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From Farm to Feed: The Role of Silage in Sustainable Livestock Production

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India is predominantly an agrarian nation with a substantial livestock population, making the dairy and livestock industries crucial subsidiary occupations for farmers. These industries contribute significantly to the economy by providing milk, meat, wool, and other products. Recently, India has emerged as the largest milk producer in the world. However, livestock productivity remains low compared to developed countries, primarily due to inadequate nutrient supply. There is a significant quantitative and qualitative gap in the availability and supply of feed nutrients, which worsens during lean and scarcity periods. The poor nutrient supply during these periods is a major concern, highlighting the urgent need to preserve nutrients from forages, including fodder tree leaves, available during flush periods for use during lean times. As a tropical monsoon country, India produces a large surplus of Kharif forages, often exceeding immediate needs. It is essential to preserve these excess nutrients from both Kharif and Rabi seasons at the proper stage of maturity to provide feed during lean periods. Poor nutritional support during scarcity adversely affects dairy animals, leading to issues like poor fertility, reproductive function, breeding coverage, bovine population, and draft energy. Successful animal production requires a consistent supply of nutrients year-round. Nutrients from forage can be preserved as silage, hay, or through high-temperature dehydration. However, high-temperature dehydration is not economically feasible due to its high energy output. Therefore, forage is best preserved as silage or hay to provide nutrients during scarcity. Additionally, efforts have been made to preserve nutrients, particularly protein, in the form of leaf meal from leguminous forages such as Lucerne and *Stylosanthes*, and leguminous top feeds like *Leucaena*, *Sesbania*, and *Gliricidia*. Fodder conservation involves the preservation and careful management of surplus fodder through chemical reactions or physical transformations to ensure it remains intact for future use when feed availability is high. During both Kharif and Rabi seasons, excess green herbage can be conserved as silage, hay, or through artificial dehydration with minimal nutritional loss. To support this effort, the Government of India offers subsidies under the National Livestock Mission and Animal Husbandry Infrastructure Development Fund (AHIDF) under Atma Nirbhar Bharat Abhiyan to individuals/entrepreneurs investing in fully mechanized silage preparation.

Ensilage: A Sustainable Approach to Nutrient Conservation in Fodder

Ensilage offers numerous advantages over other methods of nutrient preservation, especially for forages. For many years, acids have been used to preserve nutrients in forages since ancient times. Silage is produced through the controlled fermentation of nutrients under anaerobic conditions, a process known as ensiling. Proper nutrient preservation during ensiling requires careful precautions, as a lack of understanding of the factors involved can result in poor-quality silage and subsequently poor animal performance. The fermentation process is managed by microorganisms present in fresh herbage or by additives that maintain anaerobic conditions and inhibit clostridial growth with minimal nutrient loss. Recently, ensiling has been utilized to preserve carbohydrate-rich materials, either alone or through fermentation with other materials, and to store protein-rich materials used as animal feed.

Table 1. Recommended stage of harvest of forage crops

Forage Crop	Stage of Harvest
Maize	50%flowering to dough stage
Sorghum	50%flowering to dough stage
Oat	Boot to dough stage
Grasses	Early flowering

(Source: Thakur and Sharma, 1998; Mojumdar *et al.*, 1999)

Maturity of forage crop at harvest

Time of harvest has a major impact on the nutritive value of silage. Protein content, available energy, daily nutrient intake and digestibility decrease with advancing crop maturity, while later cutting represents lower carbohydrate and more lignin. Since dry matter yield per unit area are lowered by early harvest, time of harvest is a compromise between nutritive value and yield. High prices for energy and

protein tend to favour early harvest despite of lower dry matter yield. Table 1 indicates the optimum stage of harvest of forage crops when nutrients are properly preserved.

Procedure of silage preparation

1. Filling the silo: An utmost care should be taken in distributing the raw material uniformly in the silo. The material should be trampled, especially well near the walls of silo. It is believed that keeping the center higher than the outside while filling the upper part of the silo loosens the tendency of the silage to draw away from the wall as it settles. To avoid a large amount of spoilage at the top, the silage should be leveled off and trampled thoroughly from the lower few metres. It will be better if leveling, trampling, addition of preservatives etc. are done after every 30 cm layer of packing. If the materials are too dry, sprinkle water over each layer. The filling of the pit should be completed within the least possible time say 3-4 days. Avoid filling silo when it is raining. To create favourable anaerobic condition inside the silo, adequate compression of the material through trampling is essential. It helps in driving air pockets from the silo which may otherwise spoil the silage.

2. Covering and sealing the silo: It is essential to keep off air from the silage materials of silo. An anaerobic atmosphere in the silo is essential for proper fermentation of silage. Therefore, the silo, should be covered with wet straw, sawdust or other materials and plastered with 4-5-inch-thick layer of clay soil. If possible, put plastic sheet before plastering with soil. After covering, weights such as paving slabs, concrete posts, concrete cylinders and wooden logs should be kept for better compression. Check the seal from time to time and if any cracks are seen, seal them. A small door (hole) should be opened in one corner, near the surface of the silage to allow the carbon dioxide to escape.

3. Opening the silo: The silage is ready within the 42-45 days after covering of silo. Some mouldy material is invariably found at the top most portions and also on the sides. This should be discarded and not fed to the animals. The accumulation of by-products of bacterial metabolism will tend to preserve the forage material as silage for an indefinite period unless air is permitted to enter the silo.

Silo

The specialized device or container used for preparation of silage is called silo. The silos are:

1. Pile: In this type of silo there is no need of construction. Only a pile of chopped fodder is made on a ground and it is pressed with the help of tractor. This type of silo is recommended for short term preservation of fodder.

2. Long Silage Bag: This type of silo consists of long stretchable bag. After proper filling and compaction, the end of bag is closed.

3. Silage Bunker: Silage Bunker is most commonly used type of silo. This is rectangular structure which is open from one side or both sides. On both sides of walls of wood, steel, concrete are constructed. Dimensions of bunker depend upon the amount of fodder to be stored.

Temporary Bunker - Temporary bunker consists of two frames of steel or iron which are covered by sheets of steel, iron or wood. The function of this frame is same as that of the wall of bunker but difference is that these are portable and can be easily transferred from one place to another place. Wherever fodder is to be preserved, these frames are fixed with the help of stands on both sides and space is filled with fodder. After compaction of fodder these frames are removed and can be used somewhere else. Hay bales can also be used in place of frames for this purpose.

4. Silage pit - In this type of silo, a pit is constructed in ground. It may be rectangular or cylindrical. Trench silo - This is compromised form of silage pit and bunker in which some fodder is preserved inside of pit and some outside of pit.

5. Baled Silage: This is the most modern way of silage making in which fodder is preserved in the form of bale. Fodder is converted into bale via machine called silage baler and this bale is then tightly wrapped with polyethylene sheet with the help of wrapper. This bale can be easily transported.

Nutritive value of silage

Voluntary intakes of silage have been a limiting factor and lower than that of green forage which is more prevalent with high moisture silage. The main reason of low intake could be ascribed to low pH and high lactic acid content. Wilting has been reported to increase intake of silage considerably. Use of formic acid as additive has been reported to increase intake, body weight gain as well as milk production. Nutritive value of cereal forages can be improved by supplementing them with 0.5% urea or mixing with either leguminous forages such as cowpea or berseem or with top feeds such as *Leucaena leucocephala*. Nutritive values of promising silages are presented in Table 2.

Advantages/ disadvantages of ensiling

The nutrients in the forages can be preserved as silage or hay. Silage has many advantages over hay

and other methods of preservations, chiefly because of less loss of essential nutrients.

- Lower field losses particularly of leafy portion which is relatively rich in protein and minerals
- Lower probability of rain damage and thus leaching of nutrients
- Storage over longer period, if properly packed under optimal ensiling conditions
- Provide more succulent feed to livestock
- Ideal technology for preserving nutrients in temperate conditions
- Less dependence over weather conditions, particularly availability of sun lights

While disadvantages include-

- Being mechanized technology, requires considerable capital investment
- Limits the preservation of high CP containing forages such as leguminous fodders e.g. cowpea, berseem, lucerne etc alone
- Must be fed as soon as possible after removal from silo to avoid secondary fermentation
- Chopping of forage is must otherwise good packing of silo is not possible and allows the air to be trapped which in turn allows mould formation

Silage additives

1. Molasses: When the lactic acid in silage is about 1-2%, the product is invariably well preserved and palatable because the pH value is usually below 4 and there is no butyric acid. About 1 to 2 % sugar is required to produce this amount of lactic acid. The common and cheapest source of sugar for silage making is molasses.

2. Urea: Adding urea at the rate of 0.5% of fresh forages has several advantages including a way to feed urea more uniformly throughout the day than when it is fed with concentrates at particular time. The very idea of adding urea is to enrich the silage with nitrogen as cereal forages are mostly deficient in this element.

3. Limestone: This is calcium carbonate and may be added at a level of 0.5 to 1.0% to maize silage to increase acid production. It neutralizes some of the initial acids as they are formed, allowing the lactic acid bacteria to perform longer and to produce more desirable acids.

4. Salt: Salt makes the silage more palatable. It does not inhibit bacterial activity. At the most it may speed up the release of juices from the cells by plasmolysis and thus help to provide conditions suitable for fermentation in the early stage.

Feeding of silage

- Silo can be opened from one side as per need after 45 days and closed properly after taking out he silage
- Silage can be taken out as per requirement. Initially, silage can be fed @ 5 kg/animal to adjust the animals on silage feeding.
- Silage is a substitute of green fodder and can be fed like green fodder.

Good Quality Silage should have following features:

- **Color**: Bright, light green-yellow or green-brown.
- **Odor**: Pleasant lactic acid smell, without any butyric acid or ammonia odors.
- **Texture**: Firm with some softer material.
- **Moisture Content**: Should range between 65-70%.
- **Lactic Acid**: Should be between 3-14%.
- **Butyric Acid**: Should be less than 0.2%.
- **pH Level**: Should be between 4.0 and 4.2.

Conclusion

Silage plays a pivotal role in sustainable livestock production by ensuring a consistent supply of nutrients year-round, especially during lean periods. India's significant livestock population and the challenges in maintaining adequate feed supply highlight the importance of preserving surplus forage as silage. Ensilage, the process of fermenting forage under anaerobic conditions, offers numerous advantages over other preservation methods, including reduced nutrient loss, longer storage periods, and resilience against weather conditions. The Government of India supports mechanized silage preparation through subsidies to enhance livestock productivity. Properly managed silage, supplemented with additives like molasses and urea, can significantly improve the nutritional intake and overall health of livestock, contributing to the sustainability and efficiency of the dairy and livestock industries.

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