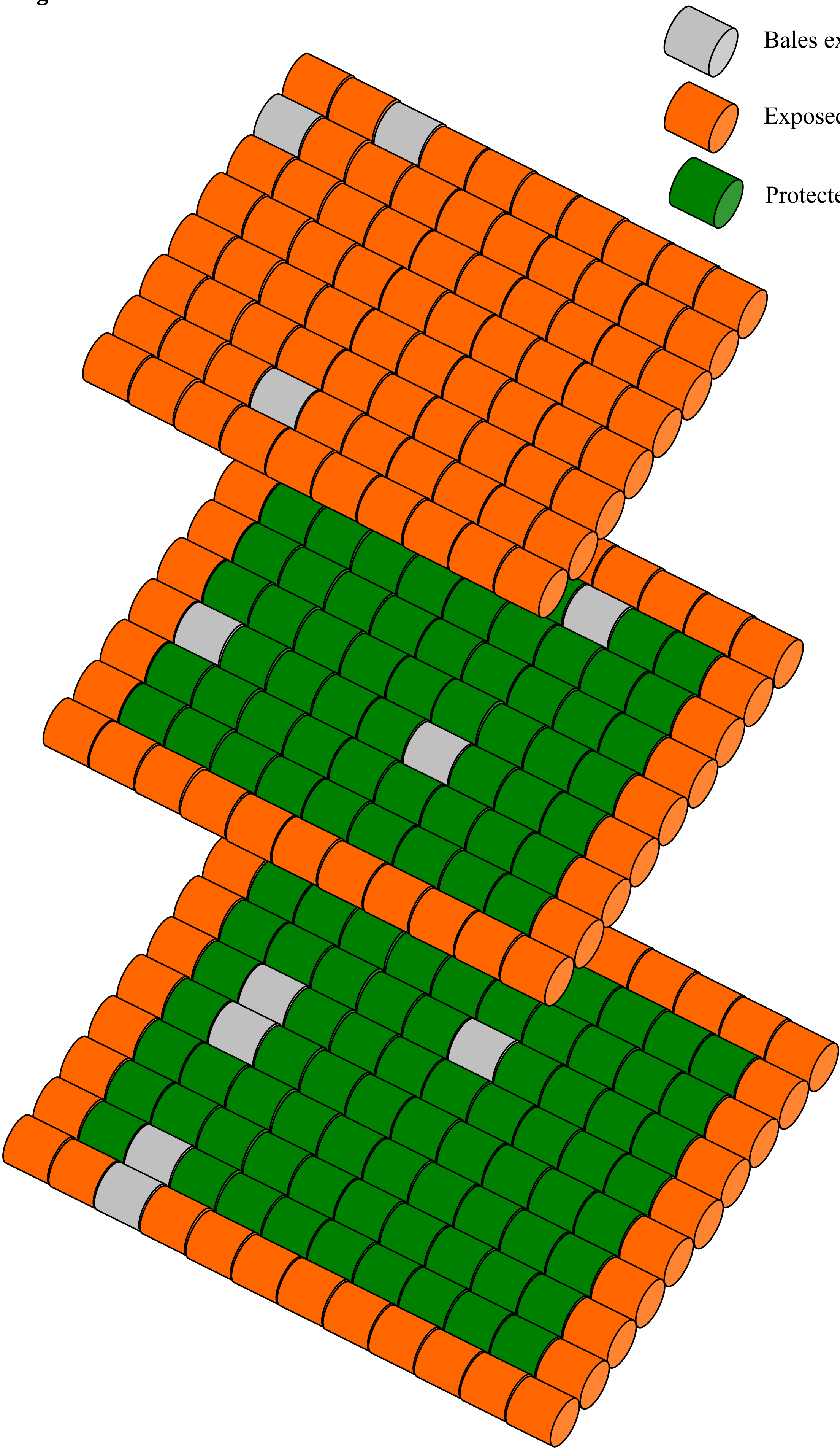


Table 5. Mean chemical analysis of forage at ensiling (g/kg DM unless otherwise stated)

	Mean	sd
Dry Matter (g/kg)	523	96.5
Crude Protein	131.6	16.10
Water Soluble Carbohydrates	158.4	29.96
Ash	48.6	6.13
DOMD (g/g DM)	0.565	0.0260

All bales were opened and assessed during January and February 2007. Eleven bales were discarded from the analysis due to uncertainty of the number of layers of film wrap applied, giving a total of 288 bales assessed.
As well as being damaged during transport, damage could occur to bales during the storage period. With this in mind we investigated exposed v protected bales as well as assessing 4 v 6 layers of film.

Table 6. Film seal, visible mould cover, *listeria*, silage dry matter and chemical composition and NIRS predictions of silage wrapped in either 4 or 6 layers of film after a 150 - 200 day ensiling period.

	4 layers	6 layers	Significance
Number of bales	143	145	
Film Seal (sec)	72.7	127.5	NS
Visible Mould (%)	1.75	0.76	NS
Listeria (CFU/g FM)	1778	1186	NS
DM (g/kg)	504	507	NS
pH	5.44	5.42	NS
Lactate (g/kg DM)	14.9	15.1	NS
Ammonia N (g/kg N)	70.0	69.8	NS
N (g/kg DM)	24.1	23.7	NS
CP (g/kg DM)	150	148	NS
ME* (mj/kg DM)	9.93	10.06	NS
Intake Factor *	103.7	104.4	NS
LWG * (300kg Steer)	0.580	0.606	NS
LWG *(500kg Steer)	0.620	0.648	NS
Intake * (kg/day)	14.17	14.20	NS
Milk Yield * (litres/day)	13.42	13.87	NS

* Predicted by NIRS

The total number of bales assessed was 143 four layered bales and 145 six layered bales (see Table 6).
Whilst no significant differences were observed between 4 and 6 layers of wrap in any factors measured some trends were apparent. The film seal was measured by creating a vacuum within each bale and measuring the time it took for the vacuum to be lost as air re-entered the bale. The mean time taken for air to re-enter the 4 layered bales was 72 second, whereas it took 75% longer for air to re-enter the 6 layered bales. This had

an effect on visible mould on the bale surface, with 6 layers of film resulting in a reduction of 55% when compared with the 4 layered treatment (0.76 v 1.75 %).
The dry matter, pH, lactate, ammonia and nitrogen contents observed were very similar in both treatments. Fermentation was limited in both treatments due to the high dry matter observed resulting in high pH and low lactate values The number of *Listeria* on silage from the two treatments were very similar and quite low, again probably due to the high dry matter content of the silage.
The metabolisable energy content of the silage was improved with increased layering. Predicted intake was not greatly affected by increased layering, but improvements in production especially milk production was improved by 0.45 litre.

Table 7. Film seal, visible mould cover, *listeria*, silage dry matter and chemical composition and NIRS predictions of protected and exposed bales after a 150 - 200 day ensiling period.

	4 layers		6 layers	
	Protected	Exposed	Protected	Exposed
Number of bales	63	80	65	80
Film Seal (sec)	74.3	71.4	121.9	132.0
Visible Mould (%)	0.62	2.64	0.33	1.11
DM (g/kg)	493	512	506	508
pH	5.37	5.49	5.40	5.44
Lactate (g/kg DM)	17.2	13.0	16.5	14.0
Ammonia N (g/kg N)	71.5	68.8	70.8	69.0
N (g/kg DM)	22.8	25.0	22.4	24.8
CP (g/kg DM)	143	156	140	155
ME* (mj/kg DM)	10.26	9.65	10.40	9.80
Intake Factor *	103.8	103.7	104.1	104.6
LWG * (300kg Steer)	0.654	0.522	0.648	0.574
LWG * (500kg Steer)	0.699	0.559	0.691	0.614
Intake * (kg/day)	14.20	14.15	14.25	14.16
Milk Yield * (litres/day)	14.55	12.55	14.75	13.18

* Predicted by NIRS

Table 7 provides a further breakdown of treatments with mean values of protected and exposed bales and these data show interesting differences between protected bales (bales surrounded by other bales) and exposed bales (bales on the outside of the stack).
Surprisingly there was no difference in the film seal between the protected and exposed bales. As the bale stack was unprotected (apart from a tyre on each bale on the top layer) it was expected that there would be differences in film seal due to bird damage. The lack of difference could possibly be due to moulds growing at any damage site and partially sealing film holes and reducing air flow. Visible mould cover was 3 to 4 times more on the exposed bales compared to the protected bales.
The predicted ME content of the exposed bales was far lower than that of the protected bales (9.72 v 10.33). This was also reflected in lower predicted production from the exposed bales, with over a 100g/day reduction in LWG in a 500kg steer and a 1.8 litre/cow/day reduction in milk when feeding exposed bales.

Using the intake and milk yield figures predicted here, a 200kg DM bale from with the bale stack would produce 206 litres of milk, whereas a similar exposed bale would produce 181 litres of milk.

Conclusions

Whilst there were relatively few significant differences in this study the data provided in this report does enable us to make some big bale silage management recommendations.

Experiment 1 indicates the importance of setting up the wrapper correctly and ensuring a minimum of four layers of film wrap are applied to the entire bale because applying insufficient film to the entire bale can lead to a dramatic increase in *Listeria* populations in the silage and silage of a poorer fermentation quality. It is worthy of note that the silage bales in this experiment were treated under experimental conditions (wrapping and stacking at the storage site) and the impact of standard farm management practices (wrapping in the filed and transporting to the stacking) were not investigated. However it is probable that damage to the bale film wrap would have exacerbated the problem of poor silage fermentation and *Listeria* populations if farm management practices were used with insufficient layers of film were applied.

Experiment 2 indicated in this study that there were very few differences between 4 and 6 layers of film wrap under the conditions investigated in this study in particular with a relatively dry silage. However silage produced on Welsh farms is often of a lower DM which was not investigated in the current study and could result in a different finding. More interestingly there were a number of differences observed when comparing between protected and unprotected bales in the stack. This appeared to have a greater effect on silage quality and performance than the number of layers of wrap. The study indicates the importance of protecting the stack from damage by covering with a net. It also indicates that from a bale quality point of view it would be beneficial for farmers to store bales in as large a stack as possible so that there are more protected bales. However this could lead to problems with effluent collection which must be taken into consideration.