aJava

Asian Journal of Animal and Veterinary Advances

Academic
Journals Inc.

www.academicjournals.com

Asian Journal of Animal and Veterinary Advances 4 (5): 219-227, 2009
ISSN 1683-9919

The Effect of Delayed Ensiling and Application of an Organic Acid-based Additives on the Fermentation of Corn Silage

S. Arbabi, T. Ghoorchi and S. Hasani
Department of Animal Science,
Gorgan University of Agriculture Sciences and Natural Resources, Gorgan, Iran

Abstract: The main objective of this study was to determine the effects of organic acid-based additives on the fermentation and delayed ensiling of corn silage. Prolonged exposure to air can adversely affect the silage fermentation process. To investigate a possible method to overcome this problem, we found that when a buffered propionic acid-based additive, is applied to chopped, whole-plant corn exposed to air before ensiling, it will affect the subsequent fermentation. Chopped whole plant corn mixed with 4 different additives consist of propionic acid in addition to control treatment without any additive. Additives were: (1) propionic acid, (2) propionic acid (85%)+formic acid (15%), (3) calcium propionate and (4) propionic acid (80%)+formic acid (15%)+ammonia (5%). The 10 g kg^{-1} dry matter of each additives mixed with chopped corn forage in 3 different times (0 (immediately), 24, 48 h). Silages were assessed by the method of appearance evaluation and DM, pH evaluation. CP, NDF, ADF, TVFA, WSC, so that, the aerobic stability and DM degradation of each treatment were determined after 60 days. Silages that exposed to air for 24 h, before ensiling had better appearance qnality than two other delaying time (0 and 48 h) in Filg's method and whole additives in this experiment had good effects on appearance quality in comparison with control group. All of silages containing buffered propionic acid-based additive, in method of DM, pH evaluation, were good and very good. These silages had lower ($p<0.05$) pH than control ones. Amount of dry matter of control silage which ensiled immediately was lower than other treated silages. NDF in control silages (without additive) was more than that in treated silages and amount of CP and TVFA increased with addition of additives especially those containing propionic acid (85%)+formic acid (15%) ($p<0.05$). WSC in control silage that wilted 48 h before ensiling was more than other samples ($p<0.05$). Buffered propionic acid-based additives increased aerobic stability in treated silages in comparison with untreated ones. Degradation of DM (*in situ*) for untreated silages that delayed ensiled was lower. Application of the additive containing propionic acid (80%)+ formic acid (15%)+ammonia (5%) resulted in highest degradation of dry matter among experimental additives. Generally, treatment with propionic acid-based additives prevented a decrease in DM degradation (*in vitro*).

Key words: Corn silage, propionic acid, formic acid, degradability, aerobic stability

INTRODUCTION

Ensiling is a preservation method for moist forage crops. Many chemical additives had been used to alter silage fermentation. For example, ammonia had been used to treat high moisture corn and corn silage. Moderate concentrations of ammonia have increased the concentrations of lactic and acetic acids, decreased proteolysis, improved DM recovery and improved the aerobic stability of corn silage.

Corresponding Author: S. Arbabi, Department of Animal Science,
Gorgan University of Agriculture Sciences and Natural Resources, Gorgan, Iran

Unbuffered propionic acid-based preservatives had also been used to improve the aerobic stability of corn silages. In recent years, marked changes had been made to the formulations and recommended application rates of additives containing propionic acid. Current recommendations for use of buffered propionic acid additives are considerably lower (0.1 to 0.2% of fresh forage weight) than classical recommendations for use of the unbuffered acid (0.75 to 1.5%). Data is lacking that directly compare the effects of buffered propionic acid based preservatives and ammonia on the aerobic stability of corn silage. A direct comparison is warranted to allow producers to make educated decisions on their relative usefulness (Kung *et al*., 2000). It is essential to have a good microbial fermentation process to produce high quality silage. A good fermentation process is not ouly depends on the type and quality of the forage crop, but also on the harvesting and ensiling technique (Oude Elferink *et al*., 1999). Fermentation inhibitors could in theory be used for all types of forages. However, in practice, they are generally only used in wet crops with a low water-soluble carbohydrate content and/or high buffer capacity (McDonald *et al*., 1991). In the Netherlands salts from acids have become the most popular fermentation inhibitors. An advantage of these salts is that they are easier and safer to handle than their corresponding acids. Silage additives inhibiting silage fermentation can reduce clostridial spore counts. In wilted grass silages a decrease in spore counts by a factor 5 to 20 has been observed. A similar decrease in spore counts could be obtained by adding molasses as a fermentation stimulant. To inhibit clostridial growth the most effective fermentation inhibitors appear to be additives based on formic acid, hexamethylene and nitrite (Oude Elferink *et al*., 1999). It is clear that to inhibit aerobic spoilage organisms, in particularly the once causing the onset of deterioration (i.e., yeasts and acetic acid bacteria) have to be inhibited in their activity and growth. Some additives which have proven to be effective in this respect include chemical additives based on volatile fatty acids such as propionic and acetic acid and biological additives based bacteriocin producing micro-organisms such as lactobacilli and bacilli (Woolford, 1975; McDonald *et al*., 1991; Phillip and Fellner, 1992; Weinberg and Muck, 1996). The effect of formic acid as a silage additive for grass crops is well documented (McDonald *et al*., 1991). When added to the crops that are difficult to ensile, a sufficient dose of formic acid will increase the lactic acid fermentation. Moreover, it will also reduce both the fermentation of acetic, propionic and butyric acids and proteolysis as well as silage pH in comparison with untreated silage. In some cases, a moderate dose of formic acid may inhibit lactic acid bacteria to a greater extent than yeasts and entrobacteria as undesirable organisms in silage. Yeasts are highly tolerant to formic acid and, when grown under anaerobic conditions, dependent on high sugar concentrations, which are usnally present in formic acid-treated silage (McDonald *et al*., 1991; Driehuis and Van Wikeselaar, 2000). Propionic acid-based additives have been used to inhibit yeasts that assimilate lactic acid when silages are exposed to air and thus, they improve aerobic stability (Woolford, 1975). After chopping, the presence of air in a forage mass delays the onset of fermentation and encourages the growth of undesirable microbes, which results in negative effects on the ensuing fermentation (McDonald *et al*., 1991). To eliminate air from the forage mass, forages should be packed rapidly and tightly into silos. However, poor management decisions, such as leaving chopped forage in wagons or piles, can end in substantial delays in filling silos; thus, forages may be exposed to air for prolonged periods of time. In addition, large bunk or trench silos sometimes require weeks to be filled, which expose forages to excessive amounts of air. Air is also detrimental during storage and feedout because it stimulates the growth of yeasts that metabolize lactic acid, which results in loss of nutrients (Woolford, 1990). High moisture grain silages are prone to spoil rapidly when exposed to air (McAllister *et al*., 1995). To improve the aerobic stability of these grains, methods to increase the concentration of propionic acid (because of its antifungal properties) in silages have been studied (Woolford, 1975). The direct method of adding propionic acid to silages has resulted in more consistent improvements in aerobic stability (Kung *et al*., 1998, 2000), but the effects of adding this acid to forage that is or has been exposed to excessive amounts of air before ensiling has not been well studied. The objective of this study was to compare the effects of delayed ensiling on silage fermentation. The effects of the application of buffered propionic acid-based additives on fermentation, aerobic stability and nutritive value of these silages were also investigated.

MATERIALS AND METHODS

Whole-plant corn was harvested one half milkline and chopped to a theoretical length of (1-2 cm) with a forage harvester. Forage treated with nothing (control), or with 0.1% of a buffered propionic acid-based additives (propionic acid) (1), propionic acid (85%)+formic acid (15%) (2), calcium propionate (3), propionic acid (80%)+formic acid (15%)+ammonia (5%) and (4) ensiled immediately in quadruplicate (10 L) micro silos. Portions of the chopped forage, untreated and treated, were left in loose piles on a clean concrete floor in a barn for 24 h before being packed into silos. Another portion of the untreated and treated forage exposed to air for 48 h and was ensiled. Empty and full weights of silos were recorded and silos were stored in the dark at ambient temperatures ranging between 18 and 25°C. All of the silos for each treatment were opened after 60 days of ensiling. The DM content of fresh forage and silage samples was determined by drying (70 to 75 g) in a forced-air oven at 60°C for 48 h. After drying, samples were ground. 10g samples of silage from each treatment were diluted (100 mL) sterile deionized water and blended for 2 min. Silage pH was determined immediately. Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) was analyzed by using sulfite and amylase (Van Soest *et al*., 1991). Crude Proteon (CP) was calculated by multiplying total nitrogen by 6.25. Fresh forage (25 g) was added to a dilution bottle that contained (225 mL) of sterile quarter-strength Ringer's solution (Oxoid BR54; Unipath, Basingstoke, UK) and homogenized in a blender for 1 min. After blending, water extracts were filtered through Whatman 54 filter paper (Whatman Inc., Clifton, NJ), acidified with 50% sulfuric acid and frozen before analysis of Water-Soluble Carbohydrates (WSC) (Nelson, 1944). The pH of silage extracts was determined within 20 min of homogenization. After 60 days of ensiling, silos were opened and silage was mixed well, then a (2 kg) sample was returned to its respective silo. No physical packing of the silage tack place. A thermometer was placed in the geometric center of each silage mass and temperatures were recorded every 3 h. A double layer of cheesecloth was placed on the top of each silo to prevent contamination but allowed for penetration of air because silos were incubated between 21 and 22°C. Aerobic stability was defined as the number of hours before a 2°C increase in the temperature of the silage mass relative to ambient temperature. The temperature and pH of silages were recorded for 144 h, each 24 h once. For the determination of *in situ* ruminal DM, dry corn silage samples were ground to pass through a (2 mm) screen and (0.5 g) of silage was weighed into Dacron bags (5×10 cm, 50 μm pore size; Ankom, Fairport, NY). Duplicate bags were placed in the rumen of a fistulated sheep fed a diet that was 82.4% alfalfa hay/grass hay, 8.8% soybean meal and 8.8% dry rolled barely. Bags were incubated for 0, 4, 8, 16, 24, 48 and 72 h. After removal from the sheep, bags were washed with water until effluent was clear and then were dried at 55°C for 48 h. Dried bags were weighed and DM disappearance was determined. The chemical composition of forages and silages was analyzed as a factorial in a completely randomized design by the general linear model procedure of SAS/STAT (1988). Factors were ADF (%), NDF (%), CP (%), WSC (%), TVFA (Mmol kg^{-1}), DDM (%), DE (Mcal kg^{-1}), ME (Mcal kg^{-1}) and TDN (%). Means were separated by Duncan test at 0.05 probability level (Duncan, 1955). The kinetics of ruminal DM disappearance *in situ* was estimated by the Naway software. This research project was conducted from 2006 to 2007, in the Department of Animal Science Gorgan University of Agriculture Sciences and Natural Resources.

RESULTS

Appearance Evaluation

In this study, each of the factors including like to smell, color and structure (appearance characters) based on Filg's method evaluation has given a number (Horiguchi and Takahashi, 2007). Treated forage with additive that exposured to air for 24 h before ensiling, had better appearance than others. Control group had lower appearance quality than the other treatments in all of sealing times.

In this evaluation method, the maximum of pH for stating in very good degree silage with 35% DM is 4.5. In the present study, average DM was 37.7% and pH ranged from 4.0 to 4.9; therefore, all of the reported silages were of good and very good quality (Table 1).

Chemical Composition

Untreated silages (control group) had higher pH than treated ones ($p<0.05$). Significant interaction was happened between for concentration of dry matter. The control group that was ensiled immediately had lower ($p<0.05$) DM content in comparison with the silage treated with additive 1. The content of DM in additive 3* 24 h delayed ensiling were higher ($p<0.05$) than others. For type of additive* 48 h delayed ensiling, silage with additive 1 had lower ($p<0.05$) concentration of DM compared with the additive 3. The chemical composition of corn silage after 60 d of ensiling is shown in Table 2 and 3. Timing of treatment with buffered propionic acid either at chopping or after

Table 1: Appearance evaluation based on dry matter and pH (Filg's method)

Delaying time[1] (h)	Additive type[2]	pH	DM (g kg^{-1})	Judgment
0	Control	4.80^{a}	335.0^{d}	Good
0	Additive 1	4.43^{b}	374.0^{bc}	Very good
0	Additive 2	4.00^{b}	367.6^{bcd}	Very good
0	Additive 3	4.40^{b}	359.2^{cd}	Good
0	Additive 4	4.30^{b}	375.0^{bc}	Very good
24	Control	4.64^{a}	380.0^{bc}	Very good
24	Additive 1	4.23^{b}	347.5^{d}	Very good
24	Additive 2	4.31^{b}	373.4^{bc}	Very good
24	Additive 3	4.09^{b}	428.5^{a}	Very good
24	Additive 4	4.18^{b}	342.0^{d}	Very good
48	Control	4.90^{a}	395.0^{abc}	Very good
48	Additive 1	4.53^{b}	367.0^{bcd}	Very good
48	Additive 2	4.33^{b}	397.0^{abc}	Very good
48	Additive 3	4.24^{b}	418.0^{a}	Very good
48	Additive 4	4.36^{b}	405.5^{ab}	Very good

[1]Delaying time of sealing: 0, 24 and 48, Control: Without any additive, Additive 1: Propionic acid. Additive 2: Propionic acid (85%)+formic acid (15%), Additive 3: Calcium propionate. Additive 4: Propionic acid (80%) +formic acid (15%)+ammonia (5%). Superscript values with unlike letter(s) differ ($p<0.05$)

Table 2: Chemical composition (DM based) of corn silage after 60 days of ensiling (sealing time is fixed)

	Treatment[1]				
		Additives			
Parameters	Control	1	2	3	4
Acid detergent fibre (g kg^{-1})	265.00	271.00	259.50	263.70	261.40
Neutral detergent fibre (g kg^{-1})	587.20^{a}	550.50^{a}	498.50^{b}	493.10^{a}	564.80^{a}
Crude protein (g kg^{-1})	98.00^{ab}	93.50^{ab}	110.30^{a}	87.50^{b}	94.90^{ab}
Total volatile fatty acid (Mmol kg^{-1})	674.00^{b}	856.50^{b}	1612.30^{a}	897.30^{b}	845.60^{b}
Digestible dry matter[2] (g kg^{-1})	682.50	677.80	686.80	683.50	685.30
Digestible energy[3] (Mcal kg^{-1})	2.94	2.92	2.96	2.95	2.95
Metabolizable energy[4] (Mcal kg^{-1})	2.41	2.39	2.43	2.42	2.42
Total digestible nutrition[5] (g kg^{-1})	666.80	662.20	671.30	669.10	669.10

[1]Control: Without any additive. Additive 1: Propionic acid. Additive 2: Propionic acid (85%)+formic acid (15%), Additive 3: Calcium propionate. Additive 4: Propionic acid (80%)+formic acid (15%)+amonia (5%). [2]Digestable dry Matter: 88.9-0.779 (ADF), [3]Digestable energy: 0.027+0.0427(%DDM), [4]Metabolizable energy: DE *0.821. [5]Total digestible nutrition: DE/0.04409 (Khalil *et al.*, 1986). Superscript values with unlike letter(s) differ ($p<0.05$)

Table 3: Chemical composition (DM based) of corn silage after 60 days of ensiling (treatment is fixed)

	Delaying time of sealing[1] (h)		
Parameters	0	24	48
Acid detergent fibre (g kg^{-1})	271.60[a]	299.00[a]	260.30[a]
Neutral detergent fibre (g kg^{-1})	529.60[a]	570.40[a]	520.90[a]
Crude protein (g kg^{-1})	97.80[a]	94.10[a]	10.09[a]
Total volatile fatty acid (Mmol kg^{-1})	639.90[b]	971.10[a]	1389.60[a]
Digestible dry matter[2] (g kg^{-1})	677.40[a]	679.40[a]	686.20[a]
Digestible energy[3] (Mcal kg^{-1})	2.92[a]	2.93[a]	2.96[a]
Metabolizable energy[4] (Mcal kg^{-1})	2.39[a]	2.40[a]	2.43[a]
Total digestible nutrition[5] (g kg^{-1})	662.20[a]	664.10[a]	670.70[a]

[1]Delaying time of sealing: 0, 24 and 48 h, [2]Digestable dry matter: 88.9-0.779 (ADF), [3]Digestable energy: 0.027+0.0427(%DDM), [4]Metabolizable energy: DE *0.821, [5] Total digestible nutrition: DE/0.04409 (Khalil *et al*., 1986), [a]Superscript values with unlike letter(s) differ (p<0.05)

Table 4: Significant interaction between delaying time and additive type for concentration of Water-Soluble Carbohydrates (WSC) in corn silage after 60 days of ensiling

Delaying time[1] (h)	Additive type[2]	Water soluble carbohydrates (g kg^{-1})
0	Control	16.8[ab]
0	Additive 1	13.4[bc]
0	Additive 2	8.8[d]
0	Additive 3	12.2[cd]
0	Additive 4	11.0[cd]
24	Control	11.4[cd]
24	Additive 1	10.7[cd]
24	Additive 2	11.5[cd]
24	Additive 3	12.2[cd]
24	Additive 4	11.4[cd]
48	Control	1.84[a]
48	Additive 1	10.8[cd]
48	Additive 2	8.8[d]
48	Additive 3	12.0[cd]
48	Additive 4	11.1[cd]

[1]Delaying time of sealing: 0 and 48 h, [2]Control: Without any additive. Additive 1: Propionic acid. Additive 2: Propionic acid (85%)+formic acid (15%), Additive 3: Calcium propionate. Additive 4: Propionic acid (80%)+formic acid (15%) +ammonia (5%). Superscript values with unlike letter(s) differ (p<0.05)

exposure to air not affected ADF content, but amount of Neutral Detergent Fiber (NDF) in treated silage with additive 2 (propionic acid(85%)+formic acid (15%)) was lower (p<0.05) than the other treatments and control groups. In this study, the crud protein content of silages with additive 2 was higher than additive 3 (calcium propionate). Total Volatile Fatty Acid (TVFA) concentration of treatment 2 was significantly higher than other treatments and control group (p<0.05). Concerning to concentrate of Digestible Dry Matter (DDM), Digestible Energy (DE), Metabolizable Energy (ME) and Total Digestible Nutrition (TDN) in the silages, no significant effects were found for the type of additive or the sealing time. Significant interaction occurred for concentration of Water-Soluble Carbohydrates (WSC) (Table 4). The WSC concentration of immediating sealing silage without any additive (control) was higher (p<0.05) than treatments 2, 3, 4. However, for additive 1*Immedating ensilage (WSC = 13.4 g kg^{-1}) the amount of WSC was higher (p<0.05) than additive 2. To concentrate WSC in the silage, no main effects were found neither for the type of additive nor for 24 h exposure to air. For type of additive* 48 h delayed ensiling, control silage (without any additive) had higher (p<0.05) concentration of WSC compared with other treatments.

In situ Ruminal DM Digestibility

Addition of the additives 1 and 4 to silages affected *in situ* ruminal DM digestibility of treated silages so that *in situ* ruminal DM digestion of control group (280.6 g kg^{-1}) was significantly (p<0.05) lower than treatment 1 (412.5 g kg^{-1}) and 4 (431.6 g kg^{-1}). Sealing time had no effect on *in situ* ruminal DM digestibility of silages (Table 5).

Table 5: Apparent *in situ* DM digestion of corn silages (sealing time is fixed)

	Treatment[1]							
		Additives				Delaying time of sealing[2]		
Parameters	Control	1	2	3	4	0	24	48
DM digestion ($g\ kg^{-1}$)	280.60^{c}	412.50^{ab}	354.60^{bc}	300.60^{c}	431.9^{a0}	335.70^{a}	335.20^{a}	373.40^{a}
Kd[3] (%/h)	6.10	4.80	5.60	5.40	4.90	5.70	5.40	5.50
SE	1.22	1.61	1.68	1.68	1.78	1.37	1.84	1.58

[1]Control: Without any additive. Additive 1: Propionic acid. Additive 2: Propionic acid (85%)+formic acid (15%), Additive 3: Calcium propionate. Additive 4: Propionic acid (80%)+formic acid (15%)+ammonia (5%), [2]Delaying time of sealing: 0, 48 and h. [3]Kd: Rate of digestion. Superscript values with unlike letter(s) differ ($p<0.05$)

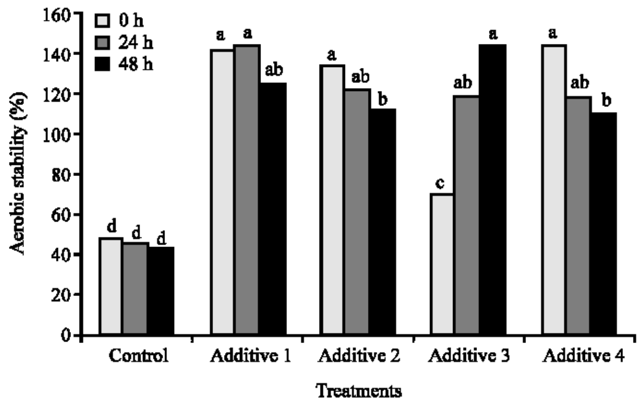

Fig. 1: The aerobic stability of corn silage. Control: Without any additive. Additive 1: Propionic acid. Additive 2: Propionic acid (85%)+formic acid (15%), Additive 3: Calcium propionate. Additive 4: Propionic acid (80%)+formic acid (15%)+ammonia (5%). Delaying time of sealing: 0, 24 and 48 h. SE = 10. Bars with unlike letter(s) differ ($p<0.05$)

Aerobic Stability

Significant ($p<0.05$) interactions between additive and sealing time were found for pH and temperature. Temperature of control silages in all sealing time after 48 h exposuring to air 2°C increased and after 144 h reached its highest peak (immediately = 34.05°C, 24 h delaying = 28.95°C, 48 h delaying = 35.80°C) (Fig. 1).

DISCUSSION

Appearance Evaluation

According to previous study, in the present research applications of organic acid-based additives improved quality of fermentation corn silage (Kung *et al*., 1998, 2000, 2004; Knicky, 2005). Therefore, all of appearance qualities of silages were stated in good and very good class.

Chemical Composition

Untreated silage had higher pH than treated silages. This is similar the results of Kung *et al*. (2000, 2004) and Randby (2000). Addition of the buffered propionic acid-based additive decrease pH, which suggests that these additives partially reduced the metabolism of some aerobic microorganisms (Kung *et al*., 1998).

Observations of DM were similar to those of Florek *et al*. (2004) and Kung *et al*. (2004), who reported that the reason of this finding was related to the limiting fermentation power of formic acid and increasing DM content power of propionic acid with unknown reason. However, Kung *et al.* (2000) reported that low levels of buffered propionic acid generally had no effects on silage fermentation. Addition and blending some additives at time of ensiling improve fermentation and increase DM of silages (Harrison and Blauwiekel, 1994; Givens *et al.*, 1993). Calcium propionate is the salt of propionic acid that increases DM with raising pH and limiting fermentation (Oude Elferink *et al.*, 1999).

Timing of treatment with buffered propionic acid either at chopping or after exposure to air made no difference in ADF content, the reason for decrease amount of NDF in treated silage with additive 2, to other treatments and control groups are unknown. Kung *et al.* (1998, 2000) and Kung (2001) reported that the application of the buffered propionic acid-based additives had no effect on fermentation end-products. Randby (2000) detected that application of formic acid in silages with 24 h delayed in ensiling, improved quality of fermentation, increased amount of true protein and sugar and decreased content of acetic acid, propionic acid, ammonia-N and pH. Additives consist of formic acid limited/stoped fermentation, decreased ammonia-N and increased silage protein quality.

This research demonstrated that TVFA concentration of treatnent 2 were significantly higher than the others, which is similar to the values reported by Kung *et al.* (2004) and Kung and Shaver (2001). They mentioned that addition of buffered propionic acid-based additive to silage caused increasing Volatile Fatty Acid (VFA) of course the highest was because of propionic acid content of silage. Timing of treatment with buffered propionic acid-based additive either at chopping or after exposure to air made the forage content of TVFA different. Randby (2000) indicated that application of formic acid additive to silage improved quality of corn silage and when the sealing was delayed 24 h, additives could eliminate negative effects of delaying. The results of some studies indicated that additive compound of formic acid influence amount of VFA and content of propionic acid increase in treating corn silage with buffered propionic acid-based additive. Treating corn silage with 0.2% (w./w. wet forage) of these additives caused by increasing lactic acid, acetic acid and propionic acid compared with untreated silages (Kung *et al.*, 2004).

To concentrate DDM, DE, ME and TDN in the silages have influenced by content of ADF, which is similar to results reported by Kung *et al.* (1998, 2000) that mentioned the buffered propionic acid-based additive have little effect on some nutrients (e.g., ADF, NDF and starch). Mills and Kung (2002) reported that content of WSC didn't have any difference between treatments consisted of the buffered propionic acid-based additive and ensiling at 0 and 24 h after chopping forage. In addition to the preservative effect of buffered propionic acid-based additive, the application of this additive resulted from little differences in end-productions of corn silage, but treating corn silages with 0.2% (w./w. wet forage) of buffered propionic acid-based additive were increased amount of WSC (Kung *et al.*, 2004). Florek *et al.* (2004) did not measure WSC raises caused by wilted corn forage that treated with formic acid-based additive before ensiling. Of course, other factors are effective in WSC content of silages, including: variation of plant, stage of growth, effect of length of the day, effect of manure (McDouald *et al.*, 1991), effect of witting and protein content of plant (Umana *et al.*, 1991). This is possible reasons of different result from earlier study related to the other effective factors in WSC.

Taking into consideration of effects of the buffered propionic acid-based additive on the chemical composition of silages in this study, was iuferred that treating corn silage with this additives improved quality of nutrition value, approximately.

In situ Ruminal DM Digestibility

Sealing time had no effect on *in situ* ruminal DM digestibility of silages. Treating with the buffered propionic acid-based additive prevented of the negative effects of exposuring to air before ensiling on *in situ* ruminal DM digestibility (Mills and Kung, 2002). Collectively, these data showed that the buffered propionic acid-based products can improve the fermentation and increase nutritive value fiual aerobic stability of silages.

Aerobic Stability

Temperature and pH values of silages after opening explained that wilting forage for 24 h before ensiling, affected in inhibiting temperature raise of silage after exposuring to air (Harrison and Blauwiekel, 1994). Among of experimental additives in all sealing time, additive 1 was more effective than others for the inhibiting of raising temperature of silages, but generally all of the additives in all of the sealing time had significant effects on increasing aerobic stability, which is similar to results of Kung *et al*. (1998, 2004) and Mills and Kung (2002).

The objective of this study was to determine the effects of some different buffered propionic acid-based additive on the characters storage corn silage including aerobic stability, that just as indicated these additives had benefit effect on this factor.

CONCLUSION

When chopped corn forage is exposed to air for a long time before ensiling, the number of detrimental microorganisms increases, whereas the concentration of fermentable substrate decreases. The application of a buffered propionic acid-based additive eliminates the destructive effects of exposure to air and improves the fermentation quality. Moreover, the addition of this additive will remove/improve the negative effects of exposure to air before ensiling such as a decrease in *in situ* DM digestion regardless of timing of the application. These results show that use of a buffered propionic acid-based additive can partially, but not totally, compensate for poor silo management practices. However, rapid filling of silos and achieving adequate packing densities to exclude excessive air should still be high priorities for making excellent quality silage.

ACKNOWLEDGMENT

The authors would like to thank Company Part Pishtaz and Gorgan University of Agricultural Science and Natural Resources.

REFERENCES

Driehuis, F. and P.G. Van Wikeselaar, 2000. The occurrence and prevention of ethanol fermentation in high dry matter grass silage. J. Sci. Food Agric., 80: 711-718.

Duncan, D.B., 1955. Multiple range and multiple F-tests. Biometrics, 11: 1-42.

Florek, S., P. Purwin, D. Minakowski, M. Stanek and F. Tredowicz, 2004. The influence of formic acid additives on the quality of silage from different plant material. Veterinaija Ir Zootechnika. T., 26: 23-28.

Givens, D.I., A.R. Moss and A.H. Adamson, 1993. The digestion and energy value of whole crop wheat treated with urea. Anim. Feed Sci. Technol., 43: 51-64.

Harrison, J.H. and R. Blauwiekel, 1994. Fermentation and utilization of grass silage. J. Dairy Sci., 77: 3209-3235.

Horiguchi, K.I. and T. Takahashi, 2007. Fermentation quality and nutritive value of green soybean stover silage. Grassland Sci., 53: 27-31.

Khalil, J.K., W.N. Sawaya and S.Z. Hyder, 1986. Nutrient composition of Atriplex leaves grown in Saudi Arabiq. J. Ranye Manaye, 39: 104-107.

Knicky, M., 2005. Possibilities to Improve Silage Conservation. Swed. Univ. Agric. Sci. Dept. of Animal Nutrition and Management, Agraria, Uppsala.

Kung, Jr. L., A.C. Sheperd, A.M. Smagala, K.M. Enders, C.A. Bessett, N.K. Ranjit and J.L. Glancey, 1998. The effect of preservatives based on propionic acid on the fermentation and aerobic stability of corn silage and a total mixed ration. J. Dairy Sci., 81: 1322-1330.

Kung, Jr. L., J.R. Robinson, N.K. Ranjit, J.H. Chen, C.M. Golt and J.D. Pesek, 2000. Microbial populations, fermentation end-products and aerobic stability of corn silage treated with ammunia or a propionic acid-based preservative. J. Dairy Sci., 83: 1479-1486.

Kung, L., 2001. Silage Fermentation and Additives. Originally Published in the 2000-2001 Direct-Fed Microbial, Enzyme and Forage Additive Compendium. Miller Publishing Co., Miiunetonka, MN.

Kung, L. and R. Shaver, 2001. Interpretation and use of silage fermentation analysis reports. Focus Forage, 3: 68-79.

Kung, L., C.L. Myers, J.M. Neylon, C.C. Taylor, J. Lazartic, J.A. Mills and A.G. Whiter, 2004. The effect of buffered propionic acid-based additive alone or combined with microbial inoculation on the fermentation of high moisture corn and whole-crop barley. J. Dairy Sci., 87: 1310-1316.

McAllister, T.A., L.B. Selinger, L.R. McMahon, H.D. Bae, T.J. Lysyk, S.J. Oosting and K.J. Cheng, 1995. Intake, digestibility and aerobic stability of barley silage inoculated with mixtures of *Lactobacillus plantarum* and *Enterococcus faecium*. Can. J. Anim. Sci., 75: 425-432.

McDonald, P., A.R. Henderson and S.J.E. Heron, 1991. The Biochemistry of Silage. 2nd Edn., Chalcombe Publications, Marlow, Bucks, UK., ISBN: 0-948617-22-5, pp: 340.

Mills, J.A. and L. Jr. Kung, 2002. The effect of delayed ensiling and application of a propionic acid-based additive on the fermentation of barly silage. J. Dairy Sci., 85: 1969-1975.

Nelson, N., 1944. A photometric adaptation of the Somogyi method for the determination of glucose. J. Biol. Chem., 153: 375-380.

Oude Elferink, S.J.W.H., F. Driehuis, J.C. Gottschal and S.F. Spoelstra, 1999. Silage fermentation prosses and their manipulation. Proceedings of the FAO Electronic Conference on Typical Silage, 1999, AGPC., pp: 1-1.

Phillip, L.E. and V. Fellner, 1992. Effect of bacterial inoculation of high moisture ear corn on its aerobic stability, digestion and utilization for growth by beef steers. J. Anim. Sci., 70: 3178-3187.

Randby, A.T., 2000. The effect of some acid-based additives applied to wet grass crops under various ensiling conditions. Grass Forage Sci., 55: 289-299.

SAS., 1988. SAS User's Guide: Statistics. Ver. 6.03, SAS Inst., Inc., Cary, NC.

Umana, R.C., R. Staples, D.B. Bates, C.J. Wilcox and W.C. Mahanna, 1991. Effects of a microbial inoculant and (or) sugar cane molasses on the fermentation, aerobic stability and digestibility of bermudagrass ensiled at two moisture contents. J. Anim. Sci., 69: 4588-4601.

Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74: 3583-3597.

Weinberg, Z.G. and R.E. Muck, 1996. New trends and opportunities in the development and use of inoculants for silage. FEMS. Microbiol. Rev., 19: 53-68.

Woolford, M.K., 1975. Microbiological screening of the straight chain fatty acids (C1-C2) as potential silage additives. J. Sci. Food Agric., 26: 219-228.

Woolford, M.K., 1990. The detrimental effects of air on silage. J. Applied Bacteriol., 68: 101-116.