THE EFFECT OF WILTING ON SILAGE MAKING FROM THE VIEWPOINT IN CONNECTION WITH MONSOON ASIA (A REVIEW)

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Summary

In spite of the well confirmed advantages of wilting on the fermentation quality, wilting silages are difficult to make at optimum dry matter content. The prolonged wilting, especially in humid condition, result in lower water soluble carbohydrate (WSC) contents, extensive protein breakdown and sometimes higher total volatile fatty acid (VFA) during wilting an ensilage. Apart from difficulty of controlling moisture content, another problem associated with wilted silages is different evaluation on the potential productivity. In temperature climate of Asia, therefore further researches on the effects of wilting on the silage fermentation and potential productivity seem to be necessary.

(Key Words: Biocehmical Change, Dry Matter(DM) Evaluation, Nutritional Loss, Potential Productivity, Silage Fermentation, Wilting)

Introduction

Silage making has advantages as the major conservation technique of crop which has high moisture content. However, the disadvantages of ensiling crop with high moisture content have been stressed by many studies as clostridial fermentation (Kung, Jr. et al., 1984), low DM voluntary intake (Donaldson and Edwards, 1976; Haigh and Parker, 1985) and large volumes of effluent with highly digestible nutrients (Anderson and Jackson, 1970; Castle and Watson, 1971; Wilson and Wilkins, 1972). Much effort therefore has been devoted to improving silage quality and feeding value by controling moisture content prior to ensiling. Wilting of the herbages prior to ensiling is regarded as a desirable process for inhibiting clostridial activity, reducing effluent losses, raising sugar content and improving intake by animals. In temperate zone of Asia, it is difficult to dry a high moisture forage to adequate moisture level because the time when the forages are harvested is in rainy season. Wilting for longer than the generally accepted optimum period, especially under humid conditions, may be responsible for reduction in digestibility and milk production (Gordon, 1980; Anderson, 1983, 1985). The main objectives of this paper are to obtain the information available for wilting prior to ensiling in the Asia as introducing the change in chemical composition and nutritional losses of ensiled materials occurred during the process of silage making, from field wilting to resulting silage, in various conditions and considering what is the major problem for further research in relation to wilting.

Changes of chemical composition during wilting

The chemical composition of the temperate herbages directly cut and wilted in various conditions is shown in table 1. Overall pH value of the herbage do not appear to be affected to any extent as the result of wilting. Greenhill (1964c) had found a slight decrease in the initial pH due to wilting and also a slight increase in buffering capacity but neither effect was significant. On the other hand, Anderson (1983) showed that rise in initial pH (Henderson et al., 1972; Anderson, 1985) and decrease in buffering capacity of grass were due to wilting prior to ensiling. These different results of wilting on the pH and buffering capacity are shown to be caused by drying methods of which wilting performed is either on

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TABLE 1. THE COMPOSITION OF FRESH AND WILTED RYEGRASS AND CLOVER

	DM (%)	pH	WSC (%DM)	TN (%DM)	PN (%TN)	NH^3-N (%TN)
Fresh	17.3	6.1	21.3	2.66	92.5	0.12
Wilted (6 h)	34.9	6.0	21.5	2.83	87.8	0.11
Wilted (48 h)	46.2	6.1	20.3	2.89	83.2	0.21
Moist wilted (48 h)	19.9	5.9	21.1	2.99	75.2	0.26
Moist wilted (144 h)	37.5	6.0	17.5	3.10	68.9	2.61

Source: Carpintero et al. (1979)

field or in dry oven, and by weather condition and wilting duration.

Although changes in total nitrogen by proteolysis during wilting are small, true protein is decreased and ammonia-N is increased. When the herbages are exposed to a prolonged wilting in humid conditions extensive protein breakdown occur during wilting (Anderson, 1985). Anderson (1983) found that wilting had the effect of markedly increasing non protein nitrogen (NPN) to reach about 38.9% of total-N after 96 h and there were concomitant increase in herbage free amino-N, amide-N and ammonia-N. These changes appear to occur in two independent steps. The proteins are first hydrolyzed to short chain peptides or free amino acids by plant enzymes. Subsequently, these amino acids are converted to other forms of NPN such as amine and ammonia by a process which is primarily mediated by bacteria. This latter transformation may contribute to the decrease in nutritional value of ensiled forage (Ohshima and McDonald, 1978).

And also a major organic change is reduction in the content of water soluble carbohydrate due to hydrolysis and subsequent oxidation of respiratory substrates of hexose sugar (Carpintero et al., 1969; Uchida et al., 1970). According to Anderson (1985), the water soluble carbohydrate content of 98.5 g kg^{-1} DM after wilting for 120 h in wet conditions was 56% lower than that of 170 h kg^{-1} of direct cut herbage. Uchida and Kitamura (1987) using tropical grasses obtained decrease in water soluble carbohydrate of 8.51, 4.22 to 3.45% for fresh, wilted and hay, respectively.

Henderson et al. (1972) have studied chemical and microbiological changes of herbage during wilting and obtained that the count of lactic acid bacteria had increased to about 10^4 g^{-1} herbage after 24 h field wilting and then 7 h later the numbers had almost 10^6 g^{-1}. However, protolytic clostridia and lactate fermenters were relatively inactive in the wilted grass.

These biochemical changes which are caused by respiration and other enzymatic process result in field losses with mechanical and leaching losses.

The dry matter losses during silage making associated with wilting.

Field losses of the herbage during wilting prior to silage making are due to three causes; mechanical, biochemical and leaching. Mechanical losses arise as physical losses caused by handling, turning and raking the drying crop (Gordon et al., 1969). A number of review paper (Ruxton et al., 1975; Marsh, 1979) have reported DM losses of about 2 3% per day which should be added an additional constant amount of 2-3% if herbage has been lacerated. If wilting prolonged, especially in rainy weather, the losses of nutrients are occurred quite dramatically (table 2). On the other hand, Castle and Watson (1973b) demonstrated that these field losses can be compensated by the reduction in storage losses as effluent if the DM concentration of the original herbage is above 250 g kg^{-1} depending studies over a four-year period (Castle and Watson, 1969, 1970a, 1970b, 1971, 1973a, Wilson and Wilkins, 1972). These results indicated that, given moderate good condition, wilting prior to ensiling is not necessarily disadvantageous in terms of DM losses. Marsh (1979) emphasized, in his review, that the justification for adopting either unwilted or wilted silage system will largely depend on the quality of the final product in relation to the requirement of the stock to which it is to be fed. In this review, however no account was taken of the effect of DM content by wilting on

TABLE 2. INFLUENCE OF WEATHER CONDITION ON INCREASE IN DRY MATTER CONTENT AND % DRY MATTER LOSSES DUR NG THE WILTING PERIOD[1]

Weather condition	No. of experiments	Field period (day)	DM content increase (%DM)	% DM losses	
				Total	Per unit DM increase
Without rain	6	2.3	29.2	3.9	0.014
Rain only on one day	4	4.5	25.1	4.0	0.015
More than one day's rain	9	6.7	22.3	9.8	0.044

[1] based on data from "The biochemistry of silage". McDonald, P. (1981). Wiley and Sons, Ltd.

further losses of DM arising from secondary aerobic deterioration.

On the other hand, Ruxton et al. (1975) recognized when ensiled herbage exceeded at DM content of 30%, although which is necessary to avoid excessive effluent production in the silo, when the silo is opened and contents are removed for feeding further losses of DM content may be occurred by aerobic deterioration. The DM losses by aerobic deterioration varied from 20.3% (Henderson, 1979), 19.2% (Rees, 1982) to 3.5% (Matsuoka, 1985). The reports of aerobic losses associated with wilting are very little and gave variable results. Ruxton et al. (1975) and Matsuoka et al. (1985) have shown that heavily wilting is one of the main factors which prone to aerobic deterioration. Other studies confirmed that there is no clear relationship between aerobic deterioration and silage DM (Ohyama and Mcdonald, 1975; Ohyama et al., 1975; Kibe, 1979).

Effect of wilting on silage fermentation and potential productivity.

In the living plant a proportion of the energy is capture in ATP which is used in biosynthesis and the remainder of the energy is liberated as heat. In the harvested herbage, however, biosynthetic reaction are limited and it is assumed that virtually all the energy in the oxidized glucose is converted into heat. The increase in temperature in the silo is dependent upon the extent and rate of this respiration, the degree of insulation of the silo and the specific heat of the ensiled mass (McDonald, 1981). Since accepting that temperature rise within the silo is a direct measure of rate of respiration (Henderson et al., 1972). Under practical conditions, it is well known that it is more difficult to prevent overheating in wilted than in fresh material because of difficulty in consolidating the crop and preventing reentry of air. McDonald et al. (1966) studied the changes in termperature during ensiling with fresh (15.2% DM) and wilted grass (26.7% DM). In this experiment, the fresh materials heated more rapidly than the wilted materials in the silos which were moderately compacted and applied pressure on the second day.

The release of intra-cellular plant juices is prerequisite for increase in lactic acid bacteria and which is responsible for a naturally primary anaerobic fermentation (Greenhill, 1964a;b). The bacterial activities, especially clostridia, can be restricted with reducing water content which results in an higher osmotic pressure (Muck, 1984) so that fermentation of silage can be restricted as DM content increased. The effect of decreasing the moisture content on the lactic acid bacteria and other micro-organisms is reflected in the high residual WSC in the wilted silage. McDonald et al. (1968) founded that about 50% of original WSC were recovered in the 34% DM silages whereas in the 47% DM content silage about 87% of the WSC were recovered. Similar results were obtained by Ohyama and Masaki (1968) and Carpintero et al. (1969). These high level of sugars remaining in the wilted silage may lead to improving utilization of nitrogen by ruminants fed these diet (McDonald et al., 1968; Anderson and Jackson, 1970).

The decline of ammonia-N at high dry matter is attributable to a restricted fermentation and possibly to a decrease in clostridial deamination (Shin and Yun, 1983; Kung, Jr. et al., 1984). According to Uchida and Sutoh (1977), there was a decrease in ammonia-N, as % of total N, from 5.8% to 3.7% in Italian ryegrass as DM content increased from 21.7% to 60.3%. By using lucerne wilted for 24 h, the content of ammonia-N (% total N) of wilted lucerne silage was almost 19.5% lower than that of fresh-cut silage (Carpintero et al., 1969). Haigh (1987) found when dry matter contents were greater than 260 g kg^{-1}, 83% of 1713 samples of silage were well fermented, with average ammonia-N concentration of 94 g kg^{-1} total-N. An ammonia-N value of less than 80-100g kg^{-1} total-N is commonly used to indicate that silage is well fermented (Haigh and Parker, 1985; Haigh, 1987).

In the study by Donaldson and Edwards (1976), wilting of the crop from a DM content of 175 g kg^{-1} to 360 g kg^{-1} decreased the lactic acid content of the silage from 102 g kg^{-1} to 59 g kg^{-1} DM and the material preserved well at a pH of 4.18 compared with the unwilted silage which had a pH of 3.94. Other fermentation products, especially acetic and butyric acids were also relatively low in the wilted silage. Therefore, it is not unable to use pH as the sole criterion for assessing silage fermentation (McDonald, 1981; Haigh, 1987) because stable condition of resulting silage can be achieved at much higher pH with increasing dry matter level (table 3). These conclusions are in agreement with Gordon et al. (1965), Uchida et al. (1970, 1971). Marsh (1979), from twenty different sources, reported a mean increase in 44%, 25% and 31% of daily DM intake with wilted silage by sheep, growing cattle and lactating cows respectively and concluded that wilting is essential for some conservation systems, in most situations it is normally an advantage.

TABLE 3. THE SUMMARY OF RELATIONSHIP BETWEEN DRY MATTER CONTENT AND pH OF STABLE SILAGE

		Fresh material		
		DM(%)	pH	pH of silage
McDonald et al.	Fresh	15.21	5.90	3.72
(1966)	Wilted	26.72	6.00	3.88
McDonald et al.	Fresh	20.30	5.90	4.00
(1968)	Wilted	48.50	6.10	4.80
Anderson and Jackson	Fresh	21.15.	6.09	3.90
(1970)	Wilted	43.31	6.20	4.90
Henderson et al.	Fresh	17.75	6.08	3.94
(1972)	Wilted	32.33	6.21	4.24
Haigh and Parker	Fresh	19.70		4.50
(1985)	Wilted	25.50		4.80

Castle and Watson (1982), Haigh and Parker (1985) showed that wilting resulted in poor preservation compared with untreated silage unless additive was applied. Anderson (1983, 1985) found that, in the poor and wet condition, wilting for 95 h or 120 h did not completely inhibit the microorganism activities, so that the content of water soluble carbohydrate decreased and NPN and ammonia-N content increased compared with direct-cut silage. Gordon (1981) considered that the decrease in DM intake of unwilted silage was obtained where the fermentation of unwilted silage was poor and made unwilted silage in a circumstance that satisfactory fermentation can be achieved with unwilted silage. Castle and Watson (1984) made wilted silage when conditions for wilting were reasonable. And they all concluded that wilting will have much smaller effect on intake and may have some managerial advantages but it has doubtful benefits in terms of milk production.

In conjunction with wilting, the addition of acids (Henderson et al., 1972; Donaldson and Edwards, 1976; Haigh and Parker, 1985; Haigh, 1987) and applying an inoculum (El Hag et al., 1982; Kung, Jr. et al., 1984) were often practised to improve preservation as silage and enhance subsequent animal performance. The beneficial effects of inoculants in relation to DM content gave variable results (Seale, 1986). Especially, Waldo (1977) had reviewed the effect of propionic acid for reducing the loss in nutrients by heat damage and of formic acid for improving the digestibility and intake associated with wilting.

Future Problems

A basic residues and ammonia-N arised as the result of decarboxylation and deamination would influence buffering capacity (McDonald and Henderson, 1962; Jasaitis et al., 1987). Mekersie (1985) demonstrated there was close positive relationship between the initial pH of forage and proteolysis during fermentation. In most reports in the literature, little account was taken of the effect of condition and duration of wilting on the change in initial pH and buffering capacity. Considering above reports, further studies are needed to provide a better estimate of relationship among wilting, the change in pH and buffering capacity, and of effect on subsequent fermentation.

There has been renewed interest in the wilting in terms of productive performance which result in a higher intake and lower digestibility and milk production (Gordon, 1980, 1981, 1987; Castle and Watson 1982, 1984; Anderson, 1983, 1985). Waldo (1977) had drawn attention to the determination error of feeding value and indicated that dry matter determination of unwilted silage by traditional oven dry method underestimates feed intake and digestibility, but overestimates feed efficiency due to a higher losses of volatile components than that of wilted silage. Many studies have stressed what dry matter of fermented silage, especially high moisture content and high volatile component, is usually underestimated and have investigated the accurate methods for estimating dry matter content (Dewar and McDonald, 1961; Fenner and Barnes, 1965; Sutoh and Uchida, 1966, 1973; Brahmakshatriya and Denker, 1971; Hood et al., 1971; Fox and Fenderson, 1978; Burdick and McHan, 1982; Uchida and Hayashi, 1985; Uchida, 1986[a], 1986[b]; Galletti and Piccaglia, 1988). Haigh and Hopkins (1977) and Uchida (1978) compared oven drying method with toluene and freeze drying method respectively, shown that oven drying method was estimated about 11% lower than toluene and freeze drying method. It is necessary to study whether of about 11% underestimated by oven drying method actually affect the evaluation of animal perfermance.

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