

Ensiling

Additives for better preservation of forages during lean seasons

**Manpal Sridhar¹, A V Elangovan², S Senani³, A K Samanta⁴,
R K Gorti⁵ and Maya G⁶**

ICAR-National Institute of Animal Nutrition and Physiology, Bengaluru, Karnataka 560 030

Though not very popular in India, ensiling is one of the best methods to preserve fresh forage with minimal losses and use it for feeding livestock during the lean seasons, a situation present at most of the times throughout the year. Factors vital for fermentation include the degree of green fodder wilting, length of the cuts used, ensiling technology adopted, and the amount and type of additives used. Silage additives are natural or industrial products added to the forage to control the preservation process so that it retains most of the nutrients present in the original fresh forage and to ensure that lactic acid bacteria predominate during the fermentation process, to ensure a good silage. Additives are used to improve the nutrient composition of silage, reduce storage losses by promoting rapid fermentation, reduce fermentation losses by limiting extent of fermentation, and improve the overall stability of the silage.

Key words: Fodder crops, Livestock feed, Silage

WHY feed livestock silage when fresh green fodder is nutritious and generally recommended? Green fodder is the mainstay in livestock production as it maintains long and healthy productive life in addition to cutting down the cost of production. The existing agroclimatic condition of India, however, does not permit round the year green fodder availability. During lean periods, this culminates into either reduction in productivity of animals or increased expenditure by livestock farmers on account of additional concentrate supplementation.

Principles of ensiling

Silage may be defined as any plant material that has undergone fermentation or pickling in a silo or storage container in which it is preserved to maximize the preservation of original nutrients present in the crop for feeding livestock during periods of scarcity. Ensilage or ensiling is the process of preserving forage for use as animal

feed during lean period.

The first objective is to achieve anaerobic conditions under which natural fermentation takes place, it is achieved by consolidating and compacting the material and sealing of the silo to prevent re-entry of air. Finer chopping of plant material results in improved compaction and fermentation of silage. This also improves palatability and intake of silage.

The second objective is to discourage the growth and activities of undesirable microorganisms such as Clostridia and Enterobacteria. Clostridia are present on crops and in soil in the form of spores multiplying under anaerobic conditions, producing butyric acid and breaking down amino acids resulting in silage with low nutritional value and poor palatability. The enterobacteria are non-spore forming, facultative anaerobes, and they ferment sugars to acetic acid and also have the ability to degrade amino acids. Growth of Clostridia and

Enterobacteria can be inhibited by lactic acid fermentation.

Lactic acid bacteria are present to a small extent on many of the harvested crops but in most cases have to be supplemented as natural populations may not be adequate for silaging. They ferment naturally occurring sugars like glucose and fructose to lactic acid, which increases the hydrogen ion concentration thus undesirable organisms inhibiting. After ensiling, the microorganisms capable of anaerobic growth, namely, lactic acid bacteria, *Bacillus* spp. enterobacteria, clostridia, and yeasts begin to grow and compete for available nutrients. The first few days of ensiling are very crucial to the success or failure of the entire fermentation. Under conducive conditions lactic acid bacteria grow quickly and acidify the environment to such an extent that the competing organisms are not able to survive resulting in a stable, low pH silage. If, however, the pH does not get lowered quickly, the undesirable microorganisms, mainly enterobacteria,

clostridia and yeasts compete for nutrients reducing the chances of obtaining a stable silage. By increasing the number of homofermentative lactic acid bacteria more efficient fermentation can take place.

Silage additives

A silage additive should be safe to handle and result in low losses of dry matter. Silage additives are added to improve the ensiling (fermentation) process, increase the nutritive value of the silage, limit secondary fermentation, reduce losses, reduce aerobic deterioration, improve the hygienic quality of the silage and improve aerobic stability so as to increase animal production.

There are following silage additives:

1. Fermentation stimulants comprising fermentable carbohydrates sugar sources (molasses, sucrose, glucose, citrus pulp, pineapple pulp, sugar beet pulp), enzymes (cellulases, hemicellulases, amylases and ligninases) and inoculants (lactic acid bacteria (LAB))
2. Fermentation inhibitors include acids and organic acid salts (mineral acids e.g. hydrochloric, formic acid, acetic acid, lactic acid, acrylic acid, calcium formate, propionic acid, propionates) and other chemical inhibitors such as Formaldehyde, sodium nitrite, sodium metabisulphite.
3. Aerobic deterioration inhibitors comprised lactic acid bacteria, propionic acid, propionates, acetic acid, caproic acid, ammonia and some inoculants.
4. Nutrients (urea, ammonia, grain, minerals, sugarbeet pulp)
5. Absorbents (grain, straw, bentonite, sugarbeet pulp, polyacrylamide etc.)

In order to improve fodder crop preservation and its feeding value, following common silage additives are added.

Biological additives

Microbial inoculants and enzyme preparations are natural thus safe to handle, noncorrosive to machinery, and do not cause environmental problems

Microbial inoculants

Organisms: Inoculants are added to silage to dominate the epiphytic (natural) population of bacteria on plants that cause dry matter losses by inefficient fermentation of sugars. The three main types of microbial inoculants are: (i) homofermentive, (ii) homolactic, and (iii) heterofermentive. Homofermentative inoculants contain lactic acid bacteria (LAB) such as *Lactobacillus plantarum*, *Pediococcus* and *Lactococcus* species.

They promote a rapid fermentation promoting production of lactic acid and bringing down the pH rapidly to 4.0, thus, preventing breakdown of the sugar and protein in the crop.

Heterofermentative inoculants contain bacteria such as *Lactobacillus buchneri* and *Lactobacillus brevis* which produce a mix of lactic and acetic acid, resulting in a slower fermentation than the homofermentative inoculants. They are designed to inhibit yeast and moulds that initiate the process of aerobic deterioration.

Fermentation and animal response

The amount of water-soluble carbohydrates necessary to obtain sufficient fermentation depends on the dry matter content and the buffer capacity of the crop so it is necessary to select the right additive. Silages treated with adequate numbers of viable LAB should be lower in pH, acetic acid, butyric acid and ammonia-N but higher in lactic acid content.

Inoculation rate, use and storage

The most desirable inoculation rate for *L. plantarum* based-inoculant results in a final concentration of 100,000 (or 1×10^5) colony forming units per gram of wet forage. Inoculants applied in the dry form are often mixed with calcium carbonate (limestone), dried skim milk, sucrose or other carriers.

Exogenous enzymes

Using exogenous fibrolytic enzymes cellulases, hemicellulases, amylases and the ligninases help in improving nutrient digestion, enhance the utilization, and animal

productivity and at the same time reduces animal fecal material and pollution. Spraying enzymes onto forages just before feeding provides greater flexibility for feeding and also bypasses any negative interactions that the ensiling process may have on silage enzyme performance. When enzymes are sprayed onto silage before feeding, binding with substrates helps to protect them from ruminal degradation. Treating forages with enzymes improves digestibility via different mechanisms like, direct hydrolysis, improvement in palatability, changes in gut viscosity, and changes at the site of digestion. There are two primary reasons for adding fiber-digesting enzymes to silage. First these enzymes could partially digest the plant cell walls (cellulose and hemicellulose) yielding soluble sugars, which could be fermented by LAB to lower the silage pH. This would stimulate silage fermentation and improve fermentation quality by increasing the rate and extent of decline in pH, increasing the concentration of lactic acid, improving the lactic acid:acetic acid ratio (which is indicative of greater efficiency of fermentation), and hence reduce DM losses. A faster decline in pH would also limit degradation and deamination of forage proteins and reduce ammonia production. Second, partial digestion of the plant cell wall may improve the rate and/or extent of digestibility.

Feed ingredients and other by-products

Incorporation of easily fermentable feed ingredients such as sugar or molasses to low dry matter sugar-limited grasses and forages is a good way of improving silage fermentation. Grains in general and processed by-products such as corn or sorghum meal, cassava meal, rice bran, citrus pulp, etc. can be used as additives partly to provide fermentable substrate but also to direct the course of fermentation by absorbing excessive moisture.

Grain: Addition of grain to corn silage is not useful but adding it to hay crop silage has benefits. It increases the energy content of the silage which reduces the amount of



A. Silaging of maize, B. In polythene bags, C. In plastic bottles

supplemental grain that has to be fed. If silage is to be the main or only feed offered, then adding grain to the forage at ensiling converts it into a more complete feed. However, grain mixed with silage prior to ensiling or at feeding is nutritionally equal. Secondly, adding grain to forage increases the dry matter content of the silage. Hay crops that are not sufficiently wilted prior to ensiling can cause seepage and result in an undesirable fermentation.

Molasses: Molasses is an effective silage additive in terms of promoting lactic fermentation, reducing silage pH, discouraging clostridial fermentation and proteolysis, and generally decreasing organic matter losses. Cane molasses (75% DM) has been most widely studied and used. It is added up to 10% (w/w) to provide fast fermentable carbohydrates for the ensilage of tropical herbages. Due to its viscosity it is difficult to apply and should be diluted preferably with a reduced volume of warm water to minimize seepage losses. When applied to tropical grasses molasses should be used in relatively high concentrations (4–5%) and with crops of very low dry matter content, a considerable proportion of the additive may be lost in the effluent during the first days of ensilage.

Starch sources: Cassava (*Manihot esculenta*) tuber meal, coconut (*Cocos nucifera*) oil meal, barley and oats added (5% wet basis) showed improved fermentation as compared to untreated silages of forages. However, it is controversial as to what extent starch is available substrate for lactic acid bacteria.

Fruit peels: Fresh citrus peels have

been added at the ensilage of Napier grass with levels up to 50% improving fermentation quality as measured by low pH values and low butyric acid content and adequate lactic acid production. Citrus peels may contain 50% WSC in DM but the low DM content (14–21%) and intensive initial fermentation lead to high seepage losses causing a serious pollution problem.

Acids

Acids are added to forages at ensiling to cause an immediate drop in pH or to increase bunk life. Formic acid and mineral acids (sulfuric and hydrochloric) added at 10–30 lbs/wet ton will reduce pH quickly and greatly limit fermentation losses of protein and carbohydrates. Mineral acids are recommended the rapid acidification of the crop with a pH of about 3.5, which was originally thought to inhibit microbial and plant enzyme activity. When acids are added, plant materials sink quickly and are easy to consolidate. Acidity may arrest plant respiration and reduce heat production and nutrient loss. Rapid acidification may also inhibit clostridia. Addition of acids increases effluent and can be potentially toxic to animals besides being corrosive to people, animals and machinery.

Formic acid and/or formaldehyde treatments: Commercial formic acid (85%) has been extensively used for the ensilage of unwilted temperate grasses, but is gradually being substituted by biological additives, certainly because it is unsafe in handling and application and corrosive to equipment.

Propionic acid: It has the greatest antimycotic activity. It can be a useful additive for silages as it is effective in reducing yeast and molds which are responsible for aerobic deterioration in silages. The antimycotic effect of propionic acid is enhanced as pH declines, making it an ideal candidate for improving the aerobic stability of corn silage where pH is low. In the past, aerobic stability was improved when large amounts of propionic acid (1% to 2% of the DM) were added to silage, but the high percentage of acid often restricted fermentation in these cases. The application rate of propionic acid additives has varied depending on moisture content of the forage, length of storage and formulation with other preservatives.

Sodium diacetate: This is mixture of acetic acid and its sodium salt. Recommended rate of application is 1 - 2 lbs active ingredient/ton of wet silage. This compound produces results similar to propionic acid and is quite effective in reducing top spoilage. Adding sodium diacetate at the recommended rate to just the last few loads of forage going into the silage is effective in reducing top spoilage.

Nutrient additives

Ammonia and Urea: Anhydrous ammonia or water- or molasses-ammonia mixes are used as silage additives. Ammonia additions result in addition of an economical source of crude protein, prolonged bunk life during feeding (aerobic stability), less molding and heating during ensiling; and decreased protein degradation in the silo. Urea is added to corn silage as an economical source of crude

protein. However, a beneficial effect of urea on improved bunk life and decrease in proteolysis has not been totally substantiated. Whenever, ammonia or urea is added to the diet, special attention should be made to ensure that degradable and undegradable protein requirements are balanced for target ruminant animal.

Minerals: Minerals such as calcium, phosphorous, sulphur and magnesium are added to forage at the time of ensiling. Usually these either have no effect on fermentation or act as buffers resulting in higher pH silage. The only reason for adding minerals at the time of ensiling is if the silage will be the only feed offered to the animals. Addition of minerals will make the silage more nutritionally complete.

At our institute research is underway for the development of a universal inoculum/s for making and storing high quality silage from grasses, fodder crops with minimal loss of nutritional qualities which

would be available throughout the year for enhancing growth and productivity of livestock.

This could solve nutritional problems on small as well as large farms when good quality forage feeds are not available and could also reduce cost of feeding. Shows the ensiling of maize forage in polyethylene bags as well as in plastic bottles in our laboratory.

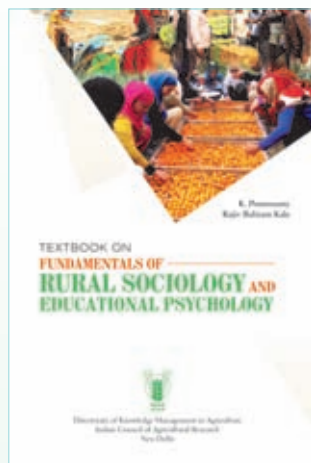
SUMMARY

It is highly essential to ensile forages to produce feed high in nutritive value and of sound microbiological quality in order to ensure the continuous superior animal health and growth during lean fodder periods. Apart from maize, most of the grasses and fodder crops require additives for good silage making. Silage additives can improve silage quality (by increasing nutritional content) as well as animal performance (body weight, milk production, reproduction). Silage

additives cannot make poor quality forage into good, but they definitely can help in making good quality silage. Silage additives can be beneficial and economical to use. Good results have been obtained with microbial inoculants, though results with enzyme additives have been inconsistent. Effects of microbial inoculants on aerobic stability are also not consistent. Anhydrous ammonia and propionic acid can improve the aerobic stability of silages, but their use is not widespread on account of handling problems and economics. To make good silage use of an additive is recommended, but caution should be exercised in choosing the right additive.

¹manpalsridhar@yahoo.co.uk, ¹Principal Scientist, Bioenergetics and Environmental Sciences Division, ²Principal Scientist, Animal Nutrition Division, ³Technical officer, Bioenergetics and Environmental Sciences Division.

Textbook on Fundamentals of Rural Sociology and Educational Psychology



India being a land of villages, rural sociology and educational psychology is an essential theme for agricultural students and professionals. Rural sociology deals with rural society and the relations of people who live in villages. Rural sociology presents a scientific picture of rural life.

Extension workers work with farmers very closely in their settings for which their understanding of rural background and farmers' psychology is very essential. Extension professionals should have necessary knowledge of the precise approaches and methods of dealing with farmers. Rural sociology can help professionals in organizing the rural structure in a constructive manner.

This textbook consists of fundamental facts of rural sociology. The book has twenty two chapters covering both rural sociology and educational psychology out of which twelve chapters consist of rural sociology and ten chapters deal with educational psychology. In this text book, emphasis has been given on various aspects of educational psychology also. It provides all the relevant information in the field of rural sociology with special emphasis on Indian culture, merits and demerits of Indian rural societies, the stressful conditions under which farmers live and work. The book will be a good basis of information reference for agriculture students, psychology students besides extension practitioners, research scientists, KVKs and agricultural colleges.

TECHNICAL SPECIFICATIONS

No. of pages : i-viii + 252 • Price : ₹ 450 • ISBN No. : 978-81-7164-181-9

For obtaining copies, please contact:

Business Manager

Directorate of Knowledge Management in Agriculture
Krishi Anusandhan Bhavan-I, Pusa, New Delhi 110 012
Tel : 011-25843657, Fax 91-11-25841282; e-mail : bmicar@gmail.com