EVALUATION OF DIFFERENT KINDS OF SILAGE SUPPLEMENTED WITH LIMESTONE

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ABSTRACT

Four fresh cereal crops included, whole corn plant, corn stover, fodder corn (Darawa) and fodder sorghum were used to evaluate the effect of limestone supplementation during silage making on chemical composition, fermentation characteristics and *in situ* disappearance of dry matter, crude protein and crude fiber. Forage crops were chopped using harvester chopper machine to 3-5 cm length. Ground limestone was added to the different crops at the levels of 0.0, 0.5, 1.0, 1.5 and 2.0 % of wet weight and then ensiled in plastic bucket with about 2 kg of weight capacity. After two months, the silos were opened, color and odor were examined and representative samples were taken for chemical analysis as well as to determine the silage quality. The rate of ruminal degradation of DM, CP and CF for the different kinds of silage was determined by using Friesian cows fitted with rumen cannulae. Results indicated that Fresh corn stover had the highest ($P<0.05$) DM and CF content, while it had the lowest contents of CP and EE. While, fresh fodder corn had significantly ($P<0.05$) the highest contents of OM and CP and the lowest ash content. Fresh whole corn plant recorded significantly ($P<0.05$) the highest contents of EE and NFE. While, fresh sorghum forage showed significantly ($P<0.05$) the highest ash content, the lowest DM and OM contents. The DM, EE, CF and ash contents of different silages significantly ($P<0.05$) increased with increasing the limestone level, while OM and NFE content significantly ($P<0.05$) decreased. The concentration of lactic acid decreased with increasing DM content of silage ($r = -0.76$). Moreover, it significantly ($P<0.05$) increased with increasing the limestone level up to 1% and decreased afterwards. There was a negative correlation exist between DM content and VFA's concentration of silage ($r = -0.75$). On the other hand, the concentration of NH_3-N decreased with increasing DM content ($r = -0.81$), but it increased with increasing CP content ($r = 0.75$). DM disappearance for different silages significantly ($P<0.05$) increased with increasing of limestone level up to 1% and decreased afterwards. The results also showed a positive correlation ($r = 0.71$) between DM

disappearance and NFE content, while there was a high negative correlation (r = - 0.81) between DM disappearance and CF content, while the CP disappearance for different silages significantly (P<0.05) decreased with increasing the limestone level. While, the undegradable fractions (u) increased and effective degradability decreased, this consequently significantly increases the amount of protein escaping ruminal degradation. The CF disappearance of the different silages increased with increasing CF content, a high positive correlation was recorded between CF content and disappearance (r = 0.97). However, it decreased with increasing NFE content, which there was a high negative correlation (r = - 0.87). The results also, indicated that the addition of limestone at the level of 1.0 % of wet weight at silage making improved silage quality, decreased ensiling losses and enhanced DM, CP and CF disappearance.
Keywords: *corn silage, limestone, ensiling losses, silage quality, In situ disappearance*

INTRODUCTION

In Egypt, shortage of feed supply particularly during summer may be considered the major constrain for further increase in animal production. Efforts and great attention are directed to increase feed supply to rectify existing feed deficits from indigenous resources through increasing and improving the local varieties of forages as a partial solution for the shortage of feeds (Makky, 1976).

In Egypt, the total planted area of corn crop was about 1.65 million feddans, 1.49 million used for grain production and 160 thousand feddens were used as silage (National Campaign of Corn Crop Rising, 2003). However, the area cultivated with fodder corn was about 222,531 feddans and the average yield per feddan was 12.67 tons (Agriculture Economics, 2003). The average yield of fresh whole corn plant per feddan was 19.57 ton on wet basis and 5.33 ton on DM basis (Bendary et al., 2001a), while the yield of fresh corn stover was 10.56 ton on wet basis and 3.42 ton on DM basis per feddan (Bendary et al., 2001b)

Corn silage is the most popular silage in the world where corn plants grow well because maximum yields of digestible nutrients per units of land can be harvested from this crop. In addition, the corn plants can be harvested early to clear the land for full plowing or for the second cropping (Perry and Cecava, 1995). Ensiling fresh corn stover material reduces field losses and may produce a more palatable feed (Colenbrander et al., 1971). Moreover, it may offer a significant reduction of feed cost as well as reduction of using concentrate mixture for lactating cows (Bendary and Younis, 1997) and lambs (Ghanem et al., 2000).

Several management practices can improve corn and sorghum silages including, harvesting at the optimum maturity, moisture content, fine chopping, rapid silo filling and packing, tight sealing and a fast feed-out rate (Bolsen et al., 1988). The use of silage additives is an alternative method for obtaining better quality silage, which can be resulted in the optimization of several important silage parameters such as pH, NH_3-N and organic acids. Limestone has been added to corn in the past to increase the calcium and lactic acid contents of silage, but little is known about its use with wetter forage sorghum silage (Bolsen et al., 1988).

Corn silage relative to alfalfa is inherently low in its concentrations of calcium, magnesium, potassium and sulfur. The recommended dietary calcium allowance is 0.8 - 1.00% (DM basis) with calcium carbonate as the primary calcium supplement. With high corn silage diets, sodium bicarbonate is recommended at the rate of 1% of lactation TMR DM to buffer acidity in the corn silage and acid production in the rumen.

The objective of the present study was to investigate the effect of limestone supplementation on chemical composition, fermentation characteristics as well as ruminal dry matter, crude protein and crude fiber disappearance for whole corn plant, corn stover, fodder corn and fodder sorghum.

MATERIAL AND METHODS

The current work was carried out at Sakha Animal Production Research Laboratories, belonging to Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture in co-operation with Department of Animal Production, Kafr El-Sheikh University. This work consists of two parts, the first one was laboratory silo study and second one was *In Situ* study.

Four fresh cereal crops included, whole corn plant, corn stover, fodder corn (Darawa) and fodder sorghum were used to evaluate the effect of limestone supplementation during silage making on chemical composition, fermentation characteristics and in situ disappearance of dry matter, crude protein and crude fiber. Whole corn plant was harvested at dough stage of maturity; corn stover was taken after harvesting the ears immediately. While fodder corn and fodder sorghum were taken after 50 days from planting. Forage crops were chopped using harvester chopper machine to 1.5-2.0 inch length.

Ground limestone was added to the different crops at the levels of 0.0, 0.5, 1.0, 1.5 and 2.0 % of wet weight. Then ensiled in plastic bucket with about 2 kg of weight capacity and pressed by hand to exclude the air from the silos, then sealed with paraffin wax. Treatments were run in triplicates (three of each). At the time of ensiling (zero time), representative samples were taken and dried in a forced air oven at 60°C for 48 hrs, ground and kept for later chemical analysis.

After two months, the silos were opened, color and odor were examined and representative samples were taken for chemical analysis and to determine the silage quality. The different silos were weighed before and after ensiling to determine the fermentation losses expressed as a percentage of initial total DM stored. The spoiled and moldy silage from the top of each silo was weighted and dried in a forced air oven at 60 °C for 48 hrs to determine the spoiled and moldy losses expressed as a percentage of total DM stored.

Water-soluble extracts were prepared by extracting 20 gm of wet silage in a blender with 100 ml of distilled water. The extracts were filtered through Whatman NO. 40 filter papers. The pH values were determined directly by using Beckman pH meter. Total volatile fatty acids (VFA`s) were determined according to Warner (1964), NH_3-N concentrations (AOAC, 1990) and lactic acid was estimated by titration with 0.1 N sodium hydroxide solution using 2-3 drops of phenolphthalein indicator according to methods of Analytical Chemistry of Foods (1995) the following equation:-

Lactic acid % of DM = ml of NaOH × 0.09/ sample weight.

The rate of ruminal degradation of DM, CP and CF for the different kinds of silages were determined by nylon bags using Friesian cows fitted with rumen cannulae. Samples of different silage kinds were ground then 5 gm were weighted into 7× 12 cm nylon bags with mean pore size 50 μm bags were tied near the end of 60 cm nylon cord anchored by a 70 gm steel weight and incubated in the rumen (in triplicate for each silage treatment) of cow for different extends time (0, 6, 12, 24, 48 and 72 hrs). Zero hour bags were washed to estimate the disappearance of DM, CP and CF due to both solubility and washing procedure. The bags after incubation in the rumen were also washed. All bags then were dried at 60 °C for 48 hrs to determine DM and the residue was analyzed for CP and CF according to AOAC (1990). Degradability constants a, b and c for DM, CP and CF were derived from the following equation: - proportional DM, CP or CF = $a + b\,(1-e^{-ct})$, according to

Ørskov and McDonald (1979). The representative samples of the different crops before and after ensiling and also after different incubation periods were chemically analysis according to AOAC (1990).

The data were statistically analyzed using General Linear Models Procedure (one way ANOVA model) adapted by SPSS (1997), while appropriate means were separated using Duncan's multiple range test.

RESULTS AND DISCUSSION

Chemical composition:-

Chemical composition of different kinds of fresh forage and silages supplemented with limestone is shown in Tables 1 & 2. The DM contents of different silages revealed the same trend of DM contents of fresh forages. While, the corn stover silage (CSS) recorded significantly ($P<0.05$) the highest contents of DM, CF and fiber fractions compared to the other silages. Dry matter contents of different silages significantly ($P<0.05$) increased with increasing the limestone level. This may attributed to that limestone was a dry ground supplement. These results agreed with those obtained by Byers (1980), Campos and Huber (1983) and Finn et al. (1985), who found that DM content of silages and diets increased with limestone supplementation.

Table 1: Chemical composition of fresh whole corn plant (WCP), corn stover (CS), fodder corn (FC) and fodder sorghum (FS).

Item	WCP	CS	FC	FS	SEM
DM, %	25.40	30.95	22.58	20.80	1.16
Composition of DM, %					
OM	91.17	89.52	92.34	89.24	0.38
CP	7.67	6.73	8.21	7.65	0.16
CF	21.76	33.46	26.95	31.86	1.38
EE	3.24	2.85	3.07	3.14	0.05
NFE	58.50	46.48	54.11	46.59	1.55
Ash	8.83	10.48	7.66	10.76	0.38
Fiber fractions, %					
NDF	50.45	69.50	57.30	63.20	1.72
ADF	29.70	41.65	33.80	38.40	1.48
ADL	4.15	7.10	4.86	5.90	0.25
Hemicellulose	20.75	27.85	23.50	24.80	0.74
Cellulose	25.55	34.55	28.94	32.50	0.86

The contents of OM were significantly ($P<0.05$) decreased with increasing the limestone level, which may be attributed to the increase of ash content and fermentation losses. Gaafar (2001) and Bendary et al. (2001b) reported that OM contents of WCP and CS decreased after ensiling. The values obtained in the present study were higher than the values obtained by Gaafar (2001), which may be attributed to that limestone supplementation increased the rate of ensiling fermentation. Nguyen et al. (2005) stated that the OM content tended to fall slightly with increase ensiling duration, as a result of the loss of organic matter. On the other hand, CP content tended to increase slightly ($P>0.05$) after ensiling, total N content in the silage tended to increase with ensiling time, because there was some loss of volatile substances during the ensiling process.

There were significant differences ($P<0.05$) among the different silages in CF and EE contents (Table 2), these significantly ($P<0.05$) increased after ensiling, while CSS and FSS recorded the highest CF contents followed by FCS, while WCPS recorded the lowest CF content. Ahmed et al. (2003) showed that CF content of CSS was higher than corn silage. Gaafar (2004) reported that CF content of corn silage decreased with increasing grain content. Gaafar (2001) found that EE content of WCP and CS increased after ensiling.

The contents of NFE of different silages significantly ($P<0.05$) decreased after ensiling as well as with increasing the limestone level up to 1% then the differences were not significant. The decrease of NFE content during ensiling might be attributed to the dissimulation of carbohydrates to carbon dioxide and water as the result of respiration by both plant cells and aerobic microflora and the fermentation of carbohydrates by lactic acid bacteria along with effluent loss as well as due to increasing the fermentation rate with limestone supplementation (Woolford, 1984). Campos and Huber (1983) reported that NFE content of silage decreased with limestone supplementation. Moreover, Gaafar (2001) and Bendary et al. (2001b) indicated that NFE contents of WCP and CS decreased after ensiling. Ash contents of different kinds of silages significantly ($P<0.05$) increased after ensiling and also with increasing the limestone level. These results agreed with those obtained by Nguyen et al. (2005), who stated that the ash content of the silages increased slightly with increasing duration of ensiling, as a result of the loss of organic matter.

Table 2: Effect of limestone supplementation on chemical composition of silages.

Limestone, %	WCPS	CSS	FCS	FSS	SEM
			DM, %		
0.0	25.64^{bD}	29.28^{aE}	24.17^{cD}	22.59^{dD}	0.42
0.5	25.91^{bCD}	29.51^{aD}	24.32^{cCD}	22.70^{dCD}	0.43
1.0	26.19^{bBC}	29.72^{aC}	24.48^{cBC}	22.85^{dBC}	0.43
1.5	26.46^{bAB}	29.95^{aB}	24.65^{cAB}	23.02^{dAB}	0.44
2.0	26.73^{bA}	30.17^{aA}	24.84^{cA}	23.21^{dA}	0.44
			OM, %		
0.0	88.28^{bA}	87.63^{bcA}	90.43^{aA}	87.36^{cA}	0.24
0.5	87.64^{bAB}	86.97^{bcAB}	89.88^{aA}	86.67^{cAB}	0.25
1.0	87.00^{bBC}	86.31^{bcBC}	89.35a^{BC}	86.00^{cBC}	0.25
1.5	86.37^{bCD}	85.64^{bcCD}	88.80a^{CD}	85.33^{cCD}	0.26
2.0	85.73^{bD}	84.97^{cD}	88.27^{aD}	84.65^{cD}	0.27
			CP, %		
0.0	8.23^{b}	7.22^{c}	8.81^{a}	8.23^{b}	0.10
0.5	8.36^{b}	7.34^{c}	8.95^{a}	8.34^{b}	0.10
1.0	8.41^{b}	7.38^{c}	9.01^{a}	8.39^{b}	0.10
1.5	8.32^{b}	7.30^{c}	8.91^{a}	8.30^{b}	0.10
2.0	8.27^{b}	7.26^{c}	8.86^{a}	8.25^{b}	0.10
			CF, %		
0.0	23.87^{d}	36.70^{a}	29.56^{c}	34.95^{b}	0.86
0.5	23.73^{d}	36.50^{a}	29.39^{c}	34.73^{b}	0.85
1.0	23.60^{d}	36.29^{a}	29.23^{c}	34.58^{b}	0.85
1.5	23.47^{d}	36.09^{a}	29.07^{c}	34.37^{b}	0.84
2.0	23.34^{d}	35.89^{a}	28.91^{c}	34.19^{b}	0.84
			EE, %		
0.0	3.48^{a}	3.06^{c}	3.29^{b}	3.38^{ab}	0.03
0.5	3.53^{a}	3.11^{c}	3.35^{b}	3.42^{ab}	0.03
1.0	3.55^{a}	3.13^{c}	3.37^{b}	3.45^{ab}	0.03
1.5	3.51^{a}	3.09^{c}	3.33^{b}	3.41^{ab}	0.03
2.0	3.50^{a}	3.08^{c}	3.31^{b}	3.39^{ab}	0.03
			NFE, %		
0.0	52.71^{aA}	40.65^{cA}	48.77^{bA}	40.81^{cA}	0.93
0.5	52.01^{aAB}	40.03^{cAB}	48.18^{bAB}	40.19^{cAB}	0.92
1.0	51.43^{aAB}	39.51^{cAB}	47.74^{bAB}	39.59^{cAB}	0.92
1.5	51.06^{aAB}	39.16^{cB}	47.50^{bB}	39.25^{cB}	0.93
2.0	50.63^{aB}	38.75^{cB}	47.19^{bB}	38.82^{cB}	0.93
			Ash, %		
0.0	11.72^{bD}	12.37^{abD}	9.57^{cD}	12.64^{aD}	0.24
0.5	12.36^{bCD}	13.03^{abCD}	10.12^{cCD}	13.33^{aCD}	0.25
1.0	13.00^{bBC}	13.69^{abBC}	10.65^{cBC}	14.00^{aBC}	0.25
1.5	13.63^{bAB}	14.37^{abAB}	11.20^{cAB}	14.67^{aAB}	0.26
2.0	14.27^{bA}	15.03^{aA}	11.73^{cA}	15.36^{aA}	0.27

$^{a, b, c \text{ and } d}$: Means within a row with unlike superscripts are significantly different.

$^{A, B, C, D \text{ and } E}$: Means within a column with unlike superscripts are significantly different.

WCPS= Whole corn plant silage **CSS**= Corn stover silage

FCS= Fodder corn silage **FSS**= Fodder sorghum silage

Fiber fractions:-

Results shown in Table 3 revealed that, the silage contents of NDF, ADF, ADL, hemicellulose and cellulose were significantly ($P<0.05$) increased after ensiling. Corn stover silage revealed the highest values followed by FSS and FCS, while WCPS had the lowest values, this may due to attributed to its grain content. These results are in accordance with those obtained by Joanning et al. (1981), who showed that increasing grain content resulted diluted the fiber components and subsequently increasing NFE content of corn crop.

Table 3: Effect of limestone supplementation on the fiber fractions of different silages.

Limestone, %	WCPS	CSS	FCS	FSS	SEM
			NDF, %		
0.0	52.26^d	71.58^a	59.02^c	65.10^b	2.19
0.5	52.15^d	71.46^a	58.94^c	65.02^b	2.19
1.0	52.03^d	71.35^a	58.85^c	64.93^b	2.19
1.5	51.90^d	71.25^a	58.76^c	64.85^b	2.19
2.0	51.78^d	71.14^a	58.68^c	64.77^b	2.19
			ADF, %		
0.0	30.79^d	42.98^a	34.98^c	39.67^b	1.39
0.5	30.71^d	42.91^a	34.91^c	39.62^b	1.40
1.0	30.64^d	42.84^a	34.85^c	39.55^b	1.39
1.5	30.57^d	42.78^a	34.78^c	39.50^b	1.40
2.0	30.50^d	42.71^a	34.72^c	39.44^b	1.40
			ADL, %		
0.0	4.39^d	7.37^a	5.11^c	6.16^b	0.34
0.5	4.35^d	7.33^a	5.08^c	6.14^b	0.34
1.0	4.32^d	7.28^a	5.05^c	6.11^b	0.34
1.5	4.28^d	7.25^a	5.01^c	6.09^b	0.34
2.0	4.23^d	7.20^a	4.99^c	6.06^b	0.34
			Hemicellulose, %		
0.0	21.17^d	28.60^a	24.04^c	25.43^b	0.81
0.5	21.14^d	28.55^a	24.02^c	25.40^b	0.80
1.0	21.09^d	28.51^a	24.00^c	25.38^b	0.80
1.5	21.03^d	28.48^a	33.98^c	25.35^b	0.81
2.0	20.98^d	28.43^a	23.96^c	25.32^b	0.81
			Cellulose, %		
0.0	26.40^d	35.61^a	29.87^c	33.51^b	1.06
0.5	26.36^d	35.58^a	29.84^c	33.48^b	1.06
1.0	26.32^d	35.56^a	29.80^c	33.44^b	1.06
1.5	26.29^d	35.53^a	29.77^c	33.42^b	1.06
2.0	26.27^d	35.51^a	29.73^c	33.39^b	1.06

a, b, c and d Means within a row with unlike superscripts are significantly different.

Ensiling losses:

The percentages of spoiled and moldy losses of FCS and FSS (Table 4) were significantly (P<0.05) higher than those of WCPS and CSS. Moreover, it significantly deceased with increasing the limestone level up to 1% and increased (P<0.05) afterwards. Luther (1986) found that the percentage of spoiled and moldy silage decreased with microbial inoculated silage. Church (1991) indicated that spoilage and moldy losses on the surface and around the perimeters are 4-12% of original DM ensiled and such material is not only unpalatable but may also be toxic.

Table 4: Effect of limestone supplementation on ensiling losses of different silages (%, on DM basis).

Limestone, %	WCPS	CSS	FCS	FSS	SEM
	Spoilage and moldy losses				
0.0	2.17^{cA}	2.16^{cA}	3.33^{bA}	3.84^{aA}	0.14
0.5	1.45^{bC}	1.45^{bC}	2.41^{aBC}	2.55^{aC}	0.10
1.0	0.38^{bE}	0.49^{bE}	1.05^{aD}	1.16^{aD}	0.08
1.5	1.03^{bD}	1.18^{bD}	2.07^{aC}	2.32^{aC}	0.11
2.0	1.88^{bB}	2.06^{bB}	3.00^{aAB}	3.42^{aB}	0.13
	Fermentation losses				
0.0	3.63^{aC}	2.81^{bC}	4.11^{aB}	4.02^{aB}	0.12
0.5	3.81^{aBC}	2.98^{bBC}	4.30^{aAB}	4.22^{aAB}	0.12
1.0	4.30^{aA}	3.41^{bA}	4.82^{aA}	4.78^{aA}	0.13
1.5	4.14^{aAB}	3.23^{bAB}	4.62^{aAB}	4.61^{aAB}	0.13
2.0	3.98^{aABC}	3.09^{bABC}	4.47^{aAB}	4.43^{aAB}	0.13
	Total losses				
0.0	5.80^{cA}	4.97^{dA}	7.44^{bA}	7.86^{aA}	0.57
0.5	5.26^{bAB}	4.43^{cB}	6.71^{aAB}	6.77^{aB}	0.46
1.0	4.68^{bB}	3.90^{cC}	5.87^{aB}	5.94^{aB}	0.38
1.5	5.17^{bB}	4.41^{cB}	6.69^{aB}	6.93^{aB}	0.36
2.0	5.86^{bAB}	5.15^{cA}	7.47^{aB}	7.85^{aB}	0.32

$^{a, b, c \text{ and } d}$: Means within a row with unlike superscripts are significantly different.
$^{A, B, C, D \text{ and } E}$: Means within a column with unlike superscripts are significantly different.

The fermentation losses of FCS and FSS recorded significantly (P<0.05) the highest values, while WCPS and CSS recorded the lowest values. It significantly (P<0.05) increased with increasing the limestone level up to 1% and decreased (P>0.05) afterwards. Brown and Kalmbacher (1986) found that fermentation losses were higher with limestone treatment than in untreated silage. Moreover, McDonald *et al.* (1995) reported that ensiling losses attributed to oxidation losses that result from the action of plant and microbial enzymes on substrates such as sugar in the presence of oxygen. Church (1991) stated that fermentation losses in well-preserved silage should not exceeded 3 - 6% of DM losses.

Results also, (Table, 4) showed that FSS recorded significantly ($P<0.05$) the highest percentage value of total losses followed by FCS and WCPS, while CSS had the least percentage. Moreover, the percentages of total losses values significantly ($P<0.05$) decreased with increasing the limestone level up to 1% and increased ($P>0.05$) afterwards. Results also, revealed that the percentages of total losses decreased with increasing forage DM content at ensiling time (Table 1). Church (1991) declared that the overall losses may be quite variable and when field losses are included, total losses may be expected to be about 15-25% of herbage dry matter present in the field.

Silage quality characteristics:-

The pH values of different silages are presented in Table 5. There were significant differences ($P<0.05$) in pH values among the different silages. Whereas CSS recorded significantly ($P<0.05$) the highest pH values followed by WCPS, while FCS and FSS had the lowest values. The optimal pH value for forage silage depends on DM content, which had a positive correlation between them being $r = 0.4$. Wilkinson et al. (1978) found that pH value of corn silage increased with increasing DM content. Generally, good silage quality should have a pH value of 4.2 or less (McDonald *et al.*, 1995). Moreover, the pH values for different silages significantly ($P<0.05$) increased with increasing the limestone level, this might be attributed to that limestone (calcium carbonate) reacts with silage moisture producing calcium hydroxide and carbon dioxide. Bolsen et al. (1988) reported that limestone treated silage produced much more extensive fermentations with higher pH value.

The concentration of lactic acid (Table, 5) decreased with increasing DM content of silage ($r = -0.76$). Moreover, it significantly ($P<0.05$) increased with increasing the limestone level up to 1% and decreased ($P>0.05$) afterwards. Thomas et al. (1975) found that the concentration of lactic acid in silage decreased with increasing DM content due to depression the extent of fermentation. Church (1991) found that the use of limestone (0.5-1% or other Ca salt) with corn and sorghum silages increased lactic acid content of silage as a result to buffer the acids producing during fermentation and resulted in a very substantial increase in lactic acid production. Li et al. (1992) stated that calcium carbonate increased the concentration of lactic acid compared with control.

There was a negative correlation exist between DM content and VFA's concentration of silage ($r = -0.75$). Moreover, the concentrations of VFA's for different silages significantly ($P<0.05$) increased with increasing the limestone level up to 1% and decreased ($P>0.05$) afterwards. The concentration of VFA's is used for judging silage quality.

The volatile substances in the good silage quality must be comparatively less than lactic acid. Mohsen and Nour (1979) and Ranjhan (1980) found that high moisture corn stover silage (31.0%) tended to have higher VFA production than that of low moisture content (25.5%).

Table 5. Some quality characteristics of different kinds of silage supplemented with limestone.

Limestone, %	WCPS	CSS	FCS	FSS	SEM
			pH value		
0.0	4.09^{abC}	4.17^{aC}	3.90^{bC}	3.99^{abC}	0.04
0.5	4.28^{BC}	4.34^{C}	4.10^{BC}	4.12^{BC}	0.04
1.0	4.38^{abB}	4.64^{aB}	4.27^{bB}	4.23^{bABC}	0.05
1.5	4.82^{aA}	4.98^{aA}	4.71^{aA}	4.37^{bAB}	0.06
2.0	5.04^{aA}	5.13^{aA}	4.88^{aA}	4.49^{bA}	0.06
			Lactic acid (% on DM basis)		
0.0	6.21^{bC}	4.68^{cB}	7.96^{aC}	7.34^{aC}	0.24
0.5	7.23^{bB}	5.16^{cAB}	8.53^{aABC}	8.20^{aAB}	0.25
1.0	8.08^{bA}	5.55^{cA}	9.08^{aA}	8.92^{aA}	0.27
1.5	7.25^{bB}	5.32^{cAB}	8.69^{aAB}	8.42^{aAB}	0.25
2.0	6.53^{bBC}	5.01^{cAB}	8.21^{aBC}	7.78^{aBC}	0.24
			Total VFA (% on DM basis)		
0.0	1.55^{bC}	1.17^{cB}	1.99^{aC}	1.84^{aC}	0.06
0.5	1.81^{bB}	1.29^{cAB}	2.13^{aABC}	2.05^{aAB}	0.06
1.0	2.02^{bA}	1.39^{cA}	2.27^{aA}	2.23^{aA}	0.07
1.5	1.81^{bB}	1.33^{cAB}	2.17^{aAB}	2.11^{aAB}	0.06
2.0	1.63^{bBC}	1.25^{cAB}	2.05^{aBC}	1.95^{aBC}	0.06
			Ammonia-N (% of total-N)		
0.0	3.80^{bA}	2.90^{cA}	5.76^{aA}	5.47^{aA}	0.21
0.5	3.41^{bB}	2.82^{cAB}	5.26^{aB}	5.00^{aB}	0.19
1.0	3.26^{cB}	2.74^{dAB}	4.94^{aBC}	4.53^{bC}	0.16
1.5	2.89^{cC}	2.65^{cBC}	4.66^{aCD}	4.18^{bCD}	0.15
2.0	2.74^{cC}	2.48^{cC}	4.28^{aD}	3.90^{bD}	0.14

$^{a, b, and c}$ Means within a row with unlike superscripts are significantly different.
$^{A, B, and C}$ Means within a column with unlike superscripts are significantly different.

The concentration of NH_3-N (Table 5) decreased with increasing DM content (r =- 0.81), but it increased with increasing CP content (r = 0.75). During ensiling, protein is degraded into ammonia, amino acids. dipeptids, volatile basis and organic acids. Strong ammonia odor indicates considerable loss in feeding value. Therefore, the high quality silage is characterized with low NH_3-N concentration. McDonald et al.

(1995) reported that NH_3-N concentration of good quality silage usually less than 10% of total-N. Sheperd and Kung (1996) found that NH_3-N concentration of silage decreased with increasing DM content, but increased with increasing CP content. Gaafar (2001) and Bendary et al. (2001b) showed that NH_3-N concentrations of WCPS and CS silages ranged from 3.60 to 9.06 and 2.42 to 3.87% of total-N, respectively. The concentrations of NH_3-N for different silages significantly ($P<0.05$) decreased with increasing the limestone level. The results might be attributed to that limestone inhibit the proteolysis bacteria during ensiling. The present data agreed with those obtained by El Tayeb et al. (1984), who indicated that silage NH_3-N concentrations decreased linearly with increasing limestone level.

In situ study:-

1- Dry matter disappearance:

Dry matter disappearance of different silages is illustrated in Table 6. The results showed that, WCPS recorded the highest ($P<0.05$) values followed by FCS and FSS, while FCS had the lowest values. Moreover, the percentage of *in situ* DM disappearance for different silages was significantly ($P<0.05$) increased with increasing limestone level up to 1% and sometimes up to 1.5%, while it is generally decreased afterwards at all incubation times. The results also showed a positive correlation ($r = 0.71$) between DM disappearance and NFE content, while there was a high negative correlation ($r = -0.81$) between DM disappearance and CF content. Rogers et al (1982), Tissera et al (1988) and Christiansen and Webb (1990) stated that the DM digestibility and disappearance increased by addition of limestone to the basal diet. Moreover, Froestschel et al. (1991) reported that the rate of *in situ* DM disappearance was positively correlated with silage DM recovery, suggesting an association with nutrient preservation

As shown in Table 7, there were no significant differences for immediately degradable fraction and rate of degradation of fraction b/h among the different kinds of silages. However, DM fraction that is slowly degraded significantly increased with increasing of limestone level up to 1% and decreased afterwards, the decrease was more pronounced at 2% limestone level. The contrast trend was noticed for ruminaly undegradable fraction. On the other hand, the effective DM degradability at outflow rates 2, 5 and 8%/hour was significantly increased with supplementation of 1% limestone for all different kinds of silages. The lower fiber content and greater NFE of WCPS explain the greater effective dry matter degradability found as compared to the other kinds of silage. These results agree with those of Christiansen and Webb (1990) and Resende et al. (2003).

Table 6. In situ dry matter disappearance (%) of different kinds of silages.

Limestone, %	DM, %	Incubation hours					
		0	6	12	24	48	72
		Whole corn plant silage (WCPS)					
0.00	25.64	12.39^{a}	17.07^{a}	21.42^{bc}	29.22^{d}	41.77^{c}	51.13^{d}
0.50	25.91	12.41^{a}	18.00^{a}	23.11^{ab}	32.08^{bc}	45.87^{b}	55.57^{c}
1.00	26.19	12.45^{a}	19.14^{a}	25.17^{a}	35.54^{a}	50.88^{a}	61.07^{a}
1.50	26.46	11.92^{a}	18.34^{a}	24.14^{ab}	34.09^{ab}	48.78^{a}	58.52^{b}
2.00	26.73	11.22^{a}	16.86^{a}	21.97^{c}	30.81^{cd}	44.08^{b}	53.06^{d}
SEM	0.42	0.29	0.34	0.45	0.66	0.91	1.00
		Corn stover silage (CSS)					
0.00	29.28	8.99^{a}	12.01^{ab}	14.84^{c}	19.98^{d}	28.51^{c}	35.13^{c}
0.50	29.51	9.00^{a}	12.99^{ab}	16.65^{abc}	23.08^{bc}	33.04^{b}	40.09^{b}
1.00	29.72	9.05^{a}	14.16^{a}	18.75^{a}	26.62^{a}	38.15^{a}	45.73^{a}
1.50	29.95	8.39^{a}	13.01^{ab}	17.18^{ab}	24.32^{b}	34.83^{b}	41.78^{b}
2.00	30.17	7.69^{a}	11.63^{b}	15.21^{bc}	21.40^{cd}	30.69^{c}	36.99^{c}
SEM	0.43	0.30	0.35	0.48	0.67	0.93	1.03
		Fodder corn silage (FCS)					
0.00	24.17	11.35^{a}	15.68^{ab}	19.70^{b}	26.90^{d}	38.42^{c}	46.96^{d}
0.50	24.32	11.36^{a}	16.52^{ab}	21.24^{ab}	29.51^{bc}	42.24^{b}	51.17^{c}
1.00	24.48	11.45^{a}	17.55^{a}	23.06^{a}	32.54^{a}	46.53^{a}	55.81^{a}
1.50	24.65	10.75^{a}	16.67^{ab}	22.00^{ab}	31.13^{ab}	44.55^{a}	53.39^{b}
2.00	24.84	10.17	15.17^{b}	19.72^{b}	27.61^{cd}	39.53^{c}	47.68^{d}
SEM		0.30	0.34	0.44	0.62	0.85	0.93
		Fodder sorghum silage (FSS)					
0.00	22.59	9.90^{a}	13.55^{a}	16.95^{c}	23.07^{d}	33.01^{d}	40.50^{c}
0.50	22.70	9.99^{a}	14.51^{a}	18.64^{abc}	25.88^{bc}	36.98^{bc}	44.75^{b}
1.00	22.85	10.0^{a}	15.34^{a}	20.15^{a}	28.42^{a}	40.70^{a}	48.89^{a}
1.50	23.02	9.54^{a}	14.67^{a}	19.30^{ab}	27.25^{ab}	38.97^{ab}	46.74^{ab}
2.00	23.21	8.82^{a}	13.39^{a}	17.52^{bc}	24.64^{cd}	35.21^{c}	42.29^{c}
SEM		0.29	0.33	0.41	0.57	0.77	0.84

a, b c and d Means within a column with unlike superscripts are significantly different.

Table 7: Effective degradability of dry matter for different kinds of silages.

Limestone %	*A*	*B*	*c*	*u*	*Effective DM degradability*		
		%			*K=0.02*	*K=0.05*	*K=0.08*
				Whole corn plant silage (WCPS)			
0.00	12.39^{a}	66.17^{b}	0.012^{a}	21.44^{b}	37.50^{d}	25.40^{c}	21.20^{b}
0.05	12.41^{a}	65.98^{b}	0.015^{a}	21.61^{b}	40.40^{bc}	27.40^{bc}	22.70^{ab}
1.00	12.45^{a}	68.78^{a}	0.017^{a}	18.77^{c}	44.10^{a}	29.90^{a}	24.50^{a}
1.50	11.92^{a}	65.74^{b}	0.017^{a}	22.34^{b}	42.30^{ab}	28.70^{ab}	23.50^{ab}
2.00	11.22^{a}	60.69^{c}	0.016^{a}	28.09^{a}	38.40^{cd}	26.10^{c}	21.50^{b}
SEM	0.29	0.76	0.001	0.86	0.70	0.51	0.42
				Corn stover silage (CSS)			
0.00	8.99^{a}	49.07^{ab}	0.011^{a}	41.94^{cd}	26.00^{c}	17.60^{c}	14.70^{b}
0.05	9.00^{a}	48.15^{b}	0.014^{a}	42.58^{bc}	29.20^{b}	19.80^{bc}	16.40^{ab}
1.00	9.05^{a}	51.19^{a}	0.018^{a}	39.76^{d}	32.90^{a}	22.30^{a}	18.20^{a}
1.50	8.39^{a}	46.89^{b}	0.017^{a}	44.72^{b}	30.10^{b}	20.40^{ab}	16.70^{ab}
2.00	7.69^{a}	42.53^{c}	0.016^{a}	49.78^{a}	26.70^{c}	18.10^{c}	14.90^{b}
SEM	0.29	0.81	0.001	0.94	0.71	0.52	0.43
				Fodder corn silage (FCS)			
0.00	11.35^{a}	60.11^{b}	0.013^{a}	28.54^{b}	34.40^{c}	23.30^{b}	19.50^{b}
0.05	11.36^{a}	60.77^{ab}	0.015^{a}	27.87^{bc}	37.20^{b}	25.20^{ab}	20.8^{ab}
1.00	11.43^{a}	62.67^{a}	0.017^{a}	25.90^{c}	40.30^{a}	27.40^{a}	22.20^{a}
1.50	10.75^{a}	59.68^{b}	0.017^{a}	29.57^{b}	38.50^{ab}	26.20^{a}	21.40^{ab}
2.00	10.17^{a}	55.08^{c}	0.016^{a}	34.75^{a}	34.50^{c}	23.40^{b}	19.30^{b}
SEM	0.29	0.72	0.001	0.83	0.67	0.50	0.41
				Fodder sorghum silage (FSS)			
0.00	9.90^{a}	53.61^{ab}	0.012^{a}	36.49^{bc}	29.70^{d}	20.10^{bc}	16.80^{b}
0.05	10.01^{a}	53.83^{ab}	0.015^{a}	36.16^{bc}	32.70^{bc}	22.10^{abc}	18.30^{ab}
1.00	10.01^{a}	55.26^{ab}	0.017^{a}	34.73^{c}	35.30^{a}	24.00^{a}	19.60^{a}
1.50	9.54^{a}	52.41^{b}	0.017^{a}	38.05^{b}	33.80^{ab}	22.90^{ab}	18.80^{ab}
2.00	8.82^{a}	47.73^{c}	0.017^{a}	43.45^{a}	30.60^{cd}	20.80^{c}	17.10^{b}
SEM	0.29	0.74	0.001	0.86	0.61	0.46	0.38

a) Immediately degradable fraction. *b*) Dry matter fraction which is slowly degraded
c) Rate of degradation of fraction b/h. *k*) Outflow rate from the rumen/h.
u) Ruminaly undegradable fraction {100 – (a + b)}
a, b c and d Means within a column with unlike superscripts are significantly different

2- Crude protein disappearance:

Results presented in Table 8 indicated that, FCS had the highest CP disappearance values, while CSS had the lowest values. However, the values for WCPS and FSS were nearly similar. The CP disappearance for different silages insignificantly (P>0.05) decreased with increasing limestone level, but it was significantly at the high levels compared to unsupplemented silage. Decreasing CP disappearance with increasing the limestone level may be due to the inhabitation of rumen proteolysis microorganism. The disappearance of CP for the different silages increased with increasing CP content (Table 1) and NH_3-N concentration of silage (Table 5), indicating a high positive correlation between them (r = 0.70 and 0.86, respectively). Wheeler (1980) observed a decrease in digestibility of nitrogen with limestone supplementation. Rogers *et al.* (1982) found a drastic reduction in CP digestibility when limestone was added to the diet. Wagner et al. (2004) reported that the limestone treatment had a significant effect on the CP digestibility.

Table 8. In situ crude protein disappearance (%) of different kinds of silages.

Limestone %	CP, %	Incubation hours 0	6	12	24	48	72
		Whole corn plant silage (WCPS)					
0.00	8.23	12.47^{a}	17.18^{a}	21.56^{a}	29.41^{a}	42.05^{a}	51.48^{a}
0.50	8.36	11.12^{ab}	16.13^{ab}	20.71^{ab}	28.74^{ab}	41.11^{ab}	49.8^{ab}
1.00	8.41	9.83^{ab}	15.12^{ab}	19.88^{ab}	28.08^{ab}	40.20^{abc}	48.25^{bc}
1.50	8.32	9.66^{b}	14.72^{ab}	19.30^{ab}	27.12^{ab}	38.90^{bc}	46.74^{cd}
2.00	8.27	9.36^{b}	14.26^{b}	18.69^{b}	26.32^{b}	37.66^{c}	45.24^{d}
SEM		0.44	0.41	0.41	0.43	0.51	0.65
		Corn stover silage (CSS)					
0.00	7.22	11.57^{a}	15.45^{a}	19.08^{a}	25.71^{a}	36.68^{a}	45.20^{a}
0.50	7.34	9.79^{ab}	14.13^{ab}	18.11^{ab}	25.10^{ab}	35.94^{ab}	43.61^{ab}
1.00	7.38	9.06^{ab}	13.42^{ab}	17.39^{ab}	24.31^{ab}	34.86^{abc}	42.14^{bc}
1.50	7.30	8.48^{b}	12.80^{ab}	16.73^{ab}	23.51^{ab}	33.68^{bc}	40.55^{cd}
2.00	7.26	8.01^{b}	12.25^{b}	16.08^{b}	22.69^{b}	32.54^{c}	39.15^{d}
SEM		0.45	0.43	0.42	0.43	0.52	0.65
		Fodder corn silage (FCS)					
0.00	8.81	12.93^{a}	18.18^{a}	23.02^{a}	31.61^{a}	45.18^{a}	55.05^{a}
0.50	8.95	12.50^{a}	17.60^{a}	22.31^{ab}	30.68^{ab}	43.89^{ab}	53.48^{ab}
1.00	9.01	11.94^{a}	17.02^{a}	21.69^{ab}	29.94^{ab}	42.79^{abc}	51.98^{bc}
1.50	8.91	11.10^{a}	16.23^{a}	20.93^{ab}	29.13^{ab}	41.68^{bc}	50.43^{cd}
2.00	8.86	10.38^{a}	15.50^{a}	20.15^{b}	28.21^{b}	40.39^{c}	48.71^{d}
SEM		0.39	0.40	0.41	0.42	0.54	0.67
		Fodder sorghum silage (FSS)					
0.00	8.23	12.33^{a}	17.31^{a}	21.91^{a}	30.11^{a}	43.11^{a}	52.63^{a}
0.50	8.34	11.73^{a}	16.66^{a}	21.19^{a}	29.23^{ab}	41.84^{ab}	50.94^{ab}
1.00	8.39	11.03^{a}	15.98^{a}	20.52^{a}	28.48^{ab}	40.77^{abc}	49.43^{bc}
1.50	8.30	10.43^{a}	15.38^{a}	19.89^{a}	27.74^{ab}	39.68^{bc}	47.91^{cd}
2.00	8.25	9.73^{a}	14.69^{a}	19.17^{a}	26.91^{b}	38.46^{c}	46.22^{d}
SEM		0.39	0.39	0.40	0.43	0.53	0.67

a, b c and d Means within a column with unlike superscripts are significantly different.

Estimates of ruminal degradation constants (a, b and c) fitted with rate of CP disappearance for different kinds of silage are presented in Table 9. The predicted constants (*a* and *b*) significantly (P<0.05) decreased with increasing the limestone level for all the different kinds of silage, while the rate of degradation of fraction b/h (*c*) was approximately the same for all the different kinds of silage at all limestone levels. However, they had more (P<0.05) undegradable fractions (*u*) and less effective degradability and consequently significantly increase the amount of protein escaping ruminal degradation. This may be due to limestone supplementations that inhabit the rumen proteolysis microorganism (Rogers *et al.,* 1982 and Wagner *et al.*, 2004).

Table 9: Effective degradability of crude protein for different kinds of silages.

Limestone %	*a*	*b*	*c*	*u*	*Effective CP degradability*		
	%				*K=0.02*	*K=0.05*	*K=0.08*
				Whole corn plant silage (WCPS)			
0.00	12.48^{a}	66.70^{a}	0.012^{a}	20.82^{d}	37.80^{a}	25.60^{a}	21.30a
0.05	11.12^{ab}	59.15^{b}	0.015^{a}	29.73^{c}	36.20^{ab}	24.60^{ab}	20.30^{ab}
1.00	9.83^{ab}	54.35^{c}	0.017^{a}	35.82^{b}	34.80^{bc}	23.60^{ab}	19.40^{ab}
1.50	9.66^{b}	52.88^{cd}	0.017^{a}	37.46^{ab}	33.80^{bc}	22.90^{ab}	18.80^{ab}
2.00	9.36^{b}	51.15^{d}	0.017^{a}	39.49^{a}	32.70^{c}	22.20^{b}	18.20^{b}
SEM	0.44	01.52	0.001	1.82	0.57	0.44	0.42
				Corn stover silage (CSS)			
0.00	11.57^{a}	63.18^{a}	0.011^{a}	24.25^{d}	33.40^{a}	22.60^{a}	18.90^{a}
0.05	9.79^{ab}	52.37^{b}	0.014^{a}	37.84^{c}	31.70^{ab}	21.50^{ab}	17.80^{ab}
1.00	9.06^{ab}	49.37^{c}	0.015^{a}	41.57^{b}	30.50^{bc}	20.70^{ab}	17.00^{ab}
1.50	8.48^{b}	46.44^{d}	0.016^{a}	45.08^{a}	29.30^{bc}	19.90^{ab}	16.30^{ab}
2.00	8.01^{b}	44.62^{d}	0.017^{a}	47.37^{a}	28.30^{c}	19.10^{b}	15.70^{b}
SEM	0.45	1.78	0.001	2.20	0.57	0.45	0.42
				Fodder corn silage (FCS)			
0.00	12.93^{a}	68.33^{a}	0.013^{a}	18.74^{d}	40.20^{a}	27.30^{a}	22.70^{a}
0.05	12.50^{a}	66.46^{a}	0.013^{a}	21.04^{d}	39.10^{ab}	26.50^{ab}	22.20^{ab}
1.00	11.94^{a}	63.01^{b}	0.014^{a}	25.08^{c}	37.90^{abc}	25.70^{ab}	21.30^{ab}
1.50	10.10^{a}	59.41^{c}	0.015^{a}	29.49^{b}	36.60^{bc}	24.90^{ab}	20.50^{ab}
2.00	10.38^{a}	56.25^{d}	0.016^{a}	33.37^{a}	35.30^{c}	23.90^{b}	19.70^{b}
SEM	0.39	1.22	0.001	1.46	0.56	0.44	0.42
				Fodder sorghum silage (FSS)			
0.00	12.33^{a}	66.25^{a}	0.013^{a}	21.42^{c}	38.40^{a}	26.00^{a}	21.60^{a}
0.05	11.73^{a}	62.76^{b}	0.014^{a}	25.51^{d}	37.20^{ab}	25.20^{ab}	20.90^{ab}
1.00	11.03^{a}	59.05^{c}	0.015^{a}	29.92^{c}	35.90^{abc}	24.40^{ab}	20.10^{ab}
1.50	10.43^{a}	55.75^{d}	0.016^{a}	33.82^{b}	34.80^{bc}	23.60^{ab}	19.50^{ab}
2.00	9.73^{a}	52.38^{c}	0.017^{a}	37.89^{a}	33.50^{c}	22.80^{b}	18.70^{b}
SEM	0.39	1.35	0.001	1.60	0.55	0.43	0.41

a, b c and d Means within a column with unlike superscripts are significantly different.

3- Crude fiber disappearance:-

Disappearance of CF for different kinds of silage is shown in Table 10. Corn stover silage recorded significantly ($P<0.05$) the highest values followed by FSS and FCS, while WCPS had the lowest values. It significantly ($P<0.05$) increased with increasing the limestone level (1 and 1.50%) especially after 6 hrs of incubation compared with the unsupplemented silage and decreased afterwards. Disappearance of CF for the different silages increased with increasing CF content, indicating a high positive correlation between them ($r = 0.97$). However, it decreased with increasing NFE content, indicating a high negative correlation (r = - 0.87). These results are in accordance with those obtained by Froetschel et al. (1991), who reported that limestone additives increased fiber digestibility of wheat silage-based rations fed to Holstein heifers. Ha et al. (1983) indicated that, lambs fed 2% limestone significantly increased fiber digestibility. Drackley et al. (1985); Kinal and Pres (1995) and Wagner et al. (2004) indicated that, the limestone treatment had a significant effect on the CF digestibility and improving digestion of fiber with additional Ca that could be attributed to increased formation of fatty acid soaps in the rumen.

Table 10. In situ crude fiber disappearance (%) of different kinds of silages.

Limestone %	CF, %	Incubation hours					
		0	6	12	24	48	72
		Whole corn plant silage (WCPS)					
0.00	23.87	6.95^{a}	10.30^{a}	13.38^{b}	18.81^{c}	27.29^{c}	33.34^{c}
0.50	23.73	8.02^{a}	11.88^{a}	15.43^{ab}	21.69^{ab}	31.46^{ab}	38.44^{b}
1.00	23.60	8.75^{a}	12.95^{a}	16.82^{a}	23.65^{a}	34.31^{a}	41.93^{a}
1.50	23.47	8.46^{a}	12.53^{a}	16.27^{ab}	22.88^{a}	33.19^{a}	40.56^{ab}
2.00	23.34	7.40^{a}	10.96^{a}	14.24^{ab}	20.02^{bc}	29.04^{bc}	35.49^{c}
SEM		0.37	0.42	0.47	0.58	0.77	0.91
		Corn stover silage (CSS)					
0.00	36.70	9.71^{a}	14.39^{a}	18.68^{a}	26.27^{b}	38.10^{d}	46.56^{d}
0.50	36.50	10.47^{a}	15.51^{a}	20.14^{a}	28.31^{ab}	41.07^{bc}	50.18^{bc}
1.00	36.29	11.21^{a}	16.61^{a}	21.57^{a}	30.34^{a}	44.00^{a}	53.77^{a}
1.50	36.09	10.59^{a}	15.82^{a}	20.62^{a}	29.08^{ab}	42.27^{ab}	51.67^{ab}
2.00	35.89	9.99^{a}	14.79^{a}	19.21^{a}	27.01^{b}	39.17^{cd}	47.87^{cd}
SEM		0.36	0.40	0.43	0.52	0.65	0.76
		Fodder corn silage (FCS)					
0.00	29.56	7.62^{a}	11.28^{a}	14.64^{b}	20.59^{c}	29.87^{c}	36.50^{d}
0.50	29.39	8.48^{a}	12.56^{a}	16.31^{ab}	22.93^{abc}	33.26^{ab}	40.65^{bc}
1.00	29.23	9.16^{a}	13.57^{a}	17.63^{a}	24.78^{a}	35.95^{a}	43.93^{a}
1.50	29.07	8.70^{a}	12.88^{a}	16.73^{ab}	23.52^{ab}	34.12^{a}	41.69^{ab}
2.00	28.91	7.96^{a}	11.78^{a}	15.30^{ab}	21.51^{bc}	31.20^{bc}	38.13^{cd}
SEM		0.36	0.39	0.43	0.51	0.66	0.77
		Fodder sorghum silage (FSS)					
0.00	34.95	8.86^{a}	13.12^{a}	17.04^{a}	23.95^{b}	34.74^{c}	42.45^{d}
0.50	34.73	9.60^{a}	14.22^{a}	18.47^{a}	25.97^{ab}	37.66^{b}	46.02^{bc}
1.00	34.58	10.40^{a}	15.40^{a}	20.00^{a}	28.12^{a}	40.79^{a}	49.86^{a}
1.50	34.37	9.92^{a}	14.69^{a}	19.08^{a}	26.82^{ab}	38.91^{ab}	47.54^{ab}
2.00	34.19	9.32^{a}	13.79^{a}	17.97^{a}	25.18^{b}	36.53^{bc}	44.64^{cd}
SEM		0.36	0.39	0.42	0.50	0.64	0.75

$^{a, b, c\ and\ d}$ Means within a column with unlike superscripts are significantly different.

No significant differences for immediately degradable fraction (*a*) and rate of degradation of fraction b/h (*c*) for CF disappearance among the different kinds of silage (Table, 11). However, the CSS and FSS had the highest (P<0.05) degradable fraction (*b*) and effective degradable fraction at different outflow rates values, while WCPS and FCS had similar values. This may be due to the higher CF and lower NFE content. Moreover, it increased (P<0.05) by increasing limestone level up to 1%, simultaneously decreased the undegradable fractions. These results are in accordance with those obtained by Froetschel et al. (1991); Kinal and Pres (1995); Resende et al. (2003) and Wagner et al. (2004).

Table 11: Effective degradability of crude fiber for different kinds of silages.

Limestone %	*a*	*b*	*c*	*u*	*Effective CF degradability*		
	%				*K=0.02*	*K=0.05*	*K=0.08*
				Whole corn plant silage (WCPS)			
0.00	6.95^{a}	41.53^{c}	0.014^{a}	51.52^{a}	24.10^{c}	16.00^{c}	13.10^{b}
0.05	8.02^{a}	47.91^{b}	0.014^{a}	44.07^{c}	27.70^{ab}	18.50^{abc}	15.20^{ab}
1.00	8.75^{a}	52.30^{a}	0.014^{a}	38.95^{d}	30.30^{a}	20.20^{a}	16.50^{a}
1.50	8.46^{a}	50.54^{ab}	0.014^{a}	41.00^{d}	29.30^{a}	19.50^{ab}	16.00^{ab}
2.00	7.40^{a}	44.24^{c}	0.014^{a}	48.18^{b}	25.60^{bc}	17.10^{bc}	14.00^{ab}
SEM	0.37	1.11	0.001	1.27	0.69	0.53	0.47
				Corn stover silage (CSS)			
0.00	9.71^{a}	58.03^{d}	0.014^{a}	32.26^{a}	33.60^{b}	22.40^{b}	18.40^{a}
0.05	10.47^{a}	62.55^{bc}	0.014^{a}	26.98^{b}	36.20^{ab}	24.10^{ab}	19.80^{a}
1.00	11.21^{a}	67.03^{a}	0.014^{a}	21.76^{c}	38.80^{a}	25.90^{a}	21.20^{a}
1.50	10.59^{a}	64.38^{ab}	0.014^{a}	25.03^{b}	37.30^{a}	24.90^{ab}	20.40^{a}
2.00	9.99^{a}	60.04^{cd}	0.014^{a}	29.97^{a}	37.20^{a}	23.30^{ab}	18.80^{a}
SEM	0.36	0.91	0.001	1.04	0.57	0.46	0.43
				Fodder corn silage (FCS)			
0.00	7.62^{a}	45.56^{c}	0.014^{a}	46.82^{a}	26.30^{c}	17.60^{b}	14.40^{a}
0.05	8.48^{a}	50.66^{b}	0.014^{a}	40.86^{b}	29.30^{ab}	19.60^{ab}	16.00^{a}
1.00	9.16^{a}	54.75^{a}	0.014^{a}	36.09^{c}	31.70^{a}	21.10^{a}	17.30^{a}
1.50	8.70^{a}	51.95^{b}	0.014^{a}	39.35^{b}	30.10^{ab}	20.10^{ab}	16.40^{a}
2.00	7.96^{a}	47.58^{c}	0.014^{a}	44.46^{a}	27.50^{bc}	18.30^{ab}	15.00^{a}
SEM	0.36	0.92	0.001	1.06	0.61	0.47	0.43
				Fodder sorghum silage (FSS)			
0.00	8.86^{a}	52.94^{d}	0.014^{a}	38.20^{a}	30.60^{c}	20.40^{b}	16.70^{a}
0.05	9.60^{a}	57.35^{b}	0.014^{a}	33.05^{bc}	33.20^{abc}	22.10^{ab}	18.10^{a}
1.00	10.40^{a}	62.21^{a}	0.014^{a}	27.39^{d}	36.00^{a}	24.00^{a}	19.60^{a}
1.50	9.92^{a}	59.25^{bc}	0.014^{a}	30.83^{c}	34.30^{ab}	22.90^{ab}	18.70^{a}
2.00	9.32^{a}	55.69^{c}	0.014^{a}	34.99^{b}	32.20^{bc}	21.50^{ab}	17.60^{a}
SEM	0.36	0.90	0.001	1.03	0.59	0.46	0.42

a, b c and d Means within a column with unlike superscripts are significantly different.

From the present study it could be concluded that, the addition of limestone at the levels of 1.0 % of wet weight at silage making improved silage quality, decreased ensiling losses and enhanced DM, CP and CF disappearance.

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الملخص العربى

تقييم الأنواع المختلفة من السيلاج المدعم بمسحوق الحجر الجيرى

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استخدم فى هذه الدراسة أربعة أنواع من محاصيل العلف النجيلية تتضمن نبات الـــذرة الكامل، سيقان الذرة الخضراء، الدراوة والسورجم وذلك لدراسة تأثير إضافة مسحوق الحجـــر

الجيرى بمستويات مختلفة (صفر، ٠,٥، ١,٠، ١,٥، ٢,٠% من الوزن الطازج) عند عمل السيلاج على التركيب الكيماوى، الصفات التخمرية لإنتاج السيلاج ومعدل اختفاء المادة الجافة والبروتين والألياف من الكرش. حيث تم حصاد نباتات الذرة الكامل في طور النضج العجينى أما سيقان الذرة فتم حصادها بعد نزع الكيزان مباشرة. بينما حصدت الدراوة والسورجم بعد ٥٠ يوم من الزراعة وبعد ذلك تم تقطيعها إلى أجزاء صغيرة طولها ٣-٥ سم وإضافة مسحوق الحجر الجيرى بالمعدلات السابقة وحفظها في برطمانات بلاستيك سعة ٢ كجم مع كبسها جيدا باليد للتخلص من الهواء وغلقها بإحكام باستخدام شمع البرافين ثم حفظها على درجة حرارة الغرفة لمدة ٦٠ يوم. وعند الفتح تم فحص رائحة ولون السيلاج كما أخذت عينات ممثلة لتقدير صفات جودة السيلاج وكذلك التحليل الكيماوى وأيضا معدلات اختفاء المادة الجافة، والبروتين والألياف من الكرش باستخدام الأبقار الحلابة المجهزة بالفستيولا.

أوضحت الدراسة النتائج الآتية:-

١- سجلت نباتات الذرة الكاملة أعلى قيم فى محتواها من كلا من الكربوهيدرات الذائبة والدهن الخام وأقل قيم بالنسبة لمحتواها من الألياف الخام بينما ارتفع محتوى سيقان الذرة الطازجة من المادة الجافة والألياف الخام وانخفض محتواها من البروتين الخام والدهن الخام، ومن ناحية أخرى ارتفع محتوي الدراوة من المادة العضوية والبروتين الخام وانخفض محتواها من الرماد. بينما أظهرت نباتات السورجم أعلى محتوى من الرماد واقل محتوى من كلا من المادة الجافة والمادة العضوية.

٢- ازداد محتوى أنواع السيلاج المختلفة من المادة الجافة، والدهن الخام، والألياف الخام، والرماد معنويا (٥%) مع زيادة مستوى مسحوق الحجر الجيرى، بينما انخفض معنويا (٥%) محتواها من المادة العضوية والكربوهيدرات الذائبة.

٣- انخفض تركيز حمض اللاكتيك مع زيادة محتوى السيلاج من المادة الجافة حيث كان هناك ارتباط سالب بينهما ($r = -0.76$)، ومن ناحية أخرى ازداد تركيز حمض اللاكتيك معنويا (٥%) مع زيادة مسحوق الحجر الجيرى حتى ١% ثم انخفض بعد ذلك.

٤- كان هناك ارتباط سلبى ($r=-0.75$) بين كلا من الأحماض الدهنية الطيارة الكلية والمادة الجافة، كما انخفض تركيز نيتروجين الأمونيا مع زيادة المادة الجافة ($r = -0.81$) في حين ازداد تركيزها مع زيادة البروتين ($r =0.75$).

٥- ازداد معدل اختفاء المادة الجافة من الكرش معنويا (٥%) مع زيادة مستوى مسحوق الحجر الجيرى حتى ١% ثم انخفض بعد ذلك، كما لوحظ أن هناك ارتباط موجب بين معدل اختفاء المادة الجافة ومحتوى مادة العلف من الكربوهيدرات الذائبة ($r = 0.71$)، بينما وجد ارتباط سالب ($r = -0.81$) بين المادة الجافة والألياف الخام.

٦- انخفض معدل اختفاء البروتين الخام من الكرش معنويا (٥%) مع زيادة مستوى مسحوق الحجر الجيرى، بينما ازداد الجزء الغير قابل للتخمر (u) وانخفض معدل مرور الجزء القابل للتخمر من الكرش. وهذا بدورة أدى إلى زيادة كمية البروتين التى لم تتعرض للتحلل بواسطة الأحياء الدقيقة الموجودة فى الكرش protein bypass معنويا.

٧- ازداد معدل اختفاء الألياف الخام من الكرش معنويا (٥%) مع زيادة نسبة الألياف حيث وجد بينهما ارتباط موجب ($r = 0.97$)، بينما انخفض معدل اختفائها مع زيادة نسبة الكربوهيدرات الذائبة حيث كان هناك ارتباط سالب بينهم ($r = -0.87$).

يتضح من هذه الدراسة أن إضافة مسحوق الحجر الجيرى بمعدل ١% على أساس الوزن الطازج عند عمل السيلاج أدى إلى تحسين جودة السيلاج، انخفاض الفاقد من السيلاج، وكذلك تحسن معدل اختفاء المادة الجافة والبروتين الخام والألياف الخام من الكرش.