Effect of chop length and level of dry matter on fermentation and nutritive value of ensiled corn stover

Ali A. Saeed
Assistant Professor
Department of Animal Production- College of Agriculture- Al-Qasim Green University
E-mail: draliameensaeed59@agre.uoqasim.edu.iq

Abstract:

This study was aimed to investigate the effect of chop length (1-1.5 or 2-2.5 cm) and dry matter (DM) levels (25, 30, 35 or 40%) on fermentation of corn stover silage and its nutritive value. Chopped samples were pretreated with 1% urea and 8% of date's honey and ensiled for 60 days. Results showed an increase (P<0.01) in DM content with increasing chop length in association with a 0.96% decrease in ether extract (EE) content. According to fermentation characteristics, all samples were good quality; pH values ranged 3.73-4.33 for the lowest and highest levels of DM respectively. Concentrations of ammonia nitrogen (NH_3-N) were below 0.5% of total nitrogen (TN). Lower pH (P<0.01) was recorded in samples of stover ensiled with fine chop length (FCSS), but it was characterized with higher NH_3-N concentrations as compared with those ensiled with coarse length (CCSS) (3.99 and 0.43 vs. 4.08, 0.33 % of TN, respectively). Results also showed higher (P<0.01) DM loss in FCSS (15.58 vs. 10.99%), however, it was 30 hours more (P<0.01) resistant to aerobic spoilage as compared with CCSS, moreover, it was prior (P<0.05) in in vitro DM and organic matter (OM) digestibilities (IVDMD and IVOMD). Quality parameters were affected by DM contents of ensiled materials, where, there was a significant increase (P<0.01) in DM loss and a decrease (P<0.01) in resistance to aerobic deterioration. Values of buffering capacity (BC) were increased (P<0.05) with increasing DM levels, higher values of 113.11 Meq. NaOH/100 g DM was estimated in 40% level of DM. This level was correlated with lower (P<0.01) IVDMD, 57.87% and IVOMD, 60.73%. Good quality of corn stover silage samples in this study was confirmed by high Fleig point values of about 86-90.

Key word: Silage, Stover, Chop length, Dry matter .

تاثير طول القطع ومستوى المادة الجافة في تخمرات سايلج علف الذرة وقيمته الغذائية

علي امين سعيد
أستاذ مساعد
قسم الانتاج الجيواني/ كلية الزراعة/ جامعة القاسم الخضراء
البريد الالكتروني:draliameensaeed59@agre.uoqasim.edu.iq

المستخلص

هدفت الدراسة للتحري عن تاثير طول القطع (1-1.5 او 2-3 سم) ومستوى المادة الجافة (25 و 30 و 35 و 40%) في تخمرات سايلج علف الذرة الصفراء وقيمته الغذائية. عوملت النماذج المقطعة قبل السيلجة

باليوريا بمستوى 1% وعسل التمر بمستوى 8% وحفظت لمدة 60 يوم. اظهرت النتائج حصول ارتفاع (P<0.01) في المحتوى من المادة الجافة بزيادة طول القطع صاحبه انخفاض في المحتوى من مستخلص الأيثر بمقدار 0.96%. وقد تميزت جميع نماذج السايلج بنوعية جيدة كما دلت على ذلك خصائص التخمرات، اذ تراوحت قيم الأس الهيدروجيني بين 3.73 و 4.33 عند السيلجة بالمستويين المنخفض والمرتفع من المادة الجافة على التوالي، وانخفاض تركيز نتروجين الأمونيا الى اقل من 0.5% من النتروجين الكلي. وقد سجلت النماذج المصنعة بالقطع الناعم اوطا (P<0.01) أس هيدروجيني، الا انها سجلت اعلى تركيز (P<0.01) في نتروجين الأمونيا مقارنة مع النماذج المصنعة بالقطع الخشن (3.99 و 0.43 % مقابل 4.08 و 0.33% من النتروجين الكلي على التوالي). كما اظهرت النتائج حصول فقد اكبر (P<0.01) في المادة الجافة في النماذج المصنعة بالقطع الناعم (15.58 مقابل 10.99%) الا انها قاومت (P<0.01) التلف الهوائي بمقدار 30 ساعة، فضلا عن تفوقها (P<0.05) في الهضم المختبري للمادة الجافة والعضوية. كما تاثرت معايير النوعية بمستوى المادة الجافة لعلف الذرة عند السيلجة، اذ لوحظ زيادة (P<0.01) نسبة الفقد في المادة الجافة مع تراجع (P<0.01) في مقاومة التلف الهوائي. كما ارتفعت (P<0.05) قيم القابلية الدارئة بزيادة تلك المستويات، فسجل المستوى 40% مادة جافة اكبر تلك القيم اذ بلغت 113.13 ملي مكافيء NaOH/100 غم مادة جافة. كما ارتبط ذلك المستوى باوطأ (P<0.01) هضم مختبري للمادة الجافة 57.87% وللمادة العضوية 60.73%. وقد تعزز الأعتقاد بجودة نوعية نماذج السايلج المصنعة في الدراسة الحالية من خلال قيم فليغ المرتفعة 86-90.

كلمات مفتاحية: السايلج، علف الذرة، طول القطع، المادة الجافة

Introduction

Good pastures and green forages are essential in ruminant feeding (44). Due to dry-low rain climate of middle and the southern parts of Iraq and the human need to green vegetables, pastures and lands planted with green forages were limited. In such conditions maintaining high rates of ruminant production will increase feeding cost as a result of compulsory increased utilization of grains and its by-products. Otherwise, breeders will mainly depend on low quality roughages and crop residues, consequently, ruminant performance will retard as a result of low crude protein and available energy contents of these materials (41). However, these roughages may be considered as s cheap source of potential energy due to its high content of structural carbohydrates. In corn stover these fractions comprise 32.96% (42). Moreover, these roughages can be utilized by ruminants through anaerobic activity of rumen microbes (52).

Corn stover is produced from corn grain production. It consists of the husks, cobs, leaves and stalks that are left in the fields after grain is harvested (32). In Babylon province huge quantities of corn stover are available. Arable land planted with corn is about 173171 acres, with acre productivity of about 1249 kg. Then, residuals after harvesting may reach 750 kg/acre (1).

DM content and chop length of ensiled materials play effective role in fermentation. Yahaya, et. al., (56) reported that ensiling grass at 30 and 45% DM levels produced good quality silage, whereas, ensiling at 20% level of DM produced poor quality silage. Ensiling wet crops associated with increased nutrients loss (29). This may due to stimulating effect of high moisture condition on the growth of *clostridia* species which consume soluble sugars as a source of energy (20). When the DM content of ensiled forage is greater than 45%, it is difficult to pack the material adequately, resulting in excessive heating and mold formation (11).

Buss and Hopkins (10) found that the optimum chop length for silage of greater than 20% DM is 10-25mm, the optimum chop length for silage of less than 20% DM is 20-40mm. Greater chop lengths are another impediment to adequate compaction, removal of oxygen from the silo during packing, delaying anaerobicity and production rate of organic acids, which negatively affected silage quality (53). Moreover, loose silage is more porous and allows greater air infiltration, increasing the rate of aerobic growth and growth of molds and yeasts (27). Effects of chop length on the fermentation process should be minimal when chop length is ∼20 mm or less (23). Therefore, this study aims to investigate the effect of chop length and DM levels on nutritive value of corn stover silage in association with rate and nature of fermentation and nutrients loss during ensiling.

Materials and methods

Samples of corn stover were ensiled at 400-500 g wet material per each. Stover was obtained from private farm in Jebalah town, eastern north of Babylon province, 50 km far of Hilla city. Stover was chopped manually into two chop lengths, 1-1.5 (fine) or 2-2.5 cm (coarse). Fresh stover (32.59% DM) contained on DM basis, 7.86% ash, 4.17% CP, 1.73% EE, 34.02% CF, 52.22% NFE, with IVDMD and IVOMD of 53.76 and 56.43%, respectively. Urea was added at rate of 1% as a cheap source of N. Low quality date's honey was added at rate of 8% as a source of soluble carbohydrates. Additives were added on DM basis. Four DM levels (25, 30, 35 or 40%) were obtained by diluting additives with water prior to mix with stover. The added water was estimated according to the following equation:

DM level required = [(DM content) ÷ (water required+ DM content)] × 100

The treated stover was packed in double nylon sacs and manually compacted to remove air and sealed immediately. Replicates of each treatment were collected in one big nylon sac and placed for 60 days in a well compacted pit silos. Thereafter, silos were opened to perform the planned determinations.

Color, odor, texture and presence of molds were assigned to study sensory characteristics as described by Saeed and Muhamad (43). pH of silage samples was measured using a pH meter (Mi 180 Bench Meter) immediately after preparing water extract as described by Levital, et. al., (33). NH_3-N and TVFA concentrations were determined in water extract according to AOAC (4) and Markham (34), respectively. DM loss during ensiling was estimated on the base of initial and final weights and DM content of the ensiled material (36). Fleig points were calculated by means of the pH values and DM of the silages according to Kilic (28):

Fleig points = 220 + (2 × % DM – 15) – 40 × pH, (Evaluation: 80-100 points, very good quality; 60-80 points, good quality, 40-60 points, moderate quality; 25-40 points, satisfying and <25 points, worthless.

Aerobic stability was determined by the time that elapsed before a 2ºC increase in silage temperature above the ambient temperature as suggested by Levital, et. al., (33). Buffering capacity (BC) was determined as described by Playne and McDonald (40). In vitro DM and OM digestibilies (IVDMD, IVOMD) of silage samples were determined using method of Tilley and Terry (51). Silage samples were analyzed for approximate analysis according to methods of AOAC (4). Fiber fractions were anlyzed according Goering and Van Soest (22). Data obtained were analyzed as a factorial experiment in completely randomized design by analysis of variance using statistical analysis system (45).

Results and Discussion

1- Sensory characteristics

Results of sensory characteristics revealed that wetter silages (25 and 30% DM) were colored with yellowish green, whereas, drier samples (35 and 40%) were darker a bit. Similar observations were reported in corn residuals ensiled with different levels of baker's yeast (42). The slight difference in color may due to the rate of breakdown of chlorophyll during ensiling (12). Variation in concentration of organic acids produced during ensiling may be contributed into this variation. Odor of diluted and concentrated vinegar were clearly wafted. This together with different pH may refer to the presence of organic acids in different concentrations. Ostling and Lindgren (38) reported that increased level of acidity in silage is correlated with completion of fermentation and rise of lactic acid concentration. As expected, FCSS samples due to ensiling with fine chopping were well caked as compared with CCSS samples. On the other hand, there was a slight presence of molds in few samples. This may due to remaining of some air related with insufficient compaction.

2- Characteristics of chemical composition

Effect of chop length and DM level of ensiled materials at ensiling on chemical composition of corn stover silages is shown in Table 1. Results revealed that ash, crude protein (CP) and nitrogen free extract (NFE) were not affected by chop length. However, CCSS recovered ($P<0.01$) 1.73% more DM content than FCSS. Gerlach, et. al., (21) reported 1.28% increase in DM content in corn silage due to increasing chop length from 1 to 2.1 cm. Efficient compaction and improvement in fermentation of FCSS and subsequent degradation of soluble fractions may explained lower DM content of FCSS. Adequate compaction is highly affected by chop length (53). Higher ($P<0.01$) DM loss of FCSS in comparison with CCSS (Table 5.) may prove this idea.

Lower ($P<0.05$) CF content was observed in FCSS as compared with CCSS, the difference was 3.85%. Bal, et. al., (28) reported that fine chopping decreased cell wall constituents of whole corn crop silage. Decrease in CF content may attribute to increase digestion of these components (27). Results also revealed higher ($P<0.01$) EE content in FCSS as compared with CCSS (2.46 vs. 1.55%). Such changes may due to improvements occurred in nature and rate of silage fermentation as evidenced by lower (P<0.01) pH of FCSS in comparison with CCSS in a current study (Table 3.). Improvement in the fermentation of FCSS may associate with the preference of compaction of fine chopped materials. Wagner, et. al., (53) declared that high bulk densities due to short particles limit the propagation of undesirable microorganisms, thus preventing undesirable rises in temperature in the silo. Increase EE content of silage may also associate with presence of short chain fatty acids resulted from anaerobic oxidation of soluble sugars during ensiling (5).

Regarding the effect of DM level of corn stover on chemical composition of silage, results showed a significant (P<0.01) increase in DM content with increasing those levels. There were 3.36, 9.01 and 13.06% increase in DM content of stover silage samples prepared at 30, 35 and 40% respectively, as compared with those prepared at 25% DM level. Gerlach, et. al., (21) obtained similar findings. Higher (P<0.05) ash content was observed in samples of stover ensiled at 35% DM content as compared with those ensiled at 25 and 30% DM. This may associated with level of DM loss occurred during ensiling. Ash content can reach up to 16% of effluent DM (46).

Table 1: Effect of chop length and level of DM on chemical composition of stover silage (%) ± SE

Items	Chop length (A) cm.		Level of DM (%) (B)				significance	
	1-1.5	2-2.5	25	30	35	40	A	B
DM	29.13[b] ± 1.33	30.86[a] ± 1.00	23.64[d] ± 0.49	27.00[c] ± 0.53	32.65[b] ± 0.35	36.70[a] ± 0.43	**	**
Ash	9.54 ± 0.18	9.80 ± 0.19	9.30[b] ± 0.17	9.33[b] ± 0.16	10.24[a] ± 0.31	9.80[ab] ± 0.31	NS	*
CP	4.42 ± 0.03	4.33 ± 0.05	4.34 ± 0.06	4.41 ± 0.05	4.34 ± 0.03	4.42 ± 0.08	NS	NS
CF	26.47[b] ± 0.50	27.49[a] ± 0.33	26.02[b] ± 0.55	25.66[b] ± 0.42	27.81[a] ± 0.55	28.45[a] ± 0.49	*	**
EE	2.46[a] ± 1.33	1.55[b] ± 1.33	2.72[a] ± 1.33	2.60[a] ± 1.33	1.69[b] ± 1.33	1.00[c] ± 1.33	**	**
NFE	56.09 ± 0.45	56.80 ± 0.45	57.60[ab] ± 0.63	57.98[a] ± 0.41	57.90[b] ± 0.59	56.30[ab] ± 0.70	NS	*

DM, dry matter; CP, crude protein; CF, crude fiber; EE, ether extract; NFE, nitrogen free extract
Means with different letters are differed significantly * (P<0.05) ** (P<0.01) NS=non-significant

Results of a current study revealed that CP content silage samples were not affected by level of DM of corn stover at ensiling. Loss in CP contents is minimized in well fermented silage. This together with low pH values as shown in Table 3, can be considered as an evidence for good fermentation quality of silages. Silages with pH values below 4.2 were judged to be good (30). Inconsistent with CF, EE content was affected in different manner due to increasing DM level of ensiled stover. CF contents showed an increase and lower value was determined in samples prepared at 25 and 30% DM levels as compared with those prepared at 35 and 40% DM (26.02 and 25.66 vs. 27.81 and 28.45%, respectively), whereas, EE contents were affected ($P<0.01$) with descending order (2.72 and 2.60 vs. 1.69 and 1% for the four levels of DM, respectively). This can be explained by the improvement in silage fermentation of samples ensiled at low levels of DM as a result of efficient compaction leading to the removal of much higher quantity of air from stored mass. Role of DM levels of ensiled materials on level of compaction in the silo is confirmed by Israelsen, et. al., (27). They reported that higher levels were associated with losses in nutrients during ensiling.

Effect of interaction between chop length and level of DM on chemical composition is shown in Table 2. Results revealed that DM, CF and EE contents were affected by a manner similar to that of main effect of these factors. Higher DM ($P<0.01$) and CF ($P<0.05$) contents were determined in FCSS and CCSS samples prepared at 40% DM level at ensiling. Whereas, different responses were shown in EE content, higher ($P<0.01$) values were determined in FCSS samples prepared at 25 and 30% levels of DM, values were 3.46 and 3.73%, respectively. In other samples EE contents were not exceeded 2%. This may attribute to higher compaction of ensiled stover and more efficient fermentation as affected by the accumulative effect of low levels of DM together with fine chopping. Wagner, et. al., (53) reported that coarse chopping may embedded efficient compaction. Long chopped silage, more than 40 mm, is likely to be less effectively consolidated, leading to poorer fermentation and spoilage, which can include molds (10). Whereas, fine chopping leads to a rapid onset of bacterial acid production and, consequently, to an early conclusion of the microbial reduction of the oxygen between the plant particles (26).

3-Characteristics of silage fermentation

The effect of chop length and DM level of ensiled materials at ensiling on fermentation characteristics of corn stover silages is shown in Table 3. Results showed that lower ($P<0.01$) pH values were recorded in FCSS, though slight differences, as compared with CCSS. Inconsistently, Schwab, et. al. (47) reported lower pH values in whole corn crop silage chopped at 19 mm as compared with that chopped at 13 mm (3.88 vs. 3.99).

The significant preference of fine chopping observed in a current study may due to nature of fermentation. Changes occurred during ensiling was supported by findings of Cherney, et. al., (13). These changes included increase number of microorganisms responsible for fermentation (8), and inhibition growth of undesirable microorganisms such as enterobacteria and clostridia due to rapid drop in pH (31). Worth mentioning, results of current study confirmed finding of Bartusevics and Gaile (7) that there was a positive significant correlation ($r=0.78$; $r_{0.05}=0.30$) between ash content and pH of corn and grass silages.

The current study involves the addition of 1% urea to all samples an ensiling in order to improve aerobic stability (57, 35). However, higher ($P<0.01$) concentration of NH_3-N in FCSS in comparison with CCSS. Similar finding was reported by Fernandez, et. al., (18) in whole corn crop silage. This may be attributed to higher degradation of urea associated with higher surface area of fine chopped stover and a probable increase in urease activity of plant and silage microbes' origin (49). Low pH silage decreases proteolysis rate during ensiling due to inhibition plant proteases (35). Since there were low pH values in all silage samples, relation of ammonia production with proteolysis processes is improbable. Concentration of TVFA was not affected by chop length of ensiled corn stover. This agreed with other studies (6, 37, 47).

Table 3|: Effect of chop length and level of DM on fermentation of stover silage (as appeared) ± SE

Items	Chop length cm (A)		Level of DM % (B)				significance	
	1-1.5	2-2.5	25	30	35	40	A	B
pH	3.99[b] ± 0.07	4.08[a] ± 0.04	3.73[d] ± 0.03	3.88[c] ± 0.06	4.21[b] ± 0.01	4.33[a] ± 0.01	**	**
NH_3-N % of TN	0.43[a] ± 0.02	0.33[b] ± 0.01	0.47[a] ± 0.17	0.41[b] ± 0.16	0.33[c] ± 0.31	0.30[c] ± 0.31	**	**
TVFA % of DM	5.42 ± 0.36	5.22 ± 0.37	5.91[b] ± 0.53	6.95[a] ± 0.39	4.46[c] ± 0.14	3.96[c] ± 0.28	NS	**

NH_3-N, ammonia nitrogen; TN, total nitrogen; TVFA, total volatile fatty acids; DM, dry matter
Means with different letters are differed significantly ** (P<0.01) NS=non-significant

Regarding the effect of DM levels of ensiled stover, results showed that pH values were increased (P<0.01) with increasing these levels. Values of pH were 3.73, 3.88, 4.21 and 4.33 in samples determined at 25, 30, 35 and 40%, respectively. This may due to more efficient compaction and subsequent improvement in fermentation. Ferraretto, et. al., (19) attributed the negative effect of high DM content on pH to decrease lactic and acetic acid concentrations. Others linked this with the effect of high DM content on the growth of lactic acid bacteria (35, 54). However, no differences were observed by Gerlach, et. al., (21) when maize silage was ensiled at 33-40% DM. Results revealed lower (P<0.01) NH_3-N concentration with increasing DM levels of ensiled stover, especially at 35 and 40% DM levels. Similar results were observed by Gerlach, et. al., (21) and Yahaya, et. al., (56). However, values determined in the current study were much lower than 7- 9 % of TN and 5-7 % of total CP reported by Gerlach, et. al., (21) and Kung and Shaver (30). This difference may be attributed to the lower CP content of corn stover and the addition of high level of dates honey (8%) used in the current study. Adequate level of soluble sugar provided lactic acid bacteria with a substrate required for growth and proliferation leading to rapid decline of pH. It seemed probable that the rapid achievement of a low pH would reduce both the extent of proteolysis and deamination, resulting into silage with a lower NH_3-N content (50). Moreover, DM levels of corn stover at ensiling were sufficient to prevent clostridial growths responsible for proteolysis and the increased concentration of NH_3-N (56).

Results also revealed significant (P<0.01) decrease in TVFA concentrations in silage samples with increasing DM levels of ensiled materials. This can be explained by the optimal fermentation may occur when chopped stover was ensiled at low DM level as affected by efficient compaction and removing of air from the sacs. Ensiled corn stover at 30% DM produced 1.04, 2.49 and 2.99, % of total DM higher (P<0.01) TVFA concentration than those ensiled at 25, 35 and 40% DM levels, respectively. Moreover, there is a negative (P<0.01) correlation between DM level and concentration of lactic acid (- 0.69) and acetic acid (- 0.42) (48).

Effect of interaction between chop length and DM levels of ensiled corn stover is shown in Table 4. It was observed that lower (P<0.01) pH was determined in FCSS samples prepared at 25 and 35% DM levels. All samples were well fermented as judged by Kung and Shaver (30) who considered silages with pH values of 3.7-4.2 as good quality silages. Lower NH_3-N concentrations were determined in CCSS. Achievement of rapid drop in pH seemed to control proteolysis and deamination processes, hence, silages with low concentration of ammonia nitrogen may be produced. Similar conclusion was attained by Tauqir, et. al., (50) in non-leguminous fodder silages. Higher (P<0.01) concentrations of TVFA were determined in FCSS samples ensiled at 25 and 30% DM levels, and CCSS samples ensiled at 30% DM level. This may consider a reflection of previously well recognized effects of lower DM levels, especially in association with fine chopping of ensiled materials.

4-Characteristics of silage quality

Results revealed 4.59% higher (P<0.01) DM loss in FCSS as compared with CCSS (Table 5.). This may due to improvement in anaerobic fermentation associated with effective compaction (37), and subsequent increase in effluent (13). Correlation between DM loss and rate of anaerobic fermentation occurred in ensiled mass after removal of oxygen has been reported by Alves, et. al., (3). After sacs were opened for evaluating quality, FCSS samples were 30 h more (P<0.01) stable in comparison with CCSS samples before a 2 Cº rise in temperature of silage. This may refer to priority of FCSS in aerobic stability which is an important parameter assessing silage fermentation component. After silos are opened for feeding, air penetrates the silages and promotes the growth of aerobic, acid-tolerant microorganisms and the oxidation of fermentation products present in the silages (15). Significant resistance of FCSS can be explained by its higher (P<0.01) concentration of NH_3-N (Table 3.). Oude Elferink, et. al., (39) observed that urea and ammonia can improve aerobic stability. This was attributed to an anti-fungal activity of ammonia (29). Coarse chopping may promote penetration of larger amounts of oxygen, thus increasing the opportunity of exposing silage to aerobic deterioration (55).

Regarding the nutritive value of stover silages, results revealed increased (P<0.05) IVDMD and IVOMD in FCSS as compared with CCSS samples. This was expected since fine chopping was associated with easer compaction and better fermentations. Hoffman, et. al., (24) reported that corn stalks should be finely

Table 2: Effect of interaction between chop length and level of DM on chemical composition of stover silage (%) ± SE

Chop length cm	1-1.5				2-2.5				Significance level and SE	
Level of DM %	25	30	35	40	25	30	35	40		
Items										
DM	22.16^{f}	25.43^{e}	31.77^{c}	37.18^{a}	25.11^{e}	28.57^{d}	33.57^{b}	36.22^{a}	**	± 0.83
% in DM										
ash	9.03^{b}	9.38^{b}	9.88^{ab}	9.86^{ab}	9.58^{ab}	9.28^{b}	10.60^{a}	9.74^{ab}	*	± 0.13
CP	4.35	4.52	4.36	4.46	4.32	4.31	4.32	4.38	NS	± 0.03
CF	25.17^{b}	24.83^{b}	27.66^{a}	28.25^{a}	26.87^{ab}	26.49^{ab}	27.96^{a}	28.66^{a}	**	± 0.30
EE	3.46^{a}	3.73^{a}	1.50^{bc}	1.16^{cd}	1.98b	1.48^{bc}	1.89^{bc}	0.84^{c}	**	± 0.18
NFE	57.98	57.53	56.59	56.25	57.23	58.43	55.21	56.35	NS	± 0.31

DM, dry matter; CP, crude protein; CF, crude fiber; EE, ether extract; NFE, nitrogen free extract
Means with different letters are differed significantly * ($P<0.05$) ** ($P<0.01$) NS=non-significant

Table 4: Effect of interaction between chop length and level of DM on fermentation characteristics of stover silage (As shown) ± SE

Chop length cm	1-1.5				2-2.5				Significance level and SE	
Level of DM %	25	30	35	40	25	30	35	40		
Items										
pH	3.62^{e}	3.78^{d}	4.24^{ab}	4.33^{a}	3.84^{d}	3.99^{c}	4.17^{b}	4.33^{a}	**	± 0.04
NH_3-N, % of TN	0.52^{a}	0.49^{ab}	0.37^{cd}	0.35^{cd}	0.42^{bc}	0.34^{cd}	0.29^{e}	0.25^{e}	*	± 0.01
TVFA, % of DM	7.19^{ab}	6.18^{b}	4.60^{c}	3.70^{c}	4.63^{c}	7.72^{a}	4.21^{c}	4.21^{c}	**	± 0.25

NH_3-N, ammonia nitrogen; TN, total nitrogen; TVFA, total volatile fatty acids; DM, dry matter
Means with different letters are differed significantly * ($P<0.05$) ** ($P<0.01$) NS=non-significant

chopped prior to ensiling to aid packing, fermentation and to minimize sorting when feeding. The significant (P<0.05) slight differences due to chop length, 1.27 and 0.87% for IVDMD and IVOMD of FCSS as compared with CCSS, can be explained by slight differences within samples due to high laboratory accuracy involved in preparing and analyzing.

Regarding the effect of DM levels of ensiled corn stover, results showed an increase (P<0.01) in DM loss with increasing DM levels. Lower values were estimated in samples prepared at 25% DM level, thereafter, it increased to 4.01, 6.93 and 12.2% at 30, 35 and 40% DM levels, respectively. Yahaya, et. al., (56) estimated an increase of 4.5 and 5 in grass silage ensiled at 30 and 45% levels of DM, respectively. Increase DM loss in a current study may attribute to reduced density of silage prepared at relatively higher levels of DM. Less dense silage allows more air into the silo and thus takes longer to ferment. The longer the forage takes to ferment the more fuel (sugar, starch and protein) is burned (14). Holmes and Muck (25) reported that losses throughout the filling, storage and feed out process in silos are strongly correlated with silage density.

Table 5: Effect of chop length and level of DM on nutritive value characteristics of stover silage (as appeared) ± SE

Items	Chop length (A) cm.		Level of DM (%) (B)				significance	
	1-1.5	2-2.5	25	30	35	40	A	B
DM loss	15.58[a] ± 0.53	10.99[b] ± 1.74	7.50[d] ± 1.74	11.51[c] ± 1.61	14.43[b] ± 0.78	19.70[a] ± 1.17	**	**
Fp	88.23 ± 1.04	88.91 ± 0.74	89.41 ± 1.30	87.93 ± 1.57	86.83 ± 1.29	90.12 ± 0.67	**	**
AS	57.40[a] ± 4.63	27.42[b] ± 0.47	51.45[a] ± 7.78	52.95[a] ± 8.90	33.00[b] ± 1.71	32.25[b] ± 2.41	NS	**
BC	97.73 ±7.12	90.77 ±4.41	82.66[b] ±10.12	83.66[b] ±5.85	97.55[ab] ±6.30	113.13[a] ±7.54	NS	*
IVDMD	59.99[a] ±0.49	58.72[b] ±0.36	59.59[ab] ±0.58	60.82[a] ±0.67	59.21[bc] ±0.48	57.87[c] ±0.49	*	**
IVOMD	62.78[a] ±0.36	61.91[b] ±0.38	62.74[a] ±0.44	63.13[a] ±0.59	62.94[a] ±0.37	60.73[b] ±0.45	*	**

DM loss, dry matter loss; Fp, Fleig point; AS, aerobic stability; BC, buffering capacity; IVDMD, in vitro dry matter digestibility, IVOMD, in vitro organic matter digestibility
Means with different letters are differed significantly * (P<0.05) ** (P<0.01) NS=non-significant

Aerobic stability in a current study was affected by the level of DM. Samples prepared at 25 and 30% levels of DM were about 20 h more stable than those prepared at 35 and 40% levels. More dense ensiled forage is more stable at feedout face (14). Densely packed silage limits the rate of oxygen diffusion, in contrast, in loosely packed silage, oxygen may move several yards into the silage from the open face (25). Higher (P<0.01) concentration of NH_3-N in stover samples ensiled at lower DM levels (Table 3.) may considered another reason for better AS in these samples.

Buffering capacity was also affected (P<0.05) by DM levels, higher values were estimated in corn stover samples ensiled at higher level of DM with Differences of 15.56, 29.45 and 30.45 Meq NaOH/100 g DM as compared with those ensiled at 25, 30 and 35% levels of DM respectively. This may due to the production rate of organic acids during fermentation as affected by DM content at ensiling. Negative correlation between moisture level of ensiled materials and BC was confirmed by Bolsen, et. al., (9).

Fleig points (Fp) which is used as an indicator for silage quality by many researchers. All silages prepared in the current study were of very good quality according to scales determined by Kilic (28). Values shown in Table 6 (86.83-91.12 points), and Table 7 (83.62-91.16 points) were close to those estimated by Saeed, et. al., (42) for ensiled yellow corn residuals (85.03-89.11). Denek, et. al., (17) reported Fp of 86.00 in corn silage and 86.72 in sorghum silage.

Results revealed a significant (P<0.01) decrease in IVDMD at higher levels of DM especially at 40%. Ensiling corn stover at this level decreased digestion with 1.72 and 2.95 units in comparison with IVDMD values determined in stover samples ensiled at 25 and 30% levels of DM. This may due to the compaction level in which fermentation may be more efficiently secured. Tauqir, et. al., (50) reported that the most important controllable factor determining silage quality is the DM content. DM content of 35% was observed to be a desirable level for good silage fermentation and digestibility of whole plant corn silage (WPCS) (6). Similarly, IVOMD at higher level of DM was decreased (P<0.01) by 2.01, 2.40 and 2.21 digestion units in comparison with 25, 30 and 35% levels of DM. This agreed with trend of changes noticed by Daynard and Hunter (16), when plant DM concentration increased from 32 to 40% digestibility of the whole corn plant was unchanged, but the stover digestibility decreased.

As shown in Table 6. DM loss was affected by interaction between chop length and level of DM. Lower (P<0.01) percentages of 2.91 and 6.81% was estimated in stover ensiled at 25 and 30%, respectively. This may be attributed to associated effects of fine chopping and lower DM levels on compaction achieved and volume of air captured in samples (56). Together with low DM loss, samples of corn stover ensiled at low level of DM were also characterized with better aerobic stability. This may associated with higher (P<0.01) concentration of ammonia (Table 3.), due to its anti-fungal effect (2). Higher values of buffering capacity were estimated in stover samples ensiled at higher level of DM, especially in FCSS. This may attribute to the role of low DM level in rate and nature of fermentation. For the same reason, lower (P<0.01) values of IVDMD and IVOMD were determined in samples ensiled at high levels of DM.

Table 6: Effect of interaction between chop length and level of DM on nutritive value characteristics of stover silage (As appeared) ± SE

Chop length cm	1-1.5				2-2.5				Significance level and SE	
Level of DM %	25	30	35	40	25	30	35	40		
Items										
DM loss	12.71[c]	16.19[b]	16.20[b]	17.23[b]	2.29[e]	6.82[d]	12.67[c]	22.17[a]	**	± 0.97
Fp	89.76[a]	88.40[ab]	83.62[b]	91.16[a]	89.05[a]	87.47[ab]	90.04[a]	89.08[a]	*	± 0.63
AS	74.70[b]	6.18[b]	4.60[c]	3.70[c]	4.63[c]	7.72[a]	4.21[c]	4.21[c]	**	± 3.32
BC	95.08[abc]	79.60[a]	98.23[abc]	120.69[a]	70.24[c]	90.39[abc]	96.88[abc]	105.58[ab]	*	± 4.17
IVDMD	60.04[b]	62.24[a]	59.26[bc]	58.44[bc]	59.14[bc]	59.40[bc]	59.17[bc]	57.31[c]	*	± 0.31
IVOMD	62.57[ab]	63.91[a]	63.65[a]	61.33[bc]	62.92[ab]	62.36[ab]	62.24[ab]	60.13[c]	*	± 0.27

DM loss, dry matter loss; Fp, Fleig point; AS, aerobic stability; BC, buffering capacity; IVDMD, in vitro dry matter digestibility, IVOMD, in vitro organic matter digestibility

Means with different letters are differed significantly * (P<0.05) ** (P<0.01) NS=non-significant

Conclusion

In view of results, it is concluded that fine chopping of yellow corn stover improves fermentations; however, it will associate with higher DM loss. All DM levels used in this study were below those which may seriously affect quality and nutritive value of the stover silages.

References

1- **Agricultural report (2016)** Production of yellow corn in Babylon Province. General directorate of Agriculture in Babylon Province. Local Statistics.

2- **Al-Sultani, H. M. (2016)** Effect of ensiling and level of nitrogen on nutritive Value of common reed (*Phragmites communis*). MSc Thesis. Al-Qasim Green University, Iraq.

3- **Alves, S.P., A. R. J. Cabrita, E. Jeronimo, R. J. B. Bessa and A. J. M. Fonseca (2011)** Effect of ensiling and silage additives on fatty acid composition of ryegrass and corn experimental silages. J. Anim. Sci. 89:2537–2545

4- **A.O.A.C. (2005)** Official methods of analysis, Association of Official Analytical Chemists, Washington, D.C.

5- **Arbabi, S. and T. Ghoorchi (2008)**The effect of different levels of molasses as silage additives on fermentation quality of foxtail millet (*Setaria italic*) silages. Asian J. Anim. Sci. 4 (3):43-50.

6- **Bal, M. A., R. D. Shaver, A. G. Jirovec, K. J. Shinners, and J. G. Coors (2000)** Crop processing and chop length of corn silage: Effects on intake, digestion, and milk production by dairy cows. J. Dairy Sci. 83:1264–1273.

7- **Bartuševics, J. and Z. Gaile (2010)** Effect of silaging on chemical composition of maize substrate for biogas production. Research for Rural Development. Annual 16th International Scientific Conference Proceedings. Jelgava, LLU, 265 pages.

8- **Bolsen, K. K. (1995)** Silage: Chapter 12. Silage: Basic Principles. Pages 163–176 in Forages, V. II: The Science of Grassland Agriculture. 5th ed. R.F. Barnes, C. J. Nelson, and D. Miller, ed. Iowa State University Press, Ames, IA.

9- **Bolsen, K. K., G. Ashbell and Z. Weinberg (1996)** Silage fermentation and silage additives-Review. Asian-Aust. J. Anim. Sci. 9: 483.

10- **Buss, J. and A. Hopkins (2011)** Silage decision factsheet. Chop length. English beef and lamb executive. Better returns programme.

11- **Castro, J. J., N. Mullis, J. K. Bernard, and J. W. West (2009)** Effect of ryegrass silage dry matter content on the performance of lactating Holstein cows. Animal & Dairy Science Reports. Coll. Agric. Environ. Sci. Georgia Univ.

12- **Catchpool, V. R. and E.F. Henzell (1971)** Silage and silage-making from tropical herbage species. Herbage Abstr.41: 213.

13- **Cherney, D. J, J. H. Cherney and W. J. Cox (2004)** Fermentation characteristics of corn forage ensiled in mini-silos. J. Dairy Sci. 87 (12):4238–4246

14- **Clyburn, B. (2012)** What can a fermentation analysis tell you about your silage? Improving food and health. CHR Hansen Animal Health and Nutrition.
15- **Danner, H., M. Holzer, E. Mayrhuber, and R. Braun (2003)** Acetic acid increases stability of silage under aerobic conditions. Appl. Envi. Micro. 69, (1): 562 567.
16- **Daynard, T.B. and R.B. Hunter (1975)** Relationships among whole plant moisture, grain moisture, dry-matter yield, and quality of whole-plant corn-silage. Canadian J. Plant Sci. 55: 77-84.
17- **Denek, N., A. Can, and Ş. Tüfenk (2004)** Mısır, Sorgum ve Ayçiçei Hasıllarına Degisik Katkı Maddeleri Katılmasının Silaj Kalitesi ve In Vitro Kurumadde Sindirimine Etkisi. J. Agric. Fac. HR. U. 8 (2): 1-10.
18- **Fernandez, I., C. Martin, M. Champion and B. Michalet-Doreau (2004)** Effect of corn hybrid and chop length of whole-plant corn silage on digestion and intake by dairy cows. J. Dairy Sci. 87:1298–1309.
19- **Ferraretto, L.F., K. Taysom, D. M. Taysom, R. D. Shaver and P. C. Hoffman (2014)** Relationships between dry matter content, ensiling, ammonia-nitrogen, and ruminal in vitro starch digestibility in high-moisture corn samples. J. Dairy Sci. 97:3221–3227.
20- **Gary, M. (1992)** Ensiling process. In: Silage Manual (Ed. M. Bjorge and H. Bjorge). Edmonton, Alberta. pp. 14-17.
21- **Gerlach, K., F. Roß, K. Weiß, W. Büscher and K. Südekum (2013)** Changes in maize silage fermentation products during aerobic deterioration and effects on dry matter intake by goats. Agricultural and Food Sci. 22: 168–181.
22- **Goering, H. K. and P. J. Van Soest (1970)** Forage fiber analysis, U.S. Department of Agriculture, Handbook. No. 379, 1-20.
23- **Hara, S. and T. Tanigawa (2010)** Effects of length of cut and mechanical processing on utilization of corn silage harvested at the black line stage of maturity by lactating dairy cows. Anim. Sci. J. 81, 187–193.
24- **Hoffman, P.C., R.D. Shaver and D.A. Undersander (2004)** Utilizing corn stalk residues for dairy cattle. http://talk.newagtalk.com/category-view.asp).
25- **Holmes, B. J. and R. E. Muck (2000)** Preventing Silage Storage Losses. http://www.uwex.edu/ces/crops/uwforage/prevent-silage-storage7.pdf. 7/17/01.
26- **Honig, H. and K. Rohr (1984)** Silomais - wie kurz häckseln? Top Agrar. 9, S.76-79.
27- **Israelsen, C., J. Barnhill, M. Pace, L. Greenhalgh and J. Gale (2009)** Chopping and Storing Quality Corn Silage. AG/Farmland/2009-02pr .
28- **Kilic, A. (1986)** Silo Feed (Instruction, Education and Application Proposals). Bilgehan Press, izmir, Turkey.
29- **Kung, L. (2002)** A review on silage additives and enzymes. http: // ag.udel.edu/ anfs/faculty/ kung/ articles/a_review_on_silage_additives_and.htm. Accessed December 8, 2005.

30- **Kung, L., and R. Shaver (2001)** Interpretation and use of silage fermentation analysis reports. Focus on Forage. 3:1–5.
31- **Kung, J., L. J. R. Robinson and J. D. Pesek (2000)** Microbial populations, fermentation end-products and aerobic stability of corn silage treated with ammonia or a propionic acid based preservative. J. Dairy Sci., 83: 1479-1486.
32- **Lane, e. and J. City (2012)** Corn stover in Missouri. university of Missouri extension, “Feasibility of corn stover in Missouri” (http:// agebb. missouri. edu/ commag/resources/CornStoverReport.pdf).
33- **Levital, T., A.F. Mustafaa, P. Seguinb and G. Lefebvrec (2009)** Effects of a propionic acid-based additive on short-term ensiling characteristics of whole plant maize and on dairy cow performance. Anim. Feed Sci. Tech. 152, 21–32.
34- **Markham, R. (1942)** A steam distillation Apparatus suitable for Micro-Kjeldahl Analysis. Biochem. J. 36. 790.
35- **McDonald, P., A. Henderson and S. Heron (1991)** The Biochemistry of Silage, 2nd Ed. Chalcombe Publications, Bucks (UK). 340 pp.
36- **Nishino, N., and E. Touno (2005)** Ensiling characteristics and aerobic stability of direct-cut and wilted grass silages inoculated with *Lactobacillus casei* or *Lactobacillus buchneri*. J. Sci. Food Agric. 85:1882–1888.
37- **Onetti, S.G., R. D. Shaver, S. J. Bertics, and R. R. Grummer (2003)** Influence of corn silage particle length on the performance of lactating dairy cows fed supplemental tallow. J. Dairy Sci. 86:2949–2957.
38- **Ostling, E. C. and A.S. Lindgren. (1993)** Inhibition of enterobacteria and Lrsteria growth by lactic, acetic and formic acids. J. Appl. Bacteriology 18-24.
39- **Oude Elferink, S.J.W.H., F. Driehuis, J.C. Gottschal and S.F. Spoelstra (1999)** Silage fermentation processes and their manipulation, FAO Electronic Conference on Tropical Silage, Rome. pp. 17-30.
40- **Playne, M.J. and P. M. McDonald (1966)** The buffering constituents of herbage and silage. J. Sci. Food Agric. 17: 264-268.
41- **Saeed, A.A (2015)** Effect of addition of baker's yeast *Saccharomyces cerevisae* and source of nitrogen on fermentation of reed silage and its nutritive value. Euphrates J. Agric. Sci. 7 (2): 10-24.
42- **Saeed, A.A., Al-Sultani, H.M.H. and Muttaleb, A.S. (2017)** Effect of addition of different levels of baker's yeast *Saccharomyces cerevisae* on fermentation quality and nutritive value of ensiled whole yellow corn crop residuals. Euphrates J. Agric. Sci. 9 (1):1-8.
43- **Saeed, A. A. and S.F. Mohammed (2017)** Ensiling characteristics and nutritive value of corn cobs as affected by addition of different levels of urea and soluble carbohydrates. IJAS, 48: (Special Issues): 92-106.
44- **Santos, M. B., G. A. Naderc, P. H. Robinsona, D. Kirand, U. Krishnamoorthy, and G. M. J. (2010)** Impact of simulated field drying on in vitro gas

production and voluntary dry matter intake of rice straw, Anim. Feed Sci. and Tech., 159: 96-104.

45- **SAS (2010)** SAS/STAT User´s Guide for Personal Computers. Release 6.08. SAS Inst. Inc. Carg, No. USA.

46- **Savoie, P., A. Amyot, and R. Theriault (2002)** Effect of moisture content, chopping, and processing on silage effluent. Trans. ASAE 45:907–914.

47- **Schwab, E. C., R. D. Shaver, K. J. Shinners, J. L. Lauer, and J. G. Coors (2002)** Processing and chop length effects in brown-midrib corn silage on intake, digestion, and milk production by dairy cows. J. Dairy Sci. 85:613–623.

48- **Soderlund, S. (1995)** Effect of moisture level and fermentation components of ensiled feedstuffs on voluntary dry matter intake. Proc. Symposium: Intake by Feedlot Cattle. Oklahoma State University, Stillwater, OK.

49- **Stephanie, D.C. and R.L. Simon (1992)** Kinetic properties of *Helicobacter pylori* urease compared with jack bean urease. FEMS Microbial. Rev. 99: 5.

50- **Tauqir, N. A., M. Nisa, M. Sarwar and S. A. Bhatti (2008)** Impact of varying moisture levels, different additives and fermentation periods on nutritive value of leguminous and non-leguminous fodder silages in lactating nili-ravi buffaloes. Pak. J. Agric. Sci. 45(2):386-402 **.**

51- **Tilley, J.M.A. and R.A. Terry (1963)** Two stages technique for the in vitro digestion of forage crops. Gr. J. Grassland Soc., 18:104.

52- **Tripathi, M. K., Karim, S. A., Chaturvedi, O. H. and Verma, D. L. (2008).** Effect of different liquid cultures of live yeast strains on performance, ruminal fermentation and microbial protein synthesis in lambs. J. Anim. Physio. Anim. Nut., 92(6):631-639.

53- **Wagner, A., K. Leurs and W. Büscher (2004)** The influence of chop length on compactability, ensiling and undesirable temperature in maize silage. Agrartechnische Forschung 10 Heft 4, S. 40-47 **.**

54- **Wayne K. C., O. F. John, K. B. Keith, W. K. Charles and C. C. Robert (1998)**.The effect of moisture concentration and types on quality characteristics of alfalfa hay baled under two density regimes in a model system. Anim. Feed Sci. Technol. 72:53-69.

55- **Wilkinson, J. M. and D.R. Davies (2013)** The aerobic stability of silage: key findings and recent developments. Grass Forage Sci. 68, 1–19.

56- **Yahaya, M.S., M. Kawai, J. Takahashi and S. Matsuoka (2002)** The Effects of Different Moisture Content and Ensiling Time on Silo Degradation of Structural Carbohydrate of Orchardgrass. Asian-Aust. J. Anim. Sci. 15, 2: 213-217).

57- **Yunus, M., N. Ohba, M. Furuse and Y. Masuda (2000)** Effects of adding urea and molasses on Napier grass silage quality. Asian-Aus. J. Anim. Sci. 13: 1542.