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Design and construction of surface silo for a goat farm in Konkan

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Abstract
In the Konkan region, small farmers have cattle, goats. They fed grass in monsoon season. But in winter and summer due to unavailability of green grass, jackfruit and local trees leaves of shivan, ashta, ghoti, hasani, kumbal are fed to goats. Also in Konkan, farmers produce finger millet crop.
The study revealed that the dry matter content in silage decreases in 45 days period to the tune of 1.75 percent. Also, the moisture content of silage increases by 1.10 percent and compacted bulk density was increased to the tune of 1.5 percent. It was observed that the colour of silage changes green to yellowish brown.

Keywords: Design and construction, surface silo, Konkan

Introduction
Green fodder is considered as economical source of nutrients for dairy animals. The constant increase in cost of concentrate feed ingredients and limited availability. So it is important to preserve green fodder to ensure regular supply for feeding animals. It is also required supplying green fodder in all seasons. Commonly in the rural area, farmers have animals on small scale. Hence, poor farmers are unable to buy quality silage from market. To supply green fodder in summer it shall be conserve in the form of green silage in silo storage structure. Silo is a farm structure which stores and produces the animal fodder providing an ideal condition. The fodder is cut and packed in the silo in an air tight condition for partial fermentation. Silage can be made from any green crop with moderately tough stalk e.g. Grass, Sugarcane, legumes, etc. Silage is more nutritive than dry stalk.
In the Konkan region, small farmers have cattle and goats in limited numbers. They fed grass in mansoon season. But in winter and summer due to unavailability of green grass jackfruit and local trees shivan, ashta, ghoti, hasani, kumbal leaves feds to cattles and goats. Also in Konkan, farmers produce finger millet. The green stalk of finger millet can be used for making silage. Thus, study includes design, construction of silo for a small goat farm and determination of physical properties of silage made from finger millet stalks.
Zimmer (1980) [11] observed losses associated with fermentation in the silo are primarily from carbon dioxide production. These losses typically are in the range of 2 to 4%. The amount of DM loss from fermentation depends on the dominant microbial species and the substrates fermented. Rees (1982) [7] reported DM losses of 1.7% for every 10°C increase in temperature in laboratory scale silos. Pitt *et al*. (1985) [6] studied at ensiling, chopped forage is still metabolically active and respires while oxygen is available. Plant tissue respiration is the primary driver for removing oxygen from the silo and producing heat, although respiration by aerobic microorganisms can contribute. At DM contents of 30 and 50%, respiration rates are about 70 and 30% of maximum, respectively. Respiration rate peaks at 46°C, but the enzymes responsible are inactivated at 54°C. Bolsen *et al*. (1993) [9] studied providing an effective seal on silos and silage piles is crucial to minimizing DM losses during the storage period. The value of a seal was shown by comparing uncovered and polyethylene (PE)-covered bunker and pilot-scale silos. Without a cover, the losses in the top 0.5 m were large. Pitt and Muck (1993) [6] stated that DM loss is to be minimised, porosity should be minimized, and this is accomplished by increasing bulk density. Borreani *et al*. (1999) [1] evaluated field DM losses from cutting to baling of alfalfa harvested at approximately 40 or 65% DM. Data showed that DM losses under good drying conditions without tedding were mainly due to conditioning treatment, with mechanical losses being highest for flail conditioning. McAllister and Hristov (2000) [3] stated that before the active fermentation phase can begin, oxygen trapped in the

packed forage allows biological and chemical processes that consume nutrients and energy, leading to the production of water, carbon dioxide, heat and free ammonia. This increases silage temperature and negatively affects the silage, both in terms of DM and quality losses (Holmes, 2006). Pahlow *et al*. (2003) [4] states that as the silo becomes anaerobic, various anaerobic and facultative micro-organisms increase in population and ferment primarily sugars and organic acids in the crop. The principal fermentative microbial groups include LAB, enterobacteria, clostridia, and yeasts. Further, it was stated that without the use of silage additives, the fermentation process is a result of the activity of the epiphytic microorganisms on the crop at ensiling. The populations of various microbial groups on crops at ensiling are influenced by the crop, growing conditions, environmental factors during wilting, and so on. Wilkinson *et al*. (2003) [9] observed that achieving a rapid wilting in the field is essential for reducing DM and nutritive value losses. Conditioning the forage and spreading the crop immediately after cutting has a major effect on the drying rate of forage. Dry matter losses, especially leaves, were directly related to the forage DM content at the time of treatment and the severity of the conditioning. Rotz (2003) [8] studied all forages not directly harvested and conserved need a field wilting period to reduce their moisture concentration, to enhance their ensilability characteristics and avoid seepage losses from the silo. The major field processes involved in crops that are wilted are mowing, dry down (wilting), and baling or chopping, with DM losses and quality changes occurring during each of these processes, reducing the quality of the final product. Yamamoto *et al*. (2011) [10] observed growth rates of the Lactic Acid Bacteria (LAB) essential to the initial ensiling fermentation are also affected by temperature, among other parameters (e.g., availability of sugars, degree of anaerobiosis and moisture levels).Temperature of the crop affects both the speed of fermentation and the microbial species that dominate fermentation. Lactic acid bacteria grow most rapidly at temperatures between 27 and 38°C. Below 27°C, their growth is slower, but most fermentations should be complete between 7 to 10 days at these temperatures. Bruning *et al*. (2018) [2] reported that slow silo filling and delayed silo sealing also negatively affect silage quality. The effects of delaying sealing of corn silage laboratory silos with a low packing density (191 kg of DM/m^3). Delaying sealing by 4 d led to DM losses of up to 11%, an increase in yeast counts, and a decline of up to 65% in water-soluble carbohydrates in silages.

Materials and Methods

Design of silo

The work was carried out in a goat farm of village-Sagave, Ratnagiri. The size of goat farm shed was 9 m x 4.5 m. The numbers of milking goats were thirty. The silo was designed as per feeding requirements of 30 goats. The parameters *viz*. number of goats, feeding required for number of days per year, quantity to be fed daily, availability of the storage space, the amount of excess feed to conserve, forage dry matter content, available labor and total costs were considered for design of silo.

Requirement of silage

Goats are ruminants like sheep and cattle, and are able to digest foodstuffs such as grass and leaves. They are naturally browsing animals and will eat bushes and trees in preference to grass. However, goats need careful feeding and cannot survive on just browsing and grazing. Nutrients are needed for maintenance, growth and milk production. Milking goats are particularly likely to lose condition without adequate feed as they give a high milk yield in relation to their size and bodyweight.

Hay or roughage should form the basis of the diet – adult goats will usually eat at least 1 to 2 kg of hay daily (more if other feedstuffs are not available) but milkers will often need nearer 3.5 kg of hay per day. Each goat needs about one to two kilogram of hay per day (3-4% of body weight), which can be fed at once or twice a day. When supplementary feeding is necessary, the amount of additional feed may be calculated as follows: An average ewe's daily pasture requirements can be replaced by 50 percent by 450 g of good hay, 1.5 kg silage or 250 g of grain.

The stepwise design calculations for total silage requirements for a small goat farm are calculated.

The number of goats in the farm was thirty. The feeding requirement for thirty goats is six months i.e. 180 days. Each goat requires on an average 1.4 kg per day fresh silage, to supplement other forages and concentrate.

The silage requirement for 30 goats at the rate of 1.5 kg per goat per day for 180 days comes to be (30 × 1.5 × 180 = 8100 Kg) 8100 Kg. The weight loss due to fermentation (this can be higher if air enters the storage) of 15 percent shall be considered. The initial weight of fresh silage that needs to be stored will be (8100 kg + 8100 x 0.15 = 9315 Kg). The compacted bulk density of fresh silage is assumed as 450 Kg/m^3. So, the volume of storage is (8100 / 450 = 20.70 m^3) 20.70 m^3. By trial and error of calculations and considering the space available on goat farm, the suitable size of surface silo comes to 4.4 m length, 2.5 m width and 2.0 m height.

Construction of silo

The construction of a surface silo of size 1.50 m x 0.75 m x 0.90 m was constructed as a proportionate model. The material used for construction was Cement, stone aggregate, laterite stone, sand and polythene sheet. The cement, sand and coarse aggregate was in ratio of 1:2:3. The mortar prepared for making joints between laterite stone was made of cement and sand mixed in ratio of 1:4. The inner and outer side of silo was plastered with mortar as shown in Fig. 1.

Fig 1: Surface silo

The finger millet stalks and grass was used for making silage. The finger millet stalks and green grass was chopped in average length 2.5 cm. If stalk lengths are longer, additional molasses may improve the fermentation. However, the stems should be chopped to small lengths because they are harder to compact. The longer length of stalks may entrap air in bulky compacted mass. Leaves can be chopped in 3 to 8 cm length. The chopped fodder was placed in the silo. Napier grass possess about 12 percent to 15 percent dry matter at harvest and needed to be wilted to at least 30 percent dry matter. Fermentation substrate was added at the time of ensiling. If the fresh forage cannot be wilted, the fermentation of the silage will be improved by mixing the chopped material with molasses just prior to ensiling. Jaggery is used as a molasses. The inner dimensions of silage are 1.50 m x 0.75 m x 0.90 m so, volume of silage comes to be 1.0125 m^3 and density assumed was 450 kg/m^3. Therefore mass of silage in silo is 455.60 Kg. Thus, that molasses was made by ½ Kg urea, 1.0 Kg jaggery, ½ Kg salt and mixed in 7.5 liter water. The material was mixed thoroughly, the prepared molasses was spread in layers over the forage at every 10 cm to 15 cm depth in equal quantity. Due to shorter chop length of stalks, better compaction was carried out. The silage was compacted to remove air and to obtain anaerobic condition (Fig. 2). The entire silage storage filled, compacted and sealed in one day. Silages in well-sealed storages prevent the entry of air or water and maintain their quality determined period. The sealing or covering the silo was with thick polythene sheet to avoid the inflow of air and water into silo. The mud layer was spread over the sheet to prevent air flow beneath the sheet (Fig. 3).

Fig 2: Silo filled with silage

Fig 3: Silo packed by thin sheet

The physical properties were observed for following parameters

Moisture content

The digital weighing balance was used to measure initial and final weight of silage during the process (Fig. 4) and calculate by the formula,

$$\text{Moisture Content, \% (wet basis)} = [(A - B)/A] \times 100$$

Where,
A = Initial weight of silage sample (gm)
B = Final weight of silage sample (gm)

Dry matter (DM)

The dry matter is a measurement of the mass of material when completely dried. The dry matter of plant material consists of all its constituents excluding water. The following formula was used calculate dry matter,

$$\text{Dry Matter} = 100 - (\text{Moisture content, \%})$$

Fig 4: Weighing process

Bulk density

Bulk density is defined as the mass of material per unit bulk volume, which includes both solids and pore space. The formula used was,

$$\text{Bulk density} = M/V$$

Where,
M = Mass of material (Kg)
V = Volume occupied by the material (m^3)

Result and Discussion

It was observed that silage was prepared in 45 days after sealing the surface silo. The initial and final observations of physical properties of silage were observed and tabulated in Table 1.

Table 1: Physical properties

Sr. No.	Properties	At the time of filling the silage into silo	After 45 days
1	Moisture content (Wet basis)	61.52%	62.19%
2	Dry matter	38.48%	37.81%
3	Silage colour	Green	Yellowish brown
4	Bulk density of Silage	437.1 Kg/m^3	443.75 Kg/m^3

Moisture content
Table 1 showed that the moisture content of silage was found to be 61.52 percent which increased after 45 days to 62.19 percent. The increase in moisture content was due to reduction in dry matter.

Dry matter
The dry matter in the silage as shown in Table 1 was initially 38.48 percent and later on after 45 days it decreased to 37.81 percent. The dry matter of silage decreased due to increase in temperature of silage. The results are in accordance to Rees (1982) [7] which reported dry matter losses of 1.7 percent for every 10°C increase in temperature in laboratory scale silos.

Silage colour
Fig. 5 showed that initially the colour of silage visible was green that turns yellowish brown after 45 days period. The change in colour is due to fermentation process. The finger millet silage was eaten by goats and preferred over dry grass (Fig. 6).

Density of silage
The compacted bulk density was initially 437.1 Kg/m^3 and after preparation of silage in 45 days the bulk density was 443.75 Kg/m^3. The increase in bulk density was to the tune of 1.5 percent. The increase was due to removal of pour spaces or air entrapped in the silage.

Fig 5: Silage after 45 days period

Fig 6: Silage feeding to goat

Summary
In the Konkan region, small farmers have cattle, goats. They fed grass in monsoon season. But in winter and summer due to unavailability of green grass, jackfruit and local trees leaves of shivan, ashta, ghoti, hasani, kumbal are fed to goats. Also in Konkan, farmers produce finger millet crop.
The study revealed that the dry matter content in silage decreases in 45 days period to the tune of 1.75 percent. Also, the moisture content of silage increases by 1.10 percent and compacted bulk density was increased to the tune of 1.5 percent. It was observed that the colour of silage changes green to yellowish brown.

Conclusions
It can be concluded that silage made from finger millet stalk have suitable moisture content, dry matter and compacted bulk density. Finger millet stalk silage was preferred by goats over dry grass.

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