Tarım Makinaları Bilimi Dergisi (Journal of Agricultural Machinery Science)
2009, 5 (2), 211 - 216

Color Changes of Bale Silage under Different Storage Conditions

Fulya TORUK, Erkan GÖNÜLOL, Poyraz ÜLGER
Namık Kemal Üniversitesi, Ziraat Fakültesi, Tarım Makinaları Bölümü, 59030 Tekirdağ,
ftoruk@nku.edu.tr

Abstract: The aim of the investigation was to determine changes on color of the silage surface under different storage conditions. For this purpose, the effect of the layer of film cover on bales, color of plastic film and different particle lengths also were examined. An experiment was designed in a 2 (4, 8 cm particle length) x 2 (16, 20 layer of film cover) x 2 (white, black film color) x 3 (storage conditions) X 3 (replication) factorial arrangement of treatments, to elucidate the relative effects of these factors on the conservation characteristics of baler silage. Alfalfa was ensiled and chopped using a bale silage machine. Baler was kept in the open air (OA), semi-closed (SC) and closed storage condition (CS). In this research, yellowness (yı*) indicates were also measured to show the effect of fermentation process on the silage color properties. As the result of experiment, it was found that storage conditions have significant effects on color of the silage surface (all parameters) statistically. Besides it was determined that yellowness was affected by the particle length and the number of layer according to storage conditions. Desired silage color was observed with particle length of 8 cm, white color wrapping with 20 layers under SC and CS condition.
Key words: alfalfa bale silage, storage condition, silage surface color, number of layer, polyethylene color

Farklı Depolama Koşulları Altında Balya Silajlarındaki Renk Değişimleri

Özet: Bu çalışmada, farklı depolama koşulları altında yonca balya silaj yüzeyinin renginde meydana gelen değişimler belirlenmiştir. Çalışmada farklı balya sarma katı, plastik rengi ve hasat edilen ürünün parça büyüklükleri denenmiştir. Deneme, x 2 sarma katı sayısı (16 ve 20) x 2 plastik rengi (siyah ve beyaz) x 2 parça boyutu (4 ve 8 cm) x 3 depolama koşulu (açık havada (OA), sundurma altında (SC) ve kapalı ortamda (CS)) x 3 tekrar olacak şekilde düzenlenmiştir. Yonca bitkisi kombine balya silaj makinesi kullanılarak balyalanmış ve depolanmıştır. Üç aylık depolama sonrasında alınan örneklerden renk analizleri yapılmıştır. Araştırmada ayrıca, silaj fermantasyonunda önemli etkisi olan sarılık (yı*) indeksi de ölçülmüştür. Deneme sonucunda, depolama koşullarının silaj yüzey rengi üzerine etkisi önemli bulunmuştur. Bunun yanı sıra, sarılık indeksi de depolama koşullarına, film sarma sayısına ve parça uzunluğuna göre de önemli bulunmuştur. İstenen silaj rengi 20 kat sarılan, beyaz renkli film ile kaplanan, 8 cm parça boyuna sahip SD ve KD depolama koşullarında elde edilmiştir.
Anahtar kelimeler: yonca balya silajı, depolama koşulları, silaj yüzey rengi, sarma sayısı, plastik rengi

INTRODUCTION

Alfalfa silage is one of the most popular silage making and storing systems.

Big bale silage, compared with other harvesting systems, has a greater flexibility with regard to the harvesting date, is less weather dependent. However, prone to spoilage because of the high surface area ratio of the bale (Borreani ve Tabacco, 2006).

It was found that lower silage quality when wrapping baled with four tours instead of six tours stretching (16 and 20 layers). The results were attributed to a perforation effect from the hard Lucerne stalks when wrapping the bales with eight or ten layers, no further improvement was noticed. Excess layer makes more expense (Keller et al., 1998).

The plastic film guarantees anaerobic conditions and quality in the silage. The necessity of anaerobic conditions for the ensiling process is well known. There is not sufficient research on this subject. Although the importance of stable anaerobic

conditions for silage is undisputed and usually low-density polyethylene (LD-PE) films are used for this purpose. There are few scientific studies on the correlation between the film parameters and success of ensiling (Muck, 1998).

Forristal et al. (1999) determined the effects of using different levels of film cover and different film colors (black, clear, green, light green and white) on silage preservation. Whereas film color did not influence the measured variables, the level of film cover on bales significantly affected silage preservation. Film thickness was also important.

Snell et al. (2003) found the influence of variations in thickness and color of plastic film on silage preservation conditions. Fort his purpose, bales were covered with five films of different thickness and color: 90 µm, white; 125 µm, green; 150 mm, black; 200 µm, green and 200 µm, white. The surface temperature of the films was found to be strongly dependent on film thickness and color. They found that the dark-colored film types, especially the black covering, heated more quickly. At midday the highest temperatures were reached outdoors. They were about 6-7 ^{o}C higher fort he dark-colored films in comparison with the white films.

Snell et al. (2002) reported that under the storage conditions investigated, the chemical analysis of silages did not reveal any significant influence of the film.

One of the main parameter to determine silage quality is the color. The color is changing from light green to light brown according to source of feed materials. Black and dark colors are not desired. It means protein and cellulose are lower digestibility. Air inside silage is also resulting with dark color (Uygur, 2009). Certain color for quality silage has not been mentioned in the studies yet. Therefore, colors difference in this study was compared according to their dark and light levels.

DLG (1987) was determined color of silage according to its quality. Quality levels are 0, 1 and 2. Silage with darker color has fewer score.

The aim of this research was to determine changes on color of the silage surface under different storage conditions. For this purpose, the layer of film cover on bales, color of plastic film and different particle lengths were also examined.

MATERIALS and METHODS

Alfalfa *(Medicago sativa L.)* was harvested at approximately 10% bloom with mower-conditioner on 28 June 2007. The silages were made from first-cut alfalfa. Swaths were wilted for 2 hours, then windrowed and made into cylindrical bales of 1.5 m x 1.2 m with a Orkel GP model 1260 silage baler. Weight of the bales was approx. 900-950 kg. There was no rainfall during wilting and harvesting periods.

Table 1 shows the properties of the bale wrapper.

Table 1. Properties of the bale wrapper

Properties	
Type	Cylinder with two wrapping arms
Tractor connection	Stable
Wrapping system	3D
Wide stretch film (mm)	750
Wrapping level (%)	65
Repetition (%)	50
Weight (kg)	1338

Chopped alfalfa (*Medicago Sativa L.*) covered with two levels of film cover and color; 16 black; 16 white; 20 black and 20 white. Each trial was done with two particle length (4-cm; 8-cm).

The properties of polyethylene film were shown in Table 2.

Table 2. Properties of the polyethylene film

Properties	**150 µm**	**150 µm**
Color	Black	White
Thickness (µm)†	150	150
Extensibility (%)*	386	488
O_2 Permeability(ml m^{-2} d^{-1})#	-	248

† DIN 53370 (1976)
*EN ISO 527 (1995/1996)
#DIN 5338 (1969)

Balers have been kept under three storage conditions; open air (OA), semi closed (SC) and closed storage condition (CS) for three months.

Pioneer® 1174 (*Lactobacillus plantarum* and *Enterococcus faecium*) was used as silage additive.

The experiment was organized in a 2 particle lengths (4 – 8 cm) X 2 film colors (black - white) X 2

numbers of layer (16-20) X 3 (replications) factorial arrangement of treatments. As a totally were done 24 big bales. The design of the research was summarized in the Table 3

Table 3. Design of the research

Storage condition	Particle length (cm)	Number of layer	Film (PE) color
OA SC CS	4	16	Black White
		20	Black White
	8	16	Black White
		20	Black White

The bales were opened after three months for analyses. Samples were taken from the between baler surface and a depth of 20 cm (Snell et al., 2003).The silage surface color was examined by a Hunter Lab D25LT. The system CIE was used. L* represents brightness (0, black; 100, white), a* represents hues from red to green (+a*, red; -a*, green) , b* represents hues from blue to yellow (-b*, blue;+b*, yellow). In this research, yellowness (yı*) indicates were also measured to show the effect of fermentation process on the silage color properties.

Alfalfa dry matter (DM) was determined by oven drying at 103 ^{o}C for 16 h (ASAE Standartds 2002). The pH values of both fresh material and silage materials were obtained using the methods reported by Chen et.al. (1994). Total nitrogen (T) concentration was measured by a Kjeldhal procedure and CP concentration was calculated as Nx6.25 (AOAC 1990).

Statistical analyze was done by using MSTAT computer program.

RESULTS and DISCUSSION

Color of the silage surface and the nutrient composition of alfalfa before ensiling are shown in Table 4.

Table 4. Color of the silage surface and nutrient composition of alfalfa before ensiling

CP	pH	DM	L*	a*	b*	ıy*
18.97	5.67	36.13	27.88	-8.16	10.47	38.16

Effect of storage conditions and particle lengths on the color of silage surface was given in Table 5.

Effect of storage conditions and particle length was found to be significant on the color of silage surface (P<0.05).

Color values of the bale kept under CS storage condition was better than the others storage conditions.

Table 5. Effect of storage conditions and particle lengths on the color of silage surface

Storage condition (A)	**OA**		**SC**		**CS**				
Particle length, cm(B)	**4**	**8**	**4**	**8**	**4**	**8**	**CV (%)**	**F****	**LSD**
Brightness (L*)	25.51 f	26.82 e	27.65 d	28.24 c	28.88 b	30.12 a	2.12	42.35	0.486
Red- green (a*)	1.09 b	1.28 a	1.10 b	1.09 b	0.97 c	0.83 d	335.75	2.08	8.208
Yellow-blue (b*)	11.33 f	12.87 d	12.57 e	12.96 c	13.51 b	14.32 a	1289.5	0.12	1.421
Yellowness (ıy*)	47.88 e	50.13 d	47.85 f	51.34 b	51.26 c	52.12 a	3331.3	0.02	1.161

**Significant at P<0.05. OA: Open air storage condition, SC: Semi-closed storage condition, CS: Closed storage condition

Brightness values of the OA silages were the lower than the fresh material (27.88). Silage color approached the desired level with increasing brightness value. This is also shown that fermentation of the silage was well done.

There was significant effect between values of the lengths. Silage with 8 cm particle length has more favorable values than 4 cm. Therefore, particle length with 8 cm is recommended. Seale et al. (1982) were stated that particle length in the bale silage must be 5 cm and longer.

Silage in CS condition and with 8 cm particle length has the best color results. Contrary silage in OA condition and with 4 cm length has the worst results.

Effect of storage conditions and number of layer on the color of silage surface was given in Table 6.

Effect of storage conditions and number of layer was found to be significant on the color of silage surface ($P<0.05$). Silage color with 20 layers has found to be more favorable result than 16 layers. A similar trend for number of layer was shown by Keller et. al., (1998) and Forristal et al., (1999).

The highest brightness was found at CS with 20 layers whereas, the lowest brightness was found at OA with 16 layers. The highest red-green values were found at SC with 16 layers and at OA with 16 layers. The lowest yellow-blue values were found at OA with 16 layers. The highest yellowness with 52.18 was found at CS with 20 layers.

It is clear that silage with more layers has better result but economic situation should be taken into consideration. Further studies on economic number of layers are needed.

Effect of storage conditions and film color on the color of silage surface was given in Table 7.

Effect of storage conditions and film color was found to be significant on the color of silage surface ($P<0.05$). White film color has better color result than black film color. The best results were found at CS condition with white film color. The results belong to OA with black film color were not desired. Snell et al. (2002) was also mentioned that silage at CS condition has better results of silage surface color.

Table 6. Effect of storage conditions and number of layer on the color of silage surface

Storage condition (A)	OA		SC		CS			
Number of layer (C)	16	20	16	20	16	20	F**	LSD
Brightness (L*)	25.21 d	27.12 c	27.56 b	29.03 b	28.75 b	29.56 a	65.78	0.486
Red- green (a*)	1.16 b	1.09 c	1.22 a	1.07 d	0.96 e	0.84 f	395.8	8.208
Yellow-blue (b*)	11.15 f	12.87 e	13.02 d	13.56 b	13.60 a	13.06 c	633.5	1.421
Yellowness (ıy*)	46.97 f	50.26 d	49.13 e	50.84 c	51.21 b	52.18 a	5371.3	1.161

**Significant at $P<0.05$. OA: Open air storage condition, SC: Semi-closed storage condition, CS: Closed storage condition

Table 7 Effect of storage conditions and film color on the color of silage surface

Storage condition (A)	OA		SC		CS			
Film color (D)	Black	White	Black	White	Black	White	F**	LSD
Brightness (L*)	25.92 d	26.41 c	28.85 a	28.93 a	27.97 b	29.15 a	12.32	0.486
Red- green (a*)	1.29 a	1.21 b	1.11 c	0.96 e	0.97 d	0.80 f	238.08	8.208
Yellow-blue (b*)	12.00 f	12.21 e	13.24 c	13.34 b	13.00 d	13.47 a	965.23	1.421
Yellowness (ıy*)	49.28 f	49.86 d	49.71 e	50.27 c	50.50 b	50.97 a	6605.3	1.161

**Significant at $P<0.05$. OA: Open air storage condition, SC: Semi-closed storage condition, CS: Closed storage condition

Snell et al. (2003) were stated that more brightness color of silage was found in the baler with white film color (37.9) than black colors' (33.1). Similar results were found in this study. These results can be explained that the silage covered with dark-colored films has more heat than with light colors.

Effects of storage condition, particle length, number of layer (16, 20) and film color (black, white) on silage color were given in Table 8.

Table 8. Effect of storage condition (OA, SC, CS), particle length (4, 8), number of layer (16, 20) and film color (black, white) on silage color

F**	Brightness (L*)	Red-green (a*)	Yellow-blue (b*)	Yellowness (ıy*)
AXBXC	34.85	49.60	385.85	899.90
LSD	0.486	1.160	2.010	1.641
AXBXD	30.76	149.69	193.20	3631.32
LSD	0.486	1.160	2.010	1.641
AXCXD	7.07	636.23	169.85	5781.55
LSD	0.486	1.160	2.010	1.641
AXBXC XD	2.21	741.14	964.22	50131.10
LSD	0.972	1.641	2.843	2.321

A, Storage condition; B, Particle length; C, Number of layer; D, Film color

All variables measured and their interaction were affected on silage color and silage fermentation product ($p<0.05$).

The particle length and storage conditions had a much greater effect on silage color than the number of layer and film color treatments studied. At OA storage condition, silage color values of the silage made from 4 cm particle length and 16 layers was lower than for other treatments. Similar results were reported by Borreani ve Tabocco (1998).

CONCLUSION

The color of the silage surface was affected by all parameters measured in this research.

The best silage color values were determined bale silage made from 8 cm particle length and 20 layers in all storage conditions.

In point of storage conditions; storage in closed area (CS) has better silage color than the others. Further studies especially on determining optimum number layers were needed.

REFERENCES

AOAC, 1990. Official Methods of Analysis. 15 th ed. Association of Official Analytical Chemists. Arlington, VA, USA, 1230 pp.

ASAE Standarts, 2002. Moisture measurement - forages. ASAE S358.2. Standards 2002: 565. St. Joseph, MI.

Borreani G, Tabocco E, 2006. The Effect of a Baler System on Fermentation And Losses of Wrapped Big Bales of Alfalfa. Agronomy Journal 98:1-7.

Chen J, Stokes MR, Wallace CR. 1994. Effects Of Enzyme-Inoculants Systems On Preservation And Nutritive Value Of Hay Crop And Corn Silages. J. Dairy Sci.,77:501-512.

DIN 53370 (1976). Prüfung Von Kunststoff-Folien-Bestimmung der Dicke Durch Mechanische Abtastung. (Testing of Plastic Films-Determination of the Thickness by a Mechanical Test) Berlin: Deutschcs Institut für Normung.

DIN 53380 (1969). Prüfung Von Kunststoff-Folien-Bestimmung der Gasdurchlässigkeit. (Testing of Plastic Films-Determination of the Permeability) Berlin: Deutschcs Institut für Normung.

DLG, 1987. Bewertung von Grünfutter, Silage und Heu, Merkblatt, No:224, DLG-Verlag, Deutschland.

EN ISO 527 (1995/1996). Kunststoffe – Bestimmung der Zugeigenschaften. (Plastics- determination of Tensile Properties). Berlin: Deutschcs Institut für Normung.

Forristal PD, O'Kiely P, Lenehan JJ. 1999. The Influence of The Number of Layers of Film Cover and Film Color on Silage Preservation, Gas Composition and Mould Growth on Big Bale Silage. In: Paulty T. Conference Proceeding of The XII th International Silage Conference. Uppsala, Sweden.pp.305-306.

Keller T, Nonn H, Jeroch H. 1998. The Effect of Sealing And Of Additives On The Fermentation Characteristics And Mould and Yeast Counts In Stretch Film Wrapped Big-Baled Lucerne Silage. Arch. Anim. Nutr. 51,63-75.

Muck RE,(1998). Influence of Air On Ensiling. American Society of Agricultural Engineers Annual International Meeting, 12-19 July, Orlando, Florida, USA. Paper No.98-1054.

Seale DR, Quınn CM, Whıttaker PA, Wılson RK. (1982). Microbiological and Chemical Changes During The Ensilage of Long, Chopped and Minced Grass. Irish Journal of Agr. Research, 21, 147-158.

Snell HGJ, Oberndorfer C, Lücke W, Van den Weghe HFA. 2002. Effects of Polyethylene Film Parameters: Color

and Thickness, on Ensiling Conditions and Silage Quality of Chopped Maize, as Investigated Under Ambient Conditions and In a Test Apparatus. Grass and Forage Science, 57, 342-350.

Snell HGJ, Oberndorfer C, Lücke W, Van den Weghe HFA. 2003. Effects of Polyethylene Color and Thickness on Grass Silage Quality. Grass and Forage Science, 58, 239-248.

Uygur,M.2009. Silaj Kalitesinin Fiziksel ve Kimyasal Yöntemlerle Belirlenmesi. Çiftçi Broşürü, No.127. http://www.etae.gov.tr/yayin-ek/ciftci-bro/127-ciftcibro.pdf