Part 01: Notion of food and feeding

Chemical composition oflivestock feed

- Forages are of extraordinary diversity in their botanical nature and their morphological, anatomical and physicochemical characteristics, all of which affect their ingestibility, their degradation in the rumen and their digestibility.
- Analyzing the chemical composition of fodder makes it possible to predict its nutritional value and thus adjust the ration distributed to the animals.

Chemical composition of fodder

- Forages are composed of water and dry matter.
- The water content varies from about 10% (hay) to 90% (green fodder).
- Dry matter includes organic matter on the one hand composed of parietal constituents, intracellular carbohydrates (starch and soluble sugars), lipids, and nitrogenous substances total;
- and on the other hand mineral matter (macroelements and trace elements).

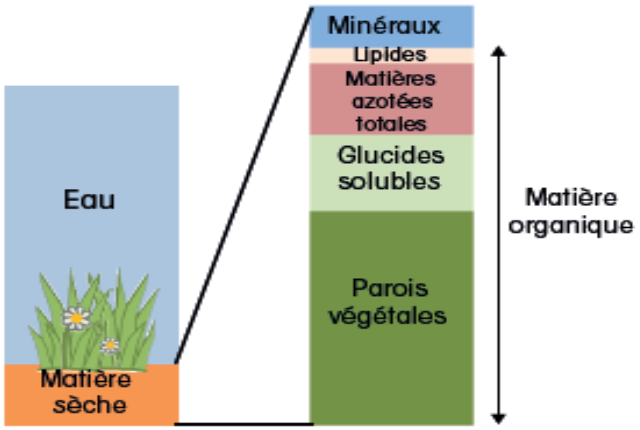

Fig. 1: Chemical composition of foods

1. Carbohydrate constituents

Two categories of carbohydrates according to their location: cytoplasmic carbohydrates and parietal carbohydrates, mainly glucose, fructose, sucrose, 3-8% DM, but also fructosans: reserve polysaccharides, (see table 2).

- **Cytoplasmic carbohydrates**

– In fodder, we mainly find water-soluble carbohydrates which are completely digestible, but their content remains quite low overall with significant variations depending on:
  - The botanical family and species;
  - The cycle number;
  - The climatic conditions;
  - The stage of development;

– Insoluble carbohydrates (starch) are generally absent in forages (except in certain legumes with low levels 0.5-3.5% of DM);

- **Cell wall carbohydrates**

We distinguish between polysaccharides (carbohydrates themselves) and the non-carbohydrate constituents associated with them.

* **<u>Polysaccharides</u>**,3 groups of polysaccharides: cellulose, hemicellulose and pectic substances.

▪ ***Cellulose:***

– Its specific structure gives it a certain resistance to enzymes (digestive juices), which partly explains its lower digestibility than cytoplasmic carbohydrates (but can be 'broken' by bacterial enzymes present in the rumen).

– Essential constituent of the cell wall, it is involved in the formation of support tissues (collenchyma, sclerenchyma) and conductive tissues (xylem). It represents 40-45% of all the walls and 15-40% of the total DM of the plant (depending on the species and especially on the age of the plant).

▪ ***Hemicellulose :***represents 12-25% of the DM of forages (evolution according to age). Their digestibility is a little lower than that of cellulose (bonds with lignin).

▪ ***Pectic substances:***represent 2% of the DM of grasses. Their digestibility is very high, close to that of cytoplasmic carbohydrates.

* **<u>Non-carbohydrate constituents</u>**

– It is mainly lignin, a complex substance that gradually encrusts the supporting and conductive tissues.

- Its content varies from 2% in young grass to 12-13% of the dry matter in straw. Lignification is all the more important as the plant is older.

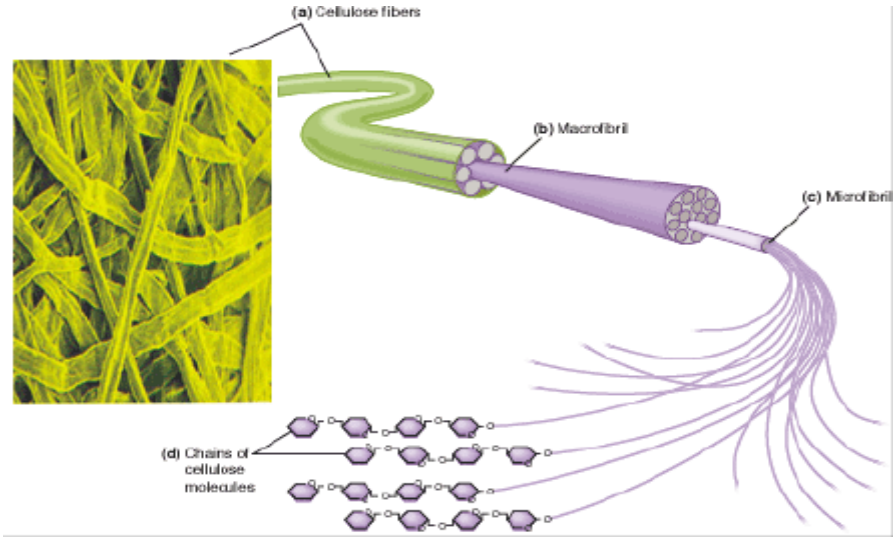

Fig.2: Membrane carbohydrates (Toutain, 2008)

2. Nitrogenous constituents

- We distinguish between: protein nitrogenous materials and non-protein nitrogenous materials.
  - **Protein nitrogenous substances(MAP)**
- Located in chlorophyll cells (chloroplasts, mitochondria, membrane);
- Comprise proteins, peptides and free amino acids;
- All give, by hydrolysis, amino acids;
  - **Non-protein nitrogenous substances(MANP)**
- Located in cell vacuoles (therefore easily digestible).
- Include amines, amides (urea),simple nitrogenous forms (NO2-, NO3-, NH4+, etc.) and nitrogenous bases of nucleic acids;
- In green fodder, they represent 15 to 35% of total nitrogenous matter, this proportion is higher in the stems than in the leaves;
- Non-protein nitrogenous matter in hay harvested under good conditions generally has a proportion of between 30 and 40% of total nitrogenous matter.

3. Lipid constituents

- They are found mainly in the form of galactolipids (glycerides-galactose), rich in unsaturated fatty acids (linolenic acid), located in the chloroplasts of cells;
- Cerides (FA+alcohol) are also found in the cuticle of leaves (cutin, indigestible);

- Represent only 2-5% of the DM of fodder,which explains the little interest they are often given.

4. Minerals

- The mineral composition of a fodder results from the action of several factors such as the vegetation stage of the plant, its botanical family and the environmental and operating conditions (such as spreading or fertilizers).
- Given the risks of insufficient mineral element intake in ruminant fodder rations, nutritionists' attention is drawn to the following mineral elements: P, Ca, Na, Mg, S, Zn, Cu, Co.
- Total mineral matter (or crude ash) represents 8 to 15% of the dry matter (DM) of fodder.
- Minerals are recommended to ensure the important organic functions of animals. They can be:
- structural components, organs and tissues, such as bone and teeth,
- elements constituting the body's fluids.
- Minerals can be electrolytes and play an important physiological role in osmotic pressure, acid-base balance, membrane permeability, nerve transmission, regulation of cell divisions and in their differentiation.
- Minerals can also act as cofactors, coenzymes, which participate in many activities in the body.
- Some minerals can also be included in the composition of certain hormones.

➢ Macroelements

They appear in plants in various chemical forms:

- Potassium and sodium are almost completely ionized;
- Phosphates are in multiple forms; inorganic P; esterified or non-esterified phosphates;
- calcium is in soluble form, partially soluble (phosphates) or in the form of insoluble oxalates, and finally a fraction of calcium can also be bound to proteins and pectins;
- Magnesium, 50% of which is in soluble form, approximately 10% associated with the chlorophyll complex, and a significant part is complexed with organic acids and lignin.

Table 1: Ranges of variation in mineral contents in fodder

(Little, 1982 cited by Meschy et *al.*, 1995)

Macro-elements	Content in g/kg of MS
P	0.2 to 7
That	0.4 to 41
Mg	0.3 to 10
N / A	0.01 to 21

K	10 to 60
S	0.5 to 4

- **Trace elements**

Forage plants can suffer from trace element deficiencies with reduced production due mainly to deficiencies encountered mainly in soils. The use of fertilizers can alter the concentration of trace elements in plants by increasing the content of Mo and Se and decreasing those of Co, Mn, Fe and Zn.

Table 2: Trace element contents of some grains and fodders (in mg/kg of DM or ppm) (INRA. 1978; Chapuis. 1991).

Food	Copper	Zinc	Manganese
Dry fodder natural meadow	5.2±0.8 2.8 - 8.0	29.1±0.4 13 - 60	158.2±5.3 12 -580
Alfalfa hay	7.1±0.3	24.6±2.1	29.0±2.4
Barley straw	3.1±0.9 2.3 - 4.7	7.3±3.9 3 - 12	17.6±9.2 4.0 - 26.3
Barley	4.1±1.0 2.6 - 5.5	24.4±3.5 20 - 30	17.6±5.9 11 - 33
Oats	3.5±0.5 2.7 - 4.9	25.2±4.1 17 - 37	38.4±13.0 21 - 78

Table 3: Distribution of trace element contents in natural meadow hays (in mg/kg of DM) (Lamand et al., 1981)

Copper (mg/kg of DM)	% total	**Zinc** (mg/kg of DM)	% total	**Manganese** (mg/kg of DM)	% total
< 5	44.2	< 25	28.7	< 25	3.5
5-7	49.5	25-50	69.9	25-50	15
7	6.3	> 50	1.4	> 50	81.5

Chemical composition of concentrates

1. Carbohydrate constituents

- **Cytoplasmic carbohydrates**

- *Water-soluble carbohydrates,*very variable content (cereals 4%, protein 7-10%, oilcakes 11-13%)
- *Water-insoluble carbohydrates,*= starch, the main constituent of the MS of cereals and certain protein crops (fava beans, peas) (tab. …), located in the albumen.

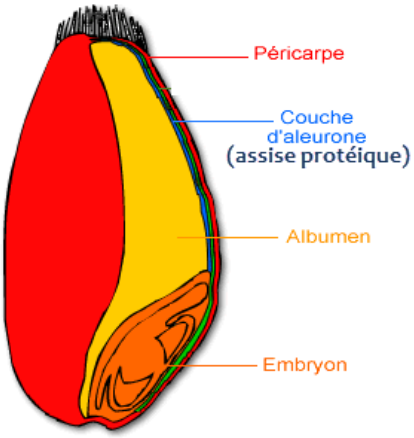

Fig .3 : Cross section of a grain of wheat

- **Cell wall carbohydrates**

Table 4 : Cell wall carbohydrate content of different concentrated foods in % DM

	Cellulose	Hémi-celluloses	Substances pectiques	Lignine
Maïs	1,8	3,8-4,5	—	—
Blé	2,3-2,9	6,3-7,8	—	1,6-2,3
Orge	3,8-4,7	7,3-8,5	—	
Avoine	10,8	11,0	—	6,3
Son de blé (gros)	12,3	34,7	—	—
Féverole	5,0	4,0	0,7	1,1
Pois	5,3	5,1	1,1	0,5
Tourteau de soja	3,9	8,9	—	2,8
Tourteau de colza	14,6	11,5	—	8,9
Tourteau d'arachide décortiqué	6,0	7,0	—	3,2

2. Nitrogenous constituents

- Represent~10% of all cereal grains, 20-25% of protein seeds and 35-55% of oilcakes;
- In these seeds, we find 4 groups of proteins: albumins, globulins (cytoplasmic), prolamins and glutelins (reserve) with variable proportions for oilcakes and protein crops, but well determined in cereals (Table 5).

Table 5 : Proportion of different protein fractions in cereals (g per 100)

(INRA 1981)

	Blé	Maïs	Orge	Seigle	Avoine
Albumines	4	4	3	5	0
Globulines	8	6	18	15	30
Prolamines	48	50	39	45	16
Glutélines	40	39	40	35	54

3. Lipid constituents

– Are mainly *triglycerides,*generally representing only 1-7% of the MS (Tab.9).

Table 6: average content of some concentrated foods (INRA 1981)

Aliments	Moyenne(g/kg MS)
Avoine	57
Blé	18
Maïs	46
Orge	21
Son fin de blé	47
Tourteau soja 48	26
Tourteau colza	26
Tourteau arachide	15