The Art and Science of Ensiling Alfalfa

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ABSTRACT

A successful silage program requires consideration of a wide variety of factors from agronomic management to harvest, storage, and feeding practices. The more common advantages of harvesting forage as silage compared to hay include, (1) more nutrients are preserved per acre, primarily due to lower field losses; (2) less chance of weather damage, since there are fewer hours between the time of cutting and harvest; (3) increased mechanization of harvesting, storing, and feeding; (4) a wider selection of crops can be harvested as silage; and (5) silage is better suited as an ingredient in total mixed rations. The more common disadvantages of silage compared to hay include, (1) with poor management, losses during storage can be excessively high; (2) spoilage losses can be substantial, if feedout rate is too slow; (3) limited alternative use for silage facilities and equipment; (4) high initial cost in facilities and equipment; and (5) marketing silage is limited due to high transportation cost and susceptibility to spoilage. There are four different phases that occur during the fermentation of forage: aerobic, anaerobic, stable or storage phase, and feeding phase. It is best to limit the time associated with the aerobic phase and adopt management strategies which promote efficient anaerobic, stable, and feeding phases. These are: (1) Harvest at greater than 30% dry matter to minimize loss of silage juice and risk of clostridial fermentation, preferred range of DM is 30-40%; (2) Pack the silage quickly and tightly, goal of 5 minutes per ton or 15 minutes per load is reasonable for bunker silos; (3) Cover the silage tightly, losses of up to 40% can occur with no covering; (4) Use a silage additive to promote an efficient fermentation; (5) Feed the silage at a rate of 4" to 6" into the silage face and across the whole silo face each day; and (6) limit the disturbance of the silo face and avoid piles of loose silage. Some points to keep in mind when transitioning from hay to silage are: talk to someone who has made silage locally, and ask lots of questions; harvest at > 30% DM; use a proven silage additive; pack the forage tightly, seal well, and feedout quickly; test the silage for fiber, protein, and dry matter; develop an honest and open relationship with your client(s), try to accurately determine their needs.

Key Words: alfalfa, silage, management, fermentation

INTRODUCTION

Silage is the end product of the fermentation of a high moisture crop (40 to 80% water) and the practice of ensiling fodder likely dates back to 1,000 to 1,500 BC. The first record of a silo in North America was in the 1870's and the practice of silage making has gained slow acceptance until today, when silage contributes over 50% of the nutrients for beef and dairy cattle production.

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A successful silage program requires consideration of a wide variety of factors from agronomic management to harvest, storage, and feeding practices.

CHOOSING BETWEEN HAY AND SILAGE

Production of quality forage requires sound management practices regardless of whether it is harvested as hay or silage. The more common advantages of harvesting forage as silage compared to hay include:

1) more nutrients are preserved per acre, primarily due to lower field losses;

2) less chance of weather damage, since there are fewer hours between the time of cutting and harvest;

3) increased mechanization of harvesting, storing, and feeding;

4) a wider selection of crops can be harvested as silage; and

5) silage is better suited as an ingredient in total mixed rations.

The more common disadvantages of silage compared to hay include:

1) with poor management, losses during storage can be excessively high;

2) spoilage losses can be substantial, if feedout rate is too slow;

3) limited alternative use for silage facilities and equipment;

4) high initial cost in facilities and equipment; and

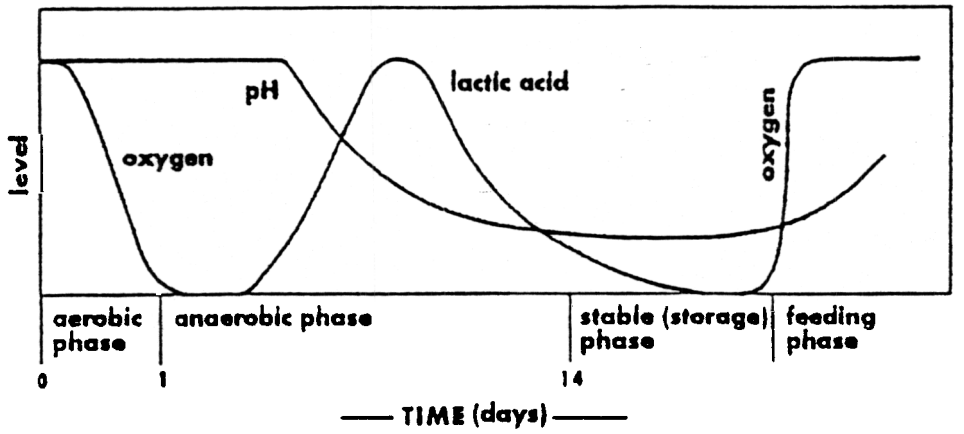
5) marketing silage is limited due to high transportation cost and susceptibility to spoilage.

THE SILAGE FERMENTATION PROCESS

The silage fermentation process involves the conversion of plant sugars to acids by anaerobic bacteria. When this process occurs in an efficient manner, there is a low pH and high concentration of lactic acid in the ensiled forage. There are four different phases (see Figure 1) that occur during the fermentation of forage:

1) aerobic
2) anaerobic
3) stable or storage phase, and
4) feeding phase.

Figure 1. Phases of the fermentation process.



Source: Allen et al, 1995

During ensiling of forage there can be four general types of fermentation.

	Energy Recovery, %
Homofermentative	
Glucose ---------→ Lactic Acid	97
Heterofermentative	
Glucose ---------→ Lactic Acid + Ethanol + CO_2	97
Fructose ---------→ Lactic Acid + Mannitol + Acetic Acid + CO_2	98
Clostridial	
Lactic acid ---------→ Butyric acid + CO_2 + H_2	81
Alanine ---------→ Propionic Acid + Acetic acid + NH_3 + CO_2	81
Yeast	
Glucose ---------→ Ethanol + CO_2	97

Source: McCullough - Sept/Oct 1984 Animal Nutrition and Health

MANAGEMENT STRATEGIES

It is best to limit the time associated with the aerobic phase and adopt management strategies which promote efficient anaerobic, stable, and feeding phases. These are:

1) Harvest at greater than 30% dry matter to minimize loss of silage juice and risk of clostridial fermentation, preferred range of DM is 30-40%;

2) Pack the silage quickly and tightly, goal of 5 minutes per ton or 15 minutes per load is reasonable for bunker silos;

3) Cover the silage tightly, losses of up to 40% can occur with no covering;

4) Use a silage additive to promote an efficient fermentation;

5) Feed the silage at a rate of 4" to 6" into the silage face and across the whole silo face each day; and

6) Limit the disturbance of the silo face and avoid piles of loose silage.

When considering the use of a silage additive for yourself or the producer you are selling your silage to, ask the following question, "What do I want from a Silage Additive?"

Improved Silage Fermentation
- lower pH
- greater amounts of lactic acid
- lower amounts of ammonia nitrogen

2) Improved Recovery of Silage Dry Matter
- less loss of dry matter during ensiling
- less loss of dry matter at the time of feedout

3) Improved Digestibility, Intake, and Animal Performance

DOES THE ADDITIVE ACHIEVE MY GOALS WITH THE CROP THAT I USE?

FORAGE/SILAGE ANALYSES AND MARKETING

Standard marketing of alfalfa generally involves a forage test for protein and fiber. Due to the wet nature of silage, it will be necessary to also include a determination of dry matter along with protein and fiber when you market silage. Listed below are the major nutrients in silage and hay.

Nutrients

Hay	Silage
Protein	Protein
Fiber	Fiber
Soluble Carbohydrates	Residual Soluble Carbohydrates
	Volatile Fatty Acids
	Lactic Acid
Ash	Ash
Water	Water
	pH (acid level)

Although not commonly run at forage testing labs, the volatile fatty acids of acetic and butyric, and lactic acid may be of some importance when considering the quality of the silage. Well fermentated alfalfa silage should have a pH below 5.0.

TO SILAGE OR NOT TO SILAGE

As indicated by the title of this paper, "The Art and Science of Ensiling Alfalfa", it should be readily apparent to you that there are some management practices that can be followed to minimize risks associated with silage making. However, you need to develop your own "art" of silage making to make it a success for you.

The main advantages of making silage vs hay is that the forage is handled fewer times, there is less loss of nutrients in the field, more forage harvested per acre, and the forage can be of higher nutritive value. This is primarily due to the increase in leaf retention in a silage system and the ability to remove the forage from the field more rapidly after harvest. Reducing the amount of time that cut forage lies in the field, increases the yield potential over the growing season.

The nutrients in alfalfa stems and leaves are summarized below. Anything that results in loss of leaf tissue will result in increased content of fiber and reduced content of protein.

Nutrients in Alfalfa

Item	Stems	Leaves
% CP	12.3	26.0
% NDF	58.8	26.4
% ADF	43.9	17.6

Research reported by Wallentine (1993) showed that harvesting alfalfa as silage (bagged) resulted in a 27% increase in yield of forage. In addition, the silage was of higher nutritive value.

Bagged	Baled
4.56 Tons DM	3.1 Tons DM
	.5 Tons grazing DM
	3.6 Tons DM

27% increase in DM yield

Nutritive Value of Alfalfa

Item	Bagged	Hay
% CP	21	17
% ADF	34.5	35.7
% DM	34.1	90.4

In a feeding trial with cows in the first trimester of lactation, cows fed silage alone, outproduced and were more profitable than cows fed hay alone or silage + hay.

Table 1. Feed dry matter intake and production data for cows fed bagged alfalfa silage and/or baled hay during the first trimester of lactation.

	Feed Source		
Item	Silage and Baled Hay	Baled Hay	Silage
DM intake (lb)	51.1	49.6	47.0
3.5% Fat Corrected Milk (lb)	73.4	76.3	78.7
Milk Fat (%)	3.16	2.96	3.06
Fat Corrected Milk/unit DM	1.44	1.54	1.68
Feed Cost ($)[a]	3.72	3.67	3.53
Milk Income ($)[b]	9.90	10.27	10.60
Income Over Feed Cost ($)	6.18	6.60	7.07

[a]Feed costs ($/ton as fed based on local market price):hay, 87.00; corn silage, 30.00; silage, 31.50; whole cottonseed, 204.00; concentrate - 14.4% CP, 150.00; concentrate - 12% CP, 135.00.

[b]13.5¢/lb x Fat Corrected Milk adjusted for pretreatment.

BREAK-EVEN ACREAGE AND RATE OF RETURN

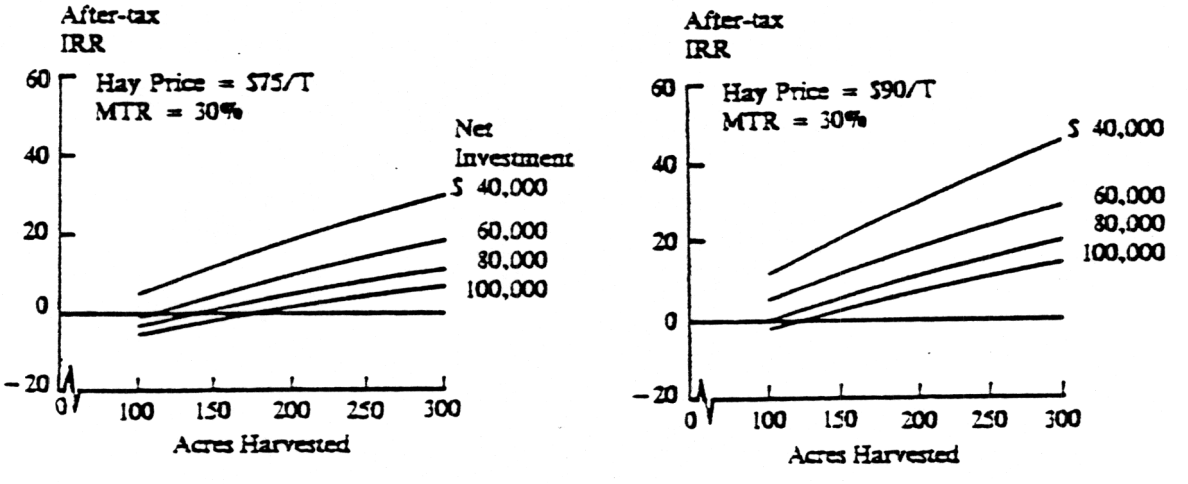
The research group of BYU in Utah pencilled out the break even acreage and tons of bagged alfalfa. In addition, they also calculated various rates of return as variables changed.

Table 2. Break-even acreage and tons of bagged alfalfa dry matter and return to investment.

Alfalfa hay market value, $/ton	87.00	75.00	65.00
DM, $ value/ton	97.00	83.33	72.22
Break-even acres	112	150	209
Break-even tons of DM	510	684	953
Net earnings on 200 acres of 912 tons DM, $/acre	86.95	64.90	46.53
Return to investment, %	30	20	11.9

Assume: $50,000 equipment investments; 5 year depreciation; 13% interest; 20% tax rate; 200 acres harvested; 4.56 tons of DM/acre or 912 tons DM total.
Source: Wallentine, 1993.

Figure 2. Internal rate of return (IRR) vs investment to convert from baled hay to chopped bagged alfalfa harvest.



IRR = internal rate of return MTR = marginal tax rate

Source: Wallentine, 1993

SUMMARY

Listed below are some points to keep in mind when transitioning from hay to silage. Honoring these points will minimize the risks associated with ensiling of alfalfa:

1) Talk to someone who has made silage locally, and ask lots of questions

2) Harvest at > 30% DM

3) Use a proven silage additive

4) Pack the forage tightly, seal well, and feedout quickly

5) Test the silage for fiber, protein, and dry matter.

6) Develop an honest and open relationship with your client(s). Try to accurately determine their needs.

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