**Chapter 8: Feed and Fodder Technology in Animal Nutrition**

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**Refreshers points:**

* **Feed technology** pertains to the processing of feeds, fodders, and formula feeds. It requires an understanding of the nutritional needs of different livestock and poultry, as well as the management of feed plants, quality control of feed ingredients, and feed storage.
* The application of physical, chemical, biochemical, biological, and engineering techniques to improve the animal system's nutritional utilization of feeds and fodders for the growth of livestock, poultry, and the feed industry is known as **animal feed technology**.
* **AAFCO** (Association of American Feed Control Officials) was established in 1909.
* FDA (Food and Drug Administration) in 1965 issued first good manufacturing practices (GMP’s) for medicated feeds and started inspecting feed mills.
* Compound Livestock Feed Manufacturers Association (CLFMA)
* **Complete feed:** A nutritionally balanced diet for animals, designed to sustain life and support production without the need for additional supplements, apart from water.
* **Concentrate:** A type of feed utilized in combination with another to enhance the overall nutritional balance, typically intended for further dilution and blending to create either a supplement or a complete feed.
* **Supplement:** A feed used in conjunction with another to enhance either the nutritional balance or the performance of the overall diet. It can be administered in three ways: (1) undiluted as an additional component to other feeds, (2) provided free-choice alongside other parts of the diet, or (3) further mixed to produce a complete feed.
* **Premix:** A consistent blend comprising one or more microingredients such as vitamins, minerals, or drugs, combined with a diluent and/or carrier ingredient. These premixes are employed to ensure the even dispersion of microingredients within a larger mixture.
* **Diluent** an ingestible substance utilized to blend with and lessen the concentration of nutrients and/or additives, thereby enhancing their acceptability to animals, safety in usage, and uniform mixing within feed.
* **Carrier** an ingestible material to which ingredients are added to aid in the uniform integration of the latter into feeds. Active components are absorbed, impregnated, or coated onto the ingestible material to serve as a physical vehicle for the active ingredient. Utilizing a carrier with a micro ingredient significantly alters the mixing characteristics.
* **Different processing methods of grains:**
1. **Dry processing**: Grinding, Dry rolling, Popping, Extruding, Micronizing, Roasting
2. **Wet processing**: Soaking, Steam rolling, Steam processing & flaking, Pressure cooking, Exploding, Pelleting and Reconstitution.
* **Grinding:** Reduction of particle size, easiest, most affordable way to prepare grain for feeding cattle. Prior to mixing, pelleting, or extrusion, it is necessary.
* **Expressing the particle size of ground feed:** Ground feed is expressed in terms of modulus of uniformity and modulus of fineness. Equipment required is **'Rotap Sieve Shaker'**.
* **Modulus of uniformity:** This ratio represents the proportions of coarse, medium, and fine particles in ground feed, typically expressed as 1:6:3.
* **Modulus of fineness:** Ranging from 1 to 7, this value decreases as the particle size of the ground feed diminishes. However, it does not provide insight into the specific proportions of coarse, medium, and fine particles within the ground feed.
* **Dry rolling:** The process of preparing rolled or cracked grain by passing it through a roller mill.
* **Popping or Puffing:** Popping occurs when dry heat (700-800°F or 370-425°C) is applied for 15 to 30 seconds, causing rapid expansion of the grain, rupturing the endosperm. This rupture of starch granules enhances starch availability to rumen microbes or animals.
* **Micronizing:** In this process, infrared burners emit microwaves with frequencies ranging from 3 x 10^8 to 3 x 10^11 cycles per second, utilized for various purposes.
* **Extruding:** Extrusion cooking has gained significance in the feed industry for producing pet feeds, fish feeds, and feed for laboratory animals. It's also used for gelatinizing cereals, cooking soybean and pulses, and processing meat, fish, and feather meals to control salmonella and enhance nutritional value.
* **Gelatinization** This term refers to the irreversible disruption of the crystalline structure in a starch granule, achieved through a combination of moisture, heat, mechanical energy, pressure, and/or pH modification, rendering the surface of each molecule accessible to solvents or reactants.
* **Roasting:** This process involves heating grains to approximately 300°F (148.9°C) by passing them through a flame, resulting in some expansion and the production of a palatable product.
* **Soaking:** Traditionally, grains have been soaked in water for 12-24 hours before being utilized in livestock feeding.
* **Steam rolling:** Grain is exposed to live steam for varying durations depending on the pressure applied before rolling. In case of steam preconditioning at atmospheric pressure, grain is subjected to live steam for 8 to 20 min. and temperature and moisture content of grain are 210-215°F (100°C) and 16-20%, respectively. In case of pressure (20 to 60 psi.) preconditioning, grain is subjected for 50 sec. to 2 min. Temperature and moisture of the grain are 250 to 300°F (121 to 148.9°C) and 18-25% respectively.
* **Steam processing and flaking:** This method, which involves steam rolling with stringent quality control measures, results in flaked feeds.
* **Pressure cooking:** Grains are cooked with live steam at 50 psi for 1.5 minutes in sealed pressure chambers.
* **Exploding:** Grain is subjected to high-pressure steam (up to 250 psi) for a very short duration (about 20 seconds), followed by a sudden decrease to atmospheric pressure.
* **Reconstitution:** Mature grain with 10% moisture content is mixed with water to increase the moisture level to 25-30%. The wet product is then stored in an oxygen-limiting silo for 14-21 days before feeding.
* **Pelleting:** Pelleted feeds are formed by agglomerating individual ingredients or mixtures through mechanical processes such as compacting and forcing through die openings
* **Roughage processing methods:**
1. **Dry processing**
* Baling
* Field chopped
* Grinding
* Pelleting
* Cubing
* Dehydration
1. **Wet processing**
* Green chopped
* Soaking
* **Baling:** This method is commonly used to enhance the convenience of handling forage. It involves cutting the forage and allowing it to dry in the field before being baled using either a stationary or field baler. This practice is particularly prevalent in developed countries.
* **Cubing:** A modification of wafer production, cubing increases the density of long hay from 7 lb/cft to 25-32 lb/cft, while pelleted hay has a density of about 40 lb/cft.
* **Grinding:** Grinding roughages is essential for mixing and pelleting processes. These mechanical actions improve voluntary intake, increase nutritive value, and facilitate the preparation of complete feeds. Roughage should be ground to lengths of 1-2" (2.5-5 cm) for roughage feeding alone or 0.5 to 1.0" (1.3-2.5 cm) when incorporating it into complete rations.
* **Pelleting:** Before pelleting, roughages are typically ground, resulting in pellet sizes ranging from 12/64" to 48/64" (4.8 mm to 19.1 mm). Pelleted roughages weigh approximately 40 lb/cft compared to 5-6 lb/cft for long hay.
* **Dehydration:** Green forage, such as alfalfa or lucerne, can be preserved by dehydrating it at high temperatures (600-1500°F) for a short duration (3-5 minutes) in a dehydrator.
* **TMR (Total mixed ration):** In conventional TMR, chopped green fodder or silage is combined with cereals, cereal by-products, protein sources, minerals, vitamins, and feed additives to create a balanced ration for dairy animals. TMR optimizes feed intake, rumen stability, and digestion while utilizing crop residues efficiently, reducing waste, and promoting environmental sustainability.
* **Methods to improve poor quality roughages:**
1. **Physical methods**
* Soaking
* Chopping
* Grinding
* Pelleting
* Wafering
* Steam under pressure
* Irradiation
1. **Chemical methods**
* Alkali – NaOH, Ca(OH)2, KOH, NH4OH
* Ammonia- gaseous, aqueous, urea-ammonia
* Acids- H2SO4, HNO3
* Salts- Na2CO3, NaCl
* Gases- Chlorine, SO2
* Oxidizing agents- H2O2 , O3
1. **Physio-chemical methods**
* Combination of physical and chemical treatments e.g. NaOH/Pelleting; NaOH/Steam
1. **Biological methods**
* Enzymes
* Rot fungi
* Mushrooms
* **Storage loss:** Storage loss, assessed by the decrease in weight, goes beyond mere quantity, encompassing qualitative aspects such as nutritional deterioration and lowered germination rates. This underscores the need for improved management practices starting from preharvest stages and extending throughout the storage process.

**Factors affecting food value deterioration during storage:**

1. **Physical factors** influencing grain storage encompass moisture levels, air temperature, relative humidity, grain condition, and storage duration. Well-maintained, intact grains tend to retain greater weight and endure longer storage periods. Conversely, damaged grains are susceptible to insect infestation, fungal growth, and moisture retention. Conditions around 28-30°C and 65-80% relative humidity are conducive to microbial and insect proliferation.
2. **Biological** factors in grain storage involve insects, fungi, and rodents. Common insect pests include the granary weevil, lesser grain borer, and various beetles and moths.
3. **Mechanical factors and chemical factors** contribute to grain damage during harvesting, transportation, and mechanical processes, potentially exposing nutrients and accelerating spoilage. Additionally, pesticide residues may compromise food value due to associated health risks for consumers.
* **Others factors** such as moisture content, temperature, oxygen supply, and feed condition also play significant roles.
* **Alternative feeds/ Newer feeds:** Due to population growth, land use restrictions, and rising prices of conventional animal feeds like grass, corn, and fish meal, there's a growing need for alternative feed sources to ensure a consistent supply of affordable feeds for livestock.

Major sources of alternative feeds include crop residues such as paddy straw and sugarcane by-products (sugarcane tops, bagasse), as well as agro-industrial by-products like oil cakes, rice bran, molasses, fruits/vegetables from canning industries, fish/meat by-products, inedible parts such as animal wastes, bio-gas slurry, and poultry manure.

* **Quality control of feed ingredients** is ensuring the quality of feed ingredients is vital for optimizing the feed manufacturing industry and enhancing production efficiency. It guarantees that animals receive balanced, nutritious, and safe feed throughout the compound feed production process.
* **Regulatory oversight:** Feed quality control is governed by legislation established by the Bureau of Indian Standards (BIS) in New Delhi, a statutory body formed under the BIS Act, 1986. It aims to promote harmonious development in standardization, marketing, and quality certification of goods nationwide.

The Animal Feeds Sectional Committee, comprising members from ICAR Institutes, State Agricultural Universities, the Feed Industry, and relevant government departments specializing in Animal Nutrition and Feed Technology, has been instituted by BIS to address matters concerning animal husbandry activities.

* **Quality control of raw materials:** Ensuring raw material quality through thorough inspection is the initial crucial step to confirm adherence to minimum contract specifications, suitability for incorporation into compounded feeds, and determination of maximum permissible inclusion levels.
1. **Preliminary Inspection of Raw Materials:** A thorough 'physical inspection' for the following is to be done when they are received at the mill.
* Colour, odour, texture, density of the material
* Evidence of wetting
* Presence of adulterants such as stones, dirt or other foreign materials.
* Storage pests
* Evidence of damaged or broken kernels, etc.
* Evidence of presence of rat faecal pellets or hair, etc.
* Moisture should not be more than 10% (Determine moisture of the feed rapidly).
1. **Chemical test:** Analyse for proximate principles
2. **Toxicological test:** Example: Glucosinolates in rapeseed, Cyanogenic glycosides in linseed and cassava, Mycotoxin (aflatoxins) in maize, GNC etc.
* **Organoleptic evaluation:** Using senses of touch, taste, vision, smell and hearing.
* **Finished feed quality:** Finshed feed assay are required to provide the mill with a final report on how well the quality was controlled. One sample of each formula per week or per batch has to be analysed.
* **Silage and hay making-**
* Bountiful of green fodders are either conserved as silage or hay to meet the demand of good quality fodder during lean season.
* **Silage:** It is the preserved green fodders produced by the controlled fermentation of crop under anaerobic conditions.
* Silage results in minimum deterioration and loss in regards to nutritive constituents of fodders.
* **Ensilage:** Preparation process of silage.
* **Silo:** Containers/pits used for ensilage.
* **Flieg index:** It is a method used for evaluation of silage quality.
* **Haylage:** When grasses and legumes are ensiled called Haylage.
* **Wastelage:** It is a term for a silage having animal organic waste (poultry droppings, poultry litter, swine excreta and bovine dung)
* **Faecal Grab sampling:** This process involves manually extracting a portion of a fecal sample from the rectum
* **Points to remember in silage making:**
1. Thick stems crop with soft & pliable are preferred, eg. Maize, sorghum, bajra
2. Harvesting crops is ideally timed between the flowering and milk stages, typically when 50% of ear emergence has occurred.
3. Wilting the fodder until 65-70% moisture.
* **Type of fermentation in silage:**
1. Lactic acid fermentation
2. butyric acid fermentation
* Lactic acid fermentation is further divided into homofermentative and heterofermentative
* In the homofermentative type, one mole of glucose or fructose yields two moles of lactic acid.
* Conversely, in the heterofermentative type, one mole of glucose and mannitol produces one mole of lactic acid, one mole of ethanol, and one mole of carbon dioxide. Additionally, one mole of fructose yields acetic acid and comparatively less lactic acid per mole of fructose.
* Homofermentative types are typically more efficient than heterofermentative types.
* **Quality and characteristics of Silage-**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sl. no** | **Attributes** | **Very good Silage** | **Good Silage** | **Fair Silage** | **Poor Silage** |
| 1. | Butyric acid | Absence | traces | little | little |
| 2. | pH | 3.8-4.2 | 4.2-4.5 | 4.5-4.8 | >4.8 |
| 3. | Ammonical Nitrogen | <10% | 10-15% | 15-20% | >20% |
| 4. | Colour | Greenish brown | Brownish | Tobacco brown | Blackish |

* Silo-filler’s Disease in farm workers is caused by inhalation of oxides of nitrogen (NOx) during silage making or after entering a silo after filling.
* **Hay making-**
* In hay making moisture percent of the crop is reduced to 12-14% to inhibit the action of plant and microbial enzymes.
* The harvested crop can be dried either by natural drying or through artificial drying.
* It is the product obtained by cutting and curing of thin-stemmed grasses and legumes.
* **Requisites for good hay-**
1. Soft pliable thin-stemmed grasses and legumes.
2. Harvested when 1/3 to ½ are in flowering stage.
3. Moisture content of the plant should not be more than 12-14%.
* Three methods of hay making- field curing, barn drying and artificial drying.
* **Nutrients losses in hay making-**
1. Losses of leaves by shattering.
2. Losses of vitamins due to bleaching and fermentation.
3. Losses of soluble nutrients by leaching in heavy rain.
* **Alternate fodder resources-**
* **Hydroponics-**
* The term "Hydroponics" was coined by W.F. Gericke in 1936. "Hydro" originates from the Greek word for "water," and "ponos" translates to "working" or "labor."
* It refers to the green fodder generated by cultivating plants in water or a nutrient-rich solution without soil, typically in greenhouses under controlled environmental conditions, and within a short timeframe
* Hydroponics fodder quality-
* Nutrients content like CP, NDF, ADF, Ca increases while organic matter and non-fibrous carbohydrate content decreases when compared with the original seed on a DM basis.
* Rich source of vitamins (A, E, C etc.) and bioactive enzymes.
* The crop is free from antibiotics, hormones, pesticides, or herbicides.
* **Tree leaves-**
* Mostly fed to sheep and goats, and sometimes to cattle during periods of fodder crisis.
* At early stages, leaves contain fairly high amounts of crude protein and a comparative low percentage of crude fibre and *vice versa* at maturity.
* The tree leaves and shrubs are generally rich in calcium but poor in phosphorus.
* Examples of tree leaves for feeding livestock are Pipal leaves (*Ficus religiosa*), Neem (*Azadirachta indica*), Mulberry leaves (*Morus indica*), Beri leaves (*Zizyphus jujuba*), Tapioca leaves (*Manihot esculenta*), Jackfruit (*Artocarpus heterophyllus*), Subabool (*Leucaena leucocephala*), Bargad (*Ficus bengalensis*).
* **Aquatic plants-**
* Examples are Duckweeds, Azolla, water hyacinth, Seaweeds.
* Various methods used for densification of roughages are-
* Bailing (bulk density 140-170 kg/m3)
* Pelleting (500-700 kg/m3)
* Briquetting
* Block making
* Bulk density of roughages is very low as compared to concentrate ingredients.
* Roughages are made more dense by grinding and pelleting, which guarantees even mixing with other components.
* The increase in bulk density due to pelleting of mash feed range from 29-135% depending on the level and type of roughage used in the complete diets.
* **Expander-extruder technology-**
* It involves expanding and extruding process.
* Expanding is the application of moisture, pressure and temperature which cause gelatinization of starchy portion.
* Extruding is pressing the feed through constriction under pressure.
* The final product is either in pellet form or block form.
* **Indicator/ Marker methods for determining nutrients digestibility-**
* This method uses inert reference substance called indicator/Marker.
* **Specification of an ideal indicator/marker-**
1. Should be totally indigestible and unabsorbable.
2. Should not have any therapeutic effect on the GIT.
3. It should mix properly and distribute uniformly in digesta.
4. It should pass through the digestive tract at a constant speed and should be voided completely.
5. It should be chemically analysed.
* **Types of indicator/marker-**
1. Internal/ natural indicator (component of feed)-

Eg. lignin, silica, acid insoluble ash, n-alkanes

1. External marker-

Eg. chromic sesquioxide (chrome green or chromic oxide, Cr2O3), magnesium ferrite, carmine red, Radioactive isotopes {51Cr-EDTA and 144Ce; rare earth elements- cerium (Ce), Ytterbium (Yb), Samarium (Sm)}.

* Chromic oxide is most commonly used for avians, swine and carnivorous species.
* Indicator method is used in grazing animals for evaluation of forage quality which needs grab sampling method to determine the total faeces voided.

**MCQ**

1. What does feed technology involve?

A. Computer programming for livestock

**B. Processing of feeds, fodders, and formula feeds**

C. Development of software for animal diets

D. Engineering of new animal species

1. AAFCO was established in what year?

A. 1809

B. **1909**

C. 2009

D. 1959

1. Which of the following is a complete feed?

A. A feed requiring additional nutrients

B. A feed used only for poultry

C. **A nutritionally adequate feed capable of maintaining life without any additional substance except water**

D. A supplement needed for growth

1. What is a concentrate?

A. A liquid feed for animals

B. A high-energy feed for pets

C. A feed used to improve the nutritive balance of the total diet

D. A feed that animals consume in large quantities

1. The first GMPs for medicated feeds were issued by the FDA in what year?

A. 1945

B. **1965**

C. 1975

D. 1985

1. What is the purpose of a premix in animal feed?

A. To increase the water content of the feed

B. **To provide a uniform mixture of microingredients**

C. To exclusively add flavor to the feed

D. To act as the main source of nutrients

1. What does pelleting involve?

A. Mixing feed with water only

B. **Agglomerating feeds formed by extruding through a die opening**

C. Cooking feed at high temperatures without pressure

D. Rolling feed into thin sheets

1. Grinding of grains is primarily for:
	* 1. Increasing the moisture content
		2. Reduction of particle size
		3. Enhancing the flavor
		4. Decreasing the nutritional value
2. What does the modulus of uniformity indicate in ground feed?

A. The nutritional value of the feed

B. The moisture content of the feed

C. **The ratio of coarse, medium, and fine particles**

D. The chemical composition of the feed

1. The process of extruding in feed technology is used for:

A. Drying grains only

B. Mixing vitamins only

C. **Production of pet feeds, fish feeds, and for cooking of certain meals**

D. Decreasing the feed's nutritional value

1. What is the primary goal of feed technology?

A. To reduce the cost of animal feed

B**. To improve the nutritional utilization of feeds and fodders**

C. To make the feeds taste better

D. To decrease the time animals spend eating

1. Gelatinization in the context of animal feed technology refers to:

A. The process of adding gelatin to feeds

B. **The irreversible destruction of the crystalline order in a starch granule**

C. The increase of moisture content in feeds

D. The blending of different feed components

1. Which method is not a dry processing method of grains?

A. Grinding

B. **Pelleting**

C. Roasting

D. Popping

1. The term "carrier" in animal feed refers to:

A. An ingredient that transports vitamins and minerals

B. A vehicle for transporting feed to farms

C. **An edible material that facilitates uniform incorporation of microingredients into feeds**

D. A compound that increases feed volume

1. Soaking of grains is done for how many hours for livestock feeding?

A. 1-2 hours

B. 6-8 hours

C. **12-24 hours**

D. 48-72 hours

1. What is the purpose of a diluent in animal feed?

A. To add bulk without nutrition

B. **To mix with and reduce the concentration of nutrients and/or additives**

C. To serve as the primary nutrient source

D. To exclusively add moisture to the feed

1. Roughage should be ground to what length for incorporation in complete rations?

A. 1-2 inches

B. **0.5 to 1.0 inch**

C. 2-3 inches

D. 3-4 inches

1. Which process involves the cooking of grains with live steam at 50 psi for 1.5 min?

A. Steam rolling

B**. Pressure cooking**

C. Pelleting

D. Micronizing

1. What is the density of pelleted hay compared to long hay?

A. Same as long hay

B. Less than long hay

C. **40 lb/cft for pelleted hay compared to 5-6 lb/cft for long hay**

D. More variable than long hay

1. TMR stands for:

A. Total Market Ration

B. **Total Mixed Ration**

C. Total Meal Replacement

D. Total Mixed Requirements

21. Among the given is not a physical method to improve roughage quality?

A. Soaking

B**. Alkali treatment**

C. Grinding

D. Pelleting

**22.** What is the purpose of using NaOH in roughage treatment?

A. To decrease moisture content

B) To increase palatability

C) **To break down lignin**

D) To decrease protein content

1. Which biological method is used for improving roughage quality?

**A) Enzymes**

B) Chlorination

C) Pelleting

D) Irradiation

**24.** At what temperature range is grain most susceptible to microbial and insect proliferation?

A) 15-20°C

**B) 28-30°C**

C) 35-40°C

D) 40-45°C

1. The Bureau of Indian Standards is responsible for:

A) Importing feed ingredients

B) **Standardization and quality certification**

C) Directly managing animal farms

D) Producing feed ingredients

1. What does the preliminary inspection of raw materials not check for?

A) Color

**B) Protein content**

C) Odor

D) Moisture

1. Maximum permissible moisture content in raw feed materials should not exceed:

A) 5%

B) **10%**

C) 15%

D) 20%

1. Which test is not mentioned as a part of quality control for feed ingredients?

A) Chemical test

B) Toxicological test

C**) Ultrasonic test**

D) Organoleptic evaluation

1. Sugarcane by-products are examples of:

A) Chemical additives

**B) Alternative feeds**

C) Enzyme treatments

D) Physical treatment methods

1. What is the role of enzymes in the biological method of improving roughage quality?

A) To increase moisture content

B) To reduce nutrient content

C) **To enhance digestibility**

D) To add flavor

1. Which gas is not used as a chemical method for improving roughage quality?

A) Chlorine

B) **Nitrogen**

C) SO2

D) Ammonia

1. The process of combining alkali treatment with steam under pressure is an example of:

A) Physical method

B) Chemical method

C) **Physio-chemical method**

D) Biological method

1. Damage from what factor can expose grains to accelerated spoilage?

A) Sunlight exposure

B) **Mechanical processes**

 C) Low humidity

D) High altitude

1. Among the given is not considered an agro-industrial byproduct?

A) Rice bran

**B) Poultry manure**

C) Fish meal

D) Molasses

1. Pelleting is a process used to:

A) Decrease the nutritional value of feed

B) Increase the moisture content of roughages

C) **Improve the physical form of the feed**

D) Extract nutrients from the feed

1. Fungi and rodents are examples of \_\_\_\_\_\_\_\_\_\_ factors in grain storage.

A) Physical

B) **Biological**

C) Mechanical

D) Chemical

1. The presence of \_\_\_\_\_\_\_\_\_\_ in roughages can be detected through toxicological tests.

A) Moisture

B) Nutrients

C) **Mycotoxins**

D) Vitamins

1. Crop residues are considered \_\_\_\_\_\_\_\_\_\_ due to their nutritional and economic value.

A) Waste products

B**) Alternative feeds**

C) Primary feeds

D) Inedible by humans

1. Organoleptic evaluation in feed quality control involves:

A) High-tech machinery

B) Chemical analysis

C) **Sensory assessment**

D) Genetic modification

1. Treatment of wheat straw with urea improves/ increases which of the following
2. Voluntary feed intake
3. TDN
4. CP
5. **All of the above**
6. Flieg index is calculated by determining the amount of
7. Lactic acid
8. Acetic acid
9. Butyric acid
10. **All of the above**
11. Desirable type of fermentation in silage making
12. Butyric acid type
13. **Lactic acid type**
14. Both A and B
15. Aerobic fermentation
16. Crops preferrable for silage making
17. Maize
18. Oat
19. Sorghum
20. **Both A and C**
21. How many moles of lactic acids are produced in homo and hetero fermentation
22. **2 and 1**
23. 1 and 1
24. 3 and 2
25. 0 and 2
26. Acid used in AIV method of silahe making
27. H2SO4
28. HCl
29. Only A
30. **Both A and B**
31. Pelleted feed reduced to granular form is called
32. **Crumble**
33. Pellet
34. Extruded feed
35. Densified feed
36. Wastelage is an ensilage of-
37. Crops rich in sugars
38. Grasses
39. **Crops with animal waste**
40. Bajra
41. Moisture of hay should not be more than
42. 9 %
43. 10%
44. 11%
45. **12 %**
46. Crops suitable for hay making is-
47. Maize
48. Sorghum
49. **Lucern**
50. Bajra
51. In hay making vitamin A is loss due to-
52. cutting
53. fermentaion
54. Bleaching
55. **Both B and C**
56. The green fodder produced by growing the plants in water without soil is called-
57. **Hydroponics**
58. soilage
59. Azolla
60. Aeroponics
61. Among the given statements are true about alternate fodder resources?
62. Mostly used during scarcity of feeds
63. Tree leaves are rich in phosphorus but poor in calcium
64. Azolla, water hyacinth, Seaweeds are Aquatic plants resources
65. BIS requirement of EE is 5%
66. (a), (b) & (d)
67. (a), (b) & (c)
68. (b) & (d)
69. **All the above**
70. The quality of nutrients intake in grazing animals is evaluated by-
71. Metabolism trial
72. Digestion trial
73. Both A and B
74. **Indicator/ Marker method**
75. Which of the following is not natural indicator/marker-
76. Lignin
77. Acid insoluble ash
78. n-alkanes
79. **Magnesium ferrite**
80. Ideal indicator/marker should be-
81. Indigestible
82. Unabsorbable
83. Completely voided
84. **All of the above**
85. Examples of Radioactive isotopes (external marker) -
86. **51Cr-EDTA**
87. n-alkanes
88. Magnesium ferrite
89. Carmine red
90. Among the given is not an example of external marker -
91. chromic sesquioxide
92. **n-alkanes**
93. Magnesium ferrite
94. Carmine red
95. Percent ammonical nitrogen in good silage-
96. 5-10%
97. 10-12%
98. **10-15%**
99. 10-20%
100. pH of a good silage-
101. 3.8-4.2
102. **4.2-4.5**
103. 4.5-4.8
104. None of the above
105. Losses in hay making are due to-
106. Bleaching and fermentation
107. Leaching
108. Shattering of leaves
109. **All of the above**
110. Pre-requisites for good hay-
111. DM not more than 86-88%
112. Thinned stemmed grasses
113. Harvested when 1/3 to ½ are in flowering stage
114. **All of the above**
115. Drying methods used in hay making-
116. Field curing
117. Artificial drying
118. Oven drying
119. **Both A and B**
120. Methods used for densification of roughages
121. Bailing
122. Block making
123. Pelleting
124. **All of the above**
125. Among the given statements are true about block making machine?
126. The machine has four jackets
127. It is operated by hydraulic press machine
128. Two blocks can be made simultaneously
129. Molasses- 15% and moisture- 15-17% are required
130. (A), (B) & (C)
131. (A), (C) & (D)
132. (A), (B) & (D)
133. **(B), (C) and (D)**
134. Degree of densification in pelleting process
135. 400-500 kg/m3
136. 450-550 kg/m3
137. **500-700 kg/m3**
138. 550-750 kg/m3
139. Degree of densification in bailing process
140. **140-170 kg/m3**
141. 145-170 kg/m3
142. 150-170 kg/m3
143. 155-170 kg/m3
144. Briquetting process densifies roughages by
145. 3-4 times
146. 5-8 times
147. **7-10 times**
148. 8-12 times
149. Among the given statements are incorrect about densification of roughages?
150. Concentrate ingredients has very low density than roughages
151. Pelleting decreases density of roughages
152. Increase in bulk density of roughages ensures uniform mixing
153. Decrease in density due to pelleting ranged from 15-35%.
154. (A), (B) & (C)
155. (A), (C) & (D)
156. **(A), (B) & (D)**
157. (C) and (D)
158. Bulk density of roughages can be increased by-
159. Grinding
160. Mixing
161. Pelleting
162. **Both A & C**
163. Among the given statements are correct about an ideal indicator/marker?
164. Completely indigestible and unabsorbable.
165. No pharmaceutical effect on digestive tract
166. It cannot be quantified chemically
167. No uniform distribution in digesta
168. (A), (B) & (C)
169. (A), (C) & (D)
170. (A), (B) & (D)
171. **(A) and (B)**
172. Alternative fodder resources used in livestock feedings are-
173. Hydroponics
174. Top leaves
175. Aquatic plants
176. **All of the above**
177. Optimum levels of moisture and molasses required for roughage block-
178. **15-17% and 15%**
179. 12-15% and 15%
180. 15-20% and 30%
181. 12-20% and 30%
182. Expander technology involves application of-
183. **Moisture**
184. Pressure
185. Temperature
186. All of the above
187. Gelatinization of starchy feed components is a result of-
188. Grinding
189. Chopping
190. **Expander-extruder process**
191. Enzyme treatment
192. Among the given statements are false about Pelleting process of crop residues?
193. Degree of densification is very low
194. It involves chopping and grinding
195. Densification ranged from 100-200 kg/m3
196. It can handle feed mixture having larger particle size
	* 1. **(i), (iii) & (iv)**
		2. (ii), (iii) & (iv)
		3. (i), (ii) & (iv)
		4. (i), (ii) and (iv)
197. What are the dry feed processing methods
	* 1. Grinding, Popping, Extruding, Micronizing, Roasting, Exploding
		2. Pelleting, Reconstitution, Soaking, Steam rolling, Pressure cooking
		3. **Popping, Extruding, Micronizing, Roasting, Grinding, Dry Rolling**
		4. Reconstitution, Extruding, Micronizing, Roasting, Grinding, Dry Rolling
198. Name roughage processing method
199. Baling
200. Cubing
201. Dehydration
202. **All of the above**

77. Commonly used roughage source in India is

A. Jowar stover

B. Oat hay

C. Bajra straw

D. **Wheat straw**

78. Meals are derived from process.

A. Ghani/ hydraulic pressure

B. Hydrolic

C. Expeller

D. **Solvent extraction**

79. Percentage of fat content in solvent extracted cakes

**A. Less than 1%**

B. 8%

C. 6%

D. 10%

80. Percentage of fat content in hydraulic pressure or ghani pressed cakes

(a) Less than 1%

**(b) 8%**

(c) 6%

(d) 10%

81. Percentage of fat content in expeller proceed cakes

(a) **Less than 1%**

(b) 8%

(c) 6%

(d) 10%

82. Maintenance type of roughage contain DCP (%)

(a) More than 10%

(b) 5-10%

**(c) 3-5%**

(d) Less than 3%

83. Productive type of roughage have DCP (%) more than

**a) 5%**

(b)10%

(c) 15%

(d)20%

84. Molasses are used in livestock feeding as

(a) A source of energy

(b) Reduce destness of ration

(c) An appetizer and binder for pelleting

**(d) All of the above**

85. What is the safe inclusion level of molasses in ruminant ration

**(a) 5-10%**

(b) 20-30%

(c) 10-15%

(d) 40-30%

86. Incriminating factor linamarin is present in

**(a) Linseeds**

(c) Berseem

(b) Cowpea

(d) N.O.T.

87. Percent of moisture in a very good quality silage is

(a) 30-40%

(c) 40-50%

(b) 50-60%

**(d) 60-70%**

88. A very good quality silage should have pH in the range of

**(a) 3.5-4.2**

(c) 5.2-5.8

(b) 4.2-5.2

(d) More than 5.8

89. Among the given cereal has more lysine content

(a) Rice

(c) Corn

(b) Wheat

**(d) Oats**

90. The straws are poorly digestible because they contain high amounts of

(a) Nitrogen

**(c) Lignin**

(b) Phytic acid

(d) Oxalates

91. The feed which is fed "whole" to poultry but "crushed" to cattle and pig

**(a) Pearl Millet**

(c) Barley

(b) Millet

(d) Jowar

92. Among the given crop is more suitable as a rabi crop

(a) Jowar

**(c) Lucerne**

(b) Maize

(d) Cowpea

93. Crop responsible for HCN toxicity in ruminants

(a) Mature jowar

(b) Lucerne

**(d) Immature jowar**

(c) Soybean husk

94. Nitrate toxicity is more serious in

(a) Horse

(c) Dog

(b) Poultry

**(d) Ruminants**

95. The Crude protein content of cereal grains is

(a) 22-25%

(b) 25-30%

(c) 15-18%

 **(d) 8-12%**

96. The principal deleterious factors present in jowar is

(a) Saponin

 (b) Gossypol

(c) Essential oil

**(d) Tannins**

97. Among the given sentence is incorrect for wheat bran

(a) High in P and low in Ca

(b) Having 13% CP

(c**) High in Ca and low in P**

(d) Prevent constipation

98. Molasses is rich in vitamin

(a) Thiamin

**(c) Pantothenic acid**

(b) Riboflavin

(d) Vitamin A

99. The Crude protein content of decorticated cottonseed meal is

**(a) 40%**

(b) 25-30%

(c) 50%

(d) 22%

100. Temperature (0 F) for popping is

(a) 100-200

(b) 200-300

(c) 500-700

 **(d) 700-800**

101. Control of salmonella in

(a) dry rolling

(b) Puffing

(c) Micronizing

**(d) Extruding**

102. Roasting temperature (0 C) is

(a) 110

(b) 120.4

(c) 130

(d) 148.9

103. Gelatinization of starch occurs in

(a) Roasting

**(b) Extruding**

(c) Grinding

(d) Dry rolling

104. The normal size of pellet is ……

(a) 1-2 mm

(b) 3-4 mm

(c) 3.9-19 mm

(**d) 3-19.9 mm**

105. Roughage should be ground to…….for roughage feeding alone

 (a) 1-2 cm

**(b) 2.5-5 cm**

(c) 6-7 cm

(d) 5.5-7 cm

106. The deleterious factors present in rapseed meal is/are

(a) Glucosinolate

(b) Sinapi

(c) Myrosinase

**(d) All of the above**

107. The Crude protein content of sunflower meal is

(a) 40%

**(b) 25-30%**

(c) 20-22%

(d) 12-15%

108. Hay stored at more than 30% moisture content

(a) Decrease quality of product

(b) Increased nutrient losses

(c) Show marked increase in temp.

**(d) All of above**

109. Pelleted feed reduced to granular form is called

**(a) Crumble**

(b) Pellet

(c) Extruded feed

(d) Densified feed

**Fill ups:**

1. **Feed technology** involves the application of various techniques to improve the nutritional utilization of feeds for livestock and poultry.
2. **AAFCO** established in 1909, stands for the Association of American Feed Control Officials.
3. The FDA issued its first good manufacturing practices for medicated feeds in **1965**.
4. A **complete feed** is nutritionally adequate for animals and is intended to be fed as the sole ration.
5. A **concentrate** is a feed used with another to improve the nutritive balance of the total and is intended to be further diluted and mixed.
6. A **supplement** is a feed used with another to improve the nutritive balance or performance of the total diet.
7. **Premix** is a uniform mixture of one or more microingredients with a diluent and/or carrier intended for dispersion in a large mix.
8. **Diluent** is an edible substance used to mix with nutrients and/or additives to make them more acceptable and safer for animals.
9. **Carrier** is an edible material that facilitates uniform incorporation of microingredients into feeds.
10. **Dry rolling** involves passing grain through a roller mill to prepare it for feeding.
11. **Popping or puffing** is achieved by applying dry heat to grain, causing a sudden expansion and rupture of the endosperm.
12. **Micronizing** uses micro waves emitted from infra-red burners to process grains.
13. **Extruding** is a cooking process used for pet feeds, fish feeds, and in the gelatinization of cereals for animal feed.
14. **Gelatinization** is the irreversible destruction of the crystalline order in a starch granule by moisture, heat, and mechanical energy.
15. **Roasting** involves passing grain through flame, heating it to about 300°F and causing some expansion.
16. Soaking grains for **12-24 hrs** in water has been a long-used method for livestock feeding.
17. **Steam rolling** subjects grain to live steam before rolling, enhancing its digestibility.
18. Pressure cooking of grains involves live steam at **50 psi for 1.5 min** in air-tight chambers.
19. **Pelleting** transforms agglomerated feeds into compacted forms by extruding through die openings.
20. **TMR (Total mixed ration)** blends various feed components to provide a balanced ration to dairy animals, optimizing feed intake and rumen stability.
21. The density of cubed hay ranges between **25-32 lb/cft**.
22. Grinding is the easiest and most affordable way to prepare grain for feeding and is necessary prior to **mixing, pelleting, or extrusion**.
23. The modulus of uniformity in ground feed is optimally expressed as a ratio of **1:6:3**.
24. Dry heat of 700-800°F for 15 to 30 seconds is used in the **popping** process to make starch more available.
25. Micronizing utilizes microwaves emitted from **infra-red** burners.
26. Extrusion cooking in the feed industry is important for the production of **pet** feeds, among others.
27. The irreversible destruction of the crystalline order in a starch granule during gelatinization makes the surface of every molecule accessible to **solvents** or reactants.
28. **Baling** is a common method used to increase the convenience of handling forage, especially in developed countries.
29. The process of **dehydration** can preserve green forage by dehydrating it at high temperatures.
30. Soaking, chopping, and grinding are examples of **physical** methods used to improve the quality of roughages.
31. The use of NaOH, Ca(OH)2, and NH4OH in roughage treatment is categorized under **chemical** methods.
32. **Enzymes** and **rot fungi** are biological methods employed to enhance roughage quality through microbial action.
33. Storage loss in grains can be exacerbated by **physical factors**, which includes both moisture retention and insect infestation.
34. The optimal temperature range for microbial and insect activity in stored grain is **28** to **30** °C.
35. **Bureau of Indian Standards (BIS)**, a statutory body under the BIS Act, 1986, is responsible for promoting standardization and quality certification in India.
36. Preliminary inspection of raw materials for feed production includes checks for color, odor, **texture**, and evidence of adulterants.
37. The maximum moisture content allowed in raw materials for feed should not exceed **10**%.
38. **Toxicological** tests are necessary to detect harmful substances like aflatoxins in maize and glucosinolates in rapeseed.
39. Crop residues like paddy straw and sugarcane by-products are considered **alternative** feeds due to their availability and low cost.
40. **Oil cakes** and **molasses** are types of agro-industrial byproducts used as alternative feeds.
41. The process of treating roughages with steam under pressure is a **physical** method aimed at improving digestibility.
42. Storage pests such as the granary weevil and lesser grain borer are **biological** factors affecting grain quality.
43. Alkali treatment of roughages can be followed by **pelleting** to enhance nutrient availability and palatability.
44. The presence of rat fecal pellets or hair during the raw material inspection indicates poor **storage** conditions.
45. **Organoleptic** evaluation involves using senses like smell and taste to assess feed quality.
46. Ammonia treatment of roughages can be done in gaseous form or through **aqueous** solutions.
47. **H2O2 (hydrogen peroxide)** is an example of a chemical agent used to oxidize and break down lignin in roughages.
48. Ensuring the quality of **raw materials** is crucial for optimizing the feed manufacturing process and animal nutrition.
49. The Animal Feeds Sectional Committee is part of the **Bureau of Indian Standards (BIS)**, which focuses on standards for animal feed and nutrition.
50. The preferred dry matter content of fodder for ensilage should be **30-35%.**
51. Silage container or pit is called **Silo.**
52. Silo-filler’s disease is caused by inhalation of **oxides of nitrogen (NOx).**
53. Method used for evaluation of silage quality is called **Flieg index.**
54. For silage making crops should be harvested at **preflowering stage.**
55. Haylage is ensilage of **grasses and legumes.**
56. Hay is product obtained by **cutting and curing**.
57. ‘Hydro’ means **‘water’** and ‘ponos’ means ‘**working’**.
58. The alternative method used for calculating digestibility coefficient without total faecal collection is **Indicator/Marker method.**
59. Density of roughages feed increases by **grinding and pelleting.**
60. Pelleting of mash feed increases bulk density from **29-135%.**
61. Indicator/ marker methods uses **inert** reference substance.
62. Example of natural indicator is **lignin/Silica/AIA/ n-alkanes**.
63. Most often used external marker for avians and swine is **chromic oxide**.
64. **Grab sampling method** is used in grazing animals to determine total faeces voided.
65. Biological treatment of lignocellulosic material in a solid state fermentation is known as **Karnal process**.
66. Losses of hay due to fermentation is **5-9%** of dry matter
67. AAFCO stands for **Association of American Feed Control Officials**.
68. **Bailing** and **Cubing**  are to be done to make handling easy, to reduce the cost of transportation and space required for storage.
69. Inhibitory factors of soyabean is inactivated by **Roasting.**
70. In pressure cooking grains are cooked at **50 psi for 1.5 min**.

**Match type questions**

1. Characteristics of good silage-

|  |  |
| --- | --- |
| **List I** | **List II** |
| 1. pH
 | 1. 10-15%
 |
| 1. Ammonical nitrogen
 | 1. 4.2-4.5
 |
| 1. Butyric acid
 | 1. Brownish
 |
| 1. Colour
 | 1. Traces
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3, D-4

b) A-2, B-3, C-1, D-4

c) **A-2, B-1, C-4, D-3**

d) A-4, B-3, C-2, D-1

1. Good quality hay-

|  |  |
| --- | --- |
| **Table A** | **Table B** |
| 1. Moisture percent
 | 1. Vitamin A
 |
| 1. Best crop
 | 1. 12-14%
 |
| 1. Harvesting time
 | 1. Oat
 |
| 1. Loss of
 | 1. 1/3 – ½ in blossom
 |

Tick the correct answer provided below:

a) **A-2, B-3, C-4, D-1**

b) A-2, B-3, C-1, D-4

c) A-3, B-1, C-2, D-4

d) A-4, B-3, C-2, D-1

1. Match-

|  |  |
| --- | --- |
| **Table A** | **Table B** |
| 1. External indicator
 | 1. n-alkanes
 |
| 1. Natural indicator
 | 1. Radioactive isotopes
 |
| 1. Ytterbium (Yb)
 | 1. Magnesium ferrite
 |
| 1. Inert reference substance
 | 1. Indicator/Marker
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3, D-4

b) A-2, B-3, C-1, D-4

c) **A-3, B-1, C-2, D-4**

d) A-4, B-3, C-2, D-1

1. Alternative fodder resouces-

|  |  |
| --- | --- |
| **Table A** | **Table B** |
| 1. Aquatic plants
 | 1. Poor in phosphorus
 |
| 1. Tree leaves
 | 1. Working
 |
| 1. *Ponos* means
 | 1. Hydroponics
 |
| 1. WF Gericke
 | 1. *Duckweeds*
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3, D-4

b) A-2, B-3, C-1, D-4

c) **A-4, B-1, C-2, D-3**

d) A-4, B-3, C-2, D-1

1. Match the following

|  |  |
| --- | --- |
| **Table A** | **Table B** |
| 1. Dry matter
 | 1. 90%
 |
| 1. Protein
 | 1. 25%
 |
| 1. Carotene
 | 1. 20-30%
 |
| 1. Energy
 | 1. 28%
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3, D-4

b) A-2, B-3, C-1, D-4

c) **A-3, B-4, C-1, D-2**

d) A-4, B-3, C-2, D-1

1. Match the following

|  |  |
| --- | --- |
| **Feedstuffs** | **Anti nutritional factors** |
| 1. Neem seed cake
 | 1. Dhurrin
 |
| 1. Salseed
 | 1. Nimbin
 |
| 1. Jowar
 | 1. Tannin
 |
| 1. Linseed
 | 1. Amgygdalin
 |
| 1. Almonds
 | 1. Linamarin
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3, D-4, E-5

b) **A-2, B-3, C-1, D-5, E-4**

c) A-3, B-5, C-4, D-2, E-1

d) A-4, B-2, C-1, D-3, E-5

1. Match the following

|  |  |
| --- | --- |
| **Silages** | **pH** |
| 1. Very good
 | 1. 4.2-4.5
 |
| 1. Good
 | 1. 4.8
 |
| 1. Fair
 | 1. 3.5-4.2
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3

b) A-2, B-3, C-1

c) A-3, B-2, C-1

d) **A-3, B-1, C-2**

1. Match the following

|  |  |
| --- | --- |
| **Silages** | **Ammonical nitrogen (%)** |
| 1. Very good
 | 1. 10-15
 |
| 1. Good
 | 1. Less than 10
 |
| 1. Fair
 | 1. 20
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3

b) **A-2, B-1, C-3**

c) A-3, B-2, C-1

d) A-3, B-1, C-2

1. Match the following

|  |  |
| --- | --- |
| **Table A** | **Table B** |
| 1. Flieg index
 | 1. Hay
 |
| 1. Mow curing
 | 1. Tannin
 |
| 1. PEG, PVP
 | 1. Silage
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3

b) A-2, B-3, C-1

c) A-3, B-2, C-1

d) **A-3, B-1, C-2**

11. Processing methods of grains

|  |  |
| --- | --- |
| **Table A** | **Table B** |
| 1. Dry processing
 | 1. Pressure cooking, Exploding, Reconstitution
 |
| 1. Wet processing
 | 1. Grinding, dry rolling, micronizing
 |
| 1. Popping
 | 1. Micro waves with 3 x 108 to 3 x 10¹¹ cycles/ sec.
 |
| 1. Micronizing
 | 1. Dry heat (700-800°F or 370-425°C) for 15 to 30 seconds
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3, D-4

b) **A-2, B-1, C-4, D-3**

c) A-3, B-1, C-4, D-2

d) A-4, B-2, C-1, D-3

12. Dry processing methods of grains

|  |  |
| --- | --- |
| **Table A** | **Table B** |
| 1. Extruding
 | 1. Heating to about 300°F (148.9°C) |
| 1. Grinding
 | 1. Grains that are rolled or cracked are commonly processed using a roller mill
 |
| 1. Dry rolling
 | 1. Pet feeds, fish feeds, feed for laboratory animals
 |
| 1. Roasting
 | 1. Reduction of particle size
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3, D-4

b) A-2, B-3, C-1, D-4

c) **A-3, B-4, C-2, D-1**

d) A-4, B-2, C-1, D-3

13. Wet processing methods of grains

|  |  |
| --- | --- |
| **Table A** | **Table B** |
| 1. Soaking
 | 1. High pressure steam (to 250 psi) for about 20 sec
 |
| 1. Exploding
 | 1. Agglomerated feeds
 |
| 1. Reconstitution
 | 1. 12-24 hrs
 |
| 1. Pelleting
 | 1. Water added to grain (10% moisure) to increase moisture to 25-30%.
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3, D-4

b) A-2, B-3, C-1, D-4

c) **A-3, B-1, C-4, D-2**

d) A-4, B-2, C-1, D-3

14. Methods to improve of poor quality roughage

|  |  |
| --- | --- |
| **Table A** | **Table B** |
| 1. Irradiation, wafering, steam under pressure, chopping
 | 1. Biological methods
 |
| 1. Chemical methods
 | 1. NaOH/ Pelleting, NaOH/Steam
 |
| 1. Enzymes, mushrooms, rot fungi
 | 1. Physical methods
 |
| 1. Physio-chemical methods
 | 1. Gases, oxidizing agents, alkali, acids
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3, D-4

b) A-2, B-3, C-1, D-4

c) **A-3, B-4, C-1, D-2**

d) A-4, B-2, C-1, D-3

15. Match the following

|  |  |
| --- | --- |
| **Table A** | **Table B** |
| 1. Crop residue
 | 1. Oil cakes, rice bran, molasses, bio-gas slurry
 |
| 1. Alternative feeds
 | 1. Paddy straw and sugarcane baggase
 |
| 1. AIBP
 | 1. Newer feeds
 |

Tick the correct answer provided below:

a) A-1, B-2, C-3

b) **A-2, B-3, C-1**

c) A-3, B-2, C-1

d) A-3, B-2, C-1

**Reference:**

Textbook “Principle of Animal Nutrition and feed technology” by DV Reddy.

Textbook “Advance Animal Nutrition” by DV Reddy.