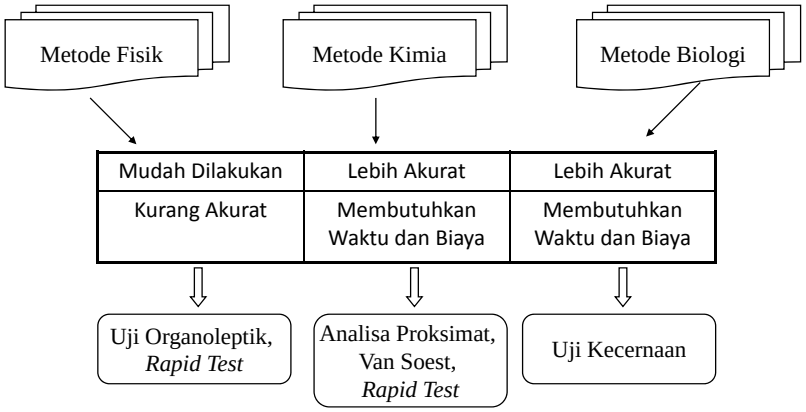
Feed Evaluation

Feed evaluation

A. **Physical evaluation** --> bulk density, sensory (organoleptic) analysis
B. **Chemical evaluation** --> proxymate analysis, Van Soest's analysis, energy
C. **Biological evaluation** --> *in vitro* fermentation systems, *in vivo* feeding trials



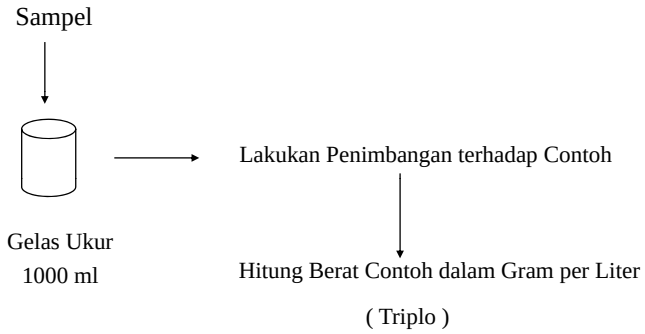
Principles

- Characterization of feed by means of chemical composition
- But it is not enough!
- Determination of the availability of feed nutrients for animals
- The most accurate method for feed evaluation: animals' biological response

A. Physical evaluation

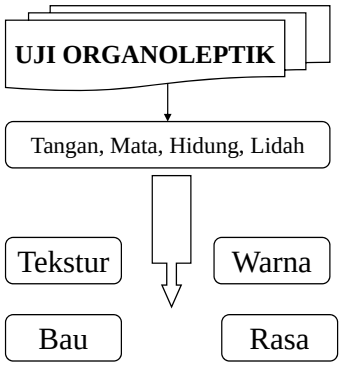
- The least accurate approach
- But it provides a quick and easy means of obtaining considerable information about the overall quality of a feed

Bulk Density



Giger-Reverdin (2000)

UJI ORGANOLEPTIK/SENSORI



Physical characteristics of good hay

- Leafy, indicating high content of protein and other nutrients
- Bright green in color
- Free from foreign material, e.g. weeds, dirt
- Free from mold and dust
- Fine stemmed and pliable, not coarse, stiff and woody
- Has a pleasing, fragrant aroma; smells good enough to eat

Physical characteristics of good silage

- Pleasing lactic acid odor, in contrast to butyric acid odor
- Pleasing taste, not bitter or sour
- Not moldy, musty or slimy
- Uniform in moisture and color
- Good: green or brownish silage; Excessive heat: tobacco brown or dark brown; Spoiled: black

Physical characteristics of good grains

- Seeds are not split or cracked
- Low moisture content (≥88% DM)
- Good color (typical color for each species)
- Free from mold
- Free from rodent and insect damage
- Free from foreign material such as iron filings
- Free from rancid odor

B. Chemical methods

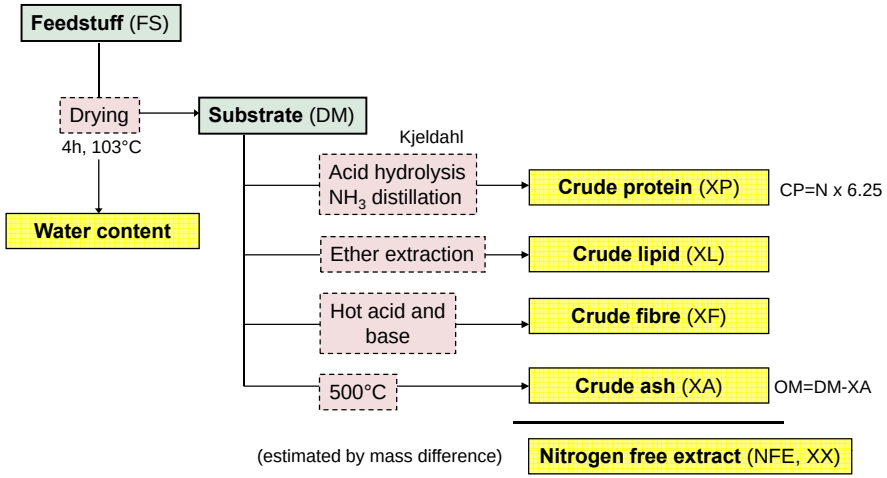
Nutritive Value of Feed

Fraction	Nutritional Availability	
	Monogastric	Ruminant
Sugars, Starch	Complete	Complete
Protein	High	High
Lipids	High	High
Pectin	High	Complete
Hemicellulose	Low	Partial
Cellulose	Low	Partial
Lignin / Cutin	Indigestible	Indigestible

(adapted from Van Soest, 1966 and 1967)

Crude Nutrients

Proximate (Weende) system of analysis, Henneberg & Stohmann 1862

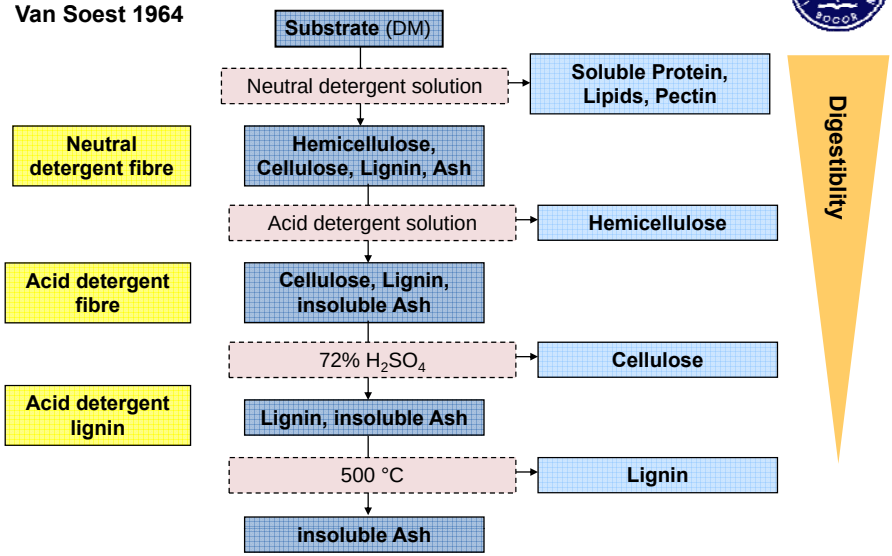


Crude protein (XP)	protein, amino acids, ammonium compound, amides od acides, nitrogenous glycosides, B vitamins
Crude lipid (XL)	fats, oils, waxes, organic acids, pigments, sterols, vitamins A, D, E, K
Crude fibre (XF)	cellulose, hemicellulose, lignin
Crude ash (XA)	macro- and microminerals
Nitrogen free extract (NFE, XX)	starch, sugars, fructosans, hemicellulose, pectin, organic acids, resins, tannins, pigments, water soluble vitamins

Cell Wall Components: Detergent Fibre System

Cellulose	**β-1,4-glucan, cellobiose + residues, forms microfibrils by intra-molecular and inter-molecular H-bonds, mechanical strength, highly crystalline or „amorphous" regions**
Hemicellulose	**(„*Cross-linking glycans*"), diverse group of carbohydrates, common xyloglucans and glucuronarabinoxylans, soluble in strong alkali, β-1,4 backbone + short side chains, form H-bonds with cellulose**
Pectin	**(pectic polysaccharides), easiest to remove from wall (hot water, dilute acid), form gels, function: determining wall porosity, providing charged wall surface for cell-cell adhesion, cell-cell recognition, pathogen recognition etc.**
Protein	**glycoproteins (polypeptide backbone + carbohydrate side chains), cross-linked to pectic substances, may have sites for lignification, extraction requires destructive conditions, function: structural role, cell signalling (growth and guidance of pollen tube)**
Lignin	**Lignin: Polymer of phenolics, esp. phenylpropanoids, strengthening agent, resists fungal/pathogen attack**
Lipids	**Suberin, wax, cutin: variety of associated lipids for strength and waterproofing**

Van Soest 1964



Comparison of Detergent & Proximate System

Detergent system		Nitrogenous	Non-nitrogenous	Proximate system
ND soluble (cell contents)		NPN compounds, proteins		CP
			lipids, ether soluble substances	CL
			water soluble substances, pectins, starch	
	AD soluble	insoluble proteins	hemicellulose	NFE
ND insoluble (cell wall) (NDF)	AD insoluble (ADF)	H_2SO_4 soluble lignified proteins	alkali soluble lignin	
			cellulose	
		H_2SO_4 insoluble	insoluble lignin (ADL)	CF

Other Methods to Determine Plant Contents

Starch/ Cell wall **Enzymatic:** Degradation and quantification of glucose/sugar monomers (degradability of different sources, solubilisation)

Refractometer: Estimation of the concentration of a starch solution by its refraction index (solubility, co-extractions)

Protein **Colorimetric assays:** (Bradford, Neuhoff) reaction of protein with dyes relative to standard (different staining, extractability)

Amino acid composition: Hydrolysis and quantification of AA by mass spectrometry (expensive, time consuming)

Lipids **Chromatography:** Extraction and quantification by HPLC (extractability, oxidation, quantification)

Estimating the Feeding Value from Substrate Composition

Monogastric animals:

- Limited amount of enzymes involved in digestion (Pepsin, Trypsin, Amylase and Lipases)
- Enzymes are known and well characterised

Ruminants:

- Primary degradation of the substrate in the rumen by microbial fermentation
- Nutrient composition reaching the lower gastrointestinal tract is different from the feed nutrient composition
- Detoxification processes
- Estimation of the feeding value by substrate composition is limited due to lack of methods to predict transformations by the rumen fermentation
- Often cooperation of enzymes and enzyme complexes needed, many still unknown or poorly characterized

Energy: Maintenance and Production

Growth MJ/kg		**Lactation** MJ/kg		**Reproduction** MJ/kg	
Cattle	34	Cattle	5.3	Cattle	25
Calf	15	Calf	--	Calf	--
Pigs	26	Pigs	7.3	Pigs	15

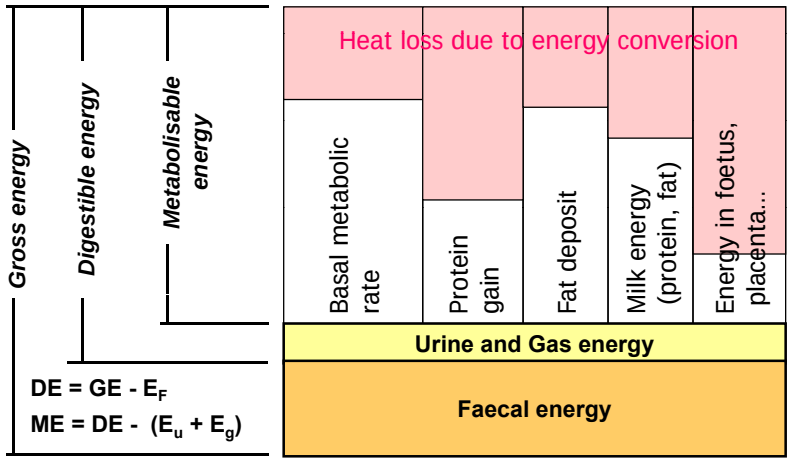
Maintenance MJ/ $kg^{0.75}$	
Cattle	0.48
Calf	0.52
Pigs	0.44

- **Fasting metabolism**
- **Maintenance requirements**

Energy Content of the Main Nutrients

Source	Energy content (MJ/kg) gross	physiological
Polysaccharides (starch)	17.6	17.6
Fat (triglycerides)	39.8	39.8
Protein	23.9	18.4

Determination of energy requirements



$$IME = ME_m * W^{0.75} + ME_{pf} * \Delta W + ME_c * \Delta Wc + ME_l * L (+ ME_o * n_o)$$

Factors influencing Energy Value of Feed

- **Feed composition:** digestibility closely related to chemical composition, degree of digestibility dependent upon crude fibre content and extent of structural/non-structural carbohydrates; variation due to source, e.g. barley little changes in digestibility, roughages variable
- **Ration composition:** „associative effect", apparent digestibility of mixture not neccessarily weighted sum of apparent digestibilities of ingredients, ANF, balance of nutrients
- **Feed preparation:** processing (crushing, chopping, cooking,...)
- **Animal factors:** digestive tract, ruminants/ non-ruminants
- **Feeding level:** increase causes faster passage rate through intestinal tract, shorter period of exposition to digestive enzymes

Thank you very much for your attention!