

FEED PRESERVATION

Nutrition course, 2nd year Veterinarian

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MCA- UNIV. MEDEA, 2025-20226

- **7. Fourrages et méthodes de conservation.**

- 1. Les foins: Technique d'obtention, composition, valeur alimentaire, utilisation.
- 2. La paille : technique d'obtention, composition, valeur alimentaire, utilisation.
- 3. Les ensilages : Technique d'obtention, composition, valeur alimentaire, utilisation.
- 4. Les racines et tubercules :
 - - Origine botanique, valeur alimentaire, utilisation
- 5. Les prairies :
 - - permanentes
 - - temporaires et artificielles
 - - valeur alimentaire de l'herbe.

Introduction: Forages and conservation methods

- Forage conservation is essential to ensure livestock feed during periods when grass is no longer growing (dry season or winter).
- Here are the three main methods used, classified by their method of preservation.n :

Introduction Hay (Dry)

- This is the most traditional method, based on natural dehydration in the sun.
- Objective: Achieve a Dry Matter (DM) content of 80 to 85% (i.e. less than 15-20% moisture).
- Advantages: Easy storage, light transport, no fermentation needed.
- Disadvantages: Very dependent on the weather (requires 3 to 5 days of good weather); Risk of loss of nutritious leaves during tedding.

Introduction: Silage (wet)

- This technique is based on lactic fermentation in an anaerobic environment (without air) to acidify the forage and stabilize it.
- Objective: A DM level of between 30 and 35% for the grass (up to 65-75% total moisture at the time of compaction).
- Key process: Rigorous compaction and hermetic sealing of the silo (tarpaulin) are crucial to drive out oxygen.
- Advantages: Less dependent on the weather than hay; Excellent preservation of energy and protein values.

Introduction Wrapping (semi-wet way)

- An intermediate method between hay and silage, often called "haylage".
- Objective: A DM rate between 45 and 55%.
- Technique: The bales are pre-faded and then wrapped in several layers of waterproof plastic film to induce a slight fermentation.
- Advantages: Harvesting flexibility (faster construction than a silo) and high nutritional value.
- Cons: Higher cost due to plastic and risk of puncture by animals or tools.

7.1. Hay: Breeding technique, composition, nutritional value, use.

- Hay is a dry forage, the quality of which depends crucially on the control of the harvest stages and the maturity of the plants.
- 1. Technique of obtaining (Haymaking)
- The goal is to reduce the humidity of the grass from 75-80% to less than 20%.
- Mowing: Carried out at the optimal stage (beginning of heading for grasses) to balance yield and quality.
- Twilding: Consists of turning and aerating the grass to speed up drying in the sun.
- Swathing: Putting dry forage in rows to facilitate collection.
- Pressing: Packaging in bales (round or square) once the dry matter has > 80-85%.
- Storage: Must be done away from moisture to avoid fermentations and Maillard reactions that degrade proteins.

- 2. Composition

- The composition varies according to the species (grasses, legumes) and the stage of harvest:

- Organic Matter: Consisting mainly of cellulose, hemicellulose and lignin (NDF/ADF fibers).

- Fiber: Crude fiber content typically exceeds 30%.

- Protein (MAT): Higher in legumes such as alfalfa (17-19%) than in grasses.

- Minerals: Rich in calcium (especially legumes) and potassium.

- 3. Food Value

- It is measured by energy, protein, and ingestibility:

- Energy: expressed in forage units (UF). Good hay varies between 0.75 and 0.90 UFL/kg DM.

- Proteins: Expressed as PDI (Digestible Proteins in the Intestine). Early hay

- Proteins: Expressed as PDI (Digestible Proteins in the Intestine). Early hay dried in a barn can reach 13-14% MAT, while late hay will be very fibrous and not very digestible.
- Digestibility: Varies from 50 to 77% depending on the maturity of the plant at the time of cutting.
- 4. Use
- Hay is the basis of the winter ration or safety ration in times of drought:
- Ruminants (Cattle, Sheep): Provides the fibre necessary for rumination and covers a large part of the maintenance and production needs.
- Equines: Essential for intestinal transit and behavioral occupation. The quality must be impeccable (no dust/mould).
- Adjustment: It is often supplemented with concentrates (cereals, oilcake) if its energy or protein value is insufficient for animals in high production.



Difference Between Alfalfa Hay (Legume) and Natural Grassland Hay

- The main difference between alfalfa hay (legume) and natural grassland hay (mostly grass) is the nutrient concentration and mineral balance.
- Comparison of Nutritional Values
- Parameter Alfalfa Hay Natural Meadow Hay
- Protein (MAT) High (15-21%) Moderate (8-12%)
- Energy (UFL) Often higher (0.7 to 0.9) Variable (0.6 to 0.8) depending on the flora
- Calcium Very high (~3x more) Moderate to low
- Sugars/Starch Lower Higher
- More digestible fibre (NDF) More crude fibre

Key Points of Differentiation

- Protein intake: Alfalfa is a "noble" source of protein. Its digestible nitrogen content (GDM) is about twice that of conventional grassland hay.
- Mineral Richness: Alfalfa hay is exceptionally rich in calcium. This makes it a great supplement for growing or lactating animals, but requires vigilance on the Calcium/Phosphorus ratio (ideally 2:1) to avoid imbalances in resting adults.
- Buffering Effect: Thanks to its protein and calcium content, alfalfa has a marked gastric buffering effect, useful for limiting stomach acidity in horses prone to ulcers.
- Specific Use: Meadow hay is often preferred for weight maintenance (less calories) and to ensure slow transit thanks to its long fibers. Alfalfa is preferred for performance and production.

7.2. Straw: production technique, composition, nutritional value, use.

- Straw, a valuable residue from cereal crops, plays a central role in the agricultural circular economy. Here are the essentials about its production, its properties and its uses.



- 1. Breeding techniques
- Straw is obtained after the grain (wheat, barley, oats, rye) has been harvested.
- Harvesting: During harvesting, the combine separates the grain from the stalk. The rods are thrown back to the back of the machine in windrows (continuous rows on the ground).
- Packaging: The dry stems are then picked up by a press which compacts them into bales (round or square) bound by twine.
- Post-harvest processing: In some cases, the stems are collected and sterilized for specific uses such as making natural drinking straws.
- 2. Chemical Composition
- Straw is a very dry material (about 90% dry matter) and rich in complex fibres.
- Major constituents: Mainly cellulose (37.5%), hemicellulose and lignin.
- Nutrients: It contains about 3.5% crude protein and 1.3% fat.
- Minerals: Nitrogen (7g/kg), potassium (12g/kg), calcium (4g/kg) and phosphorus (0.7g/kg) are found in it.

- 3. Food values
- Used as ballast fodder, its gross nutritive value is low, but it can be improved by straw processing techniques.
- Contribution: It is mainly used to bring fribricity to the ruminant ration, promoting rumination.
- Improvement: Treatment with ammonia or urea breaks the bonds of the lignin, increasing its digestibility and nitrogen content.
- Ration: It is often used to dilute a ration that is too rich or in times of fodder shortage, supplemented by energy (molasses, barley).

- Uses
- Straws are versatile and their use goes far beyond the food sector.
- Agriculture: Used mainly for animal bedding (75% of volumes) or left in the field (20%) as an organic contribution to the soil. It is also used as a mulch in the garden to protect crops and limit evaporation.
- Building: High-performance ecological insulating material for the construction of straw houses.
- Energy: Used as a biofuel in specialized boilers.
- Crafts: Basketry and manufacture of various objects.



3. Silage: Breeding technique, composition, feed value, use

- Silage is a method of moist preservation of forages by natural acidification in an anaerobic environment. This technique makes it possible to maintain a nutritional quality close to that of fresh fodder for winter livestock feed.
- 1. Technique of obtaining
- The success of a silage is based on the rapid drop in pH (ideally < 4.0) thanks to lactic acid bacteria.
- Harvest at the optimal stage: For maize, the dry matter (DM) content should be between 32% and 35%. For grass, we aim for 30% to 35% DM after a 48-hour pre-wilting.
- Fine chopping: Facilitates the compaction and release of sugars.
- Rigorous compaction: A crucial step to expel air and prevent mold. Layers 15-20 cm thick are recommended.
- Hermetic closure: Use of weighted plastic sheeting to maintain anaerobic stability.

- 2. Composition and Nutritional Value
- The value depends on the initial plant and the quality of the fermentation.
- Corn silage: High energy (high in starch, 18-37% of DM) but low in protein (5-10% of DM). Its energy value is around 0.91 UFL/kg DM.
- Grass silage: More variable value (0.65 to 0.98 UFL) but generally richer in nitrogen (60 to 130 g DINP/kg DM) than maize.
- Chemical changes: During the process, soluble sugars are converted into organic acids (lactic, acetic). The ash and fibre contents increase slightly passively as a result of the loss of gaseous DM.

3. Use in animal feed

- Silage is used as the basis of the ration, mainly for dairy cattle and beef cattle.
- Rationing: Maize silage can make up to 70-75% of dairy cows' rations, but must be supplemented with nitrogen (e.g. oilcake, clover) because it is deficient in protein.
- Distribution: Regular reworking at the silo front (smooth face) is necessary to prevent heating and degradation of the forage in the open air.

- The calculation of a balanced silage-based ration is based on the coverage of maintenance needs (animal weight) and production needs (quantity of milk or weight gain).
- 1. Key calculation parameters
- Dry Matter (DM): All weighings are done in "kilos of DM" to compare feed. For example, 15 kg of raw silage with 33% DM is worth 5 kg DM.
- Energy (UFL): The Milk Forage Unit (UFL) measures the energy value. A dairy cow needs about 0.9 UFL per kg of milk produced in addition to its maintenance.
- Protein (PDI): Digestible Protein in the Intestine (PDI) is crucial. Since maize silage is low in protein, it must be compensated for with nitrogen concentrates such as soybean or rapeseed meal

- 2. Rationing Steps
- Estimate intake capacity: A cow can ingest about 18 to 22 kg of DM per day depending on her stage of lactation.
- Calculate the basic forage intake: Silage is offered at will (often 12-15 kg DM). We then calculate how much UFL and PDI this brings.
- Adjust with concentrates: The difference between the total requirements and the inputs of the silage defines the amount of cereals (energy) and cakes (proteins) to be added.
- Mineral and Vitamin Balance (MEP): The addition of 150 to 300g of minerals is necessary for calcium, phosphorus and salt.

- 3. Precision tools
- For exact calculations, farmers use software based on INRAE standards:
- INRAtion v5: The reference software for simulating interactions between ingredients.
- Optim'AI: An online tool to optimize the economic cost of rations.
- Isalim: Technical management software for daily rationing

- Here is a typical ration simulation for a 600 kg cow producing 30 litres of milk (average rate), based on a "Maize Silage" diet.
- 1. Cow's Needs (Estimate)
- To produce 30L, a cow needs about 21 to 22 kg of Dry Matter (DM) per day, including:
 - Energy: ~19 to 20 UFL.
 - Protein: ~2000 to 2100 g of PDI.
- 2. Ration composition (Typical example)
- Feed Gross Quantity Dry Matter (DM) Intake Energy Intake Protein Intake
- Corn Silage 40 - 45 kg 14 kg DM 12.6 UFL 1000 g PDI
- Grass hay 2 - 3 kg 2 kg DM 1.4 UFL 140 g PDI
- Meal (Soybean/Rapeseed) 3 - 4 kg 3.5 kg DM 3.8 UFL 850 g PDI

Aliment	Quantité Brute	Matière Sèche	Apport Energie	Apport Protéique
Ensilage Maïs	40-45Kg	14 Kg MS	12,6 UFL	1000g PDI
Foin De Graminées	2à 3 Kg	2Kg MS	1,4UFL	140Kg PDI
Tourteau (Soja/Colza)	3 - 4 kg	3,5 kg MS	3,8 UFL	850 g PDI
Céréales (Orge/Maïs grain)	2Kg	1,8 Kg MS	2,1UFL	160g PDI
Minéraux (AMV)	250 g	0,2 Kg MS	-	-
Total	50Kg	21Kg MS		19,9UFL

- 3. Analysis of this balance
- Maize silage provides most of the energy but quickly saturates intake.
- Hay is essential for "fibrosity" (making the cow chew) and avoid acidosis.
- Meal is the key: without it, the maize ration contains only 50% of the protein needed for 30L of milk.
- 4. Tools to adjust your calculation
- The calculation varies depending on the actual quality of your forage (laboratory analysis required). You can use these simulators to refine:
- Web-Ration by Seenrest: To adjust intakes according to your own analyses.
- IDELE calculator: The Institut de l'Élevage offers technical sheets on feed efficiency.

7.3. Silage: Breeding technique, composition, feed value, use

- Silage is a method of preserving forages by wet process, based on lactic fermentation in an anaerobic (airless) environment.
- 1. Technique of obtaining
- The success of a silage is based on the control of the harvesting chain:
- Mowing and chopping: The plant (corn, grass, meslin) is cut and finely ground (0.8 to 2 cm) to facilitate compaction.
- Siloing: The fodder is spread out in successive layers.
- Compression: A crucial step in expelling air and stopping cellular respiration.
- Hermetic sealing: Use of plastic sheeting to maintain anaerobic conditions.
- Fermentation: Bacteria convert sugars into lactic acid, causing the pH to drop (ideally to around 4), which stabilizes the forage.
- 2. Composition
- The composition varies depending on the initial plant, but it is generally found:

- 2. Composition

- The composition varies depending on the initial plant, but it is generally found:

- Water: 65% to 70% (i.e. 30-35% dry matter).

- Fermentable carbohydrates: Starch (for corn) or soluble sugars (for grass).

- Organic acids: Mainly lactic acid (natural preservative).

- Nitrogenous matter: Proteins that are partially degraded by the process.

- 3. Food Value

- It depends on the maturity of the plant at harvest:

- Energy: Very high for corn silage (high in starch), more moderate for grass.

- Protein: Low for corn, but can be interesting for legume silages (clover, alfalfa).

- Ingestibility: High due to the palatability of acidity, allowing high consumption by livestock.

Usage

Targets: Mainly cattle (dairy and meat), but also sheep and goats.

Distribution: At the trough, often as a base for the winter ration.

Precautions: Monitor the "face of the face" during distribution to avoid overheating and the development of toxic mold.

- The face face (also called the face of the tank) refers to the vertical face of the silo that is exposed to the air once you have opened the tarp to feed the animals.
- This is the most sensitive area, because contact with oxygen can restart unwanted fermentation.
- Why is this crucial?
- Risk of overheating: As soon as the air enters the mass, yeasts and moulds can develop, which raises the temperature of the forage.
- Loss of value: Silage that heats up loses energy and palatability.
- Animal health: If toxic molds (mycotoxins) grow on the front, they can make animals sick or drop milk production.
- The golden rules for managing it:
- Forward speed: The silo must be "eaten" fast enough so that the air does not have time to degrade the fodder. It is recommended to advance at least 1.5 m per week in winter and up to 2.5 m in summer.

- Cleanliness of the cut: The forehead should be as smooth as possible. Ideally, a silage cutter (clean cutting tool) is used rather than a conventional bucket that "pulls" the forage and creates air pockets.
- Dimensioning: During the construction of the silo, its width must be adapted to the number of animals to guarantee this rapid progress.

Silage /Ensilage

Enrubanné/Wrapped



7.4. Roots and tubers

- Roots (beets, carrots) and tubers (potatoes, cassava) are massive sources of energy for livestock. They are often used as supplements to replace some of the grains in the ration

- 1. Production and main types
- These feeds are characterized by a high yield per hectare, but a high water content.
- Fodder beet: Very rich in soluble sugars, excellent for milk production.
- Potato: Rich in starch. We often use "sorting gaps" (unsold for humans).
- Cassava: A major source of energy in tropical areas, almost exclusively composed of starch.
- Jerusalem artichoke: Very hardy, rich in inulin (a complex sugar).

Cassava grown in tropical areas, composed exclusively of starch





- 2. Food Value
- These are called "wet concentrates".
- Energy: Very high thanks to sugars and starch.
- Protein: Very low. It is imperative to compensate with a source of nitrogen (oilcake, legumes).
- Minerals: Often high in potassium, but low in phosphorus and calcium.
- Digestibility: Excellent, they are very popular with animals (high palatability).
- 3. Conservation techniques
- Their high water content (75% to 85%) makes storage difficult.
- Storage in silos (in bulk): For beets, they can be stored in piles away from frost, but for a limited time (a few months).

- Potatoes are often steamed and then ensiled (cooking improves the digestibility of starch).
- The roots can be crushed and mixed with dry forages (straw or chopped hay) to absorb the excess juice in the silo.
- Drying (Cossettes): The roots are cut into small pieces and dried in the sun or industrially to be preserved in the form of granules (like dehydrated beet pulp).

4. Precautions for use

Cleaning: It is imperative to dig well (remove soil and stones) to avoid digestive disorders and wear and tear of the animals' teeth.

Risk of toxicity:

Potatoes: Beware of solanine (sprouted or green parts) which is toxic.

Cassava: Must often be dried or soaked to remove hydrocyanic acid.

Dietary transition: To be introduced gradually to avoid acidosis or diarrhoea due to the rapid fermentation of sugars.



- Comparing harvesting costs requires reducing expenditure per tonne of Dry Matter (t DM), because the moisture content varies enormously depending on the method.
- Here is an estimate of the average costs (mechanization + labor) based on the Scales of the Institute of Livestock (Idele) and the Chambers of Agriculture for 2024-2025:
- Method Estimated cost (€/t DM) Main cost factors
- Hay 60 € to 80 € Many passes (mowing, tedding x3, swathings, baling). Sensitive to field losses.
- Silage (grass) 75 € to 100 € High work rate but heavy equipment (forage harvester, transport, silo compaction).
- Wrapping €110 to €135 High cost of supplies (plastic, net) and low throughput.

Key Details by Method:

- Hay: This is often the least expensive method in terms of "cash-flow" if you have your equipment, but it requires more working time per hectare (about 3h30 to 4h30)
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- Silage: The cost per tonne decreases with high yields. A silage service is estimated at around €19.50/t DM; just for the harvesting site, excluding mowing and storage costs.
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- Wrapping: It has an additional cost of about 38 € / t DM compared to hay, mainly due to consumables (stretch films).

Criteria for choosing beyond the price:

- Workforce:
- Silage is fast but requires several people simultaneously.
- The wrapping is more flexible for solo work.
- Feed value: Wrapping and silage preserve protein better, which can reduce the purchase bill for concentrates (cakes) later on.

7.5. GRASSLAND CONSERVATION

The conservation of meadows (natural or artificial) for difficult times (drought/snow and harsh cold) is based on two axes:

- 1 -- the maintenance (management) of the grassland itself
- 2 -- the storage of its fodder (harvest).

Techniques include:

A. Mowing:

- 1 - Silage/wrapping for their high energy and protein value,
- 2 - hay for longer storage),

B. Pasture

- 1/ rotational grazing, and
- 2/ standing grazing to limit harvesting costs



1. Grassland Management and Conservation (Sustainability)

Natural (Permanent) Grassland: Maintain extensive farming.

Avoid undergrazing (grass > 20 cm) which wastes and promotes weeds. However, rotational grazing (daily) allows you to manage standing stocks.

Artificial Grasslands (Temporary): Ensuring the organic cover of the soil, low mechanical disturbance and crop rotation (principles of conservation agriculture).

Maintenance: Fill in the gaps by overseeding and manage fertilization, especially before winter to limit degradation..



- 2. Food Preservation (Forage Storage)
- Silage/Wrapping: Ideal method for maintaining feed value (protein) anaerobically, resulting in high-quality wet forage.
- Hay: Sun drying is the traditional method, suitable for long storage, although hay is less rich than fresh grass or silage.
- Growing Grass (Standing Stock): Leaving standing grass for winter or dry periods, practicing topping (clipping: cutting off the tops of plants) to keep leafy volunteers.
- Depressing: Grazing early at the end of winter to slow down growth while ensuring an early resource.

- 3. Techniques for "Difficult Times" (Dry Periods/Winter)
- Stand-up grass management: Organisation in rotational grazing, advancing the line daily to optimise the use of refusals.
- Harvesting: Store in the form of wrapped bales, which retain nutrients better than conventional hay if drying conditions are harsh.
- Renovation: In case of degradation, use overseeding rather than complete ploughing, using catch crops to limit weed regrowth.
- In short,
- Intensive grazing (to clean and optimize) and rest for regrowth should be alternated, while harvesting the surplus at the optimal stage (early heading) to ensure stock quality



Nutritional values of grass

- The nutritional value of grass varies considerably depending on its stage of development, its nature (natural or artificial meadow) and the method of preservation chosen.
- 1. Key indicators of nutritional value
- To assess the quality of the grass, the following are mainly used:
- Energy: Measured in UFL (Milk Fodder Unit) or CFU (Horse Fodder Unit). High-quality grass is between 0.85 and 0.95 UFL per kg of dry matter (DM).
- Protein (Nitrogen): Measured in PDI (Protein Digestible in the Intestine). Fresh grass contains between 120 and 250 g of protein per kg DM.
- Minerals and vitamins: It is a source of calcium, selenium, iron and beta-carotene.

- Factors of variation
- The value of grass is not fixed; it falls off as the plant ages.
- The stage of growth: This is the No. 1 factor. The taller and more fibrous the grass (flowering stage), the more its digestibility and energy value decrease in favour of cellulose.
- Type of grassland: Artificial grassland (alfalfa, clover) is generally richer in protein than natural grassland (0.75 to 0.80 UFL for natural hay compared to more than 0.90 for young grass).
- Season: Spring and fall grass are often richer than summer grass, drier and more fibrous.

3. Impact of conservation on value,

Each method of preservation results in a loss of nutrients compared to fresh grass:

Grass shape	Average energy (per kg DM).	Protein (per kg DM)	Comment
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Fresh grass;	0.90 - 1.00 UFL	150 - 250 g	Maximum value
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Silage;	0.65 - 0.98 UFL	80 - 110 g	Highly variable depending on the compaction
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Wrapping;	0.60 - 0.80 CFU	Medium	Good palatability
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Hay;	0.50 - 0.80 UFL	70 - 90 g	Poorer, but stable
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Advice for conservation:

To maintain a high value during "hard times", it is crucial to harvest at the leafy stage (before the ears appear). A late harvest guarantees volume, but a mediocre feed value that will require expensive supplements.

Thank you