Innovative Approaches in Covering Materials Used in Silage Making

Silage Covering Materials

Hasret CITLAK

University of Ondokuz Mayis Faculty of Agriculture Department of Animal Science

Samsun-Turkiye

E-mail: hasretcitlak@gmail.comr

Unal KILIC*

University of Ondokuz Mayis Faculty of Agriculture Department of Animal Science

Samsun-Turkiye

E-mail: unalk@omu.edu.tr
-*Corresponding author

***Abstract*—In recent years, a silage making has become widespread throughout the world and it is used as an indispensable source of roughage in animal feeding. With the development of technology, a new improvements are seen in silage making. There are some innovative equipment such as newly developed machines for the production of high quality silages and materials used to cover the silages. Because every stage in silage making carries an importance, from harvesting to animal feeding. To obtain quality silage, there should not be any air entry to the silo during fermentation, so the silo should be covered well and the materials used should be of high quality. In this context, the current review study focuses on traditional and innovative cover materials used in silage making.**

Keywords—Silage covering material; Oxygen barrier; Silage making; Recyclable material; Technology

I. INTRODUCTION (*Heading 1*)

Silage is a roughage source produced in oxygen free (anaerobic) and acidic (lactic acid) environment as a result of natural fermentation of green forage, agricultural by-products and other plant materials with a water content generally higher than 50%. It is known that both cereal grains and green plants were used to ensile during the periods starting 3500 years ago. Ancient wall paintings found in Egypt shows that the Egyptians were used ensilaging herbal products in 1000 to 1500 B.C. It is also known that Germans filled the green forages in pits and cover with animal dung in A.D. 100 (1). Although the history of silage making is very old, it has not became popular and widespread until the end of the 19th century. Nowadays, silo feed production has become a very large industry in developed countries especially Europe and the United States. In these countries, silage-based rations are used in ruminants feeding. In the widespread use of silo feeds to a large extent; cultivation of corn as a green fodder plant, developments in agricultural engineering and agricultural mechanization and the use of chemistry play an important role. Additionally, use of microbiology sciences in silage making more accurately and effectively, improvements in the production, use of additives and the development of plastic products used as a silo and silo cover material enhanced silage production (1, 2).

Roughage has an important role in the nutrition of ruminants. The digestive systems of these animals are capable of utilizing roughage at best way. Quality roughage, being abundant and inexpensive, usually minimizes the use of more expensive concentrate feeds and provides the business with great economic benefits. Feed-related costs account for 60-70% of the total operating costs of the farm [3]. For this reason, economic arrangements to be made in feeding have a great importance. There is an increasing need for high quality, abundant and cheap roughages for the feeding of ruminant animals. Therefore, silo feeds are the only solution that can cover the quality, abundant and inexpensive roughage gap needed in a short time. In the preservation of herbal material by natural fermentation (3, 4).

In practice, anaerobic conditions can be achieved in a variety of ways. Among these, the most common and efficient way is to store the material in airtight containers. Under these conditions, the oxygen in the plant is quickly consumed by the respiratory enzymes in the plant (1, 2). The efficiency of providing an anaerobic environment in open silo types depends on the degree of compression and closure of the material. Only in this way can air entry into the silos be prevented. Otherwise, if air enters the silo, aerobic microorganism activity starts and as a result, the ensiled materials will deteriorate (1, 5-6). The best way to prevent the proliferation of Clostridia spores is to encourage lactic acid fermentation. Lactic acid bacteria are facultative anaerobic microorganisms normally found in plant material. These microorganisms convert mainly sugars in the plant material structures, especially glucose and fructose, into lactic acid and other organic acids. The hydrogen ion concentration arising during this event reaches a level that will prevent clostridial development (2,7).

II. SILAGE MAKING TECHNIQUES

Silage production consists of 10 stages from the production stage of the silage plants to the use of silage in animal feeding (1). These stages must be done carefully, otherwise, silage may deteriorate or silage loss rate may increase. These stages, which form the basis of the silage making technique, cover all stages from the production of the silage material to the opening of the silage and feeding it to the animals (2, 7).

1. Properties of Silage Material

For a good silage fermentation, chemical and microbiological properties of the plants must be found sufficiently and appropriately, as well as these properties must also be well combined. Otherwise, it will not be possible to make a quality silage. Dry matter (DM) content of the products to be ensiled is very important in terms of both fermentation quality and development of LAB required for fermentation. Generally, it is desired that the products to be ensiled contain between 25-42% DM (2, 8). Ensuring a good fermentation in silage only depends on providing sufficient water-soluble carbohydrates (WSC). In order for any product to be fermented after being ensiled, it must have at least 3% WSC and its DM content must be above 15%. Plants contain many different types of microorganisms in very wide limits and densely. The number of epiphytic microorganisms in the plants varies between 10^2 and 10^7 per 1 kg of plant DM. The nature and environmental conditions such as temperature, humidity, and solar radiation affect the epiphytic microorganism populations contained in plants (1, 9, 10).

2. Harvest

Harvesting is a very important stage of silage making. The harvest time of the plants to be ensilaged is determined by the growing factors and the maturation period. Maturation period; considering the economic conditions, this is the period when the plants are in the best stage in terms of chemical and microbiological composition and maximum yield and digestibility. At the harvesting, the prefered stage is that beginning of flowing in legumes while dough satge in gramineas (2, 7, 9, 11).

3. Wilting

Wilting is the process of evaporating the water in the field for a while in order to increase the DM content of the harvested plant before ensiling. It is very important for a plant to be ensiled to contain at least 30% DM in terms of silage fermentation (2, 8). Wilting also reduces silo water output and prevents losses of fermentation, digestible energy and nutrients and increases the WSC level of plants. This situation is very important in terms of being able to safely silo difficult plants, especially legumes, which have insufficient WSC levels for fermentation. This situation is very important in terms of being able safely ensiling difficult plants, especially legumes, which have insufficient WSC levels for fermentation (1, 6).

4. Copping

In general, the chopping size of all plants to be ensilaged varies between 0.8-2.5 cm. Silage materials with high DM content should be cut into smaller, while those with low DM content should be larger in size. When plant material are copped below 0.8, excessive silo water will be produced and this leads large silage losses. In addition, when animals consume this type of silage, it immediately passes to the lower part of the digestive tract and it cannot be utilized (1, 6, 8).

5. Use of Additives

The main purpose of its use is to obtain a silage that is well fermented, has high aerobic stability and has low hygienic risks by ensuring rapid development and proliferation of LAB in the ensiled material. Various additives are used for this purpose (1, 2, 8, 11).

6. Transport and Filling

The copped plant material should be brought to the silo with a trailer or truck without causing any loss and the material should be started to be filled into the silo without delay. The silo should be filled as soon as possible. If this period is prolonged, aerobic microorganisms begin to multiply and this affects silage fermentation negatively.

7.Compressing

The compressing process is done in order to remove the air between the particles of the ensiled product. Compaction is done by tractor or construction equipment depending on the silo size. During silage compacting, it must be compressed in each 30-50 cm layers. Layers higher than a 50 cm reduce the compression efficiency and a good compression cannot be achieved. Air remains between silage particles will facilitate the degradation of the product and increases silage losses (1, 2, 6).

8. Covering

Covering the silage material is a very important part of the silage making process. It is difficult to cover silage material, especially in bench type silos (2). Silos are usually consist of solid walls that are a mixture of iron and concrete. One feature of the silo walls is that they prevent air entry into the silage material. During the silage fermentation, some acids are formed in the silo. Therefore, silages contain some acid. For this reason, silage has corrosive properties. Due to these characteristics of silages, silo walls should be protected by covering them with a protective material such as bitumen, asphalt, etc. in order to prevent the silo walls from being damaged by these acids over

time and to extend the life of the silo. Rain water and wind entry into the silo should be definitely prevented. The surface of the cover and silage material should be in contact and there should never be any air between them (1, 8).

9. Opening and Feeding

There are many factors affecting silage fermentation. Depending on these factors, the silage fermentation is completed within 7-21 days (1). However, in order to guarantee the fermentation, the silage material must not be opened within the first month. Although the opening time of the silo depends on the roughage situation of the enterprise, in terms of silage fermentation, the silo must be opened at least one month after closing. After the silage is opened, the silage surface directly comes into contact with the air and the silage starts to get air. This is not a desired situation, because this causes over 30% DM and other nutrient losses in silage (2, 8). However, the silage must be opened in order to be given to animals. In order to minimize these losses in an opened silage, some simple preventive measures should be taken to reduce the air entry into the silo. First of all, the daily amount of silage to be given to the animals should be removed from the silo. When the silage is going to give animal it should be removed carefully from the silo, so the silage remaining silage in the silo is not disturbed and then closed.

10. Coordination

The most important of the 10 basic stages in silage making is coordination. During the silage process, a very good coordination is required between all stages from the production of the ensilaged plant material to the closing of the silo. All stages should follow each other in the order stated above. Otherwise, the smallest coordination disorder that can be seen in these stages or between stages, will not allow a good quality silage to be obtained.

III. MATERIALS USED IN COVERING SILAGE

The covering is the most important stage in the silage making process. Proper fermentation of the silage depends on the silage not getting aerated. The silage should be closed properly to prevent air from getting air. By covering the filled silo, various material can be used to cut off the relationship between the silage feed and the air. Previously, a mud was used for this job, but today more plastic covers are used. A various materials are used for the silage covering process. Except tower silos, all other types such as heap-ditch, bank, silo with movable walls, vacuum type silo, plastic sausage silo and large/small bales require covering material.

1. PVC or Polyethylene Covers

In recent years, it is reported that about 15% of the plastics used worldwide is spent in agricultural production (12) and most of them consists of polyethylene films. Thus, polyethylene films have been widely used in greenhouse construction, baling silage and to cover bench type silos since the early 1950s. Since the 1960s, polyethylene materials have become widespread. It is reported that 3.4 kg of plastic film is used per year for each dairy cow in New York (13, 14). A plastic material made up of PVC or polyethylene with 0.15-0.30 mm thickness should be used to cover the silos. The plastic cover used for this purpose should provide full protection against ultraviolet rays that come from the sun, which cause nutrient losses by negatively affecting on the ensiled product. For this reason, the color of the plastic cover is also very important. Thus, if the plastic cover provides full protection against ultraviolet rays, both surfaces of the cover should be white. However, the cover which does not provide a full protection against ultraviolet rays, the upper surface should be white and the lower surface should be black. Because the upper white surface of the cover prevents the ensiled material from overheating, while the lower black surface provides protection against ultraviolet rays. On the other hand, if a cover with this feature cannot be found, as a third alternative, a cover with black surface on both sides should be used (15). By placing sand bags and used tires on the edges of well tightened silo plastic covers, will prevent opening and also provides a better compaction to the silage (Figure 1). The silo container which is carefully closed in this way, is ready for fermentation and silage can be obtained after about 6 weeks.

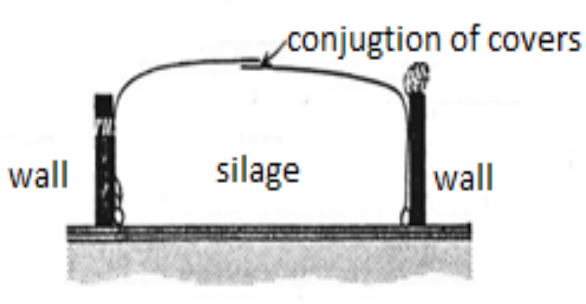

Figure 1. Covering the silage in the bench silo

2. Nylon Bags

With bag ensiling techniques, the plant materials are filled with the bags and closed tightly. Plants that are preserved anaerobically in the bags undergo fermentation and turn into silage which is a highly nutritional animal feed. Since there is no air in the material filled with vacuum, a healthy fermentation occurs. The most important advantage of this technique compared to other techniques is that it allows for indoor storage and it enables the silage to

be delivered to animals in winter without rain, mud, snow or without the need for construction equipment or tractors. Silage bags can be used many times, if care is taken while filling, stacking and unloading. Bags, which are generally preferred by small farms, can also be used in large animal farms.

3 Recyclable (Biodegradable) Materials

Borreani and Tabacco (14) reported in their studies that biodegradable cover materials gave similar results to polyethylene used as traditional cover material and did not change the silage quality during 6-month fermentation, and the researchers reported that soil-soluble cover materials can be used in silage production. Recycling of traditional materials into the soil is quite long and causes environmental pollution, it releases volatile toxic compounds, can be eaten by animals and cause health problems. Therefore, it is emphasized the use of biodegradable materials (16). These biodegradable materials are not produced from petroleum, but instead from biological sources (plants such as corn, potato, rapeseed, sunflower or some food products). However, it is recommended that the biodegradable covers should not be too thin, otherwise it may lead a high pH value and DM losses.

4 Oxygen Repellent (Oxygen barrier)

As a result of R&D studies, a structure that resembles the oxygen repellent children diapers was developed. Just like diapers, it has the ability to trap the air and drain it neither on the in nor out of the diaper. It absorbs the oxygen inside the silo and traps it between its layers and prevents the oxygen coming from outside. In this way, silostop quickly creates an oxygen-free environment in the silo and thus fermentation is guaranteed. This material consists of two layers of 80-20 microns (Figure 2). When it is covered on the silo, it traps the oxygen in the silo between its layers, while the lower layer adheres on to the silage surface. Silostop acts as an oxygen barrier 6-10 times more than conventional films. It provides optimum silage quality by providing less fermentation losses and mold formation. It is a sustainable product and can be used over and over again unless it is torn in. In a study in which Wilkinson and Fenlon (17) compared oxygen-repellent films and polyethylene covers, it was determined that oxygen-repellent films increase the aerobic stability of silages and reduce nutrient losses. The purpose of silage covering is not only to reduce the loss of nutritional value of silages, but also to reduce the damage to human and animal health. Tin this method, it can be achieved by a suitable silage making method. Standard polyethylene films are not very resistant to oxygen permeability. It has been determined that these oxygen repellent films reduce oxygen permeability compared to standard polyethylene films. Even some researchers reported that oxygen repellent films has 300 times less oxygen permeability than standard polyethylene films (14, 18). Dolci et al. (19) reported that the use of an oxygen barrier film can ensure a longer shelf life of silage after aerobic exposure.

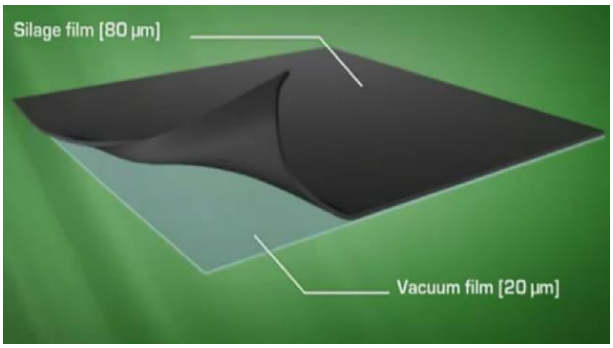

Figure 2. Oxygen-repellent silage cover

5 Industrial Waste Pulps

An abundant and cheap fresh sugar beet pulp (FSBP) which can be eaten by animals can be used to cover silage. For this purpose, a 25-30 cm thick FSBP is placed on the well compacted silo materials. After the ripening of the silage, the top layer of FSBP, the top dried black 5 cm layer will be discarded and the remaining intact part can be fed to animals with the silage. Thus, oxygen-free environment in the silage material is ensured by the use of pulp, while the cost of nylon used in silage closure and environmental pollution is prevented. In addition, since materials such as soil and sand cannot be placed on the silage cover, there will not be a risk of contamination, another advantage is that there is no need to place rubber and similar materials on the silage (5). Its cost is cheaper than plastic cover and tears, holes and similar problems that may occur in the plastic covers will be worried. Due to sunlight damaging the plastic cover, the FSBP is more suitable to cover silage. It provides a good covering without any gaps between the silo walls and the silage material. While placing soil or sand on plastic cover will contaminate silage during opening, there is no such risk for FSBP (5). However, since 85% of FSBP content is water, it should be taken into account that it may have an effect on silage DM content. In case materials with very high water content are covered, some drawbacks may occur. A negative impact can be encountered if very high water content material used as a cover.

6 Covering with Soil or Sand

The use of soil in silo closure often general. For this purpose, soil cover materials are used in application conditions. Generally, covering the silage with a thin layer of soil is not beneficial for silos. In contrast, the success rate of thick soil layer covering is higher.

However, it is likely to freeze during the winter months. In such cases, there will be difficulty in evacuating the feed from the silo. However, covering only with soil does not mean that no air will enter the silo. Contamination with soil increases in the upper layers of the silage and thus feed loss increases. Soil contaminated feed causes health problems when fed to animals (1, 2, 8, 20).

7 Covering with Stover and Straw

The problem frequently encountered in practice is the low quality of silo feed. Especially in silos covered with stover and straw this problem is frequently encountered. The silage quality is generally reduced in the upper layers in such silo feeds. Because there is a high possibility of air and rainwater entry into these feed layers. Depending on the decrease in the quality of feed, there will be a decrease in animal productivity. Therefore, it is absolutely necessary to close the silo very well (20).

8. Plastic Packages

Plastic (bag etc.) packaging is preferred by small farms. There is no fragmentation or perforation seen in nylons. A healthy fermentation with desired direction will occur since there is no air entry in the silo. Due to its strong structure, it can be used for many years.

IV. CONCLUSION

The silage cover materials are quite different, and the selection of the cover material is important in terms of both increasing the silage quality and preventing environmental pollution. The selection of covers that are sensitive to environmental pollution has become an issue that is precisely emphasized in every activity. However, the cover materials to be used for the silage production should primarily serve the purpose of making silage; provide quality silage and be economical. In the silage covering process, the material that is on the farm and which are more economically advantageous should be preferred first. Non-disposable materials (Multiple use) are generally more economical in this regard and provide quality silage. In addition, when environmental approaches are taken into account, the spread of easily degradable cover materials should be increased. Thus, it is obvious that farms using approximately 15% PVC traditional cover materials cause significant environmental pollution in the world. However, the most economical materials available to the farm should be used as silage cover material in order to make an economical livestock farming. These materials can be sugar beet pulp, previously used intact PVC covers, poor quality or spoiled grass bales etc. Thus, an economic advantage will be obtained by using the available opportunities. Whether to use or spread "oxygen repellent" and "biodegradable covers" scientific studies to determine the effects on the silage quality and cost analysis should be carried out. As a conclusion, farms should choose the highest quality and most economical materials in silage making, but they should avoid environmentally damaging materials and irresponsible behaviors such as scattering PVC covers.

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