Theme 3: Animal Nutrition and Feeding

SAMPLING FEEDS & FORAGES/ANALYSIS INTERPRETATION (Level 3)

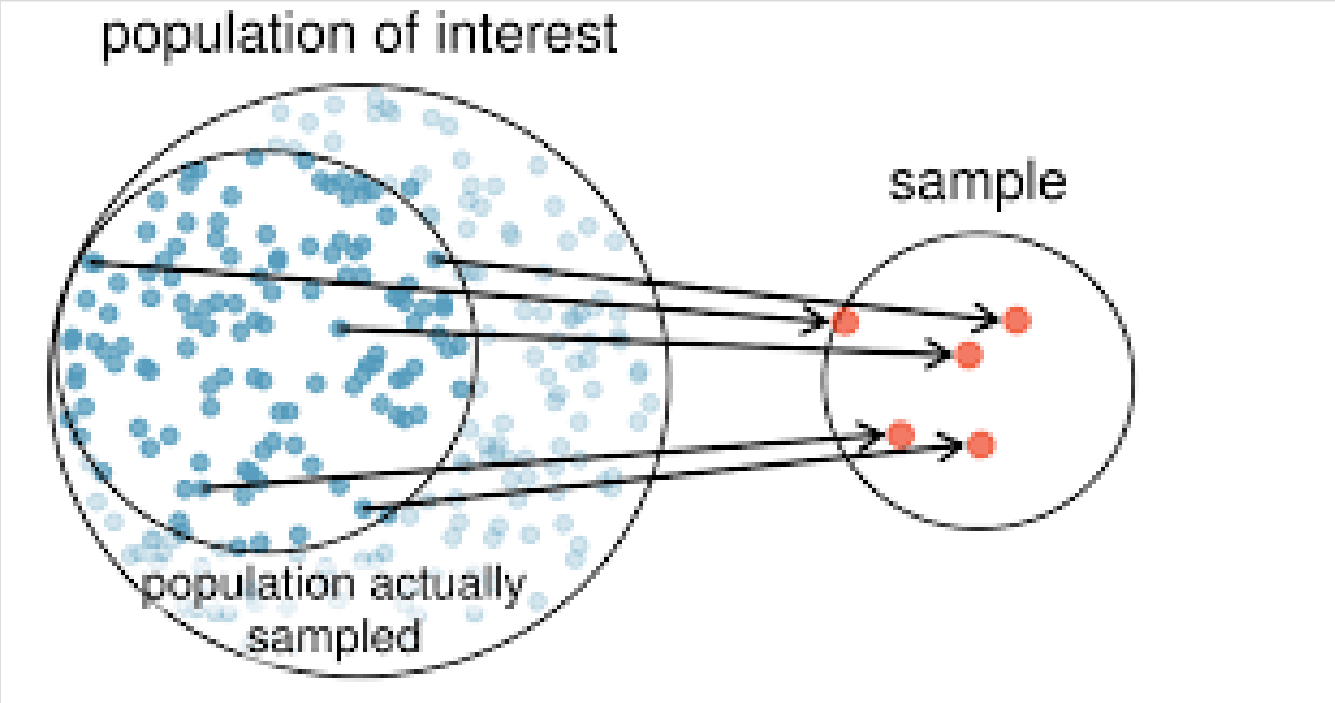
Topic	Training & information Content
3.1	Estimating feeding value of fodder & feed on dairy farms
3.2	Sampling feeds & forages/analysis interpretation
3.3	Estimating Dry Matter intake for various breeds/age categories of dairy cattle in the tropics
3.4	Reviewing feed intake, rumen fill, Body Condition Scoring (BCS)
3.5	Life weight estimation of cows
3.6	Rumen fermentation
3.7	Mineral & vitamin requirement, guidelines
3.8	Manure scoring and evaluation
3.9	Guidelines for ration calculations for various breeds, heifers, lactation stage (Rumen8)
3.10	Use of Rumen8 software for ration calculation
3.11	Optimization of ration with Rumen8
3.12	Feeding management guidelines
3.13	Feeding management of dry cows/close up
3.14	Feeding systems
3.15	Metabolic disorders
3.16	Scoring locomotion and hoof condition
3.17	Mycotoxin in dairy cattle nutrition
3.18	Heat stress in dairy cattle nutrition
3.19	Monitoring feeding management, using KPIs (based on Rumen8)

1. You will learn about (learning objectives):

- ❑ Importance of feed sampling.
- ❑ How to carry out sampling in a farm.
- ❑ Tests made on feed & forage samples.
- ❑ How to interpret feed & forage analysis results.

2. Background

- Sampling involves collecting a predetermined number of observations from a large population.
- Sampling & analysis of feed and forages is mostly done to confirm their quality for dairy cows.
- Sampling needs to be done correctly to provide a representative sample to get realistic, unbiased results.
- Chemical feed & forage analysis identifies the nutritive profile of feed and forages.



3. Importance of forage sampling & analysis

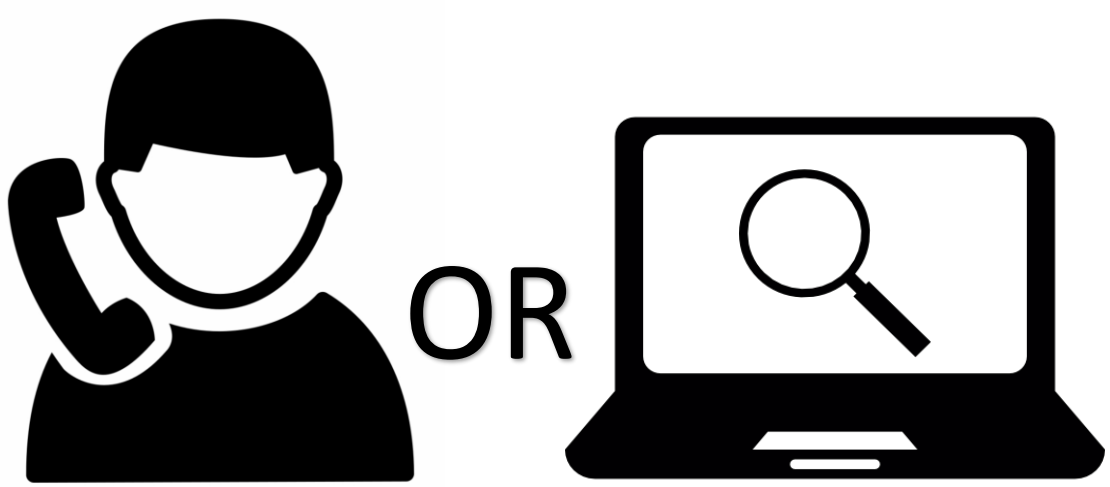
i. Helps identify the nutritive value and mineral composition of feeds and forages.
ii. Identifies contamination in feeds and forages such as: mycotoxins, chemical residues, heavy metals etc.
iii. Knowing the chemical composition of feeds and forages in relation to cost of these ration ingredients can assist to reduce/minimize total feed cost in a farm.
iv. The chemical composition (nutritive value and mineral content) helps to formulate and balance rations for different animal categories.

4. Guidelines for sampling feed/forages

- Identify feeds and forages to be tested.
- Samples need to be taken from different batches of feeds for example: harvested on the same day/week.
- All samples need to be representative of the total batch.
- Take many small portions from various places of the batch; this is better than large portions from a few places of the feed.
- Before sending the samples to the laboratory, package appropriately, label and record.

4.1 Guidelines for sampling feed/forages Cont'd…

- It can be advisable to keep an extra sample to be stored by the owner for future reference.
- Before sending samples to a laboratory, assure yourself that the laboratory is certified and accredited for feed and forage analysis.
- Sample needs to be delivered to laboratory as fasts as possible preferably within 24hrs to avoid contamination/secondary fermentation e.g. in silage.



5. Tools and equipment for sampling

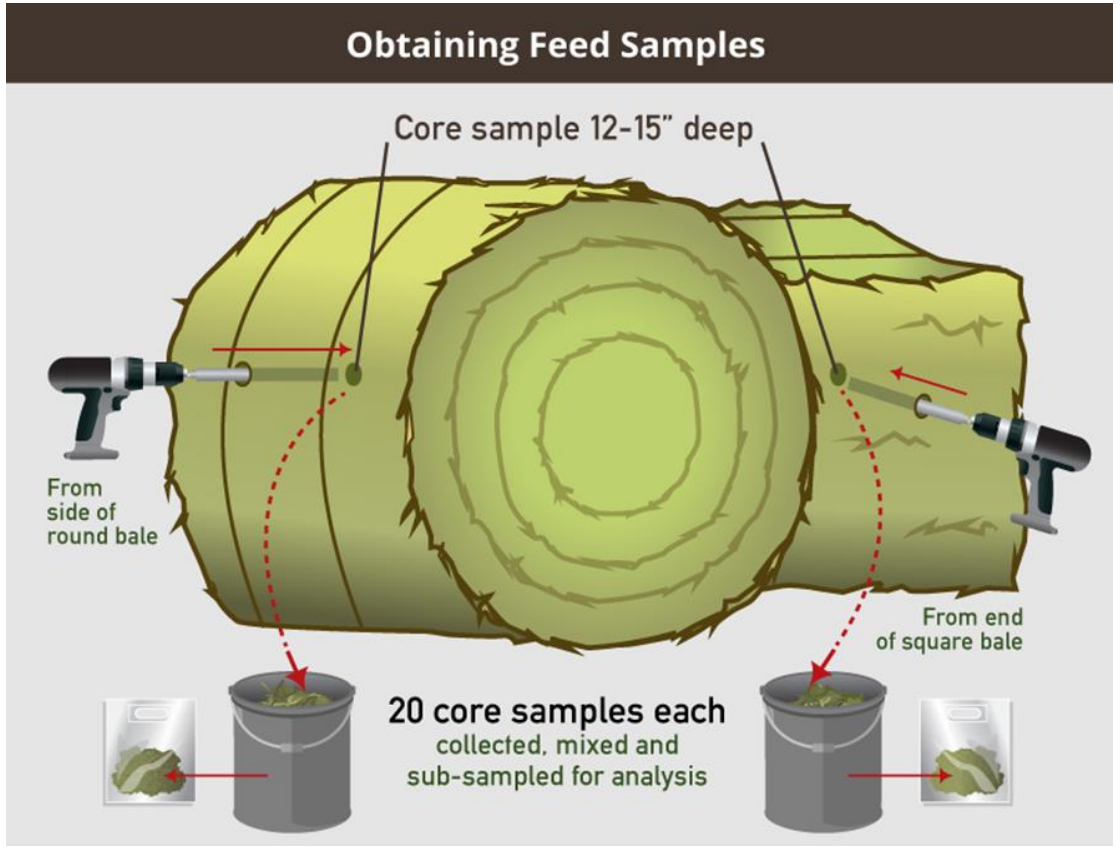
Forage probe

Grain probe

Bag with zip lock

6. Actual sampling

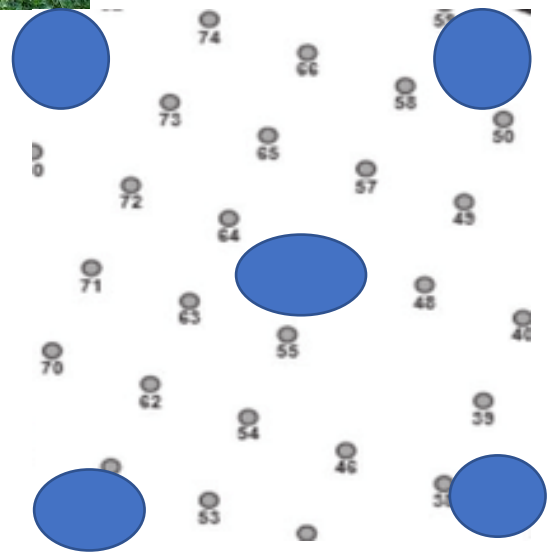
- The first step of chemical evaluation or analysis of fodder & feed is taking samples.
- Appropriate sampling needs to be done to get accurate results on the feed analysis report.
- Suitable and appropriate sample equipment needs to be used for example: slotted grain probe.
- Most samples are taken during loading and offloading or while in storage for example: silage silo/clamp, hay stack.
- Sampling procedure varies depending on the type of feed/forage.



7. Collecting samples of fresh pasture grass

- Cut one meter square sampling area at random in the plot to be harvested.
- Weigh all the grass within the meter square that is cut.
- Repeat the same procedure from various places going through the pasture in an ‘X’ or ‘Z’ pattern.
- Take a total grass samples of about 1kg from various areas and package them as fresh samples; or dry them using a microwave and weigh the dried sample again, to determine the dry matter (DM).
- Samples after packaging needs to be well sealed, labelled and recorded before sending to the lab.

Meter square sample area



8. Collecting samples from bagged feeds

- Pick sub-samples of the feed from different bags in the batch.
- Mix the different sub-samples thoroughly for example in a clean bucket.
- Collect approximately 1kg of the mixed sub-samples for analysis.
- Put the 1 kg sample in a paper bag/plastic bag (if the sample is dry). If the sample is moist, a plastic zip-lock bag is preferred.
- The sample after packing needs to be well sealed, labelled and recorded before sending it to the laboratory for analysis.

9. Collecting samples of silage from a silo

- Using a forage probe, take samples from different sites on the silage silo/clamp. One can take handful of sample from silage silo if a forage probe is not available.
- Sites picked need to be representative of the silage silo.
- Sample needs to be taken below 30 cm at all sides.
- Collect all the sub-samples and mix them in a clean empty bucket.
- Mix the different sub-samples thoroughly in the bucket.
- Take a 1kg sample from the mixture and put it in a plastic zip lock bag.
- After packing seal, label and record before sending it to the laboratory for analysis.
- Send the sample the same day or store it refrigerated (but not deep frozen).

10. Collecting samples from hay bales

- Using a hay probe, pick a sample from the center of one face of the bale.
- Face picked hay should have good distribution of leaves and stems due to looseness depending on the compaction of the bale.
- Follow the same procedure for a number of bales to get representative sub-samples of the whole batch.
- Take the different sub-samples and mix evenly in a clean empty bucket and collect approximately 1kg of the mixed sub-samples for analysis.
- The sample after packing needs to be well sealed, labelled and recorded before sending to the laboratory for analysis.

11. Types of tests in feed analysis

Modern tests involve both chemical procedures in the lab and Near infra-red (NRI) tests.

Chemical tests

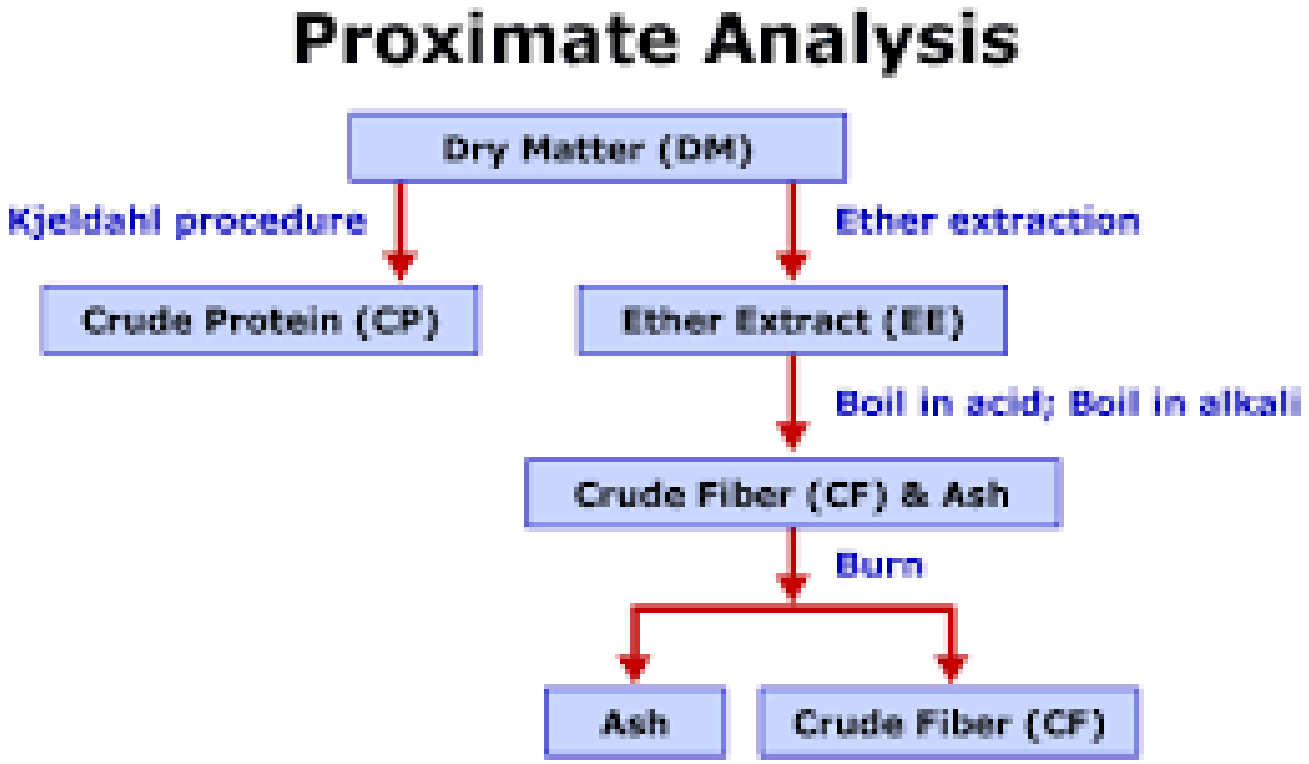
- It was also called wet chemistry.
- Forages in the past used to be tested using this method.
- It uses a series of chemical procedures in the laboratory to determine nutritive value of feed.

Near infra red (NIR) spectroscopy

- Is a new technology that uses light.
- NIR light is directed unto forages to analyze nutritive value of feeds.
- Samples used are not destroyed as compared to chemical testing.
- It is suitable for determining harvest time and quality while at storage.

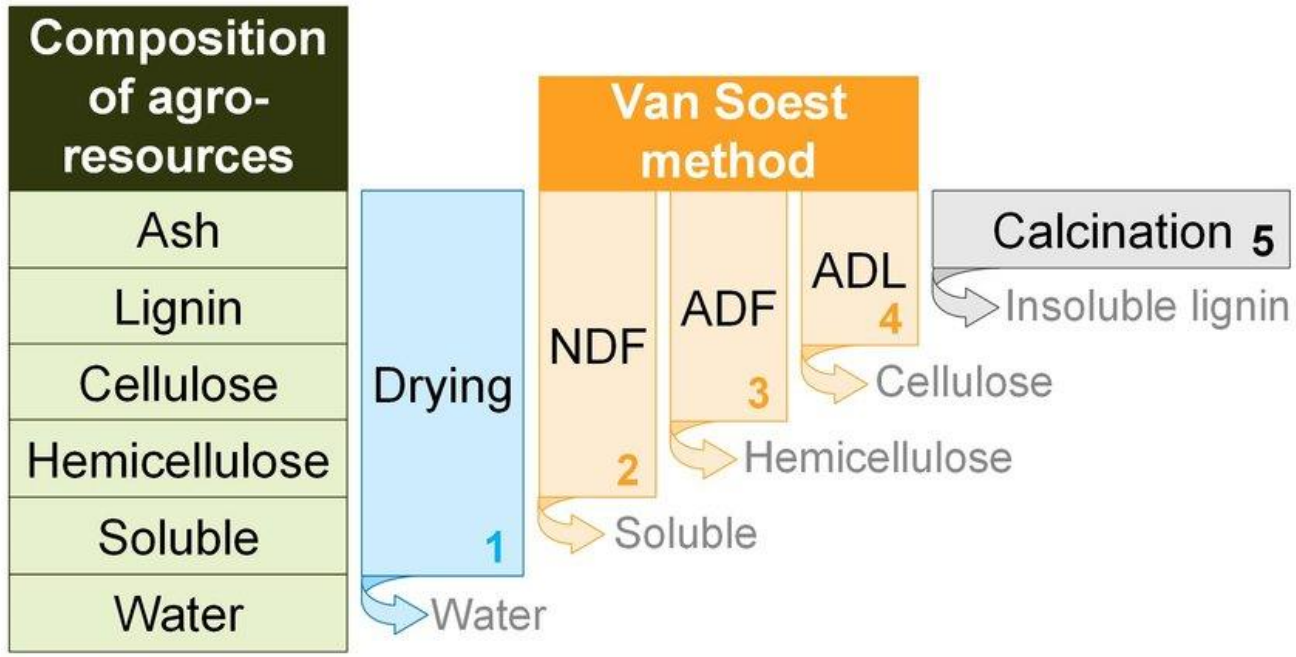
12. Proximate analysis

- This is the common and basic system used in most laboratories for testing feedstuffs.
- The analysis evaluates:
  - Dry matter content (DM)
  - Crude protein (CP)
  - Crude fiber (CF)
  - Fats/Ether extract (EE)
  - Ash
  - Starch
  - Sugar
  - Digestibility



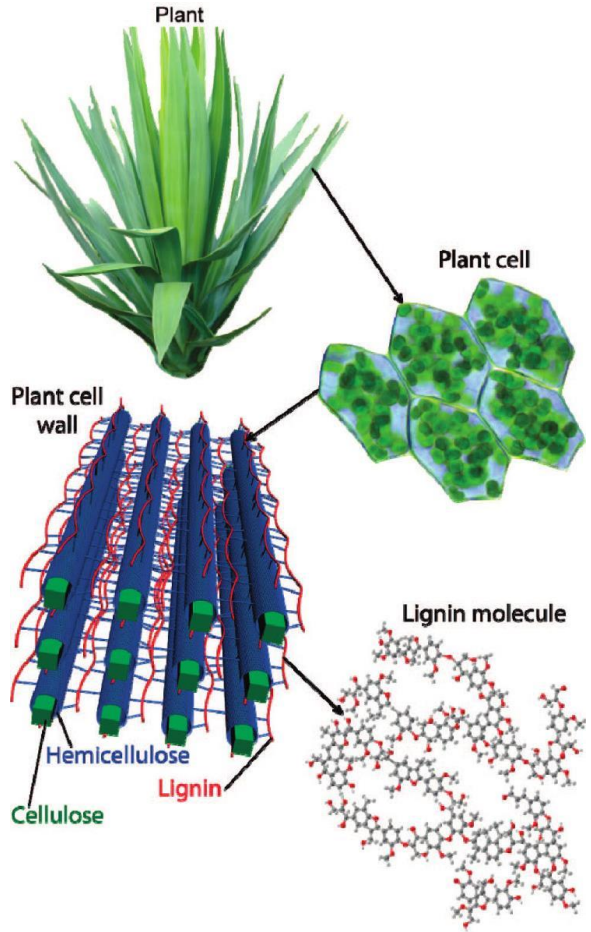
13. Van Soest analysis

- The Van Soest method of analysis looks into the composition of fiber component of forages.
- Proximate analysis offers the general analysis of crude fiber in forages.
- For ruminant nutrition, it is important to understand how different fiber components affects digestibility and intake.
- The van Soest method differentiates fiber components into:
  - Neutral detergent fiber (NDF)
  - Acid detergent fiber (ADF)
  - Acid detergent lignin (ADL)



14. Fibre components: NDF, ADF and ADL

- Neutral detergent fiber (NDF) measures all the total cell wall components of a plant (digestible and indigestible fiber parts).
- NDF indicates how bulky the feed could be.
- Acid detergent fiber (ADF) measures the indigestible portions of a plant cell wall i.e. lignin and cellulose.
- Acid detergent lignin (ADL) measures the lignin fraction in cell wall portion of forages.



NDF → ADF → ADL

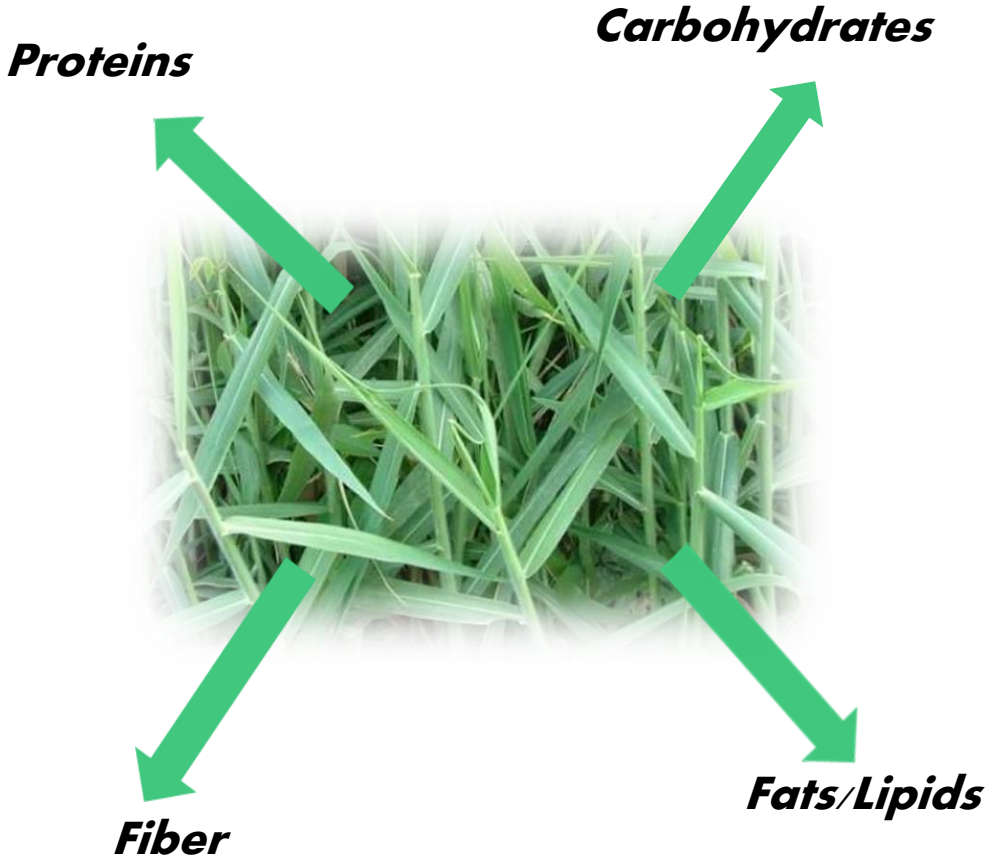
15. Interpreting feed/fodder analysis reports: Energy

- Energy value shows the amount of energy a cow can get from the feed for various body functions.
- Energy is mathematically calculated and measured in MJ/Kg.
- Total digestible nutrients (TDN) is used as a measure of energy.
- The higher the energy value the higher the energy present in the feed.
- Energy is often neglected whereas it is greatly needed for many body functions of the cow and should be given priority.

Parameter		Unit	Result	Method
Energy	E	MJ/Kg	9.41	Calculated
Protein	Protein	%	10.5	ISO 5983-2
Fibre	Fibre	%	33.8	ISO 6865
Fat	Fat	%	3.22	Gafta 3
Total Ash	Ash	%	9.53	ISO 5984
Starch	Starch	%	< 0.10	NIR
Acid detergent fibre	ADF	%	42.5	NIR
Neutral Detergent Fibre	NDF	%	67.9	NIR
Sugar	Sugar	%	< 0.50	NIR
Digestibility (NCGD)	NCGD	%	58.8	NIR
Dry matter	DM	%	94.5	ISO 6496

15.1 Total Digestible Nutrients (TDN)

- TDN gives a measure of total energy of feed when fed in a ration.
- TDN measures digestible proteins, fiber, carbohydrates and fats/lipids in feedstuff.
- TDN is in a dry matter basis and is calculated on ADF basis and directly related to digestibility.
- A high quality forage/feed will have high energy concentration (low ADF).
- Percentage TDN content of any feed represents energy of heat value of that particular feed.
- TDN over-estimates energy values of forages than grain.



15.2 Total Digestible Nutrients (TDN) Cont'd…

TDN Formular

$$TDN = \text{dig CP} + \text{dig CF} + \text{dig NFE} + (\text{dig Fats} \times 2.25)$$

$$NFE = 100 - (\%\text{Moisture} + \%\text{CF} + \%\text{CP} + \%\text{ Fats} + \%\text{ ash})$$

KEY: dig = Digestible, CP = Crude protein, CF = Crude fiber, NFE = Nitrogen free extract.

- Nitrogen free extract (NFE) consist of carbohydrates, starch and sugars like substances.
- NFE is an organic material in feedstuff that has no specific analysis.
- When fat is oxidized it produces 2.25 times more energy than carbohydrates , hence the multiplication by 2.25.

16. Crude Protein (CP)

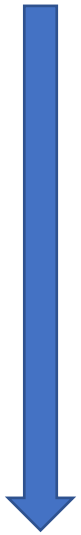
- Measures the protein content in feeds using ISO 5983-2 method.
- CP is measured in percentage (%) and also provides energy.
- Measure of protein in feed is determined by the amount of nitrogen (component of protein) in the feed.
- It is assumed that proteins contain an average of 16%N hence the conversion rate of 6.25 (100/16).
- It is calculated by multiplying the %nitrogen with 6.25

CP (%) = %N × 6.25

16.1 Crude Protein (CP) Cont'd…

Crude protein (CP) Vs stage of crop maturity

Crude Protein content decreases as plant matures



Stage of maturity	Grasses	Legumes
	% CP	% CP
Pre-head stage	> 18	> 19
Early head stage	13-18	17-19
Head stage	8-12	13-16
Post head stead	< 8	< 13

17. Crude Fat (Ether Extract)

- Measures crude fat content of feedstuff and is estimated using Gafta 3 method.
- Is a source of energy, but not an important source of energy for ruminants.
- Fat content in feed is advised to be low; at least less than 5% of the total ration as it interferes with digestion of fiber.
- High fat content in ration coat fiber in the digestive tract interferes with fiber digestion and feed palatability.
- Feeds with unsaturated fats should not be used in free form in ruminant rations, such as soybean oil.
- Limit percentage of unprotected fat to below 6% in the ration to avoid affecting milk fat.

Parameter		Unit	Result	Method
Energy	E	MJ/Kg	9.41	Calculated
Protein	Protein	%	10.5	ISO 5983-2
Fibre	Fibre	%	33.8	ISO 6865
Fat	Fat	%	3.22	Gafta 3
Total Ash	Ash	%	9.53	ISO 5984
Starch	Starch	%	< 0.10	NIR
Acid detergent fibre	ADF	%	42.5	NIR
Neutral Detergent Fibre	NDF	%	67.9	NIR
Sugar	Sugar	%	< 0.50	NIR
Digestibility (NCGD)	NCGD	%	58.8	NIR
Dry matter	DM	%	94.5	ISO 6496

18. Ash

- Ash in feed is compiled by minerals in the feed and possible contamination of soil.
- It determines the content of inorganic components in the feed.
- Value for ash should range between 5-8%.
- Grasses have ash content around 6%.
- Lucerne on the other side has a value of 8%.
- Recommended ash content should be below 10%.

Parameter		Unit	Result	Method
Energy	E	MJ/Kg	9.63	Calculated
Protein	Protein	%	13.4	ISO 5983-2
Fibre	Fibre	%	31.9	ISO 6865
Fat	Fat	%	3.88	Gafta 3
Total Ash	Ash	%	11.7	ISO 5984
Starch	Starch	%	< 0.10	NIR
Acid detergent fibre	ADF	%	42.5	NIR
Neutral Detergent Fibre	NDF	%	63.0	NIR
Sugar	Sugar	%	< 0.50	NIR
Digestibility (NCGD)	NCGD	%	60.2	NIR
Dry matter	DM	%	89.8	ISO 6496

18.1 Ash content in forage

- If ash content is higher than 10%, chances are that the forage is contaminated with soil.
- Soil can be added to the forage either during;
  - Harvesting
  - Transporting
  - Storage
  - Feeding
- If ash levels are high in silage, it may induce undesired fermentation because soil can be contaminated with undesired bacteria/microorganisms.

Source:
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.facebook.com%2FAfricanfarmresourcecentre%2Fposts%2Fhow-to-prepare-silage-for-dairy-cowssilage-is-high-moisture-fodder-preserved-thr%2F1977767655825127%2F&psig=AOvVaw2S2Yt5ktbMnmTiIV5F50HO&ust=1631281468464000&source=images&cd=vfe&ved=0CAsQjRxqFwoTCOCwzKaD8vICFQAAAAAdAAAAABAD

19. Starch

- Starch is a readily accessible source of energy for cows.
- It shows the level of starch content present in highly fermentable carbohydrates for example cereals/grains (wheat bran) and maize silage.
- Starch is analysed using Near Infra-red (NIR) spectroscopy method.
- High starch levels should be limited to dairy cows; this prevents rumen pH going low causing rumen acidosis. This condition limits fiber intake.
- Highly fermentable carbohydrates should be mixed with roughages to limit occurrence of rumen acidosis.

Parameter		Unit	Result	Method
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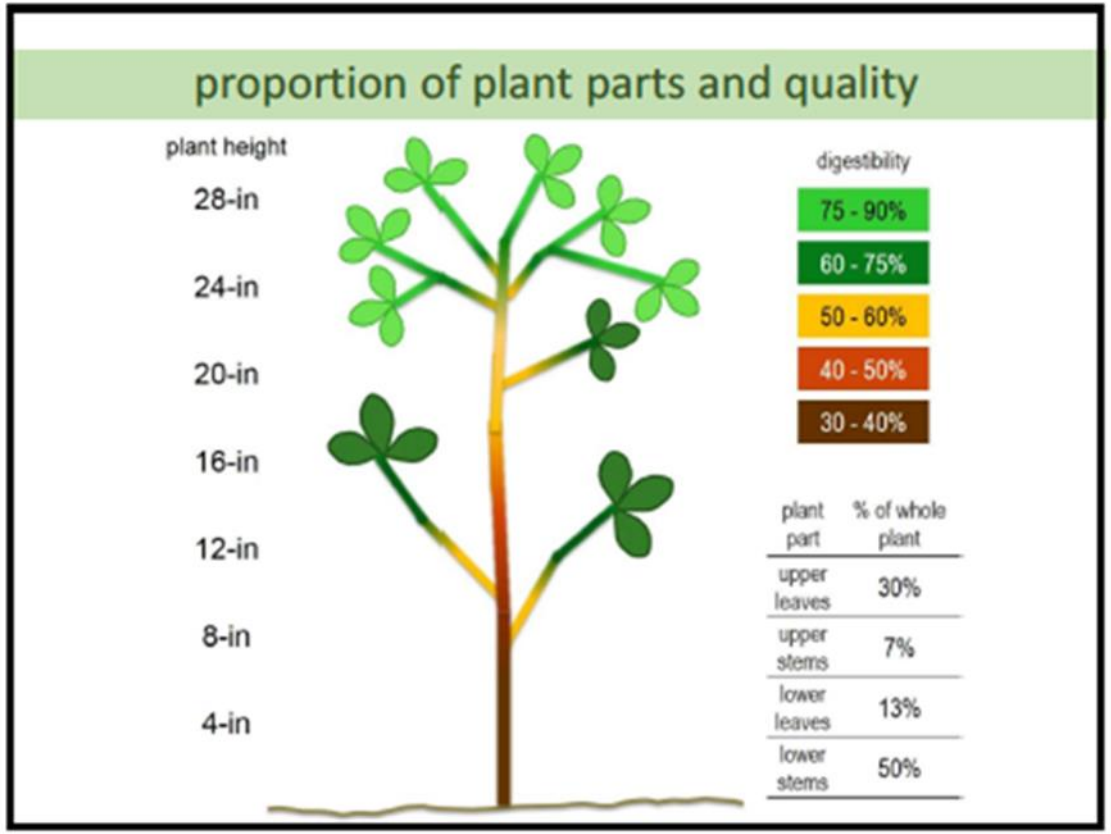
Sugar	Sugar	%	< 0.50	NIR
Digestibility (NCGD)	NCGD	%	58.8	NIR
Dry matter	DM	%	94.5	ISO 6496

20. Sugar

- Is a rapidly fermentable carbohydrate.
- Level of sugar should be considered as it can cause acidosis at excessive levels.
- Sugar is analyzed using Near Infra-red spectroscopy method.
- Sugars produce high levels of propionate and butyrate.
- Example of such feed sources are molasses and brewers waste.

21. Digestibility

- Digestibility refers to the level at which a feedstuff is absorbed in cows body as it goes through cows digestive system.
- It is measured as a percentage.
- Digestibility is analysed using Near infra-red spectroscopy method.
- It helps to figure out how best to improve feed digestibility if percentage is low; for example chopping of forage helps increase digestibility and intake.
- Digestibility varies with the type of crop and particularly stage of harvesting.



22. Dry Matter (DM)

- Dry matter is what remains after water (moisture) is removed from a feed/forage.
- Nutrients are found in the dry matter portion.
- DM is measured using ISO 6496 method.
- Rations are made on a dry matter basis.
- To convert ‘as fed’ basis to ‘DM-basis’, divide the ‘as fed’ basis by the sample percentage dry matter.

22.1 Examples of recommended DM of feed

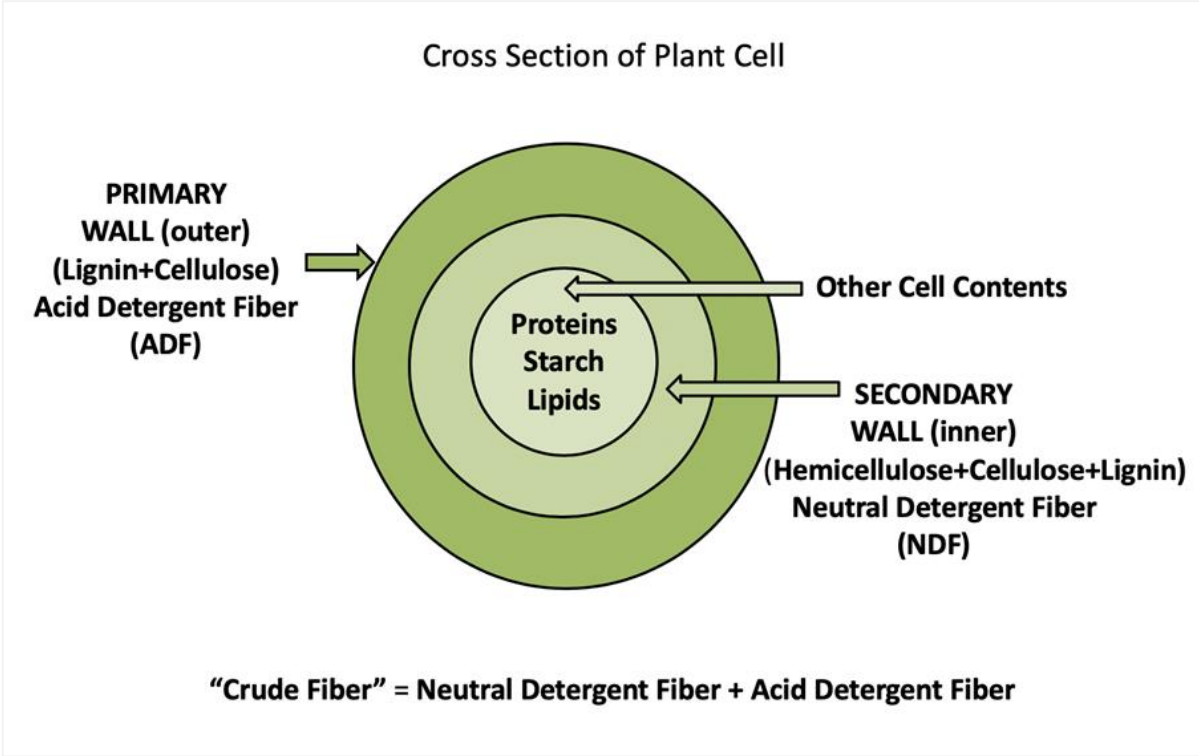
- Recommended DM of maize silage is 30-37%.
- Recommended DM of grass silage is 30-35%.
- DM in silage is influenced by time of harvesting.
- Recommended DM of dry fodder (hay) is 82-85%.
- If the dry matter content in silage is below 30%, the silage is considered to be wet.
- Wet and very dry forages are difficult to ensile.
- If the DM is above 40%, that silage is considered to be dry.

30-37% DM

82-85%DM

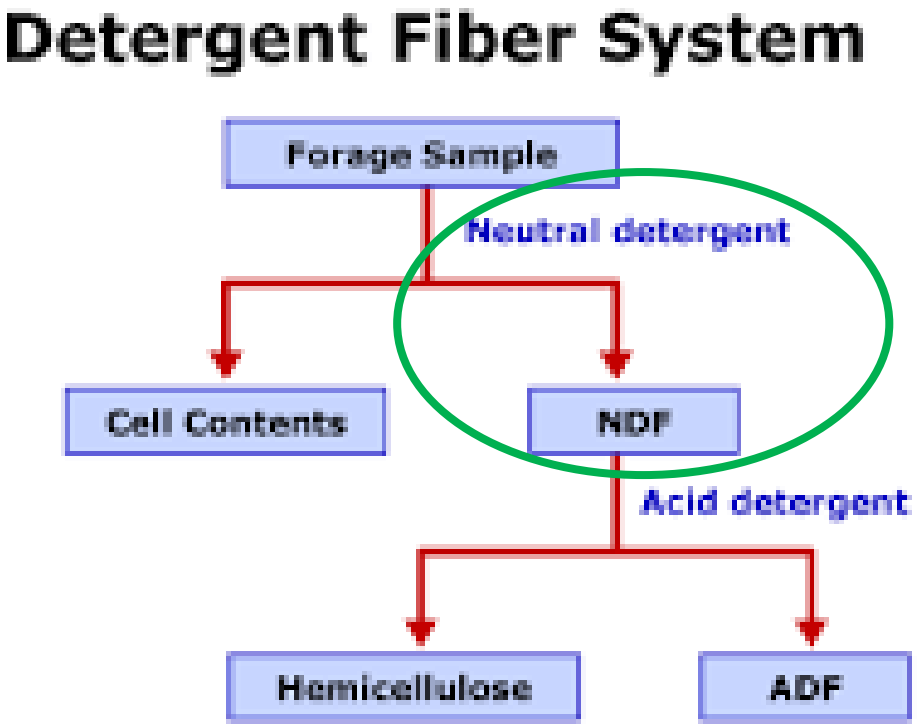
23. Crude Fibre (CF)

- Commonly represented as fiber in forage analysis reports.
- Measured using ISO 6865 method.
- Crude fiber measures the total fiber contents in forages.
- Total fiber looks at the amount of less digestible/indigestible parts of a feed that is for example; cellulose, hemicellulose and lignin.
- The higher the fiber the lower the energy content in feed.
- Most common fiber components measured in forage are crude fiber, NDF and ADF.



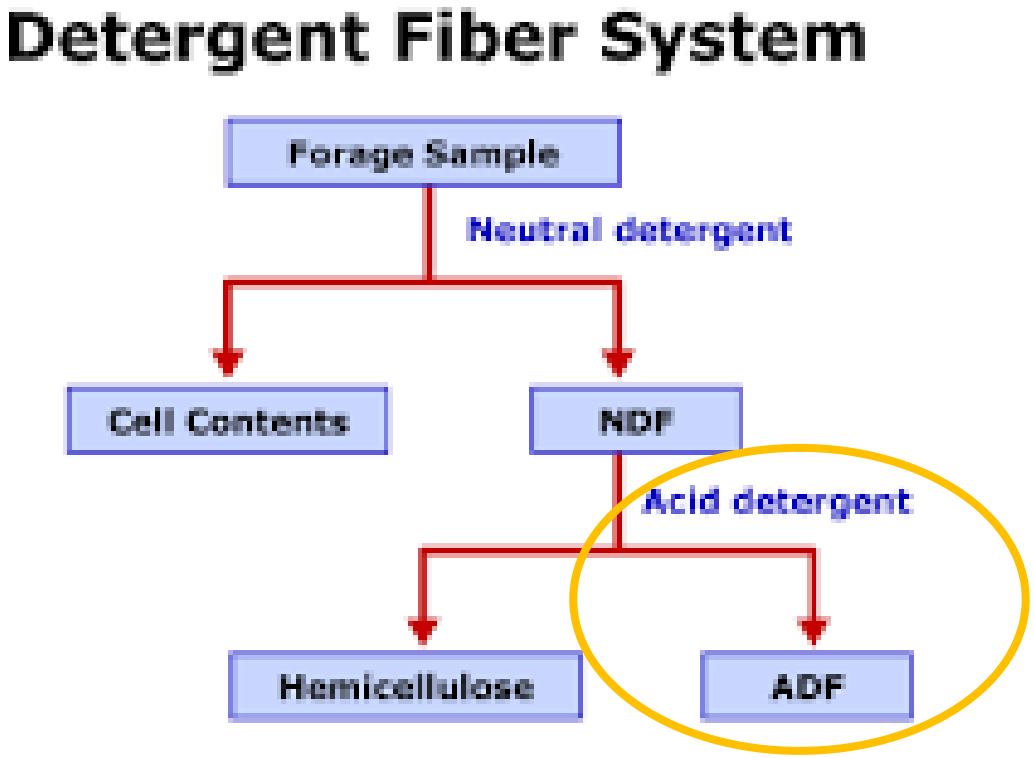
24. Neutral Detergent Fibre (NDF)

- NDF measures total cell wall content of a plant, which includes ADF fraction (lignin & cellulose) plus hemicellulose.
- It indicates the fibre content indicating plant maturity.
- High levels of NDF restricts animals intake, NDF increases as forage matures and low levels of NDF affects the rumen health, caused by rumen acidosis.
- Concentrates have the lowest NDF (causes rumen acidosis if taken in large amounts).
- NDF is measured as a percentage and is linked with DM intake of feed as it provides fill.
- The target is to keep NDF content <40% Alfalfa and NDF <55% in tropical grasses.



25. Acid Detergent Fibre (ADF)

- It measures the indigestible portions of a plant cell wall i.e. lignin and cellulose.
- ADF reflects degree of lignification.
- High ADF indicates plant is more mature & low quality hence poor digestibility.
- It is linked with energy calculation, forages that are high in ADF generally have low energy.
- Is measured as a percentage.
- Target <35% Alfalfa and <35% grasses.



26. ADF AND NDF Interpretation

NDF

- High NDF value limits dry matter intake (DMI).
- NDF value above 75% has potential of reducing dry matter intake (DMI) of a cow.

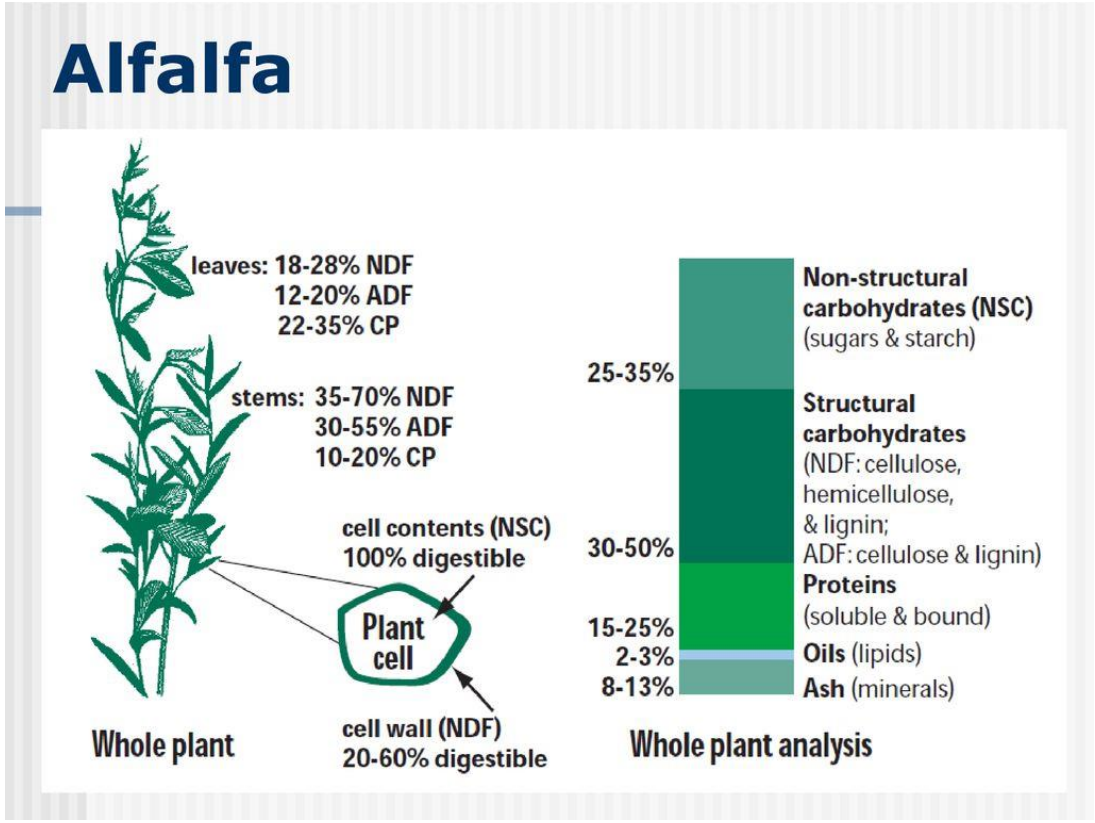
ADF

- High ADF value affects digestibility as it shows that the crop has high fiber content.
- This also shows the crop was harvested at late maturity.

Stage of maturity	Grasses	Legumes
	% NDF	% NDF
Pre-head stage	< 55	< 40
Early head stage	55-60	40-46
Head stage	61-65	47-51
Post head stead	> 65	> 51

27. CP, ADF and NDF relationship

- The CP, ADF and NDF uses a 20:30:40 rule in assessing good quality forages (grasses & legumes).
- There is a slight difference when comparing grasses and legumes' ADF & NDF values.
- Values in CP, ADF and NDF is also affected by maturity of crop.
- Legumes generally have a higher protein content than grass at the same stage of maturity.
- Difference in ADF and NDF values for legumes is 10% NDF higher than ADF, while grass has a difference of 20-25% NDF higher than ADF.
- High difference in ADF and NDF value for grasses is attributed to high amount of hemicellulose content in grass variety.



28. CP, ADF and NDF of grasses

Stage of maturity	Grasses			
	% CP	% ADF	% ADF:NDF Difference	% NDF
Pre-head stage	> 18	< 33	22%	< 55
Early head stage	13-18	33-38	22%	55-60
Head stage	8-12	39-41	22%	61-65
Post head stead	< 8	> 41	24%	> 65

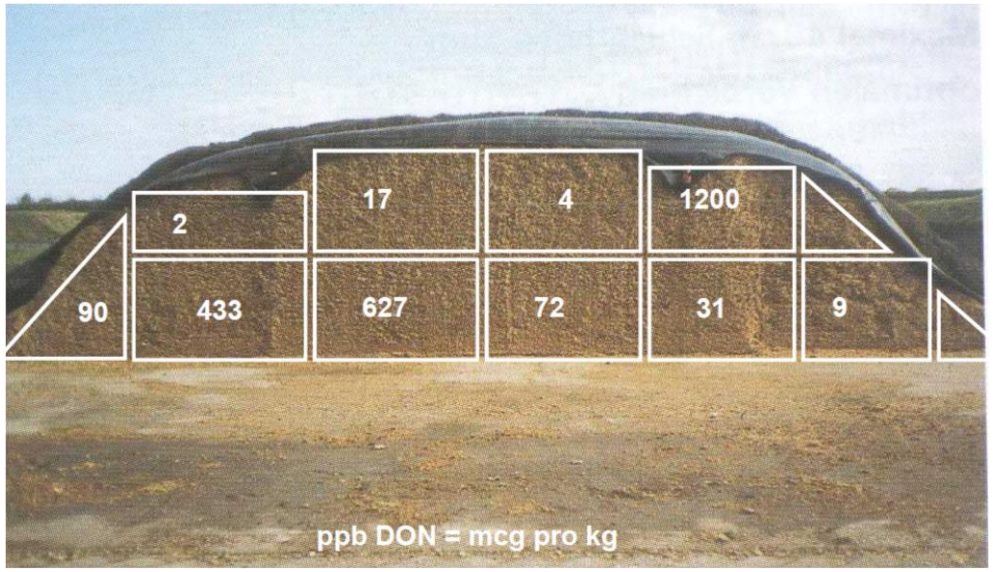
29. CP, ADF and NDF of legumes

Stage of maturity	Legumes			
	% CP	% ADF	% ADF:NDF Difference	% NDF
Pre-head stage	> 19	< 31	9%	< 40
Early head stage	17-19	31-35	9%	40-46
Head stage	13-16	36-41	11%	47-51
Post head stead	< 13	> 41	10%	> 51

30. Mycotoxin analysis

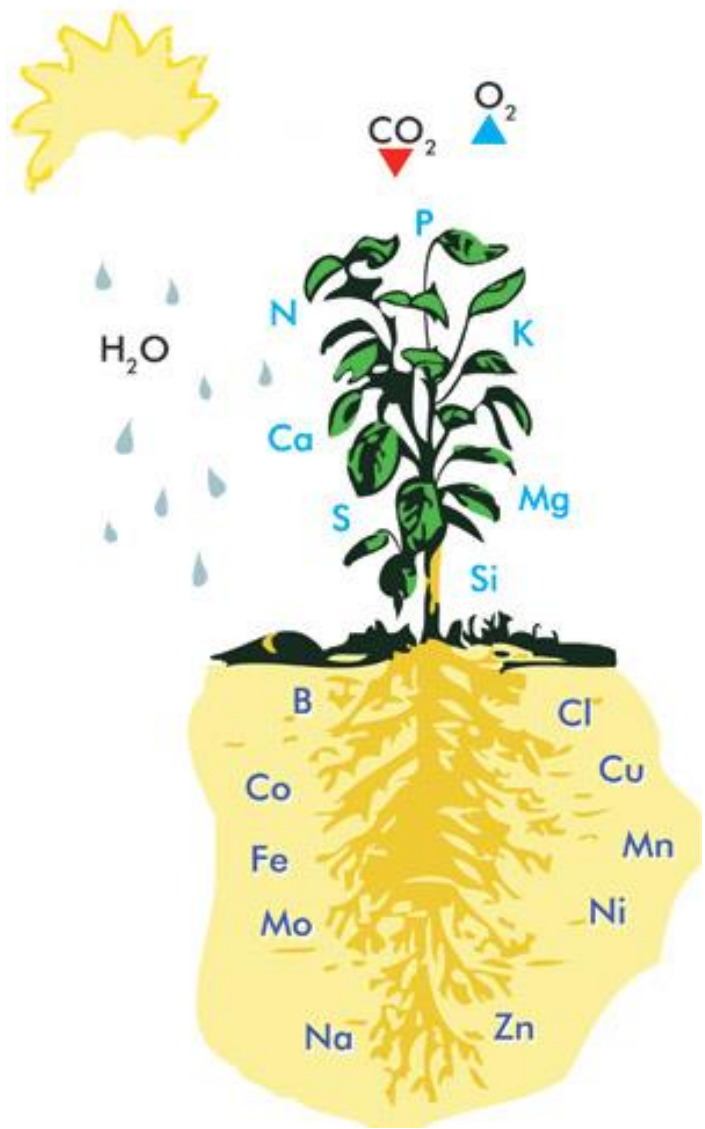
- Mycotoxins are produced by fungi as a metabolite.
- Different fungi produce different toxins; for example aflatoxins.
- High levels of mycotoxin pose a health risk to both livestock and humans.
- Milk processors test on the aflatoxin M1 level in milk and may reject the milk if the levels are too high.

Further reference:
See module on mycotoxin in dairy cattle nutrition.



31. Mineral analysis

- Mineral analysis is done to know the mineral content in feeds i.e. macro and micro minerals.
- Major/macro minerals include; calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg) and sulphur (S).
- Micro/trace minerals include; copper (Cu), zinc (Zn), iron (Fe), selenium (Se) and cobalt (Co).
- Testing minerals guides farmers on whether to offer mineral supplements or take corrective measures through fertilization.



32. Feed analysis report

Logo

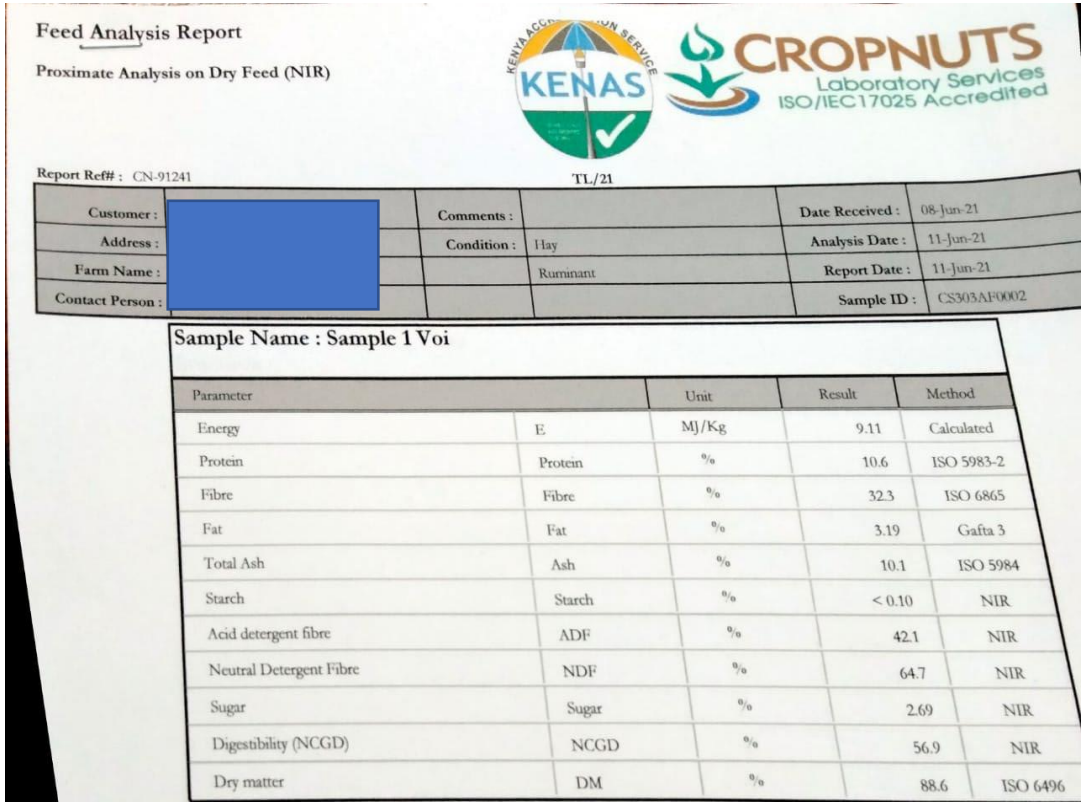
- Found at the top of the report.
- Address of laboratory can also be found here or at the bottom of the report.

Type of analysis

- Kind of analysis done is indicated at the top near the logo.

Report reference

- Client/customer detail i.e. contact and address
- Detail of sample and reason for test.
- Date i.e. when sample was received and analyzed.



Feed Analysis Report

Proximate Analysis on Dry Feed (NIR)

KENAS

CROPNUTS Laboratory Services ISO/IEC17025 Accredited

Report Ref# : CN-91241 TL/21

Customer :	[redacted]	Comments :		Date Received :	08-Jun-21
Address :		Condition :	Hay	Analysis Date :	11-Jun-21
Farm Name :			Ruminant	Report Date :	11-Jun-21
Contact Person :				Sample ID :	CS303AF0002

Sample Name : Sample 1 Voi

Parameter		Unit	Result	Method
Energy	E	MJ/Kg	9.11	Calculated
Protein	Protein	%	10.6	ISO 5983-2
Fibre	Fibre	%	32.3	ISO 6865
Fat	Fat	%	3.19	Gafta 3
Total Ash	Ash	%	10.1	ISO 5984
Starch	Starch	%	< 0.10	NIR
Acid detergent fibre	ADF	%	42.1	NIR
Neutral Detergent Fibre	NDF	%	64.7	NIR
Sugar	Sugar	%	2.69	NIR
Digestibility (NCGD)	NCGD	%	56.9	NIR
Dry matter	DM	%	88.6	ISO 6496

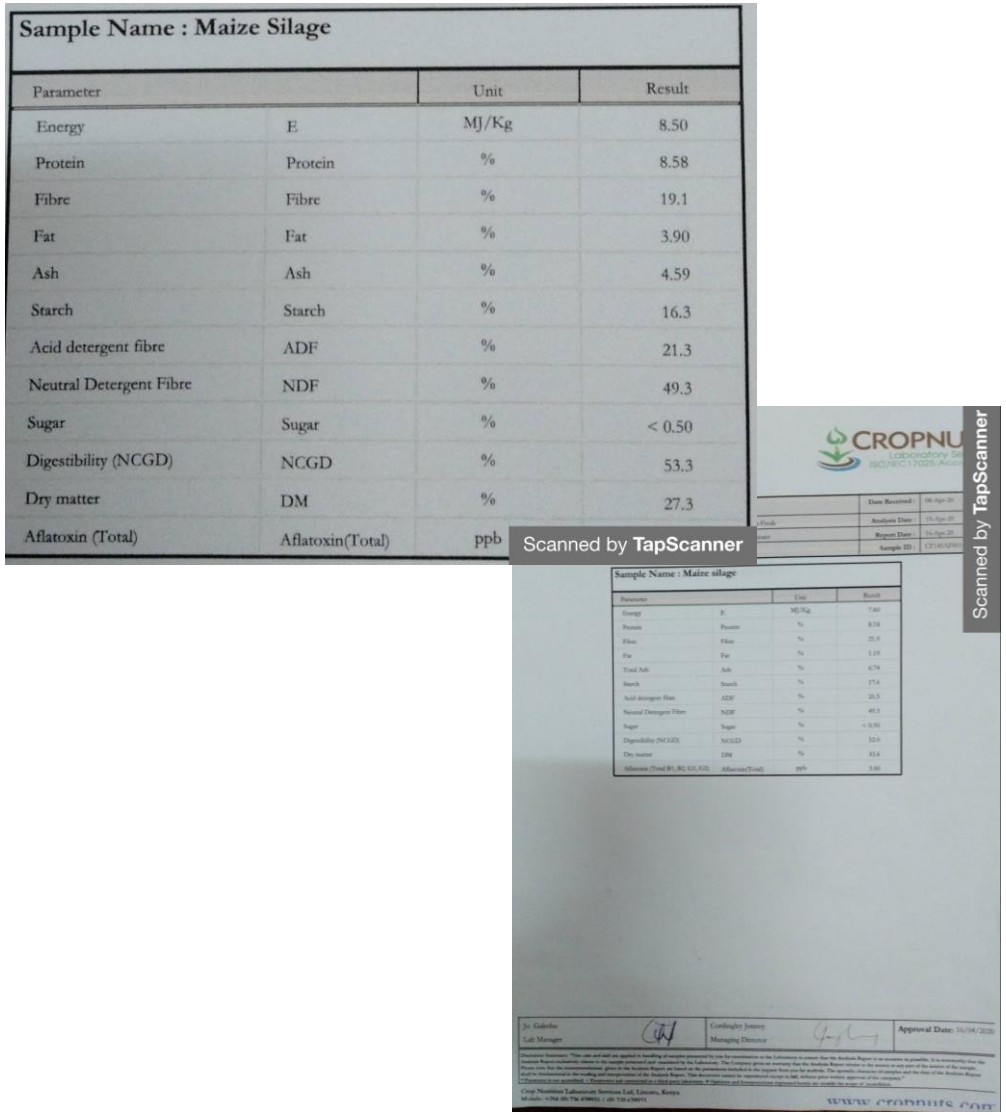
32.1 Components of feed analysis report

Results section

- Results of feed analysis are reported on Dry Matter basis.
- Other laboratories offer results on both ‘As fed’ and ‘Dry Matter’ basis.
- The table in the results section gives details of;
    i. Parameter tested
    ii. Unit of measure for specific parameter
    iii. Result of parameter
    iv. Method used to measure parameter tested.

Approval section

- Contains date and signature from authorized personnel to show result is approved by the organization.
- Comment section is also found here and in other cases at the top before results section.

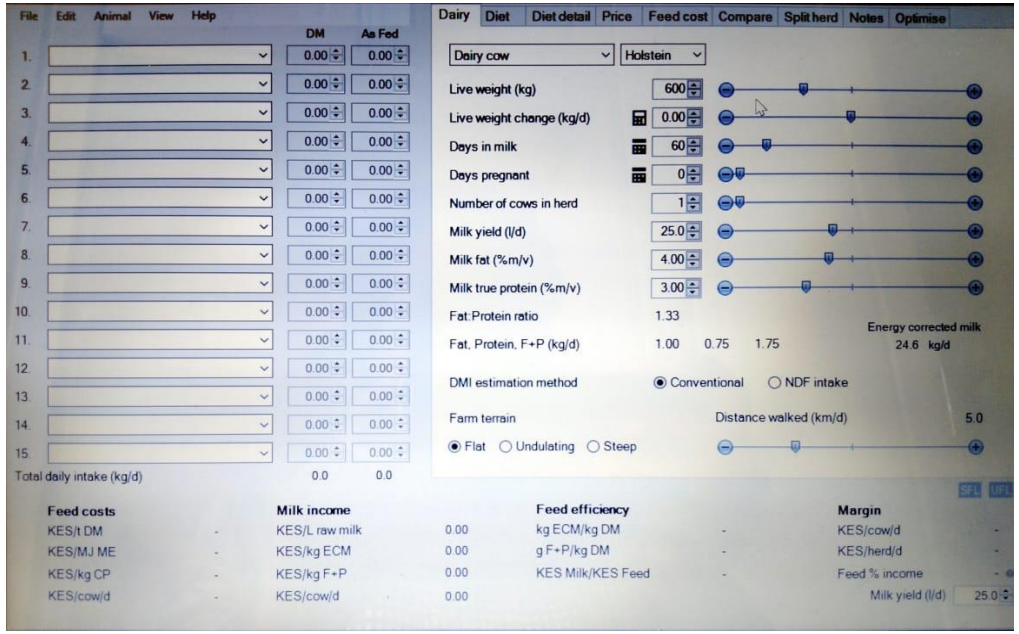


Sample Name : Maize Silage

Parameter		Unit	Result
Energy	E	MJ/Kg	8.50
Protein	Protein	%	8.58
Fibre	Fibre	%	19.1
Fat	Fat	%	3.90
Ash	Ash	%	4.59
Starch	Starch	%	16.3
Acid detergent fibre	ADF	%	21.3
Neutral Detergent Fibre	NDF	%	49.3
Sugar	Sugar	%	< 0.50
Digestibility (NCGD)	NCGD	%	53.3
Dry matter	DM	%	27.3
Aflatoxin (Total)	Aflatoxin(Total)	ppb	

33. Utilizing forage analysis report

- Results of feed analysis can be easily used to balanced feed rations for cows.
- Information from forage report guides farmers and nutritionists when supplementation should be considered .
- Cows have different requirements depending on stage of lactation, production and weight of the animal.
- Farmers can either use;
  i. Manual calculation,
  ii. Excel spreadsheet, or
  iii. Computer programs for example Rumen8.



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