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Effect of Applied Vacuum of Silage Package Machine on Silage Quality

Fulya TORUK, Birol KAYİŞOĞLU
Namık Kemal University, Faculty of Agriculture, Department of Agricultural Machinery
59030, Tekirdağ,Turkey.
ftoruk@nku.edu.tr

Abstract: Due to rich nutrient content, long-term storage period, and consuming by animals appreciatively, silage is considerable feeding material in animal nutrition. Silage has prepared with conventional methods for a long time. Recently it has been packing at desired dimension and types by mean of the new technology. Due to the fact that packed silage has lesser lost of protein, longer storage period and it can be consumed as required amount, these type silage has been preferred recently. Various of type of packed machines are used since have considerable advantage then conventional method. There are both stations and mobile type in the market. It is obvious that this different type machine have effects on the silage quality since they have different silage preparing technique. In this study it was aimed to determine effects of vacuum process on the quality of forage that was prepared by machine which packed no fermented fresh forage by means of vacuum and pressing. The main materials of the study were chopped corn, chopped corn with feed additive and seed corn. Different vacuum levels were applied to this material during the trial and in the different storage period samples were taken periodically to determine the forage quality. In addition to these silage packed without vacuum application were used as control sample. Analysis of crude protein, dry matter, pH and organic acid analyses were done to determine of quality factors for every samples. Aerobic spoil period that affects on quality was also determined. The result of experiment, It was found that the level of vacuum has significant effects on silage quality statistically. Besides it was determined that nutrient values changed with storage period.
Key words: packed silage, silage package machine, vacuum treatment, nutritive value

INTRODUCTION and LITERATURE REVIEW

Ensiling is a common preservation method for moist forage crops. Whole crop maize is the major crop ensiled in Turkey.

The pressed bag silo is an increasingly popular method of making silage (Bilgen et all.,2007). Losses are low with bag silos. Wallentine (1993) reported a 2.5 % loss in corn silage also under unspecified conditions.

Ensiling crops in plastic bags can be suitable for such conditions as it is relatively simple, can be performed manually, is flexible in handling and feed out according to needs, and does not require much input. Plastic bags could serve as a fermentation "silo" for forage crops and the resulting silage was of acceptable feeding quality. However, there is a lack of information on the mechanism of protecting the in the bags (Ashbell et al.,2001)

Corn silage quality can also be affected by fermentation length. This is an important factor for lactic acid accumulation (Bal,2006).

The objective of the present study was to evaluate the effect of different vacuum levels on the nutritive value of whole crop maize silage made with silage package machine.

MATERIAL and METHOD

Materials

The feed materials of the study were chopped corn (CS), chopped corn with feed additive (FCS) and seed corn (SC). Another material was silage package machine. The silage package machine has eight main part. These are ; [1] Material conveying to feeding tank [2]. feeding tank. [3]. Balance [4]. Vacuum unit [5]. Tie unit [6], sewing unit [7], pressing unit [8], packet conveying to delivery vehicle (Figure 1). Material is delivered from feeding tank to the bag on balance in packet filling unit. The air inside the bag is taken by vacuum unit with hand for couple of seconds. By means of determining weight of the bag, velocity of conveying band can be changed or from control panel directly (Table 1). The bag after filling as wished is tied and sewed as soon as possible. The tying unit can be driven both by foot (manual) or automatically. After than, it was left on the second conveying band. The bag after second conveying band was delivered the third conveying system. This conveying system has two bands, at the top and the bottom. The bag is pressed between the bands during conveying to fourth conveying band. Pressed bag is more convenient for loading and stowing. The vacuum pump used in vacuum system is driven electric motor, 3 kW. Capacity of the pump is 8400 liter per minute. The machine can be driven by electric network system when working stationery.

Methods

Corn *(Zea Mays L.)* was harvested using a conventional forage harvester at two-thirds stage of maturity and chopping into approximately 10 mm pieces. The chopped forages were packaged by silage package machine. Three vacuum applications were done in the study. Forages were filled in plastic bags.

The experiment was organized in a 3 (vacuum treatments); 3 (different feeds) x 3 (storage periods) factorial arrangement of treatment. Each treatment combination was replicated four times. All bags were weighed and placed indoors at room temperature which varied between 16 and 22 ^{o}C.

Vacuum treatments were arranged at three different vacuum levels; (NC,No vacuum,control; 3C,3 atm. Vacuum level; 5 atm. vacuum level).

All the samples taken from each the bags; the silage surface color was examined by a chromameter within the L*a*b* color space. Fort he statistical analysis the arithmetic mean of the nine positions was used. The system CIE (L*a*b*) is the most widely used colorimetric system. L* represents brightness (0, black; 100, white), a* represents hues from red to green (+a*, red; -a*, green) and b* represents hues from blue to yellow (-b*, blue; +b*, yellow) (Snell et all,2002). Visually, yellowness is associated with general product degradation by light, chemical

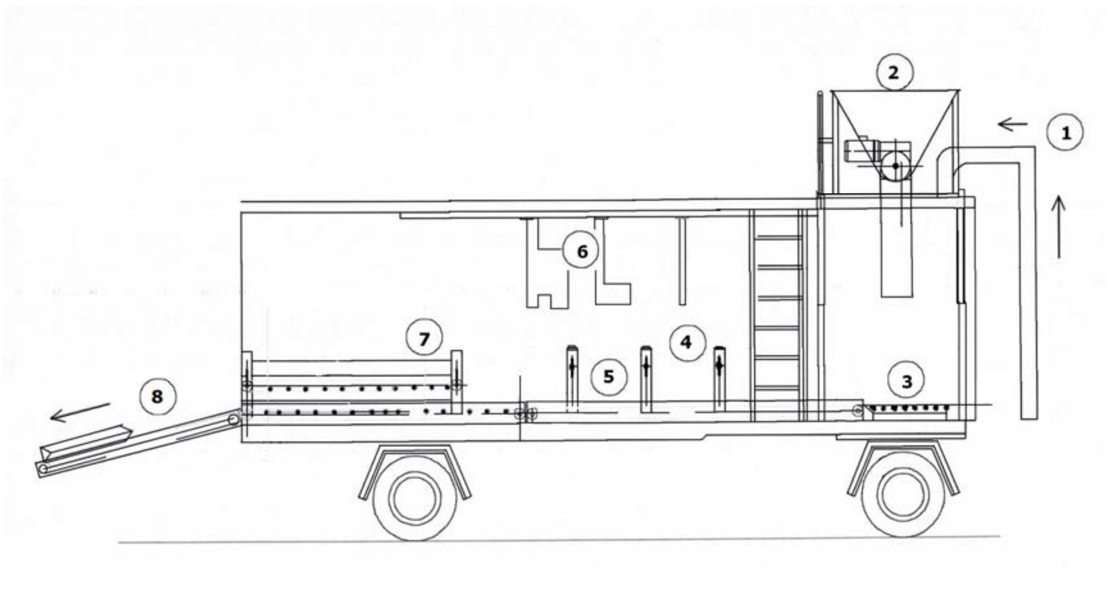

Figure 1. Silage package machine

Table 1.Conveying system

	Entering Conveying	Packaging Conveying	Pressing Conveying	Exit Conveying
Driven units (mm)	217	113	113	87
Power (KW)	2,2	2,2	2,2	0,75
Velocity (m/s)	0,647	0,065	0,130	0,136

exposure and processing (Anonim,2006). So yellowness indicates were also measured to show the effect of fermentation process on the silage color properties.

Physical properties such as color, smell, structure, total point, quality classification of silages were determined with DLG silage evaluation guide (Alçiçek and Özkan,1997). Fleig point was calculated as described by Kılıç (1986). The dry matter (DM) content of the silages were determined by oven drying at 103 ^{o}C during 24 h (ASAE Standarts, 1999). PH concentration was determined with a digital pH meter. Concentrations of acetic acid and lactic acid (LA) were determined (Bulgurlu, 1978). The crude protein (CP) was determined by a Kjeldahl method. Average densities for the bag silages were calculated based on weight ensiled (Muck and Holmes,2003). All bags were opened after 15 days, 45 days and 80 days of ensiling. Fungal populations of silage_samples were determined on potato dextrose agar (PDA, Oxoid) acidulated with 0.5 ml L^{-1} of 1 N lactic acid and modified with 0.1 ml L^{-1} of Igepal, streptomycin (100 mg L^{-1}) and chlortetracycline (50mg L^{-1}) (MPDA) (Latorre *et al.*, 1997). In the laboratory, a 5 g portion from each silage sample was added to 45 ml of sterile distilled water and shaken. This soil suspension was diluted 1:10 000 with sterile distilled water and 5 ml of the dilution was added to 95 ml of medium. This mixture was poured into five Petri dishes (20 ml in each dish). The plates were incubated for 6 days at 25^{o}C. The total number of colonies of each fungus was determined in 1-g soil samples and recorded.

Data for measurements of silage composition were analyzed by MSTAT.

RESULTS and DISCUSSIONS

Changes in nutritive values

Effects of vacuum treatments on DM (dry matter), CP (crude protein), LA (lactic acid), AA (acetic acid) and pH contents of CS (corn silage) ,FCS silages (corn silage with feed additive) and SC (seed corn) were significant ($p<0.05$) and these are presented in Table 2. The silages of the NC treatment had higher (5.52) pH than the other silages ($p<0.05$). Therefore, silages at NC spoiled upon aerobic exposure faster than the other silages. Silage pHs differed among groups ($p<0.05$).

While at NC silage had the highest pH value (5.8) on 80th day, at 5C had the lowest pH value (4.1) on 80th day. Silage quality is highly related to DM content of silage material ensiled (Tan and Tümer,1996) . DM content did not vary with vacuum treatments. But, AA content, LA and pH content were significantly affected by treatments. While AA, and LA contents were decreased according to increasing vacuum levels, CP content was increased.

There was a linear increase in CP content as storage period progressed from 0 to 80 days. Extending the fermentation length caused a linear decrease in pH. There was no significant difference for DM content across the all fermentation length (Bal,2006). Low DM content of silage material causes fermentation losses and high pH values (Demirel et all.2006). pH contents were decreased according to increasing vacuum levels (Bilgen et all,2005. The highest LA level were observed in CS silage. AA and LA contents were lowest for 15th day. The concentrations of LA and AA were affected by vacuum treatments and fermentation length ($p<0.05$) (Table 3). DM content was highest at FCS silages during all fermentation length. CP and pH were highest at SC. The CP content of the maize silage increased with increasing vacuum value. There were significant differences among the silages from made different vacuum treatments. Only 5C silages were of good quality and suitable for feeding (Table 2).

Table 2. Chemical composition of silages at different vacuum treatments

Vacuum treatment	DM	CP	pH	AA	LA
NC	26.10	7.77 ^{b}	5.52 ^{a}	0.827 ^{a}	1.98 ^{a}
3C	26.97	8.83 ^{a}	5.17 ^{b}	0.660 ^{b}	1.252 ^{b}
5C	28.91	9.21 ^{a}	4.65 ^{c}	0.505 ^{c}	0.722 ^{c}
LSD	-	0.765	0.197	0.122	0.233
CV (%)	11.04	8.9	3.88	14.33	13.87
F	-	8.46**	43.50**	17.15**	71.97**

**Mean values on the same row with the same superscript do not differ significantly at p<0.05

Table 3. Chemical composition of silages at different feed variety

Feeds	DM	CP	pH	AA	LA
CS	25.79 ^{b}	7.81 ^{b}	4.82 ^{b}	0.714 ^{a}	1.379 ns
FCS	34.87 ^{a}	8.92 ^{a}	5.21 ^{a}	0.613 ^{b}	1.259 ns
SC	21.32 ^{c}	9.08 ^{a}	5.32 ^{a}	-	-
LSD	3.014	0.765	0.197	-	-
CV (%)	11.04	8.9	3.88	14.33	13.87
F	47.16**	7.33**	15.75**	5.08**	1.94**

**Mean values on the same row with the same superscript do not differ significantly at p<0.05

Table 4. Physical characteristics and quality classification of bag silages

		CS			FCS	
Vacuum treatment	NC	3C	5C	NC	3C	5C
Silage, day 15						
Smell	11	12	12	10	11	12
Structure	2	4	4	2	4	4
Color	1	2	2	1	2	2
Total point	14	18	18	13	17	18
Quality classify	F	Ex	Ex	F	Ex	Ex
Flieg point	56.6	66.3	98.9	64.3	77.4	90.9
Quality classify	F	G	Ex	G	G	Ex
Silage, day 45						
Smell	4	8	12	4	8	12
Structure	1	2	4	1	2	4
Color	0	1	2	0	1	2
Total point	5	11	18	5	11	16
Quality classify	M	F	Ex	M	F	Ex
Flieg point	39.6	64.3	96.5	51.6	64.3	90.0
Quality classify	M	G	Ex	F	G	Ex
Silage, day 80						
Smell	1	4	11	1	4	11
Structure	0	1	4	0	1	4
Color	0	0	2	0	0	2
Total point□	1	5	17	1	5	15
Quality classify	B	M	Ex	B	M	Ex
Flieg point†	19.2	39.7	95.8	22.0	46.5	88.42
Quality classify	B	M	Ex	M	F	Ex

†0-20,(B) bad; 21-40,(M) medium;41-60,(F) fair;61-80,(G) good; 81-100 (Ex) excellent.
□16-20,(Ex) excellent;10-15,(F) fair;5-9,(M) medium;0-4,(B) bad (DLG,1987)

The highest fleig point was obtained at 5C in MS silage and there were significant differences among groups (p<0.05) (Table 4).

At 5C in CS and FCS silage was excellent in quality based on fleig point. It has been reported that silages with low DM content might have low fleig point and excellent silage can be obtained by increasing carbohydrate content of silage material. In addition, Kılıç (1986), good reported a positive relationship between fleig point and silage quality. It has been noted that silage fermentation quality did not negatively affected with increasing levels of CP in silages (Demirel et all,2006). Silage quality increased during fermentation length. Silages made from NC treatment did not well. But, at 5C silages were determined as excellent.

The results of the measurements of the total colony forming units of the silages according to vacuum treatments were presented in Table 5.

The highest CFU were observed in CS silage at NC treatment. At 5C for all feeds were lowest. The total colony forming units (CFU) of fungus species in silages were affected by vacuum treatments.

Table 5. The total colony forming units (CFU) of fungus species in silage samples tested on MPDA media

Feeds	Treatment	Total CFU of fungus species /g silage
	NC	$10.8x10^{4}$*
CS	3C	0.0
	5C	0.0
	NC	$6.0x10^{4}$
FCS	3C	$1.0x10^{4}$
	5C	0.0
	NC	$>1.0x10^{6}$
SC	3C	0.0
	5C	0.0

*Each value is the mean of 5 replicates

Color of the silage surface

The results of the measurements of the surface color of the silages according to vacuum treatments were presented in Table 6. Color was measured at the end of fermentation length 80th day. The highest brightness (L) values for the all bag silos were shown at 5C treatments. All four variables were affected by vacuum treatments. Yellow-blue (b) and brightness (L) were increased from NC to 5C.

The results of the measurements of the surface color of the silages according to feed varieties were presented in Table 7.

Yellow-blue (b) value of the CS silage almost similar to FCS silage. All four variables were affected by feed varieties (p<0.05).

Table 6.Color of the silage surface dependent on the vacuum levels

Color	NC	3C	5C	LSD	CV	F
Brightness (L)	38.73 b	39.34 b	43.51 a	1.201	2.97	41.93**
Red-green (a)	3.05 ab*	2.86 b*	3.40 a*	0.479*	18.76*	1.99*
Yellow-blue (b)	12.42 b	13.12 b	15.10 a	0.891	6.58	21.89**
Yellowness (ıy)	35.21a	33.81 b	34.07 ab	1.238	3.61	3.27**

Mean values on the same row with the same superscript do not differ significantly at p<0.05
*P<0.01

Table 7.Color of the silage surface dependent on the feeds

Feeds	CS	FCS	SC	F
Brightness (L)	33.26 c	35.71 b	52.61 a	690.74**
Red-green (a)	1.07 c	2.82 b	5.42 a	126.75**
Yellow-blue (b)	12.23 b	11.65 b	16.77 a	88.96**
Yellowness (ıy)	37.10 a	30.83 c	35.15 b	60.18**

Mean values on the same row with the same superscript do not differ significantly at p<0.05

Density

In all silages density decreased. But, density losses in bag silages made at NC and FSC treatments were the highest. The lowest density losses were observed in 5C. Average dry matter densities were changed according to vacuum treatments. The lowest DM density change was observed at 5C. Average DM densities for all feeds (CS, FCS and SC) are shown in figure 2.

Density of silages was affected by silage package machine. Within bags, density was highly variable. But, density did not change during the storage periods. Spoilage losses were measured on all bag silage. Spoilage losses were occurred in NC and 3C treatments.

Whole crop maize is a good forage to ensile, but the ensiling and nutritional quality depends upon the compaction level and also here. All silages made from 5C treatments had good ensiling properties for CS (only maize silage) and FCS (maize silage + %10 floor) silages. The nutritional values of the silages decreased with storage periods.

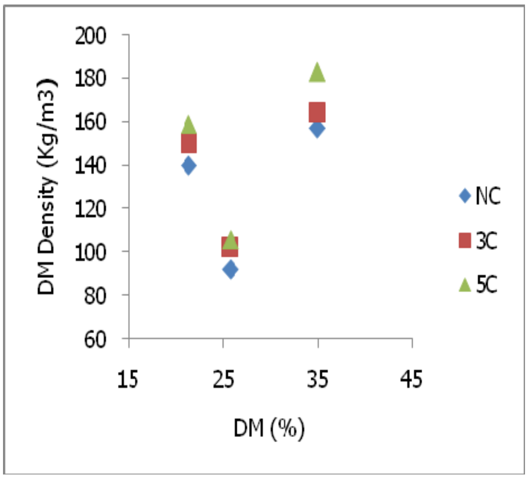

Figure 2. Average DM densities in different feeds

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