FORAGE CONSERVATION

Forage Training Course 1986

International Center for Agricultural Research in the Dry Areas

ICARDA

Training Manual

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F O R A G E

F O R A G E   C O N S E R V A T I O N

THE INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH
IN THE DRY AREAS (ICARDA)
1986

FORAGE CONSERVATION

Conservation, is the harvesting and storage of green crops as hay, silage and dried grass. It is an important operation in forage production and utilization.

In most semi-arid areas of the Middle East, forage is usually in good supply during the winter-spring season but it is in extreme short supply during summer and autumn. Off-season requirement can be met by the preservation of wet season forages; also, the residues from leguminous and cereal crops can be preserved for later use (i,e. empty pods, husk and broken seeds).

Because of the high price of animal feeds, nutritionists are investigating the use of fibrous materials which have been ignored in the past. Straw is one of these materials. A number of methods have been developed for treating straw, to increase its digestibility and voluntary intake.

The principles of conservation

When the crop is cut it dies and the plant cells lose their rigidity; the sugars in the plant juice start to oxidise and the protein starts to break down. The purpose of conservation is to check these destructive processes rapidly and completely, and to preserve, as much as possible, the yield and feeding value of the crop.

As grassland systems become more intensive, production increases and the need to conserve forages becomes all the more important.

Conservation Practices

- The crop is either dried to a stage at which both chemical breakdown and microbial action are stopped.

- Or it is preserved at a high moisture content by the action of acids or other chemicals in the process of ensilage.

Importance of conservation

Throughout the semi-dry regions of the Middle East, cereal straw and standing forages in natural grassland are the most important roughage for livestock. Hay, silage or dried grass are seldom used. However, in the future the production costs on the farm are likely to be lower than the price paid for alternative feeds, and the aim should be to include as much hay, silage, dried grass, and treated straw as possible in the total ration.

Hay Making

Hay is any forage crop which is cut before it is ripe and dried for storage. It is more nutritious and palatable than straw, because the entire crop is cut before maturity and dried. It is leafy, green in colour and free from mold, weeds and dust have a pleasant characteristic smell and aroma; when the hay is made from a mixed herbage of grasses and legumes, the products are high in feeding value. In general, hay is easy to make and can supply the animals with their requirements for energy, nitrogen, minerals and vitamins.

Principle in hay making:

High quality hay is made from fine-stemed legumes and grasses cut at the right stage of growth and dried in such a way as not to lose any of the nutrients.

To produce a high quality hay at least two conditions must be met:

- Good forage must be harvested.
- And it must be dried with a minimum loss of nutrients.

Since most of the nutrients in forage plants are stored in leaves, a good hay crop is leafy and has fine stems. Leaves are highest in protein, lowest in fibre and are more easily digested. Legumes have more leaves per unit of dry forage than do other plants. For this reason legumes are considered more valuable as hay crops than grain plants or forage grasses. Plants differ in their responses to drying. Alfalfa leaves dry more quickly than the thicker stems and this rapid drying of leaves contributes to "shattering" and a mechanical loss of the high nutrient content of the leaves.

The most important hay crops are: alfalfa, sainfoin, clovers, forage grasses, cowpeas, small grains (cereals), sorghum, sweetclover and others including grass/legume mixtures e.g. barley/vetch, triticale/vetch, etc.

Object of hay making

The aim of hay making is:

1. To reduce the moisture content of the green crop to a level enough to inhabit the action of plant and microbial enzymes and
2. To permit their safe storage without spoilage or serious loss of nutrients.

All operations in hay making are aimed at avoiding as far as possible, the loss of leaves since they form the most valuable part of the hay.

The moisture content of a green crop depends on many factors, and may range from about 65% to 85% with a tendency to decrease as the plant matures. At the stage of growth when most legumes are cut for hay, there is about 70 to 75% water; for many grasses 60% to 65% moisture is present. The maximum permissible water content for satisfactory storage in a stack or bale must be about 18-20%. The fineness of the hay, the lightness of the bale, the prevailing humidity and the amount of air movement influence the loss of moisture during drying.

The practice of cutting the crop at a mature stage when the moisture content is at its lowest is clearly a sensible procedure for rapid drying and maximum yield, but unfortunately the more mature the forage, the poorer is the nutritive value.

Proper stage for harvesting hay crops

Because of the extreme variability in plants and of the wide range of environmental conditions even in a limited geographical area, the chemical composition (and nutritive value) of any plant at the time of cutting is variable. The stage of growth of all forage plants has a high proportion of leaves which are characterised by high moisture, high protein and mineral content, low fibre and lignin. As the season advances, protein, lipids, soluble carbohydrates and minerals decrease, the cell walls become relatively more rigid, the fibre increases and there is a progressive decrease in quality and digestibility. Hence harvesting at the correct time is very important in order to make good hay. For each group of forage a number of points must be considered in order to produce high quality conserved forage.

a. **Forage grasses**

Forage grasses continue to decrease in protein, minerals, Ether Extract (fat) and Nitrogen-Free Extract (carbohydrates) and to increase in lignin as they progress towards maturity. On the basis of composition alone, no special stage of growth can be considered the best for silage or hay, but it is generally recomended that cutting be done as early as practical, though not earlier than the heading to early blooming stage.

b. **Winter cereals:**

Barley, oats and Rye increase in yield from heading to maturity. This is at the expense of quality. Harvesting when the grain is at the milk stage is recommended for good quality hay and good yield.

c. **Forage legumes:**

Alfalfa is cut when one-tenth (10%) to one fourth (25%) of the plant are in bloom or when the foliage is just turning yellow. Hay of best quality is obtained when alfalfa is cut in the period or bud stages of growth, but this early cutting may reduce the stand if done frequently.

Alfalfa hay is one of the best roughage for ruminants. It is very palatable, high in protein content, and of all the common feeds, it is the highest in calcium when properly cured; it is rich in carotene which is the precursor of vitamin A. Alfalfa is finer in the stem than clovers and it is suitable for feeding young animals.

d. **Clovers:**

Half to full bloom stage seems to be the most suitable time for cutting. Clover hay has the same advantages as alfalfa hay, except that is somewhat lower in protein and it is slightly less palatable.

e. **Seed legumes:**

Cowpeas, lentil, chick peas, broad bean and vetches should not be cut for hay until the first pods are ripe. Harvesting can be delayed, however, without serious loss until many of the pods are ripe.

Hay making procedures:

The normal method of hay making in which natural sun drying is employed is a cheap and efficient method. Artificial drying of forage may be used also and this has the advantage of conserving much of its nutritive value by avoiding losses which normally take place during slow natural sun drying. Period of rain-free weather should be selected for harvesting hay. Normally about two to three days of good drying weather are required for curing hay.

1. **Hay cutting:**

Hay crops are cut by a mower. Cutting should not be started in the morning until the dew had dried off. Cutting only in the afternoon is of no advantage in speeding up curing. It is suggested that large fields be divided into parts which can be harvested in one day. Mowing should start in each part from outside working gradually to the center in a clockwise direction. Unless the nights are warm, enough forage should be cut day to allow for wilting on that same day. It usually takes a few hours in clear weather for the forage to start wilting. Swathed forage wilts more rapidly.

The mower must cut the stubble clearly to the desired height which, depending on crop and ground conditions, can be between 5 and 10 cm.

2. **Windrowing:**

This refers to the gathering of swathed or cut forage into thin windrows by means of a rake. Raking should always be done before hay is completely day to avoid shattering and over-exposure to the sun. The best rake is the side delivery rake as in keeps the stems outside and the leaves inside. Mowing and raking could be done in one operation in the case vetch and similar forage.

3. **Turning of windrows:**

This is done to facilitate drying; it should be done when the dew is present especially for hay which is one subject to serious shattering of leaves. Legumes tend to shatter their leaves very easily.

4. **Hay storage:**

Hay, when dry, can be stored loose or in bales. It can also be chopped and cubed. Hay should be stored in the shade with proper ventilation. Moist hay will encourage the growth of mold and loss of carbohydrates. Heating may also result in oxidation of hay and perhaps to spontaneous fire.

5. Hay baling:

Baling should be carried out just as soon as the hay is sufficiently dry. Bales should be stored as soon as possible away from rain. The high cost of baling, storing and feeding conventional hay bales has encouraged the use of large round bales or mechanically formed stacks to reduce costs.

Characteristics of hay quality

Quality is a combination of chemical, physical, and biological properties that influence the intake, digestion, and utilization of the hay which in turn determine the growth and productivity of the animals consuming the hay.

When the forage is cut, as by mowing, there are sudden changes; water is evaporated from the leaf surface and this results in wilting, drying and death of the leaves. During the drying certain nutrients are lost. The more rapid the drying smaller is the loss in nutritive value. Changes in the hay occur also after drying, that is, during storage. Chemical and nutritional changes may be related to the operations of hay making and environmental conditions.

High quality hay:

1) leafy
2) made from plants cut at proper stage of maturity
3) green in color
4) not too dry
5) the stems are soft and pliable
6) has little foreign material and fungal growth
7) is of acceptable taste for livestock.

Generally, forage plants that are best suited for hay making are thin - stemmed and leafy and remain sufficiently nutritious and palatable after drying.

Legume hay is more useful in feeding livestock than grass hay, as it contains more proteins. In legumes the main difficulty is to avoid loss of leaf through shedding during the drying and curing process. Since the leaves constitute the bulk of the green material and contain about 75% of the protein, loss of leaf will reduce the quality of hay considerably.

The composition and digestibility of fresh grass and the hay made from it.

(average of four years)
(Watson 1949)

	Grass		Hay	
	Comp. %DM	Digest. %	Comp. %DM	Digest. %
Fat (Ether Extract)	2.31	53.8	9.93	40.9
Crude Fibre	28.32	63.8	29.63	66.9
Crude Protein	8.15	54.8	8.04	46.8
NFE (carbohydrate)	53.95	72.5	52.99	67.0
Minerals (ash)	7.27	50.5	7.41	43.9
Dry matter	30.8	66.5	86.5	63.2

In general, the digestibility of a conserved forage will nearly always be lower than that of the fresh forage, because of chemical changes and losses that occur during the conservation process. It is known that animals are able to eat much more of leafy hay than a stemmy hay made from older plants. The leafy hay is highly digestible, whereas the stemmy hay is of low digestibility.

For a wide range of feeds, as feed digestibility decrease, the amount of feed that animals are able to eat also decreases. This relationship is most marked with freshly-cut crops and with crops conserved as hay.

As the date of cutting of a given crop is delayed, the feeding value of the resulting conserved crop is lowered. Maturity is often described in terms of the number of days taken the crop to reach 50% ear emergence (in the case of grasses) and so this can be applied to other forage species as well. These relationships have also been extended to indicate the approximate levels of yield and protein content of a wide range of forage species. With this information the farmer can decide the stage of maturity and date of harvesting for each crop, in order to obtain best of yield and feeding value. In legumes the stage at which they are cut for hay is even more important than in grasses, in determining the quality of the hay.

An important factor that determines the feeding value of hay is the leaf-stem ratio or the proportion of leaves in the crop. At very mature stage, the leaves are highly digestible. The decline in digestibility of the crop is due to:

1) a reduction of the proportion of the more digestible tissues.

2) a lowering of the concentration of the more digestible constituents.

3) and a lowering of digestibility by lignification of the fiber.

Leaf : Stem ratio and chemical composition of timothy during growth (Wait and Sastry 1949)

%DM

Sampl-ing date	Ratio Leaf:Stem	C.P (crude protein) Leaf:	Stem	E.X. (fat) Leaf:	Stem	C.F. (crude fibre) Leaf:	Stem	N-F.E. (Carbohdrate) Leaf:	Stem
May	2.57	21.7	14.1	3.8	2.9	19.1	23.5	48.3	43.6
June	0.39	18.5	7.6	4.1	2.6	21.1	32.6	43.3	50.6
July	0.20	11.1	3.4	3.2	1.3	30.6	32.4	46.1	57.9

The carotene is relatively high in young forage and decreases as the plant ages; slow drying with an optimum temperature of about 37^{o}C in the sun, may cause over 80% destruction of carotene. Rapid drying, whether, by natural or artificial means tends to conserve the carotene. Hay is often a poor source of the vitamins because of the more advanced maturity of the forage when it is cut, and because of slow drying and weather hazards.

Factors Affecting the Feeding Value of Hay

1. **Chemical changes and losses during drying**: resulting in losses of valuable nutrients inevitably occur during the drying process. These depend on the speed of drying.

2. **Action of plant enzymes and fermentation**: losses in the soluble carbohydrate fraction and protein occur after cutting and also from fermentation during storage. Such losses are reduced to

minimum by fast drying and storage of hay at proper moisture content.

3. **Oxidation**: the visual effects of this can be in the pigments many of which are destroyed. Carotene is an important compound that is affected and its content can be reduced from 150 - 200 mg/kg DM in the fresh forage to as little as 2 - 20 mg/kg DM in the hay. On the other hand, sunlight has a beneficial effect on vitamin D content of hay.

4. **Leaching**: due to rain and mainly affects the crop after it has been dried. Leaching causes a loss of soluble minerals, sugars and nitrogen constituents, resulting in a relative increase of crude fibre content.

5. **Mechanical damage**: during the drying process the leaves become brittle and shatter very easily, and since the leaves at hay stage are richer in digestible nutrients than the stems, the resultant hay may be of low feeding value.

   Baling the crop in the field at a moisture content of 30 - 40% and subsequent drying by artificial ventilation will reduce mechanical losses considerably.

6. **Action of micro-organisms**: if drying is prolonged because of bad weather conditions, changes brought about by the activity of bacteria and fungi may occur. Moldy hay is unpalatable and may be harmful to farm animals. Recent studies with fungicides such as propionic acid have shown that these may be beneficial in preventing mold growth in hay.

7. **Stage of growth**: this is the most important factor determining the feeding value of the conserved product. The later the date of cutting, the larger will be the yield, but the digestibility, the voluntary intake of dry matter by animals will be progressively reduced. If drying conditions are similar, hays made from early-cut crops will be of higher nutritive value than hays made from mature crops.

The crude protein content of two Vicia species harvested at different stages of growth.

Stage of cutting	Crude protein in dry matter basis %
Vicia sativa	
Beginning of flowering	24.6
Pod formation	22.0
Full pod formation	20.1
Vicia dasycarpa	
pre-flowering	25.6
Beginning of flowering	23.8
Pod formation	22.9

8. **Plant species**: hay made from legumes is generally richer in protein and minerals than grass hay. Lucerne (alfalfa) is a very important legume which can be growth as a hay crop; it may contain a high level of digestible protein and about 14% DM if it is made from a crop cut in early bloom stage.

9. **Effect of drying method:** Alfalfa hay quality in comparision with dehydrated alfalfa is shown in the table below (from Shepered et al 1949)

Method	Chemical Composition			Feed Value
	% DM	% Ash (minerals)	Carotene (ppm)	% TDN
Field drying (rainy weather)	63.4	51.5	0.9	27.9
Field drying (clear weather)	79.0	67.5	3.2	84.5
Dehydration	90.3	85.9	23.5	86.9

SILAGE

Silage is a preserved product resulting from the fermentation of green plant material in the absence of air. It is preserved by the lactic acid produced by bacteria from the sugars contained in the fresh crop, or by direct addition of weak acid solution.

The process of making silage is known as ensiling. Fermentation occurs during the first two or three months; after that, the silage remains practically unchanged for another 12 to 18 months.

Any green forage crop can be made into silage. Natural pastures can be converted into silage, but the fodder value of the silage will depend on the quality of the pasture ensiled.

The advantages of silage are its palatability and its cheapness of production, and the fact that it can be stored for long periods; it can also be made whenever it is convenient for the farmer to do so.

Crops suitable for silage

Silage can be made from any crops grown on the farm. Forage maize is the commonly utilized as silage; other kinds of silage are made from mixture of grasses and legumes and small-grain crops. It is very important to asses the best compromise between crop yield and crop quality to make a high quality silage.

The sugar and protein contents of different crops must be considered as a guide for silage making.

Generally, crops that can be utilized as ay or roughage can be made into silage. Crop residues such as potato tops and beet tops can be ensiled as well.

Crops such as maize, sunflower and sorghum, when grown for silage should be planted at a somewhat higher seed rate than when grown for grain; however, the seeding rate should not be so heavy so as to greatly reduce grain or seed production. A rule of thumb is to use 20% more seed for a silage crop than that normally recommended for a seed crop.

Stage of cutting

Crops for silage should be cut at an optimum stage of growth when the highest amount of digestible nutrient could be obtained. In fact, the stage of growth of the crop at cutting will have more influence on the feeding value of the product than any of the other factors. The amount of digestible nutrient is more important than the amount of green material that can be harvested. The earlier stage of harvesting recommended for hay-making are also recommended for silage making.

How silage is formed

The principle in making silage is to keep the green fodder material tightly packed in an airtight container called a silo. The green material will consume oxygen and liberate heat and water. The crop should be harvested at the right stage of growth and it is preferable to allow the crop to get slightly wilted to reduce the moisture content before ensilage it. The material is chopped up and packed into the silo. The process depends upon the fermentation of soluble carbohydrates present in plant material, to lactic acid; fermentation results in a lowering of the PH to within a range of 3.8 - 4.2 . Well preserved silage has a lactic acid content within the range of 8-12% DM. Success in obtaining an adequate lactic acid concentration, depends basically upon having enough soluble carbohydrate and in maintaining anaerobic conditions. Silage of PH about 4 will normally remain stable as long as the mass is kept under anaerobic conditions; in this stage bacterial activity is stopped and silage is preserved. Poor silage results when three is slow production of lactic acid; this enables unfavorable bacteria to produce butyric acid and destroy proteins to ammonia. Temperature should not be allowed to increase above 35-40^{o}C. With materials wilted to 40-50% DM, it is difficult to achieve anaerobic conditions unless the storage containers are of the talltower type.

Steps in silage making

The following points are important in making good quality silage:

1. Cut the crop at the optimum stage of growth.

2. Forage that is wet should not be used. The wilting of the forage for 2-3 hours in sunshine before ensiling, will result in a better silage than that which is not wilted.

3. Achieve, if possible, a minimum crop dry-matter content of 25%. With crops of high protein content, the use of molasses is recommended to give an insurance against wrong types of fermentation.

4. Ensure that the crop coming into silo is chopped to the correct length.

5. Fill the silo by a method that prevents air movement, heating and oxidation.

6. During packing, additives are added when necessary, to each layer of material.

7. When the silo is full, it is covered by a plastic sheet kept in place by old tyres or a layer of soil.

Harvesting silage crops

As a general rule, crops for silage can be more profitably harvested by the use of machines specially made for this purpose. The forage harvester cuts and chops the forage in one operation. Otherwise the forage is mown, windrowed then chopped by a field chopper or hauled to a stationary chopper.

Chopping

Silage crop are usually chopped up into fairly small pieces for making silage. The pieces will usually vary in length from 0.6 to 1.3 cm (1/4 to 1/2 inch) if moisture is below 70% and 2 to 2.5cm (3/4 to 1 inch) for more moist forage. Chopping permits good packing of the material.

Dry matter content

Increasing the dry-matter content of silage is an important factor in making silage, and high dry matter content must be achieved at all costs before ensiling the crop. The recommended moisture level for good silage formation is 65-75% (25-35%DM).

Silage crops should be permitted to mature in the field or wilted to this moisture level before harvesting and/or packing. Silage materials containing below 25% DM will form a very sour silage that will normally lose considerable amounts of silage juices during storage; a considerable loss of nutrients can occur in this way. Silage materials with less than 25% DM do not pack well and will frequently develop mold during storage as a result of the excess amount of oxygen, which has been trapped in the chopped material.

Silage additives

1) **Carbohydrates:**

Corn, sorghum and sunflower contain enough carbohydrates for fermentation. Forage legumes and grasses are lower in carbohydrates and require the addition of readily fermentable carbohydrates to make them into good silage. If the forages are allowed to wilt such that their moisture content is 65 - 70%, no carbohydrate additives are needed. Carbohydrate source are molasses or ground grain. Molasses is added at a rate of 9-14kg/t and grain at 35-40 kg/t of grass forage; for legumes the corresponding rates are 14-18 kg/t for molasses and 70-90 kg/t for grains.

2) **Chemical additives:**

As ensilage involves chemical changes it should be possible to improve the process by the addition of chemicals.

a) formic acids - average optimum application rate 0.3 - 0.4% of fresh crop may be added during the packing and increasing to 0.8% with very wet crops e.g. clovers. This addition reduces the PH of the cut crop below 5.0 and lactic acid fermentation takes place as long as air is kept out of the silo. Formic acid is likely to improve the feeding value by increasing dry matter. A mixture of formic acid and propionic acids at 0.6% can also be used.

b) Additives based on formaldehyde and formic acid prevents protein breakdown, because the PH of the crop is rapidly reduced below the level at which the undesirable bacteria and molds can operate. The intake of this silage although higher than that made without additives is lower than the intake of the fresh crop. This is because the silage (low PH) contains a lot of acid.

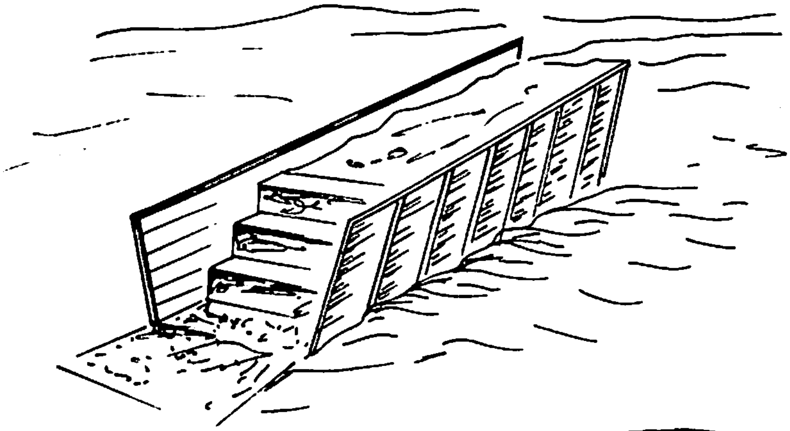
This has led to the examination of chemical additives which will preserve the crop at a high PH, but at the same time prevent protein breakdown. Formaldehyde is one such a chemical; addition of 2 gallons of formalin to each ton of wet crop (18%DM) will give efficient preservation at a PH of about 5.5 . The formaldehyde rapidly kills most of bacteria and molds present in the crop and at the same time it combines with the protein and prevents its decomposition.

c) Sodium Metabisulfite. In the U.S. silage is preserved by the addition of sodium metabisulfite at the rate of 3.6 kg/t of forage.

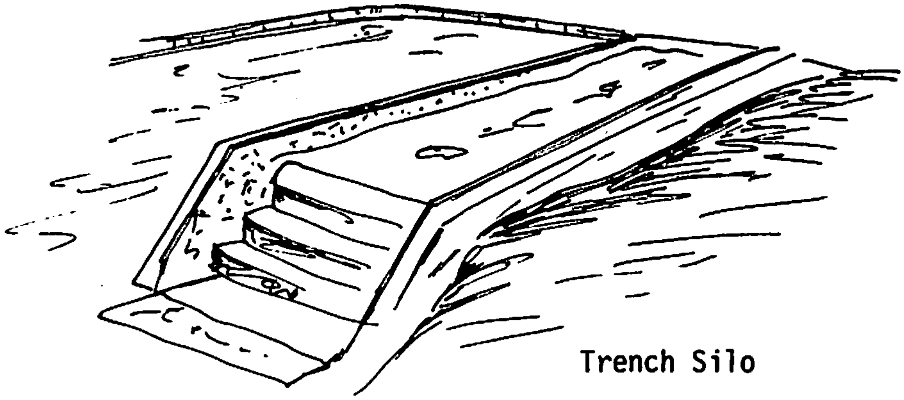
Silos

Silos are of different types including tower, pit, trench and bunker silos. The most popular silo in developing countries are the bunker and trench types. The bunker is erected above ground and the trench is dug underground.

Both should have walls slopping to the outside. The walls of the trench silo may be lined with cement or plastic.



Box Silo

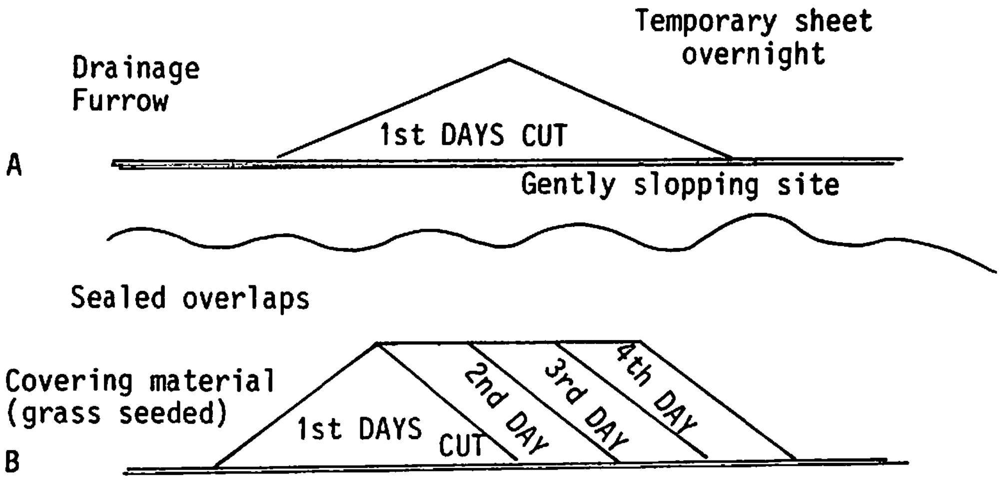


Trench Silo

DORSET WEDGE SILAGE

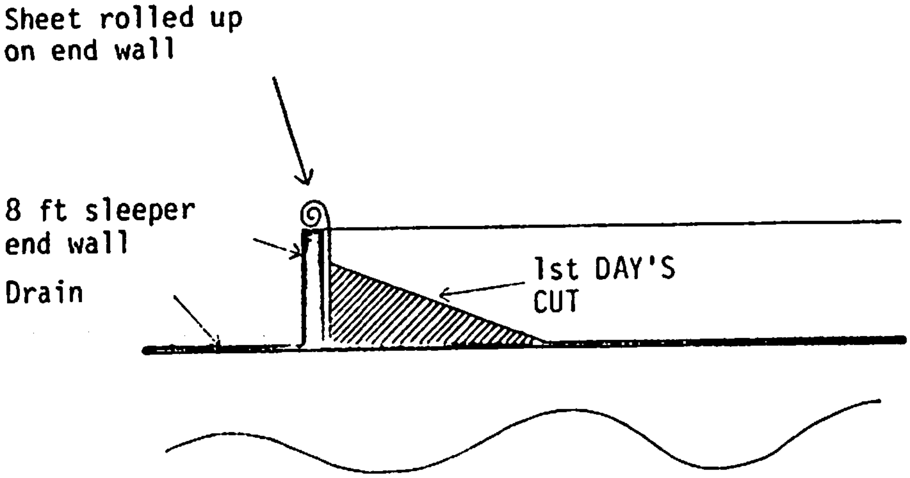
OUTDOOR UNWALLED SILO -

20° SLOPE SIDES AND ENDS



Stages in filling an outdoor sealed wedge silo

MAKING SILABE IN BUNKERS AND CLAMPS



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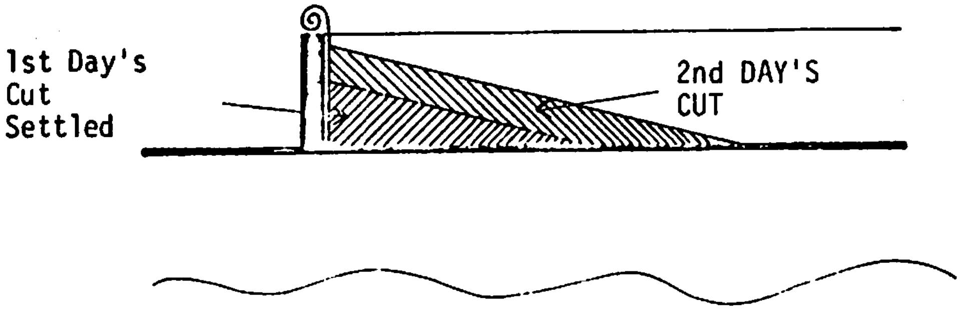

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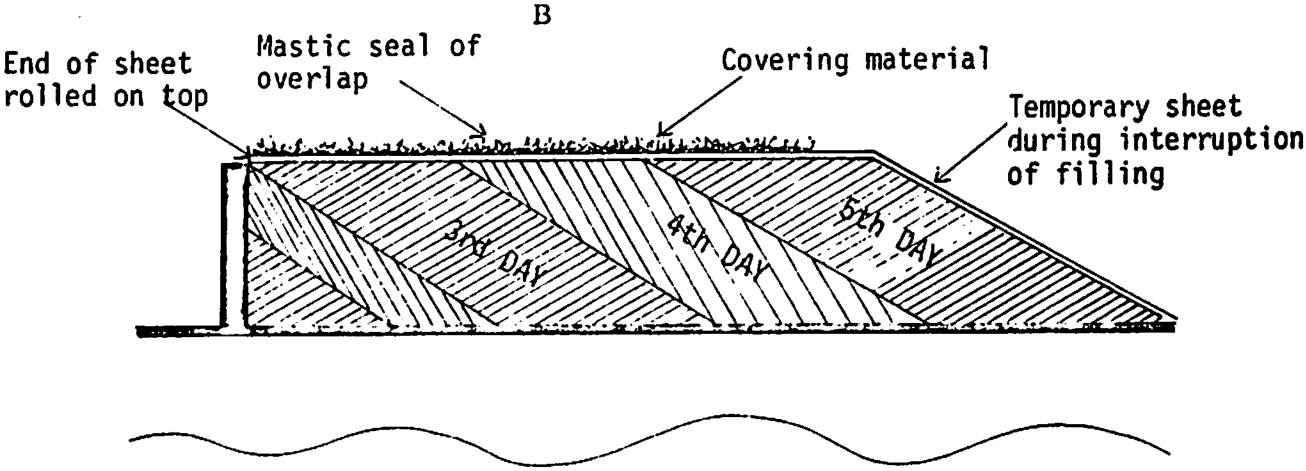

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Stages in filling a bunker silo by the Dorset Wedge method.

Silage quality

Good quality silage should

1) have good odor and a yellowish green color.
2) have no mold growth.
3) maintain a good part of the nutritive value of the green forage.

Nutritive value of silage

The nutritive value of silage is evaluated in terms of energy, crude protein content, digestibility and acceptability by the animals; it varies with forage species, stage of maturity at time of harvesting and moisture content at time of ensiling. Therefore, harvesting at the optimum stage of forage growth is important.

The composition of finished silage approximates that of the fresh material except in being lower in carbohydrate (nitrogen free extract NFE) and higher in crude fibre and ash. The moisture content of forage when it is ensiled influences the quality of the silage, because moisture affects the type of fermentation that take place. Wilting the forage to a moisture content of 60% to 70% is very effective in reducing losses.

Figures in the table below show the nutritive value of the silage made from sunflower, corn and sweet-clover in comparision with the nutritive value of these crops at the freshly cut green stage.

In general it is known that the nutritive value of the silage will not differ much from that of the original crop when ensiling has been good.

Crop and Silage	Moisture %	Crude protein %	Fat %	Crude fibre %	Carbo-hydrate %
Corn(glazed stage)	62.9	8.1	2.9	16.8	67.0
Corn silage	69.5	8.3	2.8	22.5	59.4
Sweetclover (bud stage)	65.2	21.2	2.0	29.6	38.0
Sweetclover(silage)	65.2	21.5	3.3	35.7	29.8
Sunflower	78.6	9.3	1.5	30.3	49.0
Sunflower(sliage)	73.8	10.2	2.8	32.6	44.5

It is known from animal digestibility trials that the digestibility of well made silage is almost exactly the same as that of the forage from which it was made, and also the crude protein content of silage is similar to that in the green crop.

Digestibility and protein content are two factors determining the feeding value of silage. In practical feeding, the voluntary intake is important. It has been shown that the voluntary intake of many silage is lower than the intake of hay made from the same crop. This is most marked with wet silages, particularly those containing butyric acid and product of protein breakdown.

In general it has been found that animals will eat more of the silage made from a wilted crop than that made from the same crop if it is ensiled without wilting. Forage crop silage (such as legumes, grasses ... etc.) is lower in total digestible nutrients than corn silage with same amount of dry matter, but they are higher in protein, minerals and carotene. However forage silage (grass, maize, sorghum, etc.) is an excellent feed.

Medicago sativa forage is rich in nitrogen and it can be fed either fresh or wilted, it makes excellent hay and silage, it is a valuable source of calcium, vitamin A and carotene.

The composition of silage made from different crops are shown in table below.

The chemical composition of sliage from different crops
(Lander 1949)

	Berseem		Red Clover		Sorghum & Cowpea	
	Chemical Comp.	Digestible Nutrient	Chemical Comp.	Digestible Nutrient	Chemical Comp.	Digestible Nutrient
	%	%	%	%	%	%
Moisture	76.0	-	75.6	-	67.7	-
Crude protein	2.3	81	3.9	51	2.4	54
Ether Extract(fat)	0.6	47	1.3	62	1.0	58
Crude fibre	9.6	52	6.7	49	8.5	49
Calcium			0.59	-		-
Phosphorus			0.16	-		-
Total Dig. Nut.		10.3		13.4		10.5

Factors affecting the nutritive value of silage

The nutritive value of silage is influenced by three main factors:

a- chemical changes occuring within the mass of material being ensiled.

b- the nature of the crop ensiled.

c- the degree of effeciency in silage production.

a) **Chemical changes**

These are brought about by action of plant enzymes micro-organisms present on the crop. Sugars are oxidised and the production of heat can result in the production of overheated silage which is usually dark brown or black in colour. This will be of low feeding value because of an exessive loss of soluble carbohydrate and lowering of the protein digestibility. Protein is rapidly broken down and within 24 hours about 16% is degraded to simpler substances mainly amino acids; during ensilage about 60% of the protein is broken down even in well preserved material. Fresh crops contain bacteria on their surfaces and these organisms multiply using the contents of the plant cells as a medium. As a result of this activity, many chemical components of the crop are broken down. The obvious changes in the silage is in the colour of the crop and the large amount of carotene vitamins and minerals which can be lost. As a result of these chemical changes and losses caused by a breakdown of soluble and higher digestible nutrients, grass are produced. It follows therefore, that the higher the gaseous loss, the lower will be the feeding value of the silage.

b) Nature of crop

The species, stage of growth, physical state and moisture content of the crop ensiled are important factors affecting the nutritive value of the silage. The physical nature of the crop at the time of ensiling is an important factor in the fermentation process and chopping tends to produced more favourable conditions for micro-organism activities.

c) Effluent production

In many silos, the liquid or effluent produced during fermentation carries with it soluble nutrients. The amount of effluent produced largely upon the initial moisture content of the crop, but it is increased if the silo is left partly uncovered so that rain enters. The effluent contains sugars, soluble nitrogenous compounds, minerals and organic acids produced during fermentation. These nutrients are all highly digestible and are of high nutritive value to the animals.

Advantages of making and feeding silage

1. Silage can be made all the year round.

2. The crop can be harvested and stored cheaply when it has the greatest feeding value.

3. Less waste results when crops are put in the silo than when they are handled in the dry state.

4. Silage requires less space for storage.

5. Silage provides a feed which is avaliable at all times of the year.

One disadvantage of feeding silage is that more labour is needed, adding to the cost of feeding farm animals. Silage can seldom be used as the sole ration for livestock.

Artificial Grass Drying

The principle of artificial grass-drying is to evaporate of the water present in the fresh grass and to prevent losses that take place during the natural sun drying of grasses. Normally, younger and high-digestibility crops are dried. However, since the total costs involved are high, it is essential that only crops that have high quality should be selected for conservation in this way. The water which must be removed is known as the 'drying load' and can be expressed in terms of tons of water per ton of crop.

The crops is moved and then wilted to reduce drying load. This can be done either in the field or by application of some form of mechanical extraction technique. Gains in terms of drying load must be offset against any respiration and mechanical loss of crop during the swath wilting; these losses are often between 5 and 10%. If mechanical extraction of water by the application of pressure is used, 10% - 15% of the most valuable part of the dry matter may be extruded in the juice; attempts must be made to utilize this juice.

The temperature of the drier and rate of drying depend mainly on the stage of growth; in mature grass the rate of drying is likely to be slower than that or very young grasses, because leaves dry more rapidly than stems, and the temperature should be reduced in order to avoid loses.

Equipment

Driers: the drier is the most expensive single item where equipments are concerned and success will depend on its operational efficiency. There are two types of drier:

A. **High temperature driers:**

The driers of this type are much smaller than low-temperature driers of similar evaporative capacity.

The crop, which must be chopped, is carried through the drum in the hot airstream; as the crop passes from the inlet to the exhaust end it is separated into light (dry) and heavy (wet) fractions. Leaves are dried rapidly (about 20 seconds) and then pass out of the drum into the collecting cyclone, the wet and heavy stems fall through the airstream and are carried around with the rotation of the drum as they move slowly until they are dry enough to be collected by the cyclone. The rate of feed of the crop into drier is regulated by a feeder conveyor, whose speed is controlled by the exhaust temperature. In this way grass of higher moisture content is fed in at slower rate. Stones and metal are usually removed by a stone trap and magnet.

B. **Medium temperature driers:**

It acts as continuous - flow drier, and the inlet temperature is around 150^{o}C. The grass is carried on a conveyor through which the heated air is blown. The time required for drying will vary from 20 minutes to nearly an hour depending on the drier design and the moisture content of the crop. The main advantage of this drier is that it can be used to dry grain as well as grass without much modification.

Processing equipment:

The dried grass from the rotary valve passes through the hammer mills to the pelleting press, pellets are of 0.9 - 1.3 cm (3/8 - 1/2 in) diameter, and molasses or steam can be applied to improve pellet stability. The product is suited for bulk storage and handling.

This kind of dried grass is rich in protein, carotene and xanthophyl, because this processing prevents the decline in quality during storage and mechanical handling.

Packaging;

Three basic types of packaging have been developed:

1) Wafers, in which the chopped dried grass is compressed and which retains a good proportion of long pieces of dried grass in the packages. The wafers are considered to be suitable for dairy cows.

   Some wastages can occur during processing and feeding. In general sufficient amount of hay, silage or straw must be fed with dried - grass wafers to keep up butterfat at its required level.

2) Pellets are produced by compressing milled dried grass in a rotary - die press. This is the commonest form of packaging. Pellets are more satisfactory for storage and handling. The small particle size of dried grass pellets is on ideal component in mixed rations.

3) Cobs, produced by compressing chopped dried grass in a rotary die press; the particles size of cobs is intermediate between those in wafers and pellets. The cobs can be produced in several types of rotary press in which rollers force the dried grass through holes in a fixed horizontal die. Diameter of the cobs (and pellets) can be from 1.27 to 3.8cm (1/2 to 1 2/2 in). In feeding trials it has been shown that diameter of 1.27 to 1.9 cm are preferred ley livestock. Whichever type of press is installed, its capacity must be sufficient to deal with the maximum rate of output from the drier.

All types of package must be thoroughly cooled to prevent 'sweating' and molding in storage; this can be done in a vantilated trials, or in a horizontal cooler, either of which must be as near as possible to the press as the cobs and pellets can be easily damaged by improper handling.

Harvesting grass for drying

The problems of mowing grass for drying are much the same as for hay making and silage. The main problems are weather conditions, system of harvesting, handling, drying and transportation.

Grass cut directly and loaded will contain over 80% of moisture, except during very dry weather. Field wilting is needed to reduced moisture content, and this can substantially complicate the organisation and management of the harvesting operation. For the smaller size of drier, a well-organized harvesting system is needed.

The feeding value of dried grass

Artificial drying, if carried out properly has very little effect upon the nutritive value of the crop. This can be seen from the results presented in the table below. The dry matter losses from mechanical handling and drying together are not likely to exceed 10%.

The nutritive value of artificailly dried grass depends upon the composition of the original fresh crop, and such factors as stage of growth, species ...... etc.

The drying process is known to destroy most of the vitamin C in grass, but farm animals have little or no requirement for this vitamin hence this loss is of no practical importance.

The composition and digestibility of fresh and artificially dried grass (Watson 1949)

	Low protein grass				High protein grass			
	Fresh		Artificially dried		Fresh		Artificially dried	
	Comp. %DM	dig. %DM	Comp. %DM	dig. %DM	Comp. %DM	dig. %DM	Comp. %DM	dig. %DM
Fat	2.11	55.9	2.40	55.4	2.09	38.9	2.79	53.1
Crude fibre	30.43	70.3	28.20	72.3	21.95	80.4	21.92	78.1
Crude protein	10.62	63.1	10.86	56.1	17.58	77.6	17.83	72.6
NFE (carbohydrate)	47.55	69.6	49.27	70.6	44.86	77.5	45.92	77.0
DM	21.10	66.6	90.30	67.3	17.21	74.4	86.42	72.3

The loss of carotene during drying rarely exceeds 10%, but loss of this provitamin is likely to occur during the storage of dried grass, especially if exposed to light and air. The vitamine D content of dried grass is very low.

Dried grass made from young herbage is a valuable product in the diet of farm animals since it provides a green food rich in carotene, protein and digestible energy.

In the U.S.A. considerable amounts of alfalfa are artificially dried and sold as a high vitamin feed supplement for broilers.

As a general statement it can be said that the artificail drying of grass does not appear to affect its feeding value.

TREATING STRAW FOR INCREASING FEEDING VALUE

Straws consist of the stems and leaves of plants after removal of the ripe seeds, and are produced from most cereal crops and from some legume crops as well. These products are extremely fibrous, high in lignin and are very low in feeding value.

The plant cells consist of the cell wall and cell content. The cell wall is composed principally of cellulose and hemi-cellulose and an indigestible noncarbohydrate fraction (lignin). The high lignin content of straw protects the cellulose, the hemicellulose and the cell content from fermentation and digestion in the ruminant animals. The main object of chemical treatment of straw is to change the chemical structure of the cell wall by making the lignin soluble and removing it by washing with water. So the treatment is to increase the digestibility of straw and hence the amount of it voluntarily consumed so that digestible energy intake by animals from straw is increased.

Chemical composition and feeding value of straw

During the ripening process nutrients in the plants are transferred from the stems and leaves to the grains, so that the composition of the straw to a large extent, depends upon the degree of grain ripeness at the time of cutting. The stem is very variable in composition, the lower parts being more fibrous and poorer in feeding value than the upper portions. If a barley crop is cut when the grain is ripe, then the straw is of poor feeding value. Disadvantages in feeding straw to ruminant animals are the low voluntary intake and the low digestibility. Bacterial degradation of straw is limited by the lignin content and the low nitrogen content. The straws of beans and peas are richer in protein, calcium and magnesium that the cereal straw, and if properly harvested, they can be useful roughage feeds for ruminant animals.

In the table below the cellulose, hemicellulose, lignin content and dry matter digestibility of different straws grown in SYRIA are presented.

Chemical composition and dry matter digestibility of straw (Rihawi 1976)

Straws	DM %	Min.* %	Crude Pro.** %	Crude Fibre %	Fat %	NFE %	Cal. %	Phos-phorus %	DMD***
Wheat straw	92.23	7.10	2.99	36.07	1.23	52.60	0.16	0.08	49.62
Barley "	91.01	8.20	2.45	32.29	1.00	56.05	0.31	0.09	51.34
Lentil "	91.19	6.99	4.50	32.15	1.04	55.32	0.42	0.10	51.11
French bean straw	92.48	5.62	4.62	38.17	1.18	50.10	0.38	0.09	50.05

Min.* = Mineral
Pro.** = Protein
DMD*** = Dry Matter Digestibility.

Organic matter digestibility of straw can be increased by the addition of nitrogen in the form of either protein or urea: straw can also be increased by treatment with sodium hydroxide or calcium hydroxide or by biological treatment.

The digestibility of treated straw can be depressed if it is fed in diets with more than about 30% concentrates, as is the digestibility of all roughages.

Methods used for straw treatment

The objective of straw treatment is to increase digestibility and/or voluntary intake. Treated straw can replace hay or silage in the diet. An increase in the digestibility by 10-20 units depends upon the method used. These methods can be grouped into:

1. **Physical methods**

   a) Grinding
   b) Pressure cooking

The grinding of straw appears to increase voluntary intake and weight gain of animals. The grinding of straw seems to give much less improvement in feeding value than alkali treatment. In general terms, grinding does not increase digestibility organic matter intake by more than about 30%, whereas alkali treatment increases it by up to 80%.

The effect of milling and alkali treatment of barley straw on digestibility and intake by sheep. (FAO animal production and health paper 10).

Chopped straw	Untreated straw	Treated straw
Organic-matter digestibility,%	45	61
Dry-matter intake, g/kg $W^{0.75}$	27	48
Digestibile energy intake, K cal/1g $W^{0.75}$	46	114
Milled straw		
Organic-matter digestibility, %	45	64
Dry-matter intake, g/kg $W^{0.74}$	36	54
Digestibility energy intake, K cal/kg $W^{0.75}$	60	132

2. Chemical method

a) using NaOH (sodium hydroxide)

b) using Ca $(OH)_2$ (Calcium hydroxide)

c) using urea

The chemical methods can be separated into wet methods and dry methods.

i) **Wet methods:**

In the Beckman method, the straw is soaked in diluted sodium hydroxide (NaOH) solution (1.5%) for 18 hours. After treatment, the sodium hydroxide is washed out for 18 hours after which the treated straw is drained. The straw is then ready to be fed. The Beckman treatment may also be done manually on farms.

The advantage of the Beckman method is that it gives a finished product of high digestibility. The disadvantage of the Beckman method are, of course, the high water requirement, dry-matter loss and pollution.

Several experiments have been done to compare the use of $Ca(OH)_2$ (calcium hydroxide) and NaOH for treatment of straw by Beckman method; it was found that $Ca(OH)_2$ is less effective in increasing digestibility. The most immediate problem with the Beckman method was resolved by using a closed system in which the amount of water added to the system is equal to the amount removed in the treated straw.

ii) **Dry method**

The improvement in this method is that the treated straw is not washed. The level of NaOH used is about 5 kg/100kg straw. The benefit of this method by the use of a high alkali: straw ratio is that it results on a large increase in digestibility.

An important advantage of the dry method is that it can be industrialised, whereas the wet methods can only be used on a farm. The health of livestock fed on dry treated straw is not affected if the diet contains less than 4% of NaOH on a dry matter basis. Mixture of 1kg. $Ca(OH)_2$ and 3 kg NaOH when used to treat 100 kg. have been found to be superior to other treatments.

iii) Using Urea

Urea mixed with straw at a rate of 2% and pelleted at 150^{o}C, has been found to be inferior to NaOH treatment. It is found that the amount of nitrogen in the diet affects the degree of improvement in digestibility that occurs as a result of alkali treatment. So urea supplementation of straw affects the alkali t treatment, and results in increased digesitibilty and voluntary intake. The maximum digestibility for treated straw bas been obtained when 1.2-1.8% urea is added; the digestibility of untreated straw, on the other hand, does not increase with addition of urea.

Farm scale-treatment

Farm-scale treatment methods are those that can be used on the farm. They are simple and equipment costs are low.

1. Daily treatment and direct feeding

Dry straw is sprayed with a dilute NaOH solution; the straw can be fed the day after it is treated as digestibility increase with time over the first 24 hours. If a pressure sprayer is used the volume of solution used would be reduced.

This method is the simplest of all the farm scale methods, but is unfortunately the least efficient. The straw treated by this method is moist, has a pleasing yellow colour and animals eat it readily.

The use of $Ca(OH)_2$ in treating straw has always been of interest, because it is cheaper than other alkalies. Straw treated with $Ca(OH)_2$ has consistently been found to be inferior to HaOH treated material. A newer method has been developed by treating the straw with alkali solution followed with an acid solution in a specially designed apparatus.

A considerable number of experiments with ammonia treatment has been done. Anhydrous ammonia is circulated by a fan in an insulated tank and the heat produced by the chemical reaction of the ammonia with the straw increases the digestibility. A five day treatment period has been found to give an increase in digestibility of barley straw of 15 units.

2. Bulk treatment followed by stacking

On many farms there may be reasons why the bulk treatment of straw for a whole season or for a month is more attractive than daily treatment.

The bales are shredded, a concentrated NaOH solution (usually 27%) is sprayed (5 kg NaOH/100 kg straw) and then the straw passes through a long mixing chamber in which the straw is squeezed or rubbed to facilitate the penetration of the NaOH.

The temperature rises during the first 3 days and then declines. As a result of this heating, moisture evaporates leaving the straw dry enough to be stored providing the inital moisture content does not exceed 17%. The stack must be placed in such a position so that at least one side and at the top in order to ensure adequate drying.

The straw treated by this method is dry, and has an attractive colour and smells slightly of NaOH. The digestibility is increased.

3. Bulk treatment followed by ensiling

Straw which has been spray - treated with NaOH solution and then ensiled can be stored for up to on e year. There is no microbial fermentation and the straw remains stable due to its high pH. Treated ensiled-straw has given very good results in several animal production trials.

$Ca(OH)_2$ can also be used followed by ensiling for 90 days.

4. Bulk treatment with ammonia in stacks

Ammonia treatment of straw has a advantage over NaOH treatment. There is an increase in the nitrogen content and no residual alkali. The stack of straw bales is made on ground sheet of polyethylene and covered by plastic cover, and the ammonia pipe inserted into the stack. The NH_3 is added at the rate of 3.5 kg/100 kg straw. After with-drawing the delivery pipe, the side is quickly closed. In warmer climates the maximum increase in digestibility is achieved in about 4 weeks. The stack must be aerated for a day after opening before the straw is fed to animals.

The maximum increase in digestibility occurs at about 3 kg NH_3/100 kg straw.

5. Biological treatment

The advantage of biological treatment over chemical treatment is that there is no need to use expensive chemicals which could also be a source of pollution.

Successful biological treatment must be based upon the use of organisms which degrade only lignin. White-rot fungidegrade more lignin than they do cellulose. The degree of improvement is highly correlated with the amount of lignin removed. Several methods have been developed for producing single - cell organisms which will use straw as an energy source e.g. yeast. The yeast then is dried and fed to cattle or sheep. It has a crude protein content of 7-10% and digestibility of about 47%.

The effect of alkali treatment on the digestibility of straw

The increase in digestibility that can be obtained by alkali treatment depends on the reaction which causes a change in the chemical structure of the cell wall. The lignin is rendered soluble and can be removed by washing with water. The carbohydrates in the cell wall and cell contents, which remain are highly digestible.

The feeding value of treated straw

In many of the feeding experiments conducted to examine the feeding value of treated straw, it is found that the initial digestibility of straw depending upon the method used.

Treated straw can replace hay or silage if the diet of the difference in protein content are corrected by supplementing the feed with an oil meal supplement, such as cotton seed meal, sunflower meal .... etc.

Treated ensiled-straw has given very good results in several production trials, the treated straw is dry, has an attractive golden colour and treatment can increase the intake of straw from 5.5 kg to 7.6 kg.

Treatment straw varies widely in digestibility, and this variability is as much as that encountered in hay and silage. For efficient utilization, farmers will have to be advised individually on the use of treated straw; i.e. the digestibility of individual lots of treated straw will have to be determined to assess the quality of the straw.

VARIOUS METHODS OF STRAW TREATMENT

1. Using NaOH (caustic soda)

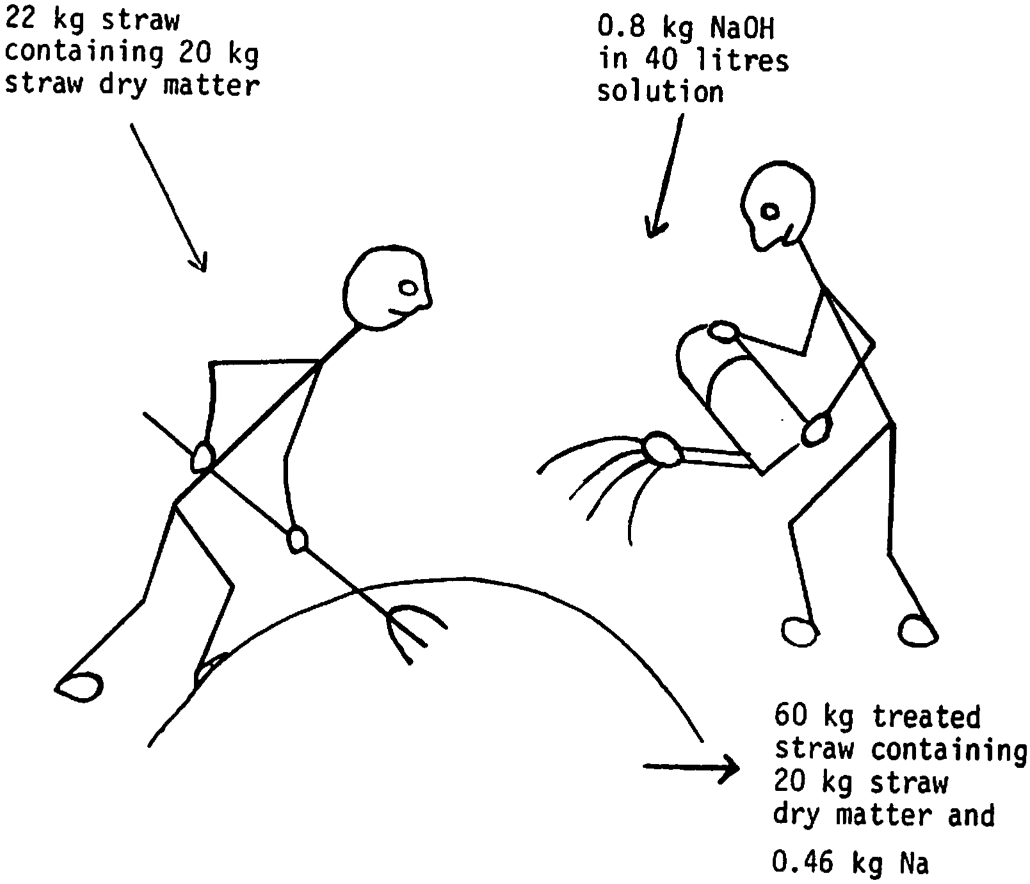
   a) Spray method (daily)
   b) Soaking method (daily)
   c) Spray method (stacking)
   d) Industrial process (spray method + pelleting)

2. Using $Ca(OH)_2$ (unslaked lime - CaO)

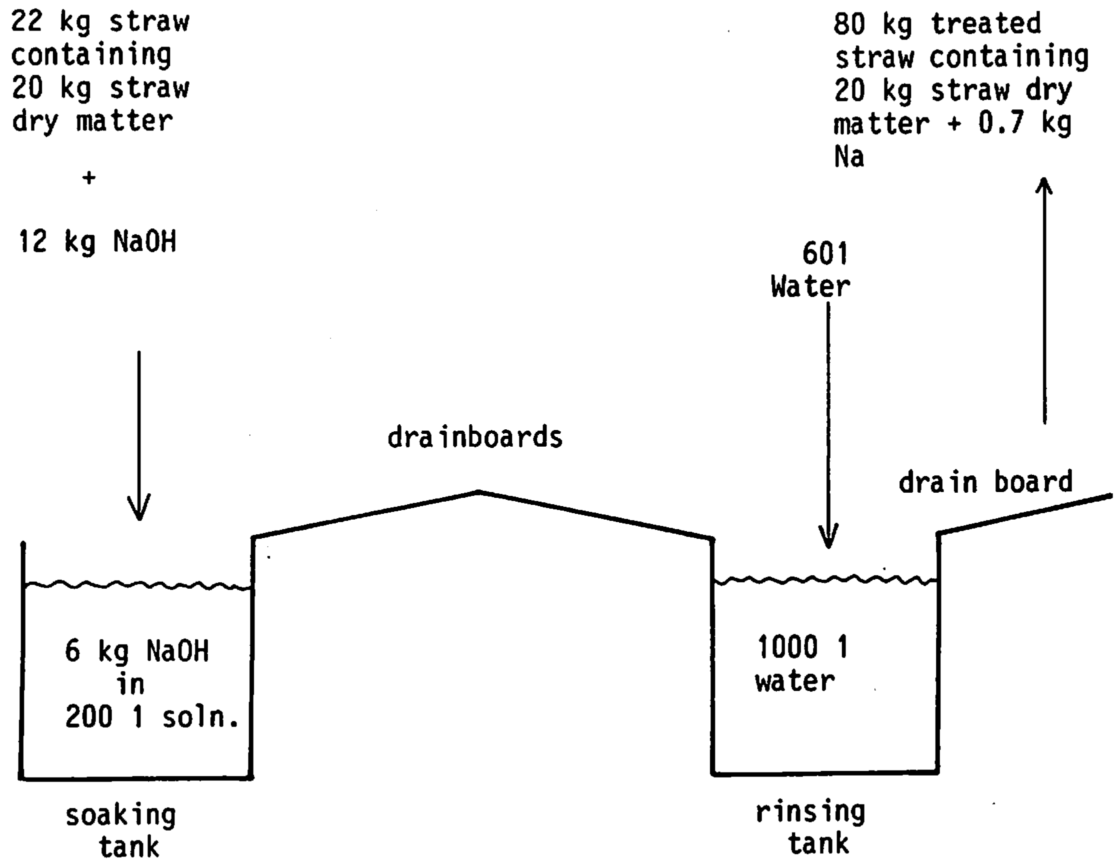
   a) Soaking method (daily)
   b) Spray method (ensiling)

3. Using Urea (to give NH_3)

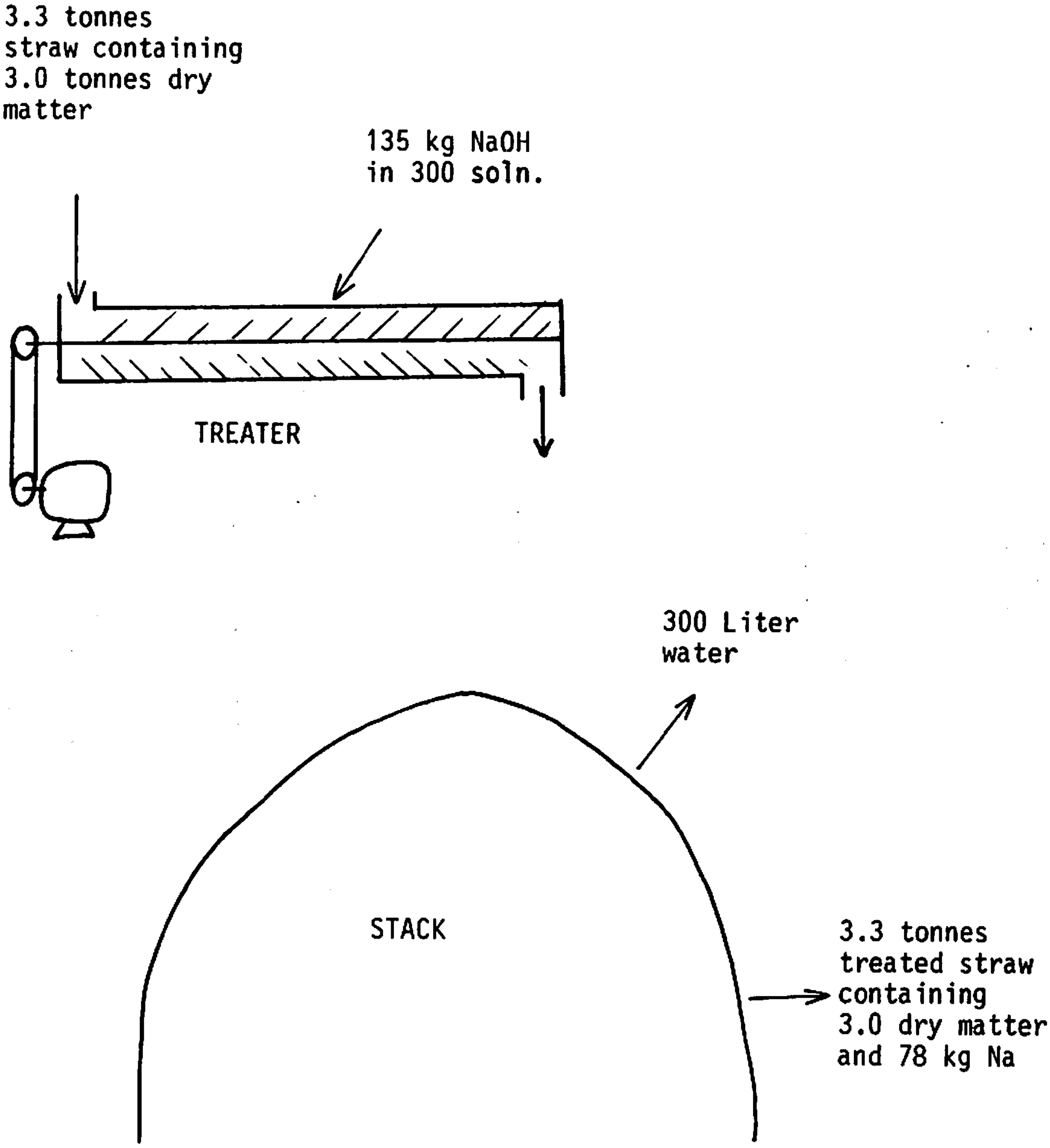
   a) Spray method (ensiling)



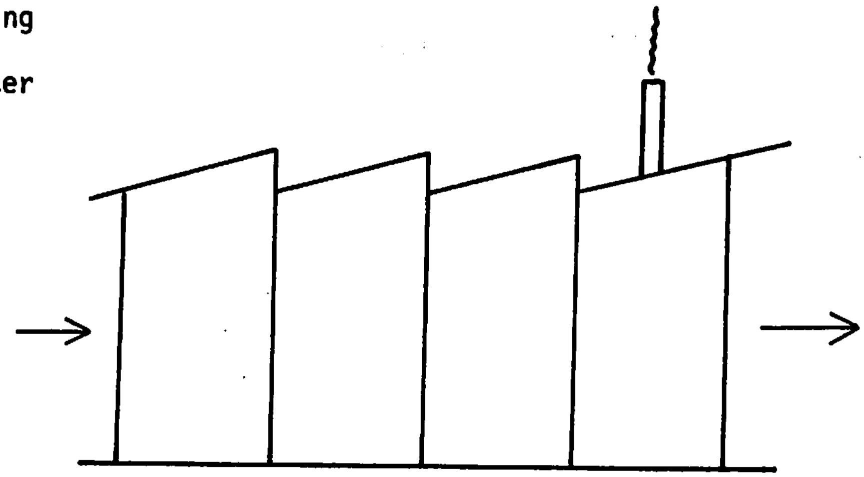
SPRAY METHOD



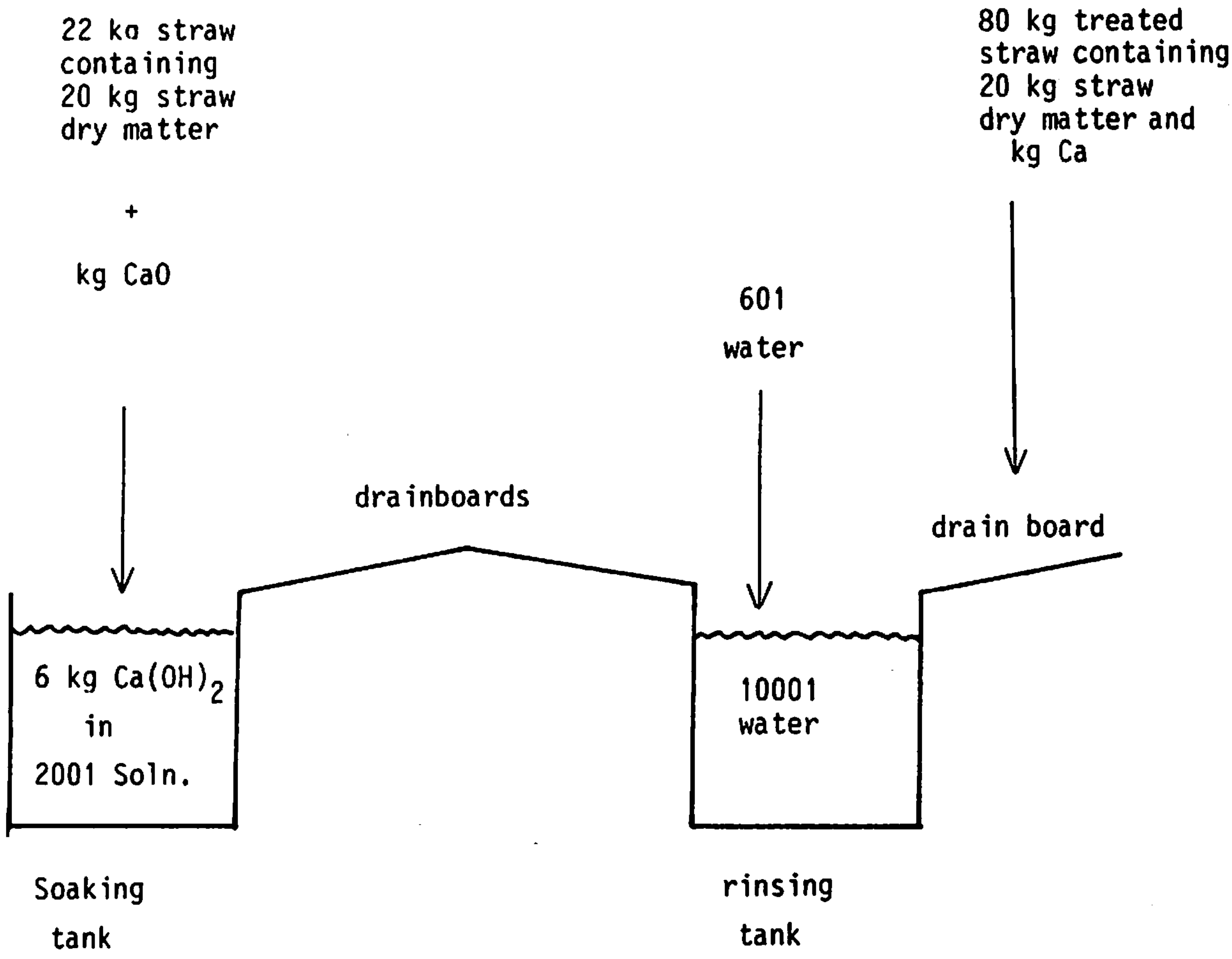
SOAKING METHOD - NaOH



SPRAY TREATMENT AND STACKING METHOD



INDUSTRIAL PROCESS (Spray method and pelleting)



SOAKING METHOD - $Ca(OH)_2$

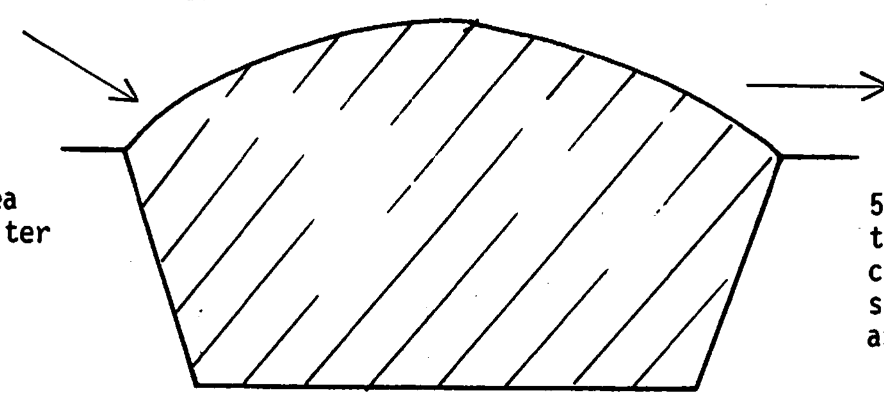
3.3 tonnes straw
containing 3.0 tonnes
straw dry matter

+

90 kg CaO in 3000 liter

Or

120 kg urea
in 2000 liter
soln



6 tonnes
treated straw
containing 3 tonnes
straw dry matter
and 64 kg Ca

Or

5 tonnes
treated straw
containing 3 tonnes
straw dry matter
and 30 kg N

SPRAY METHOD (ensiling)

Note: Urea NH_3

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