CLASSIFICATION OF FEEDSTUFFS

Dept of Animal Nutrition,
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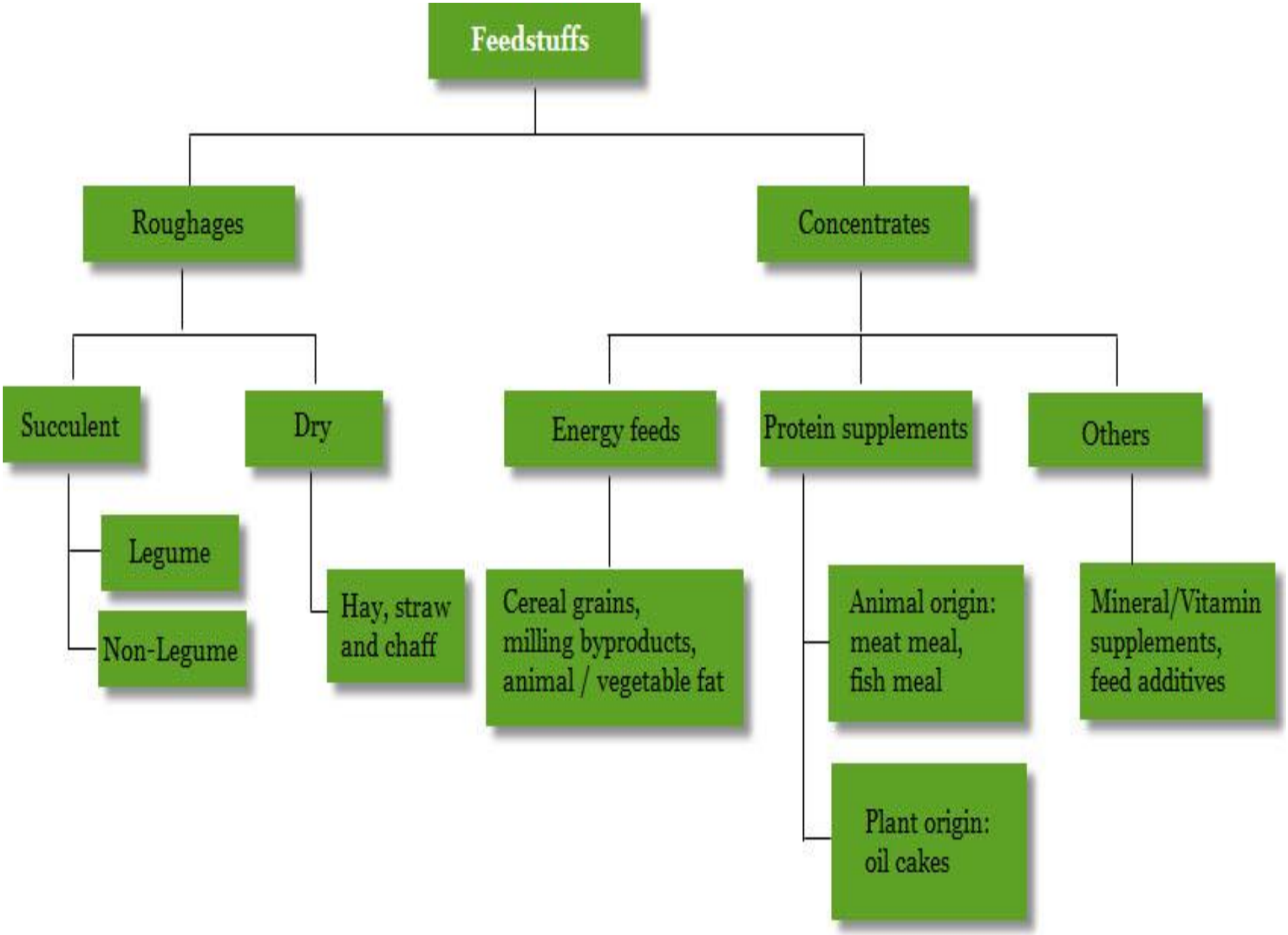
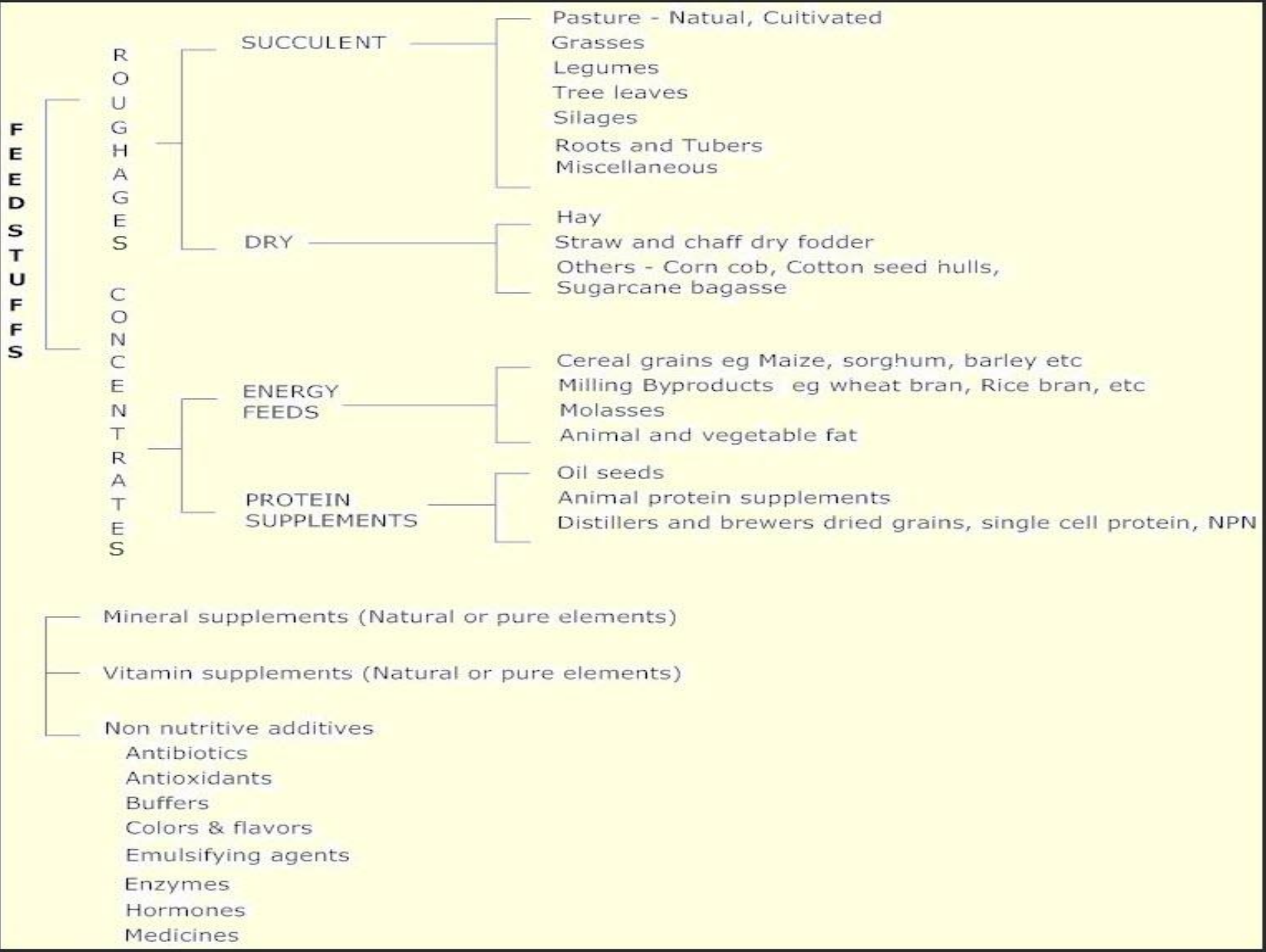

Feedstuffs
Roughages
Concentrates
Succulent
Dry
Energy feeds
Protein supplements
Others
Legume
Non-Legume
Hay, straw and chaff
Cereal grains, milling byproducts, animal / vegetable fat
Animal origin: meat meal, fish meal
Plant origin: oil cakes
Mineral/Vitamin supplements, feed additives


FEEDSTUFFS
ROUGHAGES
SUCCULENT
Pasture - Natual, Cultivated
Grasses
Legumes
Tree leaves
Silages
Roots and Tubers
Miscellaneous
DRY
Hay
Straw and chaff dry fodder
Others - Corn cob, Cotton seed hulls, Sugarcane bagasse
CONCENTRATES
ENERGY FEEDS
Cereal grains eg Maize, sorghum, barley etc
Milling Byproducts eg wheat bran, Rice bran, etc
Molasses
Animal and vegetable fat
PROTEIN SUPPLEMENTS
Oil seeds
Animal protein supplements
Distillers and brewers dried grains, single cell protein, NPN
Mineral supplements (Natural or pure elements)
Vitamin supplements (Natural or pure elements)
Non nutritive additives
Antibiotics
Antioxidants
Buffers
Colors & flavors
Emulsifying agents
Enzymes
Hormones
Medicines

ROUGHAGES

- Feed consisting of bulky and course plants or plant parts, containing a high fiber content and low total digestible nutrients, arbitrarily defined as feed with over 18% C.F. and 60% TDN.

Succulent roughages :

- A condition of plants characterized by juiciness, freshness and tenderness, making them appetizing to animals.

Dry roughages:

- Feeds in dry state that are bulky and low in weight per unit volume ; usually they contain more than 18% CF and relatively low in energy

CONCENTRATES

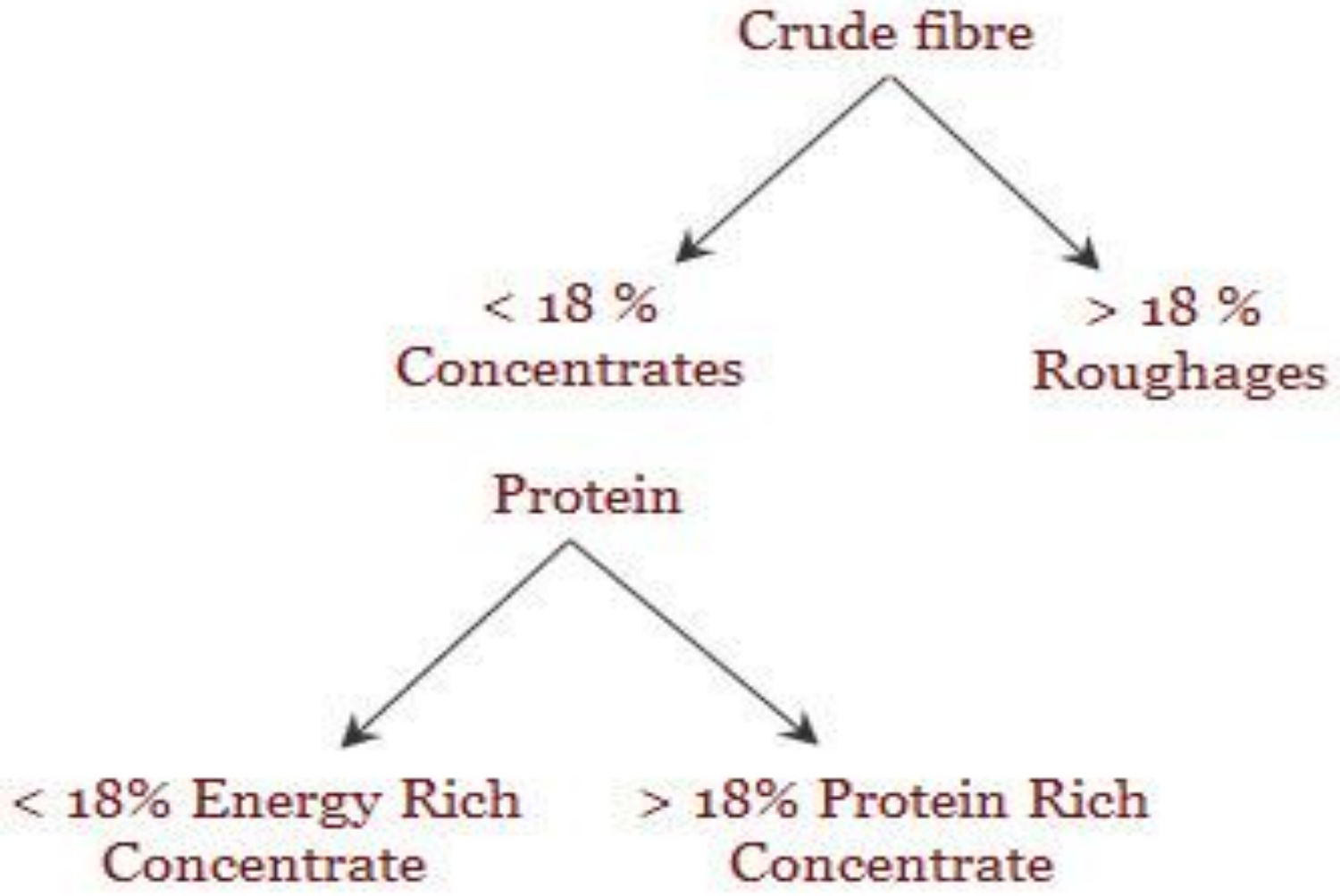
A broad classification of feed stuffs which are high in NFE and TDN but low in crude fiber (under 18%)

Energy feeds:

Feeds that are high in energy and low in fiber (under 18%), and that generally contain less than 20% protein.

Protein supplements:

Products that contain more than 20% protein or protein equivalent.


Crude fibre
< 18 %
Concentrates
> 18 %
Roughages
Protein
< 18% Energy Rich
Concentrate
> 18% Protein Rich
Concentrate

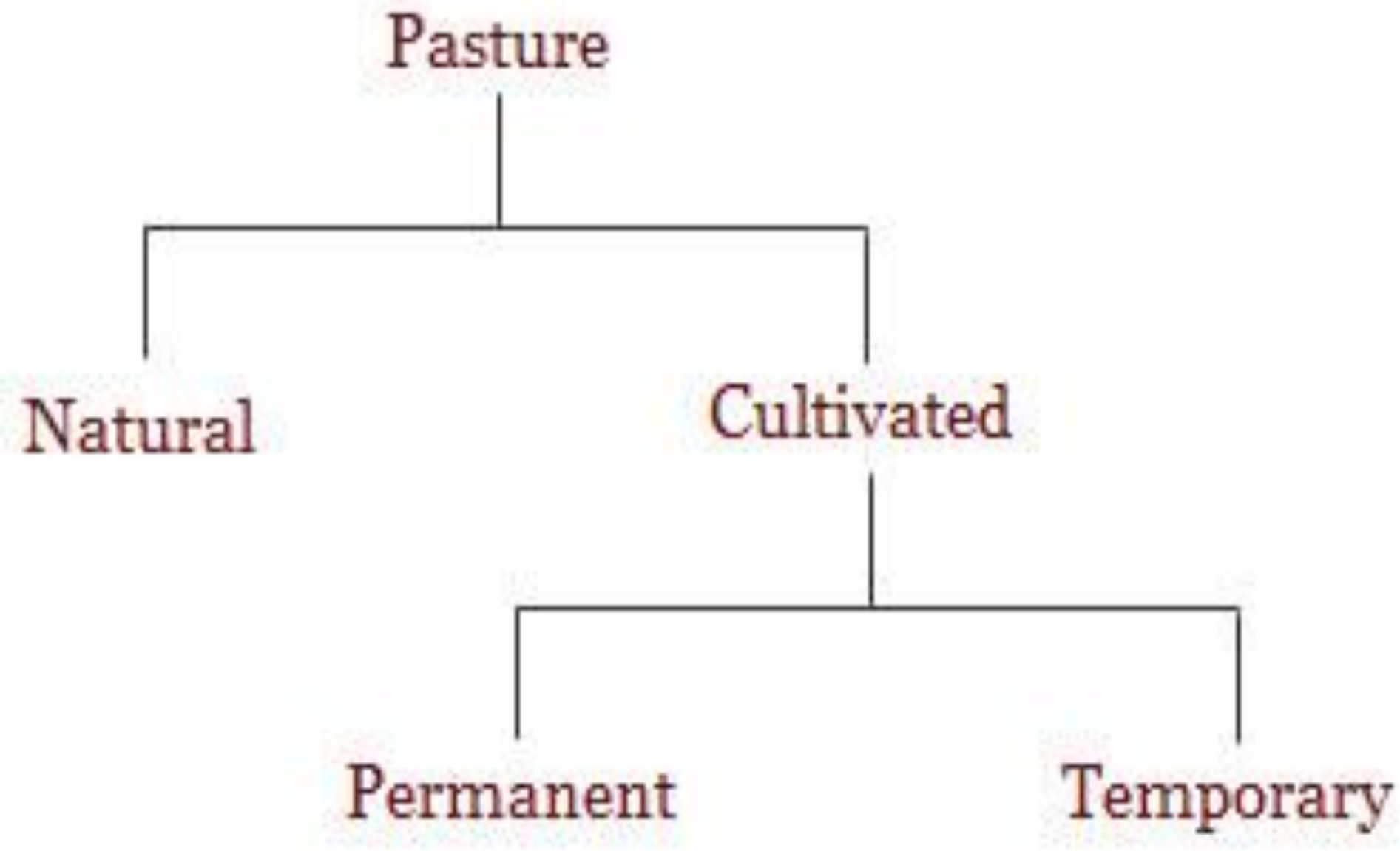
Roughase

- Three types

- maintenance type: DCP-3-5% : non legumes, cereal crops and their hay.
- Non maintenance type: DCP below -3% : straws & stover
- Productive type: DCP more than 5% : legumes fodder and their hay

PASTURE

Land where grasses and other plants grow for animals to graze.



- Natural pastureland includes rough and hilly grazing land
- Cultivated pastureland may be sub divided into permanent or temporary depending upon its usage.
- Natural pastureland includes large number of species whereas cultivated pasture land contain fewer number of chosen species.

- **NUTRIENTS IN PASTURE**
- The nutrient composition is extremely variable; CP range:3 % in mature herbage to 30 % in young heavily fertilized grass.

- The CF content: inversely related: CP content and range 20% in young grass to 40 % in mature grass.
- Digestibility declines as the plant matures.

- In early stages of growth, moisture content is high about 75 to 85% and as the plant mature, it falls to about 60 per cent.
- The pasture lipid content rarely exceeds 4 per cent of the dry matter.

- Based on the stage of growth, soil type, amount of fertiliser applied etc the mineral content varies with species.

- Green herbage is rich in carotene, precursor of vitamin A and quantities as high as 55 mg per 100 grams of dry matter of young green crops.

- The nutritive value of temperate grass varies from tropical grass.

- Tropical grasses sp. contains low protein content compared to temperate grasses.

- Legumes: ability of nitrogen fixing. Ex. – cowpea, berseem, lucerne etc,.

- Legumes: superior to grasses in protein and mineral content, particularly calcium, phosphorus, magnesium, copper and cobalt.

Grasses

- Grasses are the best and cheapest bulk feed for the livestock.

- In natural pastures and grazing area of the country: different kinds of native grasses : Bracharia, Anjan, Hariyali, Giant star, Marvel, Spear, etc. grow under rainfed conditions.

- Under irrigated conditions, grasses like Napier-Bajra hybrids, Guinea grass and Deenanath grass are suitable for cultivation.

- Non legume forages contain 5-10 % crude protein, 0.3-0.5 % calcium and 0.2-0.3 % phosphorus.

- while legume forages like Cow pea, Leucern and Sesbania contain 20-25% crude protein, 1.4-1.6 % calcium and 0.1-3 % phosphorus on dry matter basis.

CULTIVATED GRASSES

- Cultivated grasses includes Bajra Napier, Guinea grass, para grass.
- On DMB the crude protein content ranges from 6-10% with calcium content of 0.4-0.6% and phosphorus content of 0.2-0.4%.
- Grass fodders are perennial in nature and have to be harvested at the recommended intervals.
- First harvest of Hybrid Napier, Guinea grass and Para grass is done at 75 days after planting and the subsequent cuttings are done at 45 days interval.
- Bajra Napier hybrid yields 400 tonnes/ hectare; Guinea grass yields 300 tonnes/hectare; Para grass yields 80-100 tonnes/hectare.
- Cenchrus is suitable for rain fed areas and yields about 40 tonnes/hectare. Intercropping legumes improves the nutritive value of the harvested fodder.

NUTRITIONAL DIS ORDERS ASSOCIATED WITH GRASSES

Nitrate

- Nitrate : NPN present in forages.
- Itself is not toxic to animals.
- The toxic effect on ruminants is caused by the reduction of nitrate to nitrite in the rumen.
- Fertilized plants have higher nitrate levels.
- Grazing herbage: >700 ppm of nitrate N / kg DM is considered to produce toxic effect by converting to nitrite.

- Nitrite is absorbed into red blood cells and combines with hemoglobin (oxygen carrying molecule) to form brown pigment called methaemoglobin.

- Methaemoglobin cannot transport O_2 and hence animal's heart rate and respiration increases, the blood and tissues of the animal take on a blue to chocolate brown tinge, muscle tremors can develop, staggering occurs, and the animal eventually suffocates and die.

BLOAT

- Occurs in grazing land with predominant legumes like lucerne and clover.
- Ruminants carry an active population of microorganisms that generate large volumes of gas during the normal process of digestion.
- This gas either is belched up or passes through the gastrointestinal tract.
- Bloat occurs when eructation of gas is interfered.
- Natural foaming agents (Saponin) in legumes cause stable foam to form in the rumen.
- Gas is trapped in small bubbles in this foam in the rumen and the animal cannot belch up the gas.
- Pressure builds up in the rumen causing an obvious swelling on the left side of the body.
- Vegetable oils are effective for preventing and treating pasture bloat because they break down the frothy condition in the rumen contents.

PHYTO-ESTROGENS

- Pasture plants like subterranean clover, red clover and Lucerne contain Oestrogenic activity.

- Oestrogenic hormones may be produced either by pasture legumes (plant oestrogens or phytoestrogens), or by soil-borne fungi that live on pasture plants or on dead and decomposing organic matter at the base of pasture.

- Phyto-estrogen causes infertility, dystocia and other reproductive problems.

GOITROGENIC SUBSTANCE

- The genus *Brassica* includes cabbages, turnips and cauliflower.
- They contain goitrogenic substance – thiocyanate which interferes with the uptake of iodine by thyroid gland leading to goiter.

- Forage brassica also cause haemolytic anaemia in ruminants.

CULTIVATED FODDER: NON LEGUME FODDER CROPS

- Cereal crops cultivated for fodder includes sorghum, maize, oats and bajra.
- On dry matter basis the crude protein content ranges from 8-12% with calcium content of 0.4-0.6% and phosphorus content of 0.2-0.5%.
- Cereal fodders are annual crops and the fodder should be harvested at 2/3rd or 50 % flowering stage (around 45 to 60 days for most of the crops) .
- Intercropping with legumes improves the nutritive value of the harvested fodder.
- Fodder sorghum as well a fodder maize under irrigated conditions yield about 40-45 tonnes per hectare while fodder bajra and oats yields 25-30 tonnes per hectare.
- One may get 50 % of these yields under rainfed conditions

CULTIVATED LEGUME FODDER CROPS

- Berseem, cowpea, lucerne, desmanthus and stylo are the common leguminous crops grown in India.
- On dry matter basis, they contain from 15-25 per cent crude protein with 1-2% calcium and 0.2-0.4% phosphorus leading to wide calcium to phosphorus ratio.
- Legumes yields 75-100 tonnes per hectare but cowpea yields only 20 tonnes per hectare.
- Legume fodders are liable to produce “bloat” if given in large quantities and thus it is advisable that they should always be given along with some dry fodder (not exceeding a maximum of 1/3rd of total green roughages).
- Perennial legume fodders such as Lucerne are harvested at 75 days after sowing and subsequently at 30 days interval
- Annual fodders such as Berseem and Cowpea should be harvested at 50% flowering stage and are ready by 50-60 days.
- Intercropping with cereal or grasses increases the total green fodder yield per unit of land and thereby avoids overfeeding of legume alone that may lead to bloating in animals. CP: 15-25%

SILAGE

- Silage is the preserved material produced by the controlled fermentation of crop under anaerobic conditions in a structure known as silo.
- Ensilage is the name given to the silage making process.
- The main purpose of silage making is to preserve succulent fodders for usage at the time of scarcity.
- Silage making involves natural fermentation in anaerobic condition with due care to discourage activities of undesirable bacteria.

TREE FODDERS

- Tree fodders form the staple fodder for small and large ruminants in most parts of our country.
- They enhance animal productivity by overcoming seasonal nutritional deficits.
- Further, trees can tolerate varied climatic and environmental conditions, propagate readily and can serve as a valuable source of protein and minerals.
- The non-leguminous tree fodders include leaves of neem, banyan and fig while leguminous tree fodders include leaves of gliricidia, subabool, acacia, sesbania.
- The crude protein content ranges from 7-9% in non-leguminous tree fodders to 19-22% in leguminous tree fodders.
- The calcium content ranges from 1-3 % and phosphorus ranges from 0.3-0.5%. The major constraint in the use of tree fodders is the presence of anti-nutritional factors.

Subabool – Mimosine:

- In subabool, Mimosine is a toxic non-protein free amino acid otherwise chemically similar to tyrosine.
- Mimosine can cause problems when the forage is eaten in large quantities for a long period.
- Mimosine is degraded to Dihydroxypyridone (DHP) in the rumen.
- DHP reaches thyroid gland and inhibits biosynthesis of the hormone thyroxine.
- Symptoms includes reduced growth, excessive salivation, loss of hair, eroded gums, enlarged thyroid gland and poor reproductive efficiency.
- Certain strains of rumen microbes at Australia that are capable of detoxifying mimosine have been identified and are now being inoculated to livestock of other nations to overcome mimosine toxicity.

ROOTS AND TUBERS

- Roots are underground parts of plant e.g., Turnip, beet root, carrot etc.,
- Tubers are thickened stem usually formed in underground e.g., potatoes, Cassava, Sweet potatoes.
- Roots contain sucrose while tubers contain starch or fructan as carbohydrate.
- Feeding livestock with roots and tubers are common in Europe.
- However, Cassava is widely fed to livestock in India.
- Cassava contains two cyanogenicglycosides, which liberates hydrocyanic acid (HCN).
- HCN poisoning leads to death and wilting reduces HCN content to safe level

DRY FODDERS

Hay:

- **Reducing the moisture content of the green crop to a level low enough (12-14%) to inhibit the action of plant and microbial enzymes is the aim of hay making.**
- **The harvested crop can be dried either by natural drying or through artificial drying, but natural drying is preferred as there it can be done without incurring expenditure towards electricity.**
- **Hay can be stored satisfactorily in a stack or bale.**

CROP RESIDUES:

- Crop Residues are the left over portion of the crop after the main crop is harvested for human consumption.
- Crop residues may be grouped under the following headings

Straws	Stover	Aerial portion of other crops	Others
Wheat Paddy Oats Barley Millets	Maize Sorghum	Sugarcane tops Groundnut haulms Soyabean haulms	Corn cobs Bagasse Peanut hull Rice hull

Nutritional quality of crop residues

- Crop residues are generally low in crude protein, energy and micronutrients.
- They are usually high in cell wall constituents like lignin and silica.
- Hence their palatability is low leading to low voluntary intake.
- Their digestibility is also low and bulky in nature.

Straws

- Straws are produced from most cereal crops and from some legumes.
- They consist of the stem and leaves of plants after the removal of the ripe seeds by threshing.
- They are fibrous, rich in lignin and of extremely low nutritive value.
- Straw feeding is not recommended for pig and poultry.

Paddy straw

- The Paddy straw consist of lignin, about 6-7% dry matter is however lower than that of other cereals straw.
- But it has an exceptionally high ash content (17% of dry matter) having high silica level.
- In contrast to other straws, the stems are more digestible than the leaves.

The poor nutritive values of straws may be attributed to the following facts:

- Straw digestion is limited due to the formation of strong physical and/or chemical bonds between lignin and the structural polysaccharides (Cellulose and Hemicellulose).

- Cellulose itself has a highly ordered crystalline structure: very strong association with lignin, which even the most potent cellulosic enzymes cannot have access to the cellulose unless the bondage between lignin and cellulose is broken.
- Crystalline structure of cellulose is also responsible for low digestibility of cellulose.
- Highly deficient in other nutrients like minerals, vitamins, fatty acids and in proteins.
- High silica content of straw is known to depress organic matter digestibility.
- It is economical to increase the nutritive values of all types of poor quality roughages by physical, chemical or biological treatment.

Legume straws

- The husks of the pods with leaves and tender stems are remaining as byproducts after harvesting the seeds of pulses.
- These products can be utilised as nutritious cattle feeds.
- Most common pulse are
  - Urad (*Phaseolusmungo*),
  - Moong (*Phaseolusradiatus*),
  - Moth (*P.aconitifolius*),
  - Cow peas (*Vignacatiang*) etc.
- The energy value of these straws is comparable with those of cereal straws but they are a fairly good source of digestible protein.
- Supplementation with energy-rich feeds like cereal grains will, however will be necessary in the case of high milk producing cattle.
- **Other straws (Cereals) that are commonly fed to animals are**
  Wheat straw, Rye straw and Oat straw.

Stovers

- Consists of the leaves and stalks of corn (maize), sorghum or soybean plants that are left in a field after harvest.
- It can be directly grazed by cattle or dried for use as fodder (forage).
- Its nutritive value is similar to straw.

Sugarcane tops

- It is the top portion that has been removed from the highest fully formed node in sugarcane.
- It includes the green leaves, bundle leaf sheath and variable amounts of immature cane.
- At the time of sugarcane harvest, abundant quantities of sugarcane tops are available.
- Though sugarcane tops serve as green fodder, it has low nutritive value (4 % crude protein and 48 per cent TDN), dries up quickly and hence wasted.
- To preserve sugarcane tops in succulent form, ensiling with one percent urea, molasses and salt is beneficial.

Haulms

- The stems of peas, beans etc., are called as haulms.
- The aerial portion of groundnut plant (groundnut haulms) and Soybean plant (Soybean haulms) can serve as a potential source of fodder for livestock.
- Haulms contain about 15 percent crude protein and 30 % crude fibre and have better nutritive value than stovers.

Others

- A corncob is the left over portion after removal of maize grain.
- Corncobs can be used as fibre source in ruminant feeding.
- Bagasse is the fibrous residue remaining after sugarcane is crushed to extract their juice. It has very low palatability.
- Hulls are outer shell of pods and are fibrous in nature with low nutritive value.
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CONCENTRATES

CEREAL GRAINS

- (Maize, Barley, Oats, Wheat, Rice, Rye, Millets, Sorghum and Bajra)
- Cereal grains are rich in starch containing 8-12% of CP with low lysine and methionine, 2-5% fats, less than 0.15% of calcium and relatively higher phosphorus to the extent of 0.3-0.5%.

- Phosphorus in cereals is present in the form of phytates, which has the ability to immobilize dietary calcium.

- Cereal grains are rich source of thiamine and vitamin E but deficient in vitamin A and riboflavin except yellow maize, which is rich in provitamin A.

Nutritive value:

- **CP: 8-12%**
- **TDN: 68-72%**
- **Fat: 2-5%**
- **Low in lysine, Methionine.**
- **P in the form of phytates**
- **Ca; 0.15%; P 0.3 –5.0%**

Maize or Corn (*Zea maize*):

- Maize has high metabolisable energy value with low fibre content and 8-13% of crude protein.
- The maize kernel contains two main proteins Zein and Glutelin.
- Recently, new variety of maize (Opaque 2,Floury 2) was produced at UK with high methionine and lysine.
- Farm animals are fed with crushed maize.
- Flaked maize decreases the acetic acid to propionic acid proportion in rumen and hence depresses the butterfat content of milk.
- Improperly stored maize having higher moisture content is prone to *aspergillusflavus* infestation and produce aflatoxin.

Barley (Hordeumvulgare):

- Barley has high fibre content with 6-14% of crude protein having low lysine and less than 2% of oil content.
- Barley is a main concentrate food for fattening pigs in UK.
- The awns of barley should be removed, crimped or coarsely ground before feeding poultry or swine.
- Veriety “Notch 2” developed at UK is rich in lysine.

Oats (*Avena sativa*):

- Oats has highest crude fibre of 12 - 16% with 7-15% of crude protein.
- Methionine, histidine and tryptophan are deficient in oats but abundant in glutamic acid.
- Cattle and sheep are fed with crushed or bruised oats whereas pigs and poultry are fed with ground oats.

Wheat (Triticumaestivum):

- Wheat contains 6-12% of crude protein.
- The endosperm contains prolamin (gliadin) and glutelin (glutenin) protein mixture, which is referred as gluten.
- Wheat gluten decides whether the flour is suitable for bread or biscuit making.
- Strong gluten is preferred for bread making since it form dough, which traps the gasses, produced during yeast fermentation.
- Finely milled wheat is unpalatable to animals because it forms the pasty mass in the mouth and may lead to digestive upset.

Rice (Oryza sativa):

- The crude protein and energy values are comparable to maize.
- It is widely used for human consumption

Millets :

- Millets are cereals having high percent of fibre and produce small grains and are mostly grown in tropics. e.g. Sorghum, Bajra, etc.
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Sorghum /Jowar / Milo (*Sorghum vulgare*):

- Sorghum is similar to maize in chemical composition but they have higher protein and low fat than maize.
- Pig and poultry can be fed with cracked grain whereas cattle are fed with ground sorghum.

Bajra / Cumbu (Pennensetumtyphoides):

- Nutritive value of bajra is similar to sorghum with 8-12% of crude protein and rich tannin content.
- Seeds are hard so they have to be ground or crushed before feeding to cattle.

MILLING BYPRODUCTS

Bran:

- It is the outer coarse coat of the grain separated during processing. E.g. rice bran, wheat bran, maize bran.

Rice bran:

- Rice bran is a valuable product with 12-14% of protein and 11-18% oil mostly with unsaturated fatty acids and hence it becomes rancid
- The oil removed rice bran is available as deoiled rice bran in the market for livestock feeding.

Wheat bran:

- Wheat bran is an excellent food for horses with more fibre content.
- It is laxative when mashed with warm water but tends to counteract scouring when it was given dry.
- It is not commonly fed to pigs and poultry because of the fibrous nature and low digestibility.

Gluten:

- Gluten is a tough substance obtained after the removal of starch from flour.
- This is not usually given as a feed to non- ruminants due to poor quality protein, bulkiness, unpalatability.

Middling:

- A byproduct from flour milling industry comprising several grades of granular particles of bran, endosperm and germ.
- Middlings contain 15-20% protein and deficient in calcium.

Polishing:

- During rice polishing this byproduct accumulates to contain 10-15% protein, 12% fat and 3-4% crude fibre.
- It is rich in B- complex and good source of energy.
- Due to high fat content rancidity may occur

Molasses:

- Byproduct during juice / extract prepared from selected plant material.
- Concentrated water solution of sugars, hemicellulose and minerals.
- Four varieties of molasses are commonly available :

  Cane molasses, Beet molasses, Citrus molasses and Wood molasses
- Cane molasses is a product of sugar industry, contains 3% CP,10% ash.
- Beet molasses: product during production of beet sugar and 6%CP
- Citrus molasses is bitter in taste with highest protein (14%) and produced when oranges or grapes are processed for juice.
- Wood molasses is a product of paper industry with 2% protein and palatable to cattle.
- Molasses is a good source of energy and an appetizer.
- It reduces dustiness in ration and is very useful as binder in pellet making.
- Molasses can be included upto 15% in cattle ration and upto 5% in poultry ration.
- The molasses quality in terms of sweetness is indicated in Brix unit.
- Cane molasses usually have 80.0 degree Brix unit.

ANIMAL AND VEGETABLE FAT

- To increase energy density in diet.
- A higher level of energy in the ration :increasing cereal grains.
- Higher levels of grain: negative effects on rumen metabolism.
- Fats :potential source of energy in the rations.
- Protected fat gained considerable importance.
- High growth rate in broilers :requires high energy density in diet
- Fat provides 2.25% more energy than carbohydrate or protein.
- Oil and fat reduces the dustiness in feed
- Vegetable oils like corn oil, Groundnut oil, sunflower oil and animal fat like lard, tallow are extensively used in livestock / poultry feeding.

- Animal fat contains saturated as well as unsaturated fatty acids of C20, C22, C24.
- Vegetable fats contain greater proportion of linoleic acid.

- Higher level PUFAS :rancidity :anti oxidants :Butylatedhydroxytoluene (BHT) or Ethoxyquin included in high fat diet.

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Protein supplements

can be obtained from animal origin or plant origin

- Other sources from which protein supplements can be obtained include NPN compounds, single cell protein etc.

Animal Origin	**Plant Origin**
Mostly over 47% CP	Mostly under 47% CP
Mostly over 1.0% Ca	Mostly under 1.0% Ca
Mostly over 1.5% P	Mostly under 1.5% P
Mostly under 2.5% fibre	Mostly over 2.5% fibre

PLANT ORIGINPROTEIN CONCENTRATES

OIL SEED CAKE / MEAL

- The byproducts left after extraction of oil from oil seeds are used for feeding all kinds of livestock.
- Oil content and protein content varies according to the method of processing.
- Three main processes are used for removing oil from oil seeds.
  - Use pressure to force out oil (ghani and expeller).
  - Use of an organic solvent to dissolve the oil from the seed.
- Material of higher oil content undergoes modified screw pressing to lower the oil content to a suitable level followed by solvent extraction.
- Only material with oil content of less than 35% is suitable for solvent extraction.

OIL SEED CAKE / MEAL: Cont……

Nutritive value

Protein:

- Oil seed proteins: low cysteine and methionine and lysine.
- Cannot provide adequate supplementation to the cereal proteins with which they are commonly used.
- They should be used in conjunction with an animal protein when given to simple stomached animal.
- 95% of the nitrogen in oil seeds meals is present as true protein with digestibility of 75-90%.

Fat:

- When oil content is high in the oil seed cakes, it makes a significant contribution to the energy content of the diet.
- This purely depends upon the process employed in extracting oil and its efficiency.
- Digestive disturbances may occur from uncontrolled use of cakes rich in oil.
- Milk or body fat may be soft and carcass quality is lowered when the oil is unsaturated.

OIL SEED CAKE / MEAL: Cont……

Micronutrients:

- The oil seed meals usually have high phosphorus content, which generally tend to aggravate their low calcium content.
- They may provide useful amount of B vitamins but poor sources of carotene and vitamin E.
- Commonly used oil cake / meals in livestock feed are groundnut or peanut oil meal, soybean oil meal, linseed meal, coconut meal, cotton seed meal, safflower meal, sunflower meal, mustard cake, sesame seed meal, rape seed meal, palm kernel meal etc.

GROUNDNUT CAKE

- Contains about 45% CP: deficient in cysteine, methionine and lysine, but good source of Vitamin B12 and calcium.
- In rainy season: contain mycotoxin: – Aflatoxins : *Aspergillus flavus*.
- There are four Aflatoxins, B1, G1, B2, G2 out of which B1 is most toxic.

SOYBEAN MEAL

- Soybean meal: 44 -46% CP: Rich in all EAAS except cysteine, methionine
- Protein inhibitors : *Kunitz* anti-trypsin inhibitor and *Bowman-Birk* chymotrypsin inhibitors are practically significant.
  - Trypsin inhibitors especially interferes the protein digestion in monogastric animals.
  - Protein indigestibility affects growth rate, egg production and feed efficiency and also may lead to hypertrophy of pancreas and excess endogenous loss of essential amino acids.

SOYBEAN MEAL Cont……

Antinutritional factors in soybean meal

Haemogglutinin (Lectin): ANF agglutinates red blood cells of rats, rabbits and human except sheep and calves.

- Lectins are proteins capable of binding carbohydrate moieties in the epithelial cell lining of small intestine, disrupting the brush boarder and reducing the efficiency of absorption.

Genistein: a plant estrogen in soybean

- Saponins :inactivated by proper heat treatment during processing.

SUNFLOWER CAKE

- 40% CP with low lysine and twice the amount of methionine than soy protein.
- It has very short shelf-life.
- The expeller variety of SFmeal or cake has high content PUFAS: produce soft pork in pigs and soft butter in cows when fed in large amount.
- It can be fed to cattle ration up to 20% level and 10% to poultry ration.
- Sunflower cake is not recommended for calves, lambs, chicks and young pigs.

COTTONSEED MEAL

- Protein :low content of cysteine, methionine and lysine.
- The calcium : phosphorus is 1:6, so calcium deficiency may occur.
- Lactating cows fed large amount: milk become hard and firm, butter from such milk fat: difficult to churn
- Decorticated/ undecorticated cottonseed oilcake are available
- Cottonseed meal contains 0.3-20g/kg DM: yellow pigment (ANF) known as Gossypol, a polyphenolic aldehyde.
- It is an antioxidant and polymerization inhibitor.
- It is toxic to simple-stomached animals and the symptoms include depressed appetite, loss of weight and even lead to death due to cardiac failure.
- Gossypol toxicity can be reduced by the addition of calcium hydroxide and iron salts.

LINSEED MEAL

- Form: viscous slime due to 3-10% of mucilage.
- Cyanogenetic glycoside, linamarin and an associated enzyme, linase in immature linseed hydrolyses it with the evolution of hydrocyanic acid.
- HCN is a potent respiratory inhibitor and hence, depending on the species the minimum lethal dose taken orally has been estimated as 0.5-3.5 mg/kg of body weight.
- Proper water washing, drying and storage can reduce glycosides in the feedstuffs.

LINSEED MEAL Cont…….

- Protein: low methionine and lysine content
- Rich in P which is present as phytase
- Good source of vitamins like riboflavin, nicotinamide, pantothenic acid and choline.
- Linseed cake/meal is not suitable to poultry but good feed to horses and ruminants.

MUSTARD CAKE

- It is widely used in cattle feed in Northern India.
- Its nutritive value is lesser than groundnut cake.
- D.C.P and T.D.N values are 27% and 74 % respectively.
- Up to 10% of the ration, it can be fed to poultry and for pigs it may be up to 20%.
- It has rich calcium and phosphorus content of about 0.6% and 0.1% respectively.

SESAME SEED MEAL / GINGELLY OIL CAKE / TIL OILCAKE

- It contains 40% protein rich in leucine, arginine and methionine but low lysine.
- It was produced from the residues of sesame meal after removal of oil from sesame seed.
- There are three verities – red, black, white.
- White is of high nutritive value than red.
- It has high phytic acid, which make phosphorus unavailable to monogastric animals.
- Sesame seed meal has laxative action and can be included in the cattle ration upto 15%.
- Sesame seed meal is not suitable to young pigs and poultry

RAPESEED MEAL / CANOLA MEAL

- It contains low protein content than soybean meal with balanced essential amino acids.
- It also contain 14% fibre with low ME.
- It has favourable calcium phosphorus ratio.
- Rapeseed meal contains tannins and consequently lowers the digestibility
- ANF: glucosinolates accompanied by thioglucosidase (myrosinase) may lead to goiter and liver and kidney dysfunction in some animals.
- Canadian produced a variety of rapeseed:referred as canola: meal derived from canola : Canola meal.
- Canola meal is low in glucosinates and warrants lysine supplementation.

ANIMAL PROTEIN CONCENTRATES

- Animal protein concentrates @15% in the ration.
- Included mainly to makeup the deficiency in EAAS content.
- Animal protein concentrates are expensive.
- Animal protein concentrates should be free from pathogens like *salmonella* and *E.coli*.

- Protein supplements from animal origin are Fish meal, Meat meal, Blood meal, Hatchery waste, Milk products

FISH MEAL

- Fishes can be used as a fishmeal after they have been dried or ground.

- Cooking fish and pressing to remove water and oil is : sterilizes fishmeal produced by drying the cooked fish.

- High levels lysine, methionine and tryptophan and Ca , P
- Rich in vitamin B complex and Animal Protein Factor (APF).

- Fishmeal should be tested for salt toxicity, *E.coli* bacteria.
- Feeding: simple-stomached animals due to high quality

- Diets may include up to 10% of fishmeal.

MEAT AND BONE MEAL

- Rendering is a process that converts waste animal tissue into stable, value-added materials.
- The carcasses of animals can be used as meat meals after drying or grinding.
- The product must be substantially free of hooves, horns, bristle, hair and feathers, skin and contents of stomach and viscera.
- CP : 60-70% useful as lysine supplement but less amount of amino acids like methionine and tryptophan affect their protein quality.
- It has fat level upto 9%.
- The enteric factor from the intestinal tract of swine, the '*Ackerman*' factor and growth factor in ash are important in meat meal.

HATCHERY WASTE

- It is otherwise known as Incubator waste or Hatchery By Product Meal (HBPM).
- The mixture of infertile, unhatched eggs and eggshells have been cooked, dried, and powdered to produce this kind of meal.
- It is found to replace 33% of fishmeal especially in Broiler chicks to enhance weight gain.

POULTRY LITTER

- Dried poultry excreta has been used as ruminant feed.
- A single layer hen weighing 1.8kg can generate up to 113.4g/day of manure. About 75% of this amount is water, so we're left with 28.35g dry manure per hen per day.
- Generally, the total digestible nutrient (TDN) value of poultry litter approximates 50 percent and crude protein averages 21 to 28 percent

SINGLE CELL PROTEIN(SCP)

- Nowadays, single cell organisms like yeast and bacteria are exploited in various fields.
- They can grow very rapidly and double their cell mass in large-scale fermentors.
- A range of nutrient substrates can be used including cereal grains, sugar beet, sugar cane, and its byproducts, waste products from food manufacture to culture bacteria
- SCP has high levels of nucleic acids of 5-12% DM in yeast and 8-16% DM in bacteria.
- Some of the purine and pyrimidine bases in these acids can be used for nucleic acid biosynthesis.
- Uric acid or allantoins, the end products of nucleic acid catabolism, are excreted in the urine of animals consuming SCP.
- SCP does contain a crude fibre fraction and lacks cellulose, hemicellulose and lignin, it contains glucans, mannans and chitin.

- Dietary SCP for broilers is 2-5% concentration and nearly 10% is recommended for laying hens.

NON PROTEIN NITROGEN COMPOUNDS

- NPN is an important source of nitrogen for ruminant animals.
- Its use depends upon the ability of the rumen microbes to use them in the synthesis of their own cellular tissues and thus supply animal protein in the form of microbial protein.

UREA

- It is a nitrogen rich (46%), white, crystalline compound with the formula $NH_2-C=O-NH_2$.
- Rumen microbes hydrolyze urea with the help of urease enzyme and produce ammonia.
- The wastage of nitrogen may occur with excessive absorption of ammonia from the rumen leading to ammonia toxicity which cause ataxia, muscular twitching, tetany, excessive salivation, bloat and respiratory disorders.
- Urea should be given in such a way as to slow down its rate of breakdown and enhance NH_3 utilization for protein synthesis.

- Rumen microbes require readily available source of carbohydrate to serve as energy for capturing ammonia and therefore urea diet should contain readily available carbohydrate so that the animal can satisfy the needs of its rumen microorganisms.
- One gram of urea should be given along with 0.13g of anhydrous sodium sulfate at the N:S ratio of 15:1 thus minimize sulfur containing amino acids deficiency.
- Urea does not provide energy, minerals, or vitamins to animals so adequate supplementation of these nutrients in diet is necessary.
- To avoid the danger of toxicity, frequent, small intake of urea is preferable.
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