

# **CROPS, FUNDAMENTALS AND MANAGEMENT OF SILAGE IN THE WESTERN U.S.**

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## **ABSTRACT**

Silage (haylage) emerged in the last 30 years as an alternative method to dry hay for long-term storage of feedstuff in the western U.S. Several contributing reasons include: the increased growth of western dairies requiring greater capacities, a greater diversity of crops ensiled, increased available byproducts from food processing, improved harvesting, packing and silos, and greater knowledge by producers on the understanding of ensiling basics. This paper reviews some fundamentals for successful silage making along with a check list of some do's and don'ts to consider when making silage.

## **INTRODUCTION**

The last major silage publication was published a decade ago by the American Society of Agronomy "Silage Science and Technology" (Buxton et al. 2003). For active crop consultants, Extension advisors, researchers and silage producers, a must-have resource. A decade before that monograph, Dr. Wallentine from Utah State discussed animal performance comparing alfalfa hay and silage (Wallentine, 1993) and Dr. Harrison from Washington State (Harrison et al., 1994) provided an in depth review of grass silage production and utilization in the western U.S. Silage is an important way to handle wet, unstable forage crops or processed crop residues in the west. Ancient peoples stored forages products as silage, just like we do today, for feeding animals when the climate conditions did not permit crop growth. Crops, structures and methods have changed over time, and we know more about the science of fermentation, but overall the basics and fundamentals are similar. Silage principles may be as mysterious today as they were for our ancestors. This paper is a short review on fundamentals of silage making with crops commonly grown and processed crop residues in the western region. It's impossible to cover all aspects but rather than counting on luck, understanding that small details make a big difference in ensiling success or malfermentation. Remember, we are the ultimate consumer of silage feedstuffs!

## **SILAGE FUNDAMENTALS:**

The goal of ensiling is conversion of actively growing, wilting or crop residue from a wet and unstable condition to a wet but stable state, Figure 1. This sounds easy and for more than 3000 years (Wilkinson et al., 2003) farmers have successfully made silage for livestock. Silage making truly mixes the science (all the chemistry and microbiology) with art (how efficient the operation was from growing the crop to the proper equipment to harvest, transport and store at different structures) and business (we need to make money from silage and feed ourselves at the same time).

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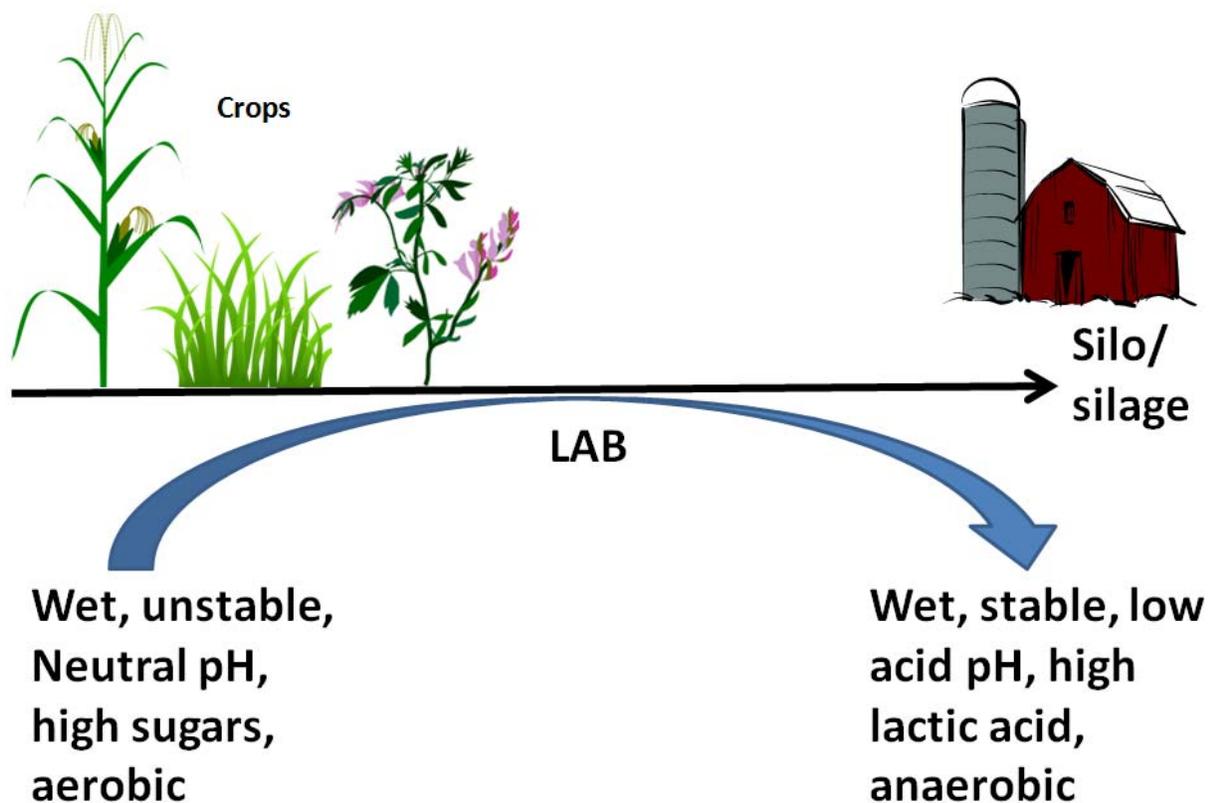


Figure 1. Successful conversion of forage crops into silage.

**Moisture:** Actively growing crops range in moisture content from ~ 40 to 90 percent (60 to 10% dry matter, DM, respectively). Because the ultimate use of silage is to feed animals who are fed on a DM basis, most silage managers think of silage on a DM basis rather than wet, moisture or as-is basis. Initial moisture at harvest plays a major role in success of ensiling. Generally, and this works for nearly all crops and all situations, a moisture content of 65% (35% DM) is nearly ideal for feedstuffs entering a silo. There is an increased chance of effluent runoff when crop DM is lower than 35% and with higher DM the crop maybe more difficult to pack and remove air (oxygen) at the silo. Either situation is not perfect but it is very difficult to always hit the target of 35% DM!

**Sugars:** Another challenge is silage making lies within the crop. Not all crops are equal in sugars, which are necessary for the lactic acid producing bacteria (*Lactobacillus*) to use as energy to produce the acids necessary to lower pH for ensiling. An excellent review paper of sugars in grasses was recently published by Halford et al. (2010). Grass crops, like corn, sorghum, wheat, perennial ryegrass, orchardgrass, etc. generally have higher sugar concentrations than legumes, like alfalfa. Grasses usually have lower protein (N) than legumes, which also contributes to more efficient fermentation. As silage managers, we choose (if Mother Nature allows) the stage of maturity for the crop to be harvested and ensiled. For corn, the 50% milk line is about 35% DM. Less mature corn at dent stage, often ranges between 25 and 30% DM. Perennial grasses are harvested multiple times per growing season, thus crop DM differs

between cuttings. The goal is to cut, wilt and ensile between 25 and 35% DM. At first cutting, when most of the seedheads are produced, we recommend harvest at boot or very early heading stage. Regrowth, which is nearly all vegetative growth, cuttings are more on a calendar or field tonnage basis rather than stage of maturity. Alfalfa has higher quality a bud stage and if allowed to wilt for 24 to 48 hours the DM will increase to about 30 – 35% DM. Alfalfa in the flowering stage is already more mature so has higher DM than bud stage crops. Alfalfa will produce a new set of buds and flowers with each cutting compared to perennial grasses that go reproductive once per growing season.

**Bacteria:** Lactic acid bacteria (LAB) are necessary for rapid conversion of plant sugars to important volatile fatty acids plus lactic acid. The net result is a drop pH of the forage mass in the silo, this is necessary for long-term storage and stability of the material. Tens of thousands of colony forming units (cfu) of bacteria reside on plant leaf surfaces. The number of cfu's per gram of leaf surface is dependent on the crop and time of seasonal harvest. Often there is abundant bacteria to do the job, other times they are lacking in abundance or relative activity. At this time it is advisable to supply additional bacteria for effective fermentation. Some regions of the world, like Europe and England, also use direct acidification, with organic acids added directly to the crop at the silo to lower pH and stabilize the material. These acids can be hazardous to both humans and the equipment. Western silage managers have chosen to use natural fermenters, LAB, to do the job of proper ensiling. These bacteria will convert glucose sugar (the building block for starch in grains and a component of fructosans in perennial cool-season grasses) to lactic and other acids by homofermentation or heterofermentation (Woolford, 1984). Homofermentation produces only lactic acid without DM or energy losses while heterofermentation results in various acids, some desirable and some not but always with a loss of DM and energy. LAB promotes the four phases of silage making, Figure 2 (Pitt, 1990).

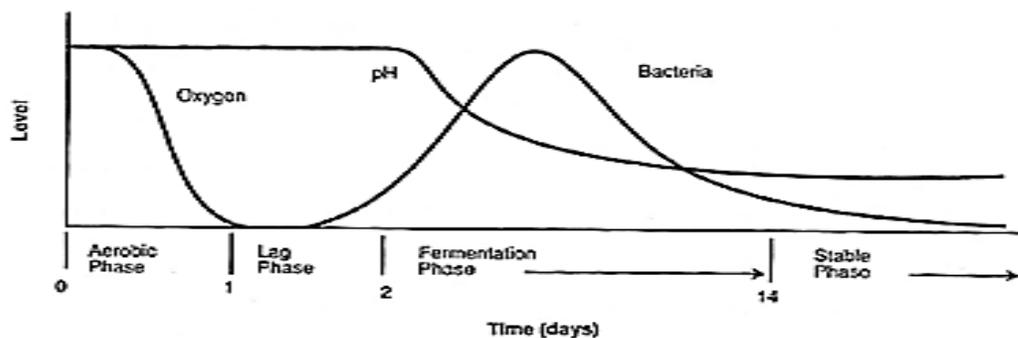


Figure 2. Silage fermentation phases and idealized timeline for each phase (Source: Pitt, 1990)

**Ensiling Phases:** Phase 1; aerobic, is the rapid transition of the forage, completely surrounded in an aerobic (oxygen rich) environment through field harvest, chopping, hauling and delivery to the silo. Actually, few plant cells are broken (lysis) during the harvesting process, which is rich in oxygen with continuing plant respiration and in a moist environment, and certainly temperature of the plant mass starts heating. Mold, yeasts and other bacteria enhance all those early activities in Phase 1 of ensiling, but phase 1 generally lasts a day or two. Correct theoretical length of cut (TLC) of field forage, rapid filling and silo packing to initially remove as much oxygen as possible followed by completely covering the silo, collectively reduces DM and

nutrient / energy losses at Phase 1. This phase is not complete until the stored mass is oxygen free.

Pitt (1990) fermentation figure integrates the transition post-aerobic through the physiological change of the forage mass becoming anaerobic (oxygen free) and the extended period for LAB to convert glucose and other sugars into lactic acid and specific volatile fatty acids. Increasing mass acidity and lowering pH as a continuous process, through Phases 2 and 3. Rapid speed of lactic acid production not only lowers pH but inhibits energy and DM consuming yeasts, clostridia and other nutrient robbing bacteria. Lysis of plant cells increases rapidly in the early stages of Phase 2, which is easily seen with effluent or runoff leaking on the ground from the silo if ensiling DM is low or smelling gases being released into the atmosphere. The ensiling process continues as more cells lysis releasing more nutrients, sugars and proteins as pH continues to decline as acids increase.

Later in Phase 3 we observe the silage mass physically shrinking in pit or bunker silos and bagged haylage will squat a bit. Once the ensiled forage mass is stabilized the silage should be rich in lactic and desirable acids, pH is lowered to inhibit undesirable microbes from flaring up and growing again. Oxygen is absent from entering the ensiled mass. Tears in bags, cracks in pit or bunker silos, improper covering of the walls and top of the silo are all sources of oxygen entering the silage mass. Oxygen is the Achilles tendon of silage making so frequent inspection of the silo is important to eliminate any damage that has occurred to the silo and prevent oxygen from entering. Proper sealing of all silos, even single haylage bag packages, is critically important!! Even though the pH is low and acid levels high, some of the undesirable yeast, *Clostridia* and other bacteria can lie in a dormant state, so when oxygen is allowed to penetrate, these undesirable organisms emerge from dormancy causing pockets of damage. If oxygen supply continues entering the silo, more damage will occur until you visibly see rotting. If Phase 3 has been successful, the ensiled mass if kept free of oxygen, the silage should be stable for a very long time, years! However, most producers feed much of the growing season's crop during the winter and through the next summer, until new crops of silage are produced.

Phase 4 is the stable, feed-out phase, when we get use and transform all that work and expense into returns (money) from animal products (milk, meat, wool, etc.). So we purposely open the silo to gain access to the ensiled forage mass. This reintroduces oxygen into the silo, the same oxygen we have worked hard to keep out. Experimentally, during Phase 4 we will assess how stable the silage is at the silo and the feeding bunker. This is commonly referred to as "bunk life". The more acidic the silage, the longer bunk life in front of the animals and the more stable the silage face. If problems existed in the ensiled mass before Phase 4, they will only get much worse during Phase 4. Meaning, fresh oxygen will initiate new undesirable microbial growth, revive those dormant yeast, *Clostridia* and other bad bacteria with rapid use of free sugars they will grow rapidly and mold, etc. can be seen on the silo face. This is why it is important to size the silo correctly for the daily silage demand needed by the herd so a fresh, clean face is produced each day. The silo face, without use a couple days, will grow white and gray molds. One may think this is really not much of a concern, consider this: Mehren (2012) described a practice in which silage was removed from the silo then fed over the next three days. Animals did fine the first day, second day intakes decreased but by day three they completely rejected the spoiled silage. Simply saying, animal performance is directly linked to forage quality, quality of silage fermentation and how animals are fed.

## **WESTERN CORN SILAGE MANAGEMENT**

Silage is a major use of corn in the west. As the dairy industry has increased in several states (i.e. Idaho and New Mexico with further expansions in the Pacific coastal states), corn silage is a primary crop to fill those feedstuff needs. Relative crop maturities for corn grown in the western region, range from 80 to 85 days in western WA to 115 to 120 days in the southern CA. Corn breeders have improved hybrids for many stacked traits which did not exist 30 years ago.

Conventional corn silage chopping allowed for many corn kernels to remain whole after harvest. After feeding conventional corn chopped silage to dairy cattle, many corn kernels could be seen in the manure. To overcome the problem of reducing corn kernel size in the silage and ration, onboard kernel processing technology was developed about 20 years ago. Unprocessed kernels reduced starch availability in the rumen, thus a loss of energy for milk production. Western dairy studies suggest positive results of corn silage with kernel processing (Johnson et al., 2003) and this technology has been promoted by Extension (Israelsen et Al., 2009). One consideration is the stover is not processed in this operation, largely just the kernels. When using this mechanical processing technology setting the correct distance for fragmenting the kernels is important. This distance can change by many factors including the hybrid, kernel size, crop moisture, etc. Two issues have emerged with kernel processing of corn silage: first, responses were not very effective with longer TLC and secondly, with higher DM corn silages, release of starch was not as effective as expected.

An emerging corn silage technology “shredlage” has been investigated by dairy scientists at the University of Wisconsin (Ferraretto and Shaver, 2012). Shredlage processes not only processes the corn kernels but also the stover. In this case the stover has a longer TLC, set from 26 to 30 mm while the rollers are set at 2 to 3 mm distance. The advantage is to maintain longer particle length of the corn silage necessary for sustained animal performance. Ferraretto and Shaver compared shredlage to kernel processed corn silage. They used the same hybrid grown on 20 acres harvested half the field one day with storage in a 200 foot bag, then the following day harvested the remaining field with the second harvester. These two silages were fed to high producing dairy cattle in WI for eight weeks. Silage quality characteristics were comparable between the two silages. They made numerous comparisons of physical characteristics and animal response. The most interesting was the interaction between the silage chopping methods and the response of dairy animal milk production over time. They found a rapid decline in milk production with kernel processing starting after 2 weeks of feeding, which declined much faster than the shredlage treatment. Milk yield was not different between treatments after eight weeks, but if the study had been conducted for another month, there could have been treatment differences in animal performance. This is an example of technology improvements in silage making that appears to be impacting animal response.

## **SILAGE INOCULANTS**

Pitt (1990) presented a flow chart depicting both silage and hay additives, Figure 3. This chart provides a broad overview of the various types of additives but without specific products. There has been great improvement in developing specific products for specific needs. A couple ideas to keep in mind: first, one product is not going to do everything. Know what you want and select the correct additive to meet that need. Second, store the product as instructed. Usually this means to keep the material in a cool, dry, often dark area for storage. Third, care must be used when

using any of these materials. A material like, ethoxyquin, used to inhibit microbes in hay, will produce cyanide gas if applied to hay and that hay spontaneously combusts. There have been hundreds of studies comparing thousands of products to a control treatment with a majority showing positive, very specific responses. Scientists have found different strains within the same bacterial species have greater affinity and effectiveness between crops, crop DM at harvest, storage, DM recovery and animal response. Know what you need, then select the correct product.

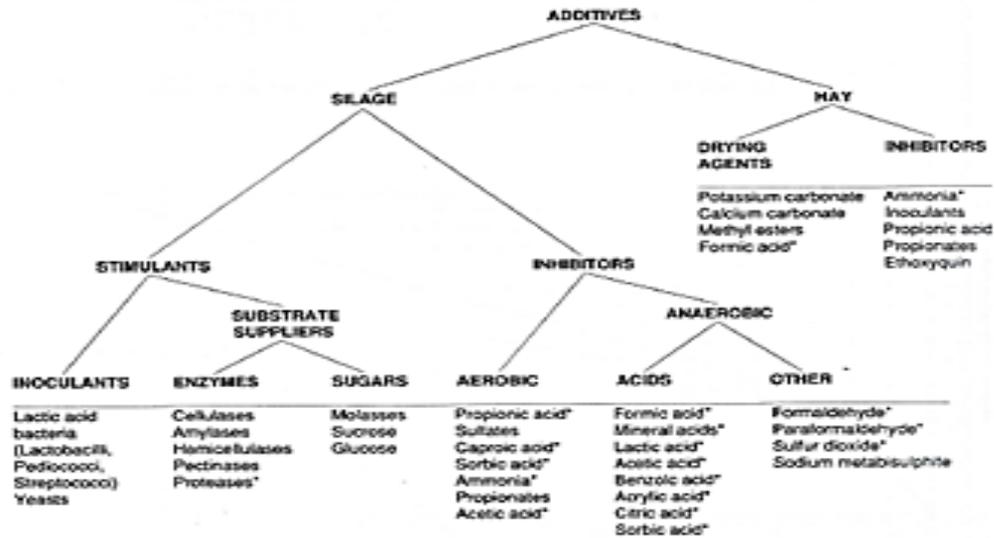


Figure 3. Flow chart of additive classes used in silage and hay. (Source: Pitt, 1990)

### DO'S AND DON'TS WHEN MAKING SILAGE IN THE WEST

As with producing any agricultural product, to be successful with silage requires time, energy, space, equipment, and management. There are numerous small details that should be prepared for and constantly monitored during the successful transition of producing a wet, unstable, standing forage crop to a wet, stable, low pH silage mass that is ready to be used by the target livestock sometime in the future (Figure 1). Table 1 provides comparisons of what I think one should or should not do when making silage. A few of those issues have been touched on in this paper.

Table 1. Comparisons of parameters for successful making of silage in the west.

Item / Issue	Do's	Don'ts
Crop / variety selection	Spend time over winter reviewing available information; ask questions to company reps, Extension, neighbors	Just assume every crop and variety is the same (they are not!).
Soil test	Soil test silage fields annually or every-other year. Soils deficient in key nutrients will not support either high yields or quality at harvest.	Just assume the soil this year was as good (or bad) as before! Think you're wasting your time and money by trying to correct soil nutrient problems.
Annual crop seedbed	Apply lime during winter if	Just assume the crop and

preparation	possible. Use no-till, minimum-till or conventional tillage for good soil-seed contact, rapid establishment and seedling growth. Control weeds and other pests to each field needs.	variety chosen will somehow emerge and out-compete weeds, bugs and diseases. This is the time to start trusting in miracles!
Perennial crop maintenance	Apply nutrients to the specific crop at the correct time. If soils are compacted due to heavy traffic when wet, then consider aerating, during the “off-season” (reducing crown and root damage).	Just assume the roots are fine, that anaerobic conditions do not occur on your fields. It’s time to start hoping for miracles with the perennials; annuals are more forgiving!
Harvest plan	Consider proper cutting height: perennial grasses leave 3 to 4 inches stubble; perennial legumes leave 2 inches. Annual grasses: sudangrass, corn and sorghum (forage and sweet) at 6 to 8 inch stubble are common.	What the heck are you worried about stubble heights for? Just assume you can take it all – that’s what it’s there for! Right? We’ve done it that way for years!
Harvest equipment	Inspect and repair all swathers, choppers, trucks, wagons and blowers/pushers two months before you go to the field. The equipment should be ready to go before crop season!	Repair what? Hey, it worked last year, what’s the big deal??? We have plenty of time to make adjustments in the field ! Who sweats the small stuff? It’s the big stuff we’re worried about!
Silos	Clean, repair and reseal silos before use: bunker / pit silo walls, floors; wrapped and bagged or tube silos basal area, front and back pads. We know oxygen entering silos dries, heats and rots forage, and acids eat away at silo surfaces.	You’re driving me crazy with all this preparation and worrying! I drove by the silos a while back and things looked fine. Yes, a few cracks and wet areas, a bad smell in the area, but hey, everybody’s silo smell like that!

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