COURSE GUIDE

ANP 511
ANIMAL PRODUCTION RESOURCES
(2 UNITS)

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Introduction

ANP 511: Animal Production Resources (2 Units) is a 2-Credit Unit course offered in the fifth year to students of the undergraduate degree programme in Animal Sciences. There are fifteen study units in this course. The course is a guide for distance learners enrolled in the B.Agric. programmes of the National Open University of Nigeria.

In this guide, you will find very useful information about this course: aims, objectives, what the course is about, what course materials you will be using; and information on practical sessions. It also offers you guideline on the amount of time you are likely to spend on each study unit and your tutor marked assignments.

I wish you all the best in your learning experience and successful completion of this course.

This course examines the chemistry of feed nutrients, their implication and application in animal production. The various definitions and terminologies used in animal nutrition were also defined. The classes of food and the nutritional value of the different feedstuff was considered. The feedstuff and ingredients available which could be used as livestock feed, such as cereals grains and by products, legumes, oilseeds and forages were listed. The course also describes the importance of storage and feed quality in livestock production.

2.0 Course Aims and Objectives

- This course aims to introduce you to the knowledge of different feedstuff available for animal production, their nutritive value and application in animal production.

There are objectives to be achieved in each module of the course on completion of this course. You should be able

- Explain the importance of animal nutrition
- Explain the meaning of common terms used in animal nutrition
- list the different classes of food
- Explain the importance of carbohydrates to animal production
- Describe the functions of carbohydrates
- Explain the importance of proteins to animal production.
- List the important sources of fats and lipids used in livestock feeds.
- Explain the importance of fats and lipids animal production
- Describe the functions of fats and lipids
- Explain the importance of minerals and vitamins animal production
- Explain the types of water and effects of water in feed
- Describe the various food groups that animal foodstuffs are based upon
- Enumerate the nutritional value and characteristic of forage and roughages
- Explain the importance of forages and roughages in crops animal feeds.
- List the important sources of energy feedstuff
- Mention the nutritional characteristic of energy feedstuff
- Describe various energy feedstuff
- Define supplement
- Explain nutritional characteristics of protein supplement
- Mention examples of protein supplement
- Explain the importance of vitamins and minerals supplements

- List vitamins and minerals supplements commonly used in livestock feed
- Explain the importance of Nonnutritive Additives
- Explain the meaning of succulent feeds
- Explain the role of succulent feeds in feeding livestock
- List the importance of concentrates
- Explain the importance of cereals in animal production
- Describe and explain common cereals
- Explain cereal grain By-products
- Explain importance of legumes in animal feed
- Highlight nutritional quality of legumes
- Mention examples of some legumes
- Explain the meaning of oilseeds
- Highlight the importance of oilseeds
- Describe oilseed cakes and meal
    - Explain the role of grasses in ruminant nutrition
    - Nutritional quality of grasses
- Explain the importance of storage in feedstuff and forage
- Describe quality control of feedstuff and forages
- Describe the types of processing method
- List Common Processing Methods for Roughage

Working through the Course

To complete this course, you are advised to read through this course guide to familiarize yourself with the structure of the course. read the study units and attend all tutorial sessions where available. You are also encouraged to practice all assignments contained in this material. The course guide also helps you to know how to go about your Tutor-Marked-Assignment which will form part of your overall assessment at the end of the course.

At the end of the course, there is a final examination. The course should take you not less than forty-two hours to complete. It is advised you draw up your own timetable and allocate time to read each study unit in order to complete the course successfully and on time. A great effort was put into this course thereby enriching it with a lot of useful information.

Course Materials

You will be provided with the following materials course guide and study units. In addition, the course comes with a list of recommended textbooks and materials which though are not compulsory for you to acquire or indeed read, are necessary as supplements to the course material.

Study Units

There are thirteen study units in this course and they are:

- Terms and Definitions
- Carbohydrates and Proteins
- Fats, Vitamins, Minerals and Water
- Dry Forages and Roughages
- Energy Feeds
- Protein Supplements
- Mineral and Vitamin Supplements, Non-nutritive Additives
- Succulent Feed and Concentrate feeds,
- Cereals
- Legumes
- oil seeds
- Chemistry and nutritive values of some Nigerian grasses
- Storage, Quality control of feeding stuffs and feeds

Module 1 Classification of foods,

Unit 1 Terms and Definitions

Unit 2 Carbohydrates and Proteins

Unit 3 Fats, Vitamins, Minerals and Water

Module 2 Classification of feeding stuff and feed supplements

Unit 1 Dry Forages and Roughages

Unit 2 Energy Feeds

Unit 3 Protein Supplements

Unit 4 Mineral and Vitamin Supplements, Nonnutritive Additives

Module 3 Succulent Feed, Concentrate feeds, cereals, legumes and oil seeds

Unit 1 Succulent Feed and Concentrate feeds,

Unit 2 Cereals

Unit 3 Legumes

Unit 4 oil seeds

Module 4 Nutritive values of some Nigerian grasses, storage and quality control of feedstuff

Unit 1Chemistry and nutritive values of some Nigerian grasses

Unit 2 Storage Quality control of feeding stuffs and forages

MODULE 1 CLASSIFICATION OF FOODS,

Unit 1 Terms and Definitions

CONTENTS

1.0 Introduction

Nigeria is blessed with vast range of feed resources such as forages, grains, oilseeds and agro-industrial by-products which could be used in the formulation of quality livestock feed. These local available feed resources in Nigeria have potential to support a flourishing livestock industry. However, these potentials are grossly under-utilized by the farmers resulting in a depressed livestock industry, thus making it second to crop production in Nigeria. This low capacity feed resources utilization could be linked to inadequate information based on location and localization of feed resources, processing, preservation/storage and quality enhancement/assessment.

The rapid success and expansion of the livestock industry therefore, depends on the availability of good quality, quantity and cheap compounded feeds. This is particularly true of the intensive livestock enterprises such as poultry, pigs and rabbits, whose performance depends mainly on the use concentrate and balanced compounded feeds. Therefore, the single most important constraint facing the livestock industry are several problems relating to the inadequate supply, high cost and poor quality of feeds have seriously threatened the (poultry) livestock industry in recent times.

2.0 objectives

- Explain the importance of animal nutrition
- Explain the meaning of common terms used in animal nutrition

3.0 Main content

3.1 Importance of feeds in Animal nutrition

The importance of feed in animal production is enormous and must be properly understood. The chemistry of feed nutrients, their implication and application in animal production must be studied to have success in the enterprise. Feeding has a direct impact on the growth rate, production capacity and health status of the animal. Feeding is key for a profitable and sustainable farming. The cost of feeding has long been recognised as the major cost and the largest cash expense in animal production. It has effect on the animal's product quality. In addition to this, it also has effects on the environment. Therefore, knowledge on animal nutrition is key for a profitable and sustainable farming. Animal nutrition focuses on studying the dietary needs of the animals.

3.2 Common terms Used in Animal nutrition

Before looking at the different types of food stuffs in more detail, there are several terms and definitions with which you should become familiar.

Nutrition – the science involving various chemical and physiological activities, which transform feed elements (nutrients) into body elements.

Feed – is a material, which after ingestion by the animal is capable of being digested, absorbed and utilized i.e. before transformed into body elements of the animal. A feed is merely the carrier of nutrients.

Feedstuff/Feed ingredients – a feeding stuff is any product, whether of natural origin or artificially prepared that when properly used has nutritional value in the diet. It includes It includes naturally occurring plant or animal products and by-products. synthetic and other pure nutrients. It also includes vitamin or mineral supplements that are chemically synthesized, or otherwise manufactured pure nutrients.

Nutrients – a nutrient is defined as any feed constituent or group of feed constituents of the same general chemical composition or a pure chemical compound that aids in the support of animal life. The constituents of a feed that are capable of being transformed into body elements are known as nutrients

A ration is a 24-hour allowance of feed stuff or of mixture of the feedstuffs/feed ingredients that is given to an animal. The important thing to note is that the term carries no implications that the allowance is adequate in quantity or kind to meet the nutritional needs of the animal for which it is intended. These can be explained as follows: RATION: the daily allowance of food for one person (e.g. a soldier) or one animal (e.g. a steer). Remember, the ration may not be enough for optimum production. DIET: this is what the person or animal usually eats or drinks

Feeding – is a practical application of nutrition, (consideration of management, formulation, palatability, economics), etc.

Formulation – is the process of constructing a feed or diet formular.

Balanced diet – the food or feed that supplies all the essential nutrients in the proper amounts required for optimum performance of the animal.

Complete feed – a balanced ration for the animal in a single form. It provides all the nutritional requirements (except water) needed to maintain normal health or to promote production.

Basal (Energy) Feeds – nutritionally, basal feeds are mainly concentrated sources of energy being especially rich in starches and sugars. They are grains and grain by-products that contain not more than 16% protein and 18% crude fibre.

Supplement – is a feed or a feed mixture use with another feed to improve the nutritive balance of the total ration or diet.

Concentrate – is usually described as feed or feed mixture which are rich in primary nutrients (protein, carbohydrates and fat) but low in fiber. for example, corn, soybean meal, oats, wheat, molasses It is a commercially prepared supplement which refers to a concentration of protein, minerals or of vitamins in excess of those found in basal feeds.

Husks – is leaf enveloping an ear of maize or outer covering of kernels or seeds especially in the dry form.

Ear of maize – entire fruiting head of Zea mays including only cob and grain.

Cob – the fibrous inner portion of the ear of maize from which the kernels have been removed.

Kernel – refers to a whole grain.

Hulls – outer covering of grain or kernel.

Forage or roughage – any material substance for feeding livestock, which contains more than 18% crude fibre, materials making up the fodder.

Anorexia – loss of appetite in disease condition.

Appetite – is a desire or inclination for food. It is a conditioned reflex. It is related to taste, smell and appearance of food. Appetite is well developed in man than in farm animals.

Additive – a substance (or mixture of substances) added to the feed to meet a specific purpose. An additive may enhance the nutritive value, sensory value or shelf life of the feed. Additive is involved in the production, processing, packaging and/or storage of the feed without being a major ingredient.

GIT- Gastro intestinal tract, responsible for the digestion, absorption and assimilation of feed and nutrients.

Ration Formulation – this is the act of combination and recombination in specific ratios of feed ingredients/feedstuffs to obtain feed for the nutrient requirement of farm animals.

Feedmill – is an establishment/place where feeds/commercial feeds are provided using specialized equipment according to the feed formulation.

Feedmillers – owner of a feedmill, for commercial/personal use.

Proximate Analysis – this refers to the analysis of chemical constituents of feed, feed ingredients using established standard methodologies/procedures AOAC (1995).

Nutrient Requirements – this refers to specific requirements for nutrients by farm animals and this can be affected by several factors.

Antinutritional factors – these refers to chemical compounds/metabolites which interfere with the normal process of digestion, absorption and assimilation of nutrients from feedstuffs/feeds.

Feed Microscopy – this is the science of identification, evaluation of feeds/feedstuffs by visual appraisal using a microscope, hand lenses. Essentially it involves physical and textural examinations.

Nutrition evaluation – refers to the assessment of feed/feedstuff for its nutritional adequacy. This can be physical, chemical, biological or microbiological in nature

ADF: acid detergent fibre - a laboratory estimate of the less digestible fibre in the plant. ADF is the best indicator of the fibre requirement for healthy rumen fermentation.

Fiber-Crude Protein (ADFCP) ADICP (or ADFCP) is the insoluble protein fraction remaining in the acid detergent fiber residue of a feed sample.

Digestibility refers to the extent to which a feedstuff is absorbed in the animal body as it passes through an animal's digestive tract. It varies greatly with the type of feedstuff and type of animal concerned.

Dry Matter Basis. Dry matter basis indicates the nutrient levels in a feed sample based on its dry matter content (i.e., excluding its water content).

Non-ruminants (monogastric) are animals having a single compartment or simple stomach system (e.g., swine, horse, cats).

Palatability refers to the appeal and acceptability of feedstuffs to an animal.

Ruminants are a class of animals that have multiple organs (compartments) working together to accomplish digestion.

Toxicity refers to the extent to which a substance can exert a poisonous effect on animals.

Rancidity refers to hydrolysis or oxidation of fats when exposed to air, light or moisture resulting in unpleasant taste or odour.

Forage is plant crops that is generally grown in a particular area or field with the intention of having it grazed by various livestock. The crop plants usually grown for this purpose are of legumes, grasses, corn, oats, elephant grass, millet, and other edible plants. The act of eating or grazing upon the plant matter is known as foraging.
Fodder is used to describe plants that is given to the animals after the plants have been harvested Fodder, a type of animal feed, is any agricultural foodstuff used specifically to feed domesticated animals
Hay: This is grass cut. dried and preserved for animal's future use.
Amino acids - The simplest organic structure of which proteins are formed; all have the common property of containing a carboxyl group and an amino group on the adjacent carbon atom.

Essential (indispensable) Amino acids - Those that must be present in the diet; they include arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

Nonessential (dispensable) Amino acids - Amino acids found in common proteins but which may be partly or completely synthesized by the animals.

Antioxidant - A substance that inhibits the oxidation of other compounds

Biological value - The efficiency with which a protein furnishes the required amounts of essential amino acids; usually expressed as a percentage.

Bran - The pericarp or seed coat of grain which is removed during processing and used as animal feed. Butyric acid - One of the volatile fatty acids commonly found in rumen contents and in poor-quality silages.

By-product - (Part) Secondary products produced in addition to the principal product.

Cake - (Physical form) The mass resulting from the pressing of seeds, meat, or fish in order to remove oils, fats, or other liquids.

Carotene - A yellow organic compound that is the precursor of vitamin A.

Cellulose - A polymer of glucose characterized by a linkage between the glucose molecules that is resistant to hydrolysis by most digestive enzymes (except some produced by microorganisms).

Premix - A uniform mixture of one or more microingredients and a carrier, used in the introduction of microingredients into a larger batch

Stover - The mature, curled stalks and leaves of corn after the ears, or sorghum after the heads have been harvested.

As-fed Basis : Feed analyses reports often state results based on the feed's natural state (i.e., including water) and/or on a dry matter basis. The term "As-fed Basis" is used to alert the reader that the analytical results of a feed sample are based on its natural state including water. That means it is affected by the sample's moisture level before drying

4.0 Conclusion

This unit serves as a general introduction to highlight the importance of animal nutrition in animal production. In order to enhance understanding the various terms used commonly in animal nutrition were explained.

5.0 Summary

The knowledge of animal nutrition is key for a profitable and sustainable farming. Animal nutrition focuses on studying the dietary needs of the animals. It requires a great deal of skill, knledge and practice to be able to feed animals optimally. An animal that is fed well is given just enough (but not more) of the correct foods (feed having the right nutrients) so that it can realise its production potential.

6.0. Tutor Marked Assignment

1.Briefly explain the importance of animal nutrition

2.Define the following terms:

1. Antioxidant
2. Non-ruminants
3. Palatability
4. Ruminants
5. Biological value
6. Supplement
7. Concentrate
8. Bran
9. Feedmill
10. Proximate Analysis
11. Nutrient
12. Antinutritional factors

7.0. References / Further Reading

Uttam S., Leticia S., Dennis H., Nicholas H., Lawton S., Gary H. and David K. (2010). Common Terms Used in Animal Feeding and Nutrition. University of Georgia Cooperative Extension Bulletin 1367 June 2010

Lee I. C. (2009). Animal Nutrition Handbook Second Revision. unpublished

Unit 2 Carbohydrates and Proteins

CONTENTS

1.0. Introduction

Many elements in varying combinations make up feed nutrients. These elements include carbon, hydrogen, oxygen, phosphorus, potassium, iodine, nitrogen, sulphur, calcium, iron, cobalt, chlorine, magnesium, sodium, copper, Florine, manganese, zinc, molybdenum, selenium and chromium

2.0. Objectives

- list the different classes of food

- Explain the importance of carbohydrates to animal production
- Describe the functions of carbohydrates
- Explain the importance of proteins to animal production.

3.0. Main Content

Animal feed can be classified based on the nutrients they supply. There are six components of feed/food that are useful to the body.

- Carbohydrate
- Proteins
- Fats
- Minerals
- Vitamins
- Water

Carbohydrates are an essential compound of all organic life on this planet. Carbohydrates are sources of calories or energy which accounts for a large portion of an animal's daily food supply. Carbohydrates comprises of Carbon, Hydrogen and Oxygen with an empirical formula $Cn(H2O)n$. This class of food includes sugars, starch and cellulose.

3.1 Formation of carbohydrates in plants

Carbohydrates are formed in plants during photosynthesis. This is achieved by reaction of carbon dioxide and water in the presence of sunlight. Glucose (simple sugar) is formed from this process. Carbohydrates form 75 percent of all dry matter in plants.

3.1.1 Carbohydrates in animals

Animals receive these starches through foods, especially those made from plant life such as grains and bread. Animals contain less than one percent carbohydrates, it is present in the liver, muscle and blood. The carbohydrates present in animal body is also known as animal starch or glycogen. If they are not used immediately, they will be stored as fat. Based on digestibility and solubility carbohydrates can be divided into two groups.

a. Soluble carbohydrates, these are also called nitrogen free extract (NFE) which are made up of simple sugars, starch and hemicellulose. These group of carbohydrates are easily digestible in the body.
b. Insoluble carbohydrates include hard fibrous substances like crude fiber, cellulose and lignin. These group of carbohydrates are less digestible by non-ruminants and easily digested by ruminants through rumen microflora and micro fauna.

3.1.2 Carbohydrates metabolism in animals

The intermediary metabolisms of carbohydrate in the mammalian organisms are as follows:

1. Glycolysis – the breakdown of glucose or glycogen to pyruvate and lactate by the Embden – Meyerhof pathway
2. Glycogenesis – The synthesis of glycogen from glucose
3. Glycogenolysis – the breakdown of glycogen to glucose in liver and to pyruvate and lactate are main products in muscle
4. Oxidation of pyruvate to Acetyl – COA – this is a necessary step prior to the entrance of the products of glycolysis into the citric acid cycle, which is the final common pathway for the oxidation of carbohydrate, fat and protein
5. Gluconeogenesis – formation of glucose or glycogen from non-carbohydrate sources mainly in the citric acid cycle and glycolysis. Substrate for gluconeogenesis are glucogenic amino acids, lactate, glycerol and in the ruminant, propionate.
6. Hexose Monophosphate Shunt (pentose phosphate pathway) – is an alternative pathway to the Embden-Meyerhof pathway for the oxidation of glucose.

3.1.3 Functions of carbohydrates

1. Carbohydrates serve as a major source of energy supply in animal body
2. They are essential component of production, temperature control and proper functioning of different parts of the body
3. Essential component of milk (lactose) which is important in lactation
4. Carbohydrates are stored as glycogen, excess carbohydrates are converted to fat and stored in fat depot. These are reserved energy materials of the liver and muscle in animals
5. Help in metabolism of amino acids and fatty acids
6. Helpful in absorption of calcium and phosphorus
7. Help in secretion of digestive juice in the gastrointestinal tract
8. Provide suitable environment for rumen bacteria and protozoa
9. Help in peristaltic movement of food
10. Maintain blood glucose level
11. They are component of several important biochemical compounds such as nucleic acid, coenzyme and blood group substance

3.1.4 **Classification of carbohydrates**

1. Monosaccharide

is a carbohydrate that cannot be hydrolysed to simpler compounds
These are simple sugars with only one molecule of sugar.
They are soluble in water and sweet for example glucose, fructose, galactose

2. Disaccharide

Is a carbohydrate that can be hydrolysed to two monosaccharide molecules for example sucrose, lactose, maltose

3. Polysaccharide

is a carbohydrate that can be hydrolysed to many monosaccharide molecules for example starch, glygogen, cellulose and fiber

There are also sweet carbohydrates, which are found contained in large quantities in many foods such as confectioneries, soft drinks, cakes, supplies only energy. Others are fructose in fruit, honey, lactose in milk and malt.

Non-sweet carbohydrates – not sweet starch, are found it is the bulk in yams, bread, beans and cereals. These contain other valuable nutrients.

The main types of food/feed carbohydrates, their monosaccharide composition and their most common sources are listed below:

Table displaying the common food carbohydrates, types, composition and sources

Type	**Composition**	**Sources**
Polysaccharides		
Starch, dextrins	D-glucose	Cereals, roots, tubers, plantains
Cellulose	D-glucose	Cereals, fruits, vegetables
Glycogen	D-glucose	Liver, animal tissue, sweet corn
Hemicelluoses	L-Arabinose D-xylose	Cereals, fruits, vegetables
Gums	L-Rhamnose, D-galactose, mannose, glucose, glucuronic	Cereals, legumes, nuts, seaweeds
Pentosan	L-Arabinose, D-xylose	Fruits, vegetables
Oligosaccharides		
Raffinose, Stachyose	D-gal, D-glu	Legume seeds, cereals
Maltooligosaccharides	D-Glu	Starch syrups, malt

Dissacharides		
Sucrose	D-glu, D-fru	Sugarcane fruits, vegetables
Maltose	D-glu	Starch syrups, malt, honey
Lactose	D-gal, D-glu	Milk, dairy products

Examples of Carbohydrates include Yam, maize, sorghum, wheat, breadfruit, cassava, sugar, plants, cereals, roots and tubers, etc.

3.2 PROTEINS

Proteins are highly complex nitrogenous organic compounds occurring naturally in all living matter and forming an essential part of animal feed requirements.

Protein is important in feeding farm animals and human beings, because it is the nutrient found in highest concentration (after water) in organic and muscle tissues. Protein is one of the critical nutrients particularly for young rapidly growing animals and for high producing mature animals such as dairy cows and fish. The young, growing animal has the highest requirements for protein when expressed as a percentage of the diet. In addition, productive functions such as gestation and lactation greatly increase the protein requirement because of the needs of the foetus during gestation and for milk protein production during lactation. Optimal use of protein is a must in any practical feeding system, since protein supplements are much more expensive than energy, fibrous and fat feedstuffs and wasteful usage increase the cost of production in almost all instances. If there is shortage of fat in the diet, then carbohydrates and proteins can be converted into body fat. If there is shortage of carbohydrate in the diets, fats and proteins can be converted into energy, but if we are short of protein in the diet, carbohydrates and fats cannot be used to build up the body or repair the wear and tear that takes place. It is therefore essential that an adequate quantity and quality of protein is supplied by the feed.

3.2.1 Protein quality

Proteins are made up of some building blocks (individual organic compounds) called amino acids. Protein quality is a measure of the ability of protein supplement/feedstuffs to supply needed amino acids in the diet when ingested (plant and animal origins). For practical purposes, protein quality refers to the amount and ratio of essential amino acids in a protein source. The amino acids contained may either be essential amino acids (indispensable) which are those amino acids that are required for the functioning of the body but cannot be synthesized in the body hence, they must be supplied in the diet. The non-essential amino acids are those amino acids that are necessary for the functioning of the

body but can be synthesized within the body (dispensable). Therefore, a good quality protein is that which contains a high proportion of the essential amino acids.

The term biological value is used to express protein quality and it is dependent on the relative quantities of the essential amino acids present. For all practical purposes, egg has a biological value of 100 and considered a standard good quality protein, however, cereals like maize/corn have low biological value of 40 as it lacks the amino acid lysine. Ten (10) essential amino acids are Arginine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan, Valine. The non-essential amino acids are – Alanine, Asparagine, Aspartic acid, Glutamic acid, Glutamine, Glycine, Proline, Cysteine, Tyrosine, Serine. It is the specific sequence of amino acids and the manner in which the amino acids strands are connected to each other than determines the physical and chemical properties of each individual protein and its biological functions.

3.2.2 Types of protein based on origin

There are two main types of proteins

- Animal Proteins
- Plant Proteins

3.2.3 Characteristics of Animal Proteins

These are proteins of animal origin

1. Have better quality protein than vegetable proteins.
2. Have high biological value meaning high profile of essential amino acids.
3. They are called “complete” protein.
4. They are costly (high price),
5. Not affected by seasonal variations and available all year round.
6. Lack or have limited antinutritional factors.
7. Require little or no processing before incorporation in animal feed.
8. Included in small quantities in animal feeds.
9. Chemical composition is relatively standardized.
10. Crude protein in most case is greater than 65% CP.

Examples include fish meal, meat meal, blood meal, egg, milk or dairy products, feather meal, chicken offal meal, maggot meal, termite meal, grasshopper meal, frog/toad meal.

3.2.4 Characteristics of Plant Proteins

These are proteins of plant origin,

1. They are often termed “incomplete” proteins.

2. Have low biological value (BV) lower profile of essential amino acids.
3. They are included in higher percentages in animal feed,
4. The percentage constituent crude protein is between 20-45% CP.
5. Its use is affected by seasonal availability, not available all year round.
6. It contains high levels of antinutritional factors especially in the raw state,
7. Proximate composition or chemical composition is not standardized i.e. variable.
8. Their price is low when compared to animal proteins.
9. They require a lot of processing before incorporation in animal feed.
10. They are deficient in one or more essential amino acids
11. Their protein quality is lower when compared to animal proteins

Examples include – soybean meal, groundnut cake, cottonseed cake, sunflower cake, palm kernel cake, rapeseed meal, jack bean, pigeon pea meal, castor seed meal.

3.2.5 Functions of proteins

Proteins are complex polymer of amino acids, found in all cells, involved in most of the vital chemical reactions of plant and animals' metabolism.

1. Proteins are the chief structural units of protoplasm, cytoplasm and cell membrane
2. Proteins in diets serve as primary source of amino acids the building block of cellular proteins
3. The biological catalysts known as enzymes are proteins
4. Some of the hormones, the regulators of chemical reactions are proteins or peptides
5. Antibodies are complex proteins and are used for protection of the body
6. Protein play an important role in the transport of water, inorganic ions, organic compounds and oxygen
7. They can contribute through functional properties of proteins, in foods by contributing to colour, flavor, odour, foam formation e.g. maillard and browning reactions.
8. May also be used to provide energy e.g. meat, insects, soyabean meal, eggs, fish meal, groundnut cake, cowpea, milk.
9. Needed for growth, tissue maintenance and repair of worn out tissues, e.g legumes such as soya bean, cotton seed, groundnut cakes, etc
10. Make up a greater part of some body tissues such as brain, spinal cord, nerves.
11. Parts of animal body such as skin, hooves, wool, feathers and skin.

Note that for ruminants, lack of protein or a specific amino acid deficiency is not apparent as in non-ruminants. This is because of the action of rumen microbes which can partially degrade a nitrogen source in the rumen to ammonia and most likely for some of the essential amino acids such as methionine or for some peptides. However, high producing ruminant animals also by-pass some ingested proteins into the intestine without it being broken down in the rumen. Hence, it is probable that protein quality is more important under these circumstances than for animal producing at low levels and consuming much less feed.

4.0. Conclusion

Many elements in varying combinations make up feed nutrients There are six components of feed/food called nutrients that are useful to the body. These ingredients must be fed to the animal in their correct proportions.

5.0. Summary

Carbohydrates and protein are indispensable in animal production. They serve various function in the animal body. they are necessary for profitable animal production.

6.0. Tutor Marked Assignment

- list two classes of food
- Describe three functions of carbohydrates in animals
- Explain the importance of proteins to animal production.

7.0. References / Further Reading

Durrance, R D., Applied animal nutrition agricultural development training manual US peace corps ECHO, e-mail: echo@echonet.org; website- http://www.echonet.org/

Lee I. C. (2009). Animal Nutrition Handbook Second Revision. unpublished

Unit 3 Fats, Vitamins, Minerals and Water

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3.4.2Water Activity
3.4.3Sources of water
3.4.4 Functions of water
3.4.5 Effects of water on feed/feed ingredients

1.0 Introduction

In the previous unit we considered two out of the six classes of food. In this unit we shall consider Fats, Vitamins, Minerals and Water. In contrast to other previous nutrients considered, most of the nutrients here are not used for structural requirements or as raw materials for synthesizing other compounds. However since the body cannot make then must be supplied by our feed.

2.0 Objectives

- List the important sources of fats and lipids used in livestock feeds.
- Explain the importance of fats and lipids animal production
- Describe the functions of fats and lipids
- Explain the importance of minerals and vitamins animal production
- Explain the types of water and effects of water in feed

3.0. Main Content

3.1 FATS

Fats are made up of carbon, hydrogen and oxygen. Fats are essential components of all cells. The distinction between an oil and a fat is simply that at ordinary room temperature oils are liquid and fats are solid. A molecule of fat consists of glycerol with three open chain fatty acids (1 Glycerol + 3 fatty acids ---------- fat + 3 H2O). Fats supply essential fatty acids needed for adequate nutrition and normal health. They are mainly included as energy sources as they furnish 9.3 calories per gram compared to 4.1 calories per gram from carbohydrate. Fats are found in foods of animal and plant origin, we have “visible” fat such as butter, palm oil,

groundnut oil and fat in pork, but fat can also be “invisible” like the fat contained in egg yolk, fish, oil seeds

3.1.1 Classification of fats

The common dietary fat is the triglyceride composed of both saturated, monosaturated and polyunsaturated fats. Levels of up to 20% are acceptable in the diets, however, large levels may reduce feed intake and other essential nutrients thereby resulting in reduced growth. Another problem with fat inclusion is the problem of rancidity.

3.1.2 Essential fatty acids

Essential fatty acids, or EFAs, are fatty acids that humans and other animals must ingest because the body requires them for good health but cannot synthesize them. There are four (4) essential fatty acids

1. Oleic (an omega-9 fatty acid)
2. Alpha-linolenic acid (an omega-3 fatty acid)
3. Linoleic acid (an omega-6 fatty acid).
4. Arachidonic acid (an omega-6 fatty acid).

Deficiency of these fatty acids leads to defective growth, dry hair, scaly skin and susceptibility to infections. These essential fatty acids are found in soya bean oil, groundnut oil. palm oil, coconut oil, groundnut oil, melon seeds, fish oil, poultry oil, cotton seed oil and sunflower oil.

3.1.3 Functions of fats

1. Supply energy, a concentrated energy source
2. Fats act as carriers and storage of fat-soluble vitamins
3. Fats are important for maintenance of the skin and coat
4. Steroids, hormones and cholesterol are also fats
5. Insulation of organs
6. Improves palatability
7. Reduce dustiness of feed especially cassava and sweet potato based diets
8. keeping the body temperature under control
9. storage or reserve food energy in the body and egg of animal
10. sparing agent in protein metabolism

3.2 VITAMINS

In the tropics, the lush vegetation is full of fruits, leafy vegetables, insects and meat animal that provides source of all vitamins. A varied balanced diet will supply all

the necessary vitamins however, in complete absence of a vitamin, clinical conditions known as deficiency diseases develop with fatal consequences. Animals obtain vitamins through feed they consume, additional supplements of salt lick, microbial synthesis or through maternal transfer As animal welfare becomes a more important issue with animal protein buyers, the inclusion of necessary vitamin supplements in animal feed should be more important for farmers looking to maximize their animal production. Vitamins are a group of complex organic compounds which are generally required in the diet in rather small amounts for normal growth and maintenance of health. In contrast to other nutrients, vitamins are not used for structural or energy requirements or as raw materials for synthesizing other compounds.

Vitamins are of two types – fat soluble and water soluble

3.2.1 Fat soluble vitamins:

	Names	**Function(s)**	**Deficiency Symptom(s)**	**Source(s)**
I.	Vitamin A (Retinol)	Normal vision Epithelium formation	Night blindness Keratinisation Retard growth	Provitamins in green leafy vegetables Milk, fat, liver, carrot
II.	Vitamin D (Cholecalciferol)	Absorption of minerals Ca, P and phosphatase levels Bone formation Efficiency of feed utilization, Reproduction	Rickets Irregular teeth	Dry forage, Fish oils
III.	Vitamin E (Tocopherol)	Normal reproduction and lactation Antioxidant	Low fertility	Egg yolk, germ oils, oils from oilseeds
IV.	Vitamin K (Phylloquinone)	Formation of prothrombin	Failure of blood to clot	Green leafy material, liver Eggs, fish meal

3.2.2 Water soluble vitamins

	Names	**Function(s)**	**Deficiency Symptom(s)**	**Source(s)**
I.	Thiamine (B1)	Carbohydrate metabolism	Beriberi Anorexia, paralysis, convulsions, impaired gastric secretions	Yeast, cereals Plant proteins
II.	Riboflavin (B2)	Electron transport system Energy metabolism	Watery eyes “blood shot” Fatty liver Low hatchability	Yeast, green leaves Milk products Eggs

III.	Niacin	Electron transport chain	"Black tongue" Pellagra Nervous symptoms	Yeast, distillers soluble, rice Wheat bran
IV.	Pyridoxine (B6)	Amino acid metabolism	Improper heart function Microcytic anaemia Convulsion	Yeast, cereals Animal tissue
V.	Pantothenic acid	Carbohydrate Lipid metabolism	Intestinal disturbances Convulsions	Yeast, liver
VI.	Cobalamin (B12)	Amino acid synthesis Protein and nucleic acid synthesis	General weakness	Animal tissue
VII.	Folic acid	Transfer of single carbon units Synthesis of choline & N2-bases	Anemia	Groundnuts Liver, leafy vegetables
VIII.	Biotin	Fatty acid synthesis Carbohydrate metabolism	General weakness	Yeast, distillers soluble, liver
IX.	Choline	Formation of acetylcholine	Fatty livers	Plant protein, wheat Animal tissue
X.	Vitamin C	Formation of tissues Wound healing	Bleeding and swollen gums Scurvy	Fruits and vegetables Liver Green peas

Generally, vitamins are important in regulating body processes and keeping the animal healthy.

3.3 MINERALS

These are inorganic elements useful to the body in many ways. Minerals regulate body processes, can be used for growth and replacement of tissue. Like proteins, the body cannot make minerals hence, minerals must be supplied by our feed

They yield no energy but have important roles to play in many activities in the body.

The total mineral content of plants or animals is called ash.

3.3.1 Classification of minerals

I. Major minerals

These are minerals required in large quantities in the diet these include Calcium, Phosphorus, Sodium, Chloride, Potassium and Magnesium.

II. Trace/micro minerals

These are minerals required in small amount, examples are Iron, copper, cobalt, manganese, iodine, zinc selenium Sulphur and Fluorine.

The Functions, Deficiency Symptoms and Source of minerals are shown in the table below

	Names	**Function(s)**	**Deficiency Symptom(s)**	**Source(s)**
I.	Calcium	Ossification of bones and teeth Muscle tone Coagulation of blood Selective cell permeability	Rickets Osteomalacia Enlarged parathyroid	Bones Milk Animal products
II.	Phosphorus	Ossification of bones and teeth Fat and CHO metabolism Nucleic acid metabolism	Rickets Osteomalacia Retarded growth	Animal products Plant material
III.	Sodium	Osmotic regulation Electrolyte and water balance Nerve and muscle action	Muscular cramps General weakness Vascular collapse	Common salt Animal products
IV.	Chlorine	Maintains osmotic concentrations Transport of CO2 Solubility of proteins Activates salivary amylases	Alkalosis Hyperexcitability	Animal products Common salts
V.	Potassium	Osmotic regulation Enzyme reactions Electrolyte and H2O balance Nerve and muscle action	Slow growth Muscular weakness Herpetrophy of the adrenals	Most ingredients
VI.	Magnesium	Ossification of bone and teeth Enzyme activator Decrease tissue irritability,	Nervousness Twitching	Oilseed meals Cereals Bones
VII.	Sulphur	Component of some amino acids and vitamin Component of cartilage Synthesis	Reduced thiamine synthesis Retarded growth	Most ingredients
VIII.	Iodine	Thyroxine synthesis	Goitre, Stillborn births Cretinisms	Sea food Iodized salts
IX.	Iron	Component of Hb and Myglobin Component of cytochrome and Xanthine oxidase	Anaemia Reduced growth Difficult breathing	Meat Green vegetables
X.	Copper	Increase iron absorption Formation of erythrocytes Component	Anaemia De-pigmentation Impaired bone formation	Plant materials

		of enzymes	Impaired reproduction	
XI.	Cobalt	Synthesis of Vitamin B12 Activator of peptidases	Emaciation Macrocytic anaemia	Plant materials
XII.	Manganese	Bone formation Functioning of reproductive system	Defective ovulation Testicular degeneration	Grains and roughage
XIII.	Zinc	Co-factor of enzymes Bone and feathers RNA synthesis	Lesions on epithelium Atrophy of male reproductive organs	Animal products
XIV.	Selenium	Component of enzyme Glutathione peroxidase	Degeneration of pancreas Muscular dystrophy	Plant materials, fish and egg
XV.	Fluorine	Prevent dental caries	Enamel density reduction	Drinking water

3.4 WATER

Water is an important constituent of all forms of life. Its wide distribution within feeds and feedstuffs coupled with its effect on feed quality makes the study of water a significant part of animal nutrition. Water comprises 65-70% of body weight of an animal at birth and 40-50% of body weight at slaughter. The animal blood is made up of 90-95% water.

Moisture refers to the absolute amount of water present in a feed while water activity has to do with the form in which the water exists in the feed such as free or chemically bound water. Moisture is the amount of water present in a feed as component, relative to all the other solid constituents such as proteins, carbohydrates, oils and non-water liquids.

3.4.1 Types of water in feed

1. Free water is lightly entrapped and therefore easily pressed from feed matter/feed; the water can be seen and felt. Free water acts as a dispersing agent and solvent and can be removed by drying foods.
2. Adsorbed water or structural water is a second type of water, which associates in layers via intermolecular hydrogen bonds around hydrophilic food molecules.
3. Bound water sometimes called the water of hydration is a third form of water in feed or food. It exists in a tight chemically bound situation, such as within a crystalline structure via water-ions or water-dipole interactions. Bound water does not exhibit the typical properties of water such as freezing at C or solvent.

3.4.2 Water Activity

Water activity is a measure of the availability of water molecules to enter into microbial, enzymatic or chemical reactions. This availability determines the shelf-life of feed/food. The bound water is inversely related to water activity, as the percentage of bound water in a food increases, the water activity decreases. At any given food/feed moisture, water activity will increase with an increase in temperature.

3.4.3 Sources of water

The main sources of water are potable water

(1) Metabolic water – is produced by metabolic processes in tissues mainly by the oxidation of nutrients, oxidation of 1g of CHO yields 0.6g of H_2O, 1g of fat yields 1.1g of H_2O and 1g of protein yields 0.4g of H_2O, metabolic H_2O is about 5-10% of the total water intake.

(2) Portable water – (stream, borehole, rain, river, bottled water, well, lake)

(3) Tropical feeds and fruits – oranges, watermelon and

(4) Leafy vegetables – water leaf

3.4.4 Functions of water

1. Water is found in all body cells and water is the most abundant of all the nutrients.
2. Water helps in moistening the alveoli in the lungs for respiration and gaseous exchange
3. Water has high specific heat and by this property it disperses heat fast
4. It regulates body temperature through sweat and consequently cools the body.
5. Water intake helps to prevent constipation in animals
6. Water is responsible for movement of minerals across cells and removal of metabolic wastes from the body.
7. It is essential for mixing of drugs for man and farm animals
8. Water supports chemical reactions like digestion, absorption, excretion and maintains shape of cells.
9. Water lubricates and cushions joints and organs in the body e.g. synovial fluid, cerebrospinal fluid.

3.4.5 Effects of water on feed/feed ingredients

1. The nutritive value and dry matter content of the feed is affected by the amount of water present in the feed.
2. High water content (above 15%) lowers nutritive value at storage and moulds may grow.

3. Water make silage making easy where 90% water content is fairly tolerated, at times water may be added to mature forage crops to ease packing which is done to exclude air.
4. Water affects silage preservation; excess water content of silage may cause loss of mineral through seepage into the surround soil of silage pit.
5. Water prevents dustiness of prepared feed/feedstuff but animals get little nutritive value when fed feeds of high water content.
6. Water dilutes concentration of energy in feeds hence feeds should be supplied to animals on dry matter basis.
7. Water as an ingredient. Water is given to farm animals and can be incorporated as component of processed food.

4.0 Conclusion

It is important to note the various feed nutrients considered in this unit as the lack of any will affect the health of the animal and thereby affect product quality.

5.0. Summary

Feed nutrients such as fats, minerals, vitamins and water are essential because the animal cannot synthesize them. Their various functions and their sources have been studied so as to know the basis of using different feeds.

6.0. Tutor Marked Assignment

- Mention two Essential fatty acids
- Highlight the importance of vitamins in animal production
- With relevant examples give the classes of minerals
- Identify the effects of water on feed ingredients

7.0. References / Further Reading

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Module 2 Classification of feeding stuff and feed supplements

Unit 1 Dry Forages and Roughages

CONTENTS

1.0 Introduction

1.0. Introduction

The term 'food' is usually used in relation to human diets while the term 'feed' is used in relation to farm animals. However, foods and foodstuffs are sometimes used for both farm animals and human beings to describe foods and feed ingredients that are sources of nutrients in the diet. The term feeds include all such material which can be used for feeding of livestock. There are various types of feed stuffs available for livestock feeding. These feed stuffs can be grouped into different classes based on bulkiness and chemical composition.

No two feeding stuffs are alike in the composition and characteristic but in practical feeding, substitution of one feeding stuff is made with another depending upon the market price and availability in a particular region. Therefore, it is necessary to know the categories of the feeds within which substitutions are justified for the feeds having similar nutritional properties. Feeds of many origins, qualities, and availabilities are used in animal diets and nutritive content varies tremendously among them. The National Research Council groups feedstuffs with others with similar characteristics. Feedstuffs within a group generally have similar nutritive values. Most feeds fall into these categories:

Classification of feedstuffs

1. dry forages and roughages
2. pasture, range plants and green forages
3. silages

4. energy feeds
5. protein supplements
6. mineral supplements
7. vitamin supplements
8. nonnutritive/feed additives

Now in this unit we shall consider dry forages and roughages.

2.0. Objectives

- Describe the various food groups that animal foodstuffs are based upon
- Enumerate the nutritional value and characteristic of forage and roughages
- Explain the importance of forages and roughages in crops animal feeds.

3.0. Main Content

3.1 Dry Forages and Roughages

Forage is a plant material (mainly plant leaves and stems) other than separated grain, produced to be grazed or harvested for use as feed for animals. While the term forage has a broad definition, the term forage crop is used to define crops, annual or biennial, which are grown to be utilized by grazing or harvesting as a whole crop. The term forage could also be defined as herbaceous plants or plant parts fed to domestic animals. On the farm, roughage is normally considered to be material making up fodder such as hay, silage; pastures, etc. The distinguishing characteristic of roughage is usually a high fiber content. Roughages are plant based feedstuff with a high fiber content forages. Sometimes roughages and forages are used interchangeable. Roughages comprise over 50% of all feedstuffs fed to livestock animals.

3.1.1 Characteristics of dry forages and roughages

Dry forages and roughages

- are high in cellulose, hemicellulose, and possibly lignin
- are low in readily digested carbohydrates such as starch and sugars.
- Fibrous carbohydrates are associated with the structural components of plants
- Roughages may also contain relatively high amounts of lignin. Lignin content increases with plant maturity.
- in a nutrition analysis, the fiber components of roughages may be expressed as crude fiber, acid detergent fiber (ADF), and/or neutral detergent fiber (NDF). Crude fiber contains cellulose and a portion of the lignin. ADF

contains cellulose and lignin. neutral detergent fiber (NDF) contains hemicellulose, cellulose, and lignin.

- The nonfibrous carbohydrate content is comprised of simple sugars (i.e. fructose, glucose, and sucrose), starches, and/or fructosans.
- Generally, the digestible energy contents of roughages are low. Feeds placed in this category contain at least 18% crude fiber, with values ranging up to 50% crude fiber.
- The protein component in forages comprise of both true protein and nonprotein nitrogen compounds. Protein content varies from nearly 30% for alfalfa to 2-3% for some straws for example young, well-fertilized wheat pasture can have high crude protein and be very digestible while late season prairie hay is the opposite.

As a rule of thumb, legumes and grasses have about the same energy content, but legumes have much higher protein, calcium, and carotene contents. Grasses, even when dormant, are fair to good sources of energy for ruminant animals, but other nutrients, especially crude protein and carotene, are likely deficient when plants are dormant. New foliage is always more digestible than more mature foliage

Legumes have a higher calcium and magnesium contents compared to grasses. Roughages are also a good source of the B-complex vitamins and fat-soluble vitamins.

- Roughages may contain one or more antinutritional factors such as alkaloids, cyanogenic glycosides, toxic amino acids, and/or mycotoxins.
- The moisture content is usually between 50-85% but can be quite variable. A forage is generally considered to be of higher quality than a roughage.

It is common to divide forages and roughages into legumes (e.g., alfalfa, lespedeza, soybeans, and clovers) and grasses (e.g., prairie grasses, timothy, Bermuda grass, and wheat). Grasses are plants with jointed stems. The stems are normally hollow between the joints (node). Leaves are in two rows on the stem. Veins in the leaves are parallel. About 75% of forage consumed in the tropics is grass. Legumes are generally better quality feed than grasses because the former has a lower stem and higher leaf content. The mineral content of roughages is influenced by roughage and mineral content of the soil.

- Generally, roughages are higher in calcium, potassium, and microminerals and moderate to low in phosphorus when compared to concentrates. In addition to grasses and legumes many other kinds of plants are at times valuable. Although seldom cultivated, they may be parts of the unimproved pasture and be convenient to use under some circumstances.

3.1.2 Miscellaneous group of roughages and forages

This group includes annual herbs (forbs) and woody shrubs and trees (browse).

1. Forbs are broad-leaved plants with aboveground growth that dies back each year. Most forbs have net veins in the leaves, but a few have parallel veins. Broadleaf weeds and wild flowers are examples of forbs.
2. Grass-like plants look like grasses but have solid, though not hollow, stems without joints. Stems may be triangular. Veins in the leaves are parallel for example sedges and rushes.
3. Browse Leaf and twig growth of shrubs, woody vines, trees, cacti, and other non-herbaceous vegetation available for animal consumption. Trees and shrubs are plants with persistent woody stems that live from one year to the next. Shrubs have stems that branch from near the base, while trees have a definite trunk and are usually bigger than shrubs. Some plants can take on a shrub or tree growth form, depending on environmental conditions.

The season of scarcity in the tropics is governed by rainfall, not temperature; the length of the dry season varies with latitude and site, from a few months to over half the year, but even when there is adequate moisture late in the season, especially in high-rainfall areas, the mature herbage may be almost worthless as animal feed and only selective grazing, and fire to "freshen" the grass, may assure survival of the stock.

Hay made from natural grassland in the tropics is, unfortunately, much less likely to give satisfactory results than that from other zones; bush hay is usually made late in the rains because of the difficulty of drying at other times and is no better than straw or stover. This, along with a relatively low stock density in the past, may be why there is little if any tradition of haymaking in the humid and sub-humid tropics. Hay from sown crops can be made on mechanized farms under tropical conditions, but its quality will be governed by the genetic limits of tropical grasses, except at high altitudes, where exotics can be grown.

Discussing herbage quality from tropical pastures - at all stages, not just over-mature - Butterworth (1967; 1985) indicates that the crude protein content of 235 samples was 7.5% ±3.5%, with 235 under 7% (7% is the level for zero liveweight gain.). Crude protein content decreases with maturity as the cell contents are diluted by structural components. As the crude protein content decreases, so does its digestibility. Of 473 samples, 58% were below the needs for growth of beef cattle. The average total digestible nutrients (TDN) of 312 samples was 54.0 ±7.9%, with 43.5% below the 55% level recommended by the Agricultural Research Council (ARC) for grazing cattle; in tropical pastures, TDN is less likely to be limiting than is crude protein.

3.1.3 Vegetation terms /definitions

1. Forage: Edible parts of plants, other than separated grain, that can provide feed for grazing animals, or that can be harvested for feeding. Includes browse, herbage, and mast. Forage could be

Carbonaceous (low protein) - Fresh Grama grass, fresh Wheatgrass etc.
Proteinaceous (high protein) - Fresh & early vegetative Wheatgrass, etc.
Grazed parts (growing & dormant), greenchop, food crop residues, etc.

2. Herbage: The biomass of herbaceous plants, other than separated grain, generally above ground but including edible roots and tubers.
3. Forb: Any herbaceous broadleaf plant that is not a grass and is not grass-like.
4. Legume: Members of the plant family Fabaceae.
5. Grass: Members of the plant family Poaceae.
6. Grass-like plants: are plants similar to grass in appearance and is usually a member of the plant family Cyperaceae (sedges) or Juncaceae (rushes).
7. Mast :Fruits and seeds of shrubs, woody vines, trees, cacti, and other non-herbaceous vegetation available for animal consumption.

3.2 Pasture

Pasture is a field or land planted with grass or similar plants suitable for animals to eat. Pasture it could also be defined as an area enclosed for growing forage and allowing animals, such as cattle, sheep, or goats, to graze. Pastures can support a wide range of plant species, offering varying degrees of nutrition for the grazers, stability for the pasture in terms of soil health, and habitat for wildlife**.**

3.3 Range plants

The EPA defines rangelands as "those lands on which the native vegetation (climax or natural potential plant community) is predominantly grasses, grass-like plants, forbs, or shrubs suitable for grazing or browsing use. Rangelands include natural grassland, savannas, many wetlands, some deserts, tundra, and certain forb and shrub communities." Rangeland is less intensively managed than pastures, typically supports more native species, can be open (not enclosed by fencing) and can be grazed by wildlife or livestock

3.4 Fodder

Fodder is a type of animal feed, it is any agricultural foodstuff used specifically to feed domesticated livestock, such as cattle, rabbits, sheep, horses, chickens and pigs. "Fodder" refers particularly to food given to the animals (including plants cut and carried to them), rather than that which they forage for themselves (called forage). Fodder can be also called provender and includes hay, straw, silage,

compressed and pelleted feeds, oils and mixed rations, and sprouted grains and legumes (such as bean sprouts, fresh malt, or spent malt).
In many cases the production of grass for cattle fodder is a valuable intercrop between crops for human consumption, because it builds the organic matter in the soil.

3.5 Function of roughages

1. Feeds in these categories provide the bulk of the diets of herbivorous species (ruminants and cecal fermenters).
2. Roughages also function to maintain and optimize the efficiency of the GI tract for selected species.
3. For selected species, fibrous carbohydrates function to maintain structure, activity, and microbial population of the GI tract, essential for optimal function of the GI tract.
4. Roughages are a link to the efficient utilization of earth's resources.
5. Roughages alone are of minimal value to humans. However, roughages consumed by selected species provide a means for conversion of relatively low-quality raw materials to relatively high-quality products such as food and fiber that may be used to fulfill human needs.

3.6 Types of roughages

Roughages may be fed either in a fresh, dried, or ensiled state.

- grazed roughages (e.g. pasture and range),
- preserved roughages (e.g. hay and silage)
- crop residues and by-products (e.g. groundnut husk, maize cob, cowpea haulms and cowpea husk).
- and hulls

Roughages are further classified into two major group as:

1) Green / succulent roughages – They contain about 60-90 percent moisture examples are pastures, cultivated fodders, tree leaves, root crops and silages.
2) Dry roughages – They contain about 10-15 percent moisture e.g. Straw, Hay and kadbi.

3.7 Factors affecting utilization of roughages

In addition to other factors such as plant species, the nutritional value of roughages depends on the proportion of cell contents to cell wall components and on the extent of cell wall lignification. Most roughages can be effectively incorporated into at least one type of ration. Effective use of a roughage requires matching nutrient requirements of an animal with the nutritional value of a roughage.

Effective use of a roughage also requires appropriate processing and supplementation.
As stated earlier, in ruminants, enzymes from rumen microorganisms are required for the digestion of roughages. As the population of rumen microorganisms is dep3.7endent upon the feedstuffs consumed, the composition of the diet influences the extent and rate of digestion of roughages. Feeding of high-energy feedstuffs has a negative associative effect on the degree of utilization of a roughage. As with other feedstuffs, addition of roughages to rations is dependent on the GI tract. As roughages are high in fibrous carbohydrates and microbial enzymes are required for digestion of fibrous carbohydrates, utilization efficiency of roughages is dependent on the site and extent of microbial fermentation in the GI tract. Roughages are primarily added to the rations of herbivores. For monogastric animals such as swine and poultry, the low utilization efficiency limits the use of roughages in rations. Roughages can be added to the ration of swine with low nutrient requirements.

3.8 Characteristics of good-quality forage

- being relatively immature when harvested;
- being green and leafy;
- having soft, pliable stems;
- being free from molds or mustiness;
- being palatable;
- and being free from foreign material

3.9 Factors affecting the nutritive content of forages and roughages

- maturity at the time of harvesting,
- weather damage,
- soil fertility,
- plant species,
- and harvesting method.

Maturity at the time of harvesting is perhaps the most important factor because all nutrients, except fiber (which increases), decrease with maturity. The digestibility and palatability of a forage decreases with advancing maturity and increasing fiber level. The rate of change is much greater for some plants than for others. The effects of maturity are more pronounced for grasses than for legumes.

3.10 Examples of dry forages and roughages

legume hay,
grass hays,
wheat straw,
cornstalks,
corncobs,
cottonseed hulls,
peanut hulls,
and rice hulls.
Pasture, range plants, and green forages
Bermuda grass pasture,
sorghum-sudan grass,
tall-grass prairie species,
wheat pasture.

Other feeds, such as sugar beet pulp, brewers' grains, and pineapple bran, are by-products that remain after a food crop has been processed for human use. Surplus food crops, such as wheat, other cereals, fruits, vegetables, and roots, may also be fed to animals.

Table 7–2
SELECTED NUTRIENT ANALYSIS OF SOME FORAGES AND ROUGHAGES

Feedstuff	As Fed (% DM)	TDN (%)	NE_m (Mcal/lb)	NE_g (Mcal/lb)	CP (%)	EE (%)	CF (%)	ADF (%)	Ash (%)	Ca (%)	P (%)	K (%)	Mg (%)
Alfalfa, hay	90.6	60.0	1.31	0.74	18.6	2.39	26.1	33.8	8.57	1.4	0.28	2.43	0.28
Bermuda grass, fresh	30.3	64.0	1.44	0.86	12.6	3.70	28.4	36.8	8.1	0.49	0.27	1.7	0.17
Citrus pulp, silage	21.0	78.0	0.86	0.57	7.3	9.7	15.6	25	5.5	2.04	0.15	0.62	0.16
Corncobs, ground	90.0	50.0	0.44	0.19	3.2	0.7	36.2	35	1.7	0.12	0.04	0.87	0.07
Orchard grass, fresh, early bloom	23.5	68.0	1.57	0.97	12.8	3.70	32.0	30.7	8.1	0.25	0.39	3.38	0.31
Potato silage	25.0	82.0	0.91	0.61	7.6	0.4	4.0	5	5.5	0.04	0.23	2.13	0.14
Rice hulls	92.0	12.0	0.00	0.00	3.3	0.8	42.9	72	20.6	0.10	0.08	0.57	0.83
Sorghum silage, 30% DM	30.0	60.0	0.60	0.34	7.5	3.0	27.9	38	8.7	0.35	0.21	1.37	0.29
Wheat straw	89.0	44.0	0.34	0.10	3.6	1.8	41.6	54	7.8	0.18	0.05	1.42	0.12

Source: Bath et al., 1997; NRC, 1996
TDN = total digestible nutrients
NE_m = net energy for maintenance
NE_g = net energy for gain
CP = crude protein
EE = ether extract
CF = crude fiber
ADF = acid detergent fiber
Ca = calcium
P = phosphorous
K = potassium
Mg = magnesium

Source: Damron 2013

3.11 Silages

Silage refers to the feed preserved by an anaerobic fermentation process (e.g., corn silage, haylage, high moisture corn) in which lactic acid and volatile fatty acids (produced by fermentation) lower the pH of the silage. The low pH preserves the silage by killing off bacteria, molds, and other destructive organisms. One common misconception is that ensiling improves the nutritive content of a feed. Fermentation uses nutrients and thus reduces nutritive content of the material. Silage additives refer to the substances added during the ensiling process to enhance production of lactic acid and/or a rapid decrease in pH of the feed.

The nutritive value of grass silage depends upon the composition of the original material and the losses incurred during the process of ensiling. Such losses occur from initial respiration, fermentation and seepage at the top and sides of the silo. All of these losses may be considerable unless the silage is well made. For a well-made grass silage, the loss of original dry matter and TDN (total digestible nutrients) is approximately 25%. A poor-quality silage frequently results from under-consolidation. This occurs when the ensiled material consists of very young, wet, high protein grass which has a low content of fermentable carbohydrate. When the silage mass is under-consolidated, over-heating occurs which leads to excessive destruction of carbohydrates and a marked reduction in the digestibility of the proteins. Hence, over-heated silages have a low nutritive value, but are very palatable. The other type of poor-quality silage also made from young high-moisture grass occurs when the fermentation and acidification rate is very slow. This happens when there is not enough fermentable carbohydrate in the ensiled material. Butyric acid-forming organisms increase rapidly, very little heat is produced and considerable breaking down of proteins to ammonia occurs. The result is very unpalatable silage with an unpleasant smell, and a lowered feed value because of protein losses.

4.0. Conclusion

In this unit we have seen that forages and roughages provide inexpensive feed ingredients for animals and available.

5.0 Summary

The nutritional value, function and types of roughages and forages have been explained.

6.0 Tutor Marked Assignment

- Describe the various food groups that animal foodstuffs are based upon
- Enumerate the nutritional value and characteristic of forage and roughages
- List three examples of forage and roughages

7.0. References / Further Reading

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Unit 2 Energy Feeds

CONTENTS

1.0. Introduction

Energy Feeds are also called Basal feeds, they are concentrated sources of energy and are especially rich in starches and sugars. Energy feeds make up 60 - 90% of all rations. Energy feeds consists of feed ingredients that contain less than 20% of protein in dry state, less than 18% crude fiber and more than 60 percent TDN. They are less bulky and have higher digestibility. They are concentrated source of nutrients and therefore, they have higher nutritive value than roughages. Energy feeds primarily include the cereal grains, by-product feeds made from cereal grains, fruits, nuts, starchy roots, fats and oils, sugars and syrups, bakery products, barley, corn, molasses (dried), oats, oat groats, sorghum, wheat and wheat bran etc. These are fed to ruminants and cecal fermenters to increase the energy density of their diets, and to monogastrics as the primary source of energy. The cereal grains are very low in crude fiber, with a range of being about 2-10%. The lower the fiber levels, the higher the energy content tends to be. The energy values of grains is

high, with the TDN as high as 90% on a dry-matter basis. These values are high because of the high starch content, low fiber content and high digestibility. The protein digestibility ranges from 50-80%, but the protein quality is generally poor because the essential amino acid content of grains is poor.

2.0. Objectives

- List the important sources of energy feedstuff
- Mention the nutritional characteristic of energy feedstuff
- Describe various energy feedstuff

3.0. Main Content

3.1 Categories of energy feedstuff

- Roots and tubers.
- Cereal grains and by-products

3.2 Starchy roots and tubers

Starchy roots (i.e. tubers and roots crops) most widely cultivated in tropical and sub-tropical part of the world are cassava, yams, cocoyam's and sweet potatoes in that order roots are also eaten in small quantities in some tropical countries. In temperate countries, the most widely cultivated root crop is irish potato. Irish potatos are also grown in some tropical areas. Starchy roots contain large quantities of starch and so are high in energy per hectare than most cereals. They are however, generally low in protein (1 – 4%) minerals and vitamins. Starchy roots form the major part of the diet of man in many parts of the world. They are sometimes used in feeding of farm animals for example cassava and its products like gari, cassava flour or fermented cassava meal may be used to replace a large proportion or all of the grains in poultry and pig diets. In using cassava, care must be taken to balance the diets for protein and amino acids, especially methionine. Starch and root crops are relatively easy to grow with high yield even on poor soils. They contain large quantities of starch and so are good energy source.

1. Cassava

Types of cassava

- Manihot utilisima
- Manihot esculentus
- Manihot palmate

It is a very popular tropical plants use in feeding man and all classes of livestock.

It is easy to propagate from stem cutting and is one of the most productive root crops in the tropical areas. Its yield is between 10 and 20 tons per hectare. It is available all the year round. Cassava contains between 50 and 70 % water. It is low in protein (1 – 3 %), oil, ash and crude fibre (up to 5% CP can be obtained from some of the new variety). The protein content of cassava tuber is deficient in lysine, methionine, tryptophan, tyrosine and phenylalanine but high in arginine. It is low in minerals and most vitamins but high in energy content. The peels of cassava are richer in protein, oil and ash than the peeled portion. On a dry basis, cassava leaves have protein content that range between 14 and 69% DM. It is fair in lysine content marginal in tryptophan and isoleucine but deficient in methionine. Cassava is able to serve as substitute to maize in livestock feeds at levels between 5 and 50 %, well processed cassava leaves and peels are widely fed to cattle, sheep and goats.

Limitations

Both the bitter and sweet varieties contain cyanide. The content of cyanide in fresh tuber of bitter varieties contain less than 100mg/kg. The peels contain 3 – 10 times more cyanide than edible portion. Levels of cyanide less than 50mg/kg are considered harmless, 50 – 80mg/kg slightly poisonous, 80 – 100mg/kg toxic and above 100mg/kg fatal.

Symptoms of eating raw or improperly processed cassava

Symptoms of eating raw or improperly processed cassava in man include feeling of sickness, nausea, vomiting, abdominal distention, respiratory difficulty and collapse. Over a long period of consumption, raw cassava may cause goitre, deformed and mental defective cretinism, ataxia, neuropathy with mental retardation.

Detoxification

Cyanide is detoxified into thiocyanide and thus involves the use of sulphur. Some of these sulphur are obtained from sulphur containing amino acid. Cyanide also interfere with thyroid gland and therefore interfere with iodine metabolism. However, much of the cyanide is removed during processing of cassava. The processing method include cooking, frying, boiling, washing, grating, soaking, fermentation and sun drying and long period of storage. Properly processed cassava products are virtually free of HCN (hydrogen cyanide). High levels of cassava in feed make the feed to become dusty, hence molasses and oil may be added to reduce the level of dustiness. The leaves and peels of cassava are widely fed to cattle, sheep and goats, although with fatal consequences sometimes.

2. Yam

Types of yam

- Water yam - Dioscorea alata
- Aerial yam - Dioscorea bulbifera
- Yellow yam- Dioscorea cayeneusis
- Tritollate yam -Dioscorea dumetorium
- Chinese yam - Dioscorea esculenta
- White yam - Dioscorea rotundata

Yam is high in water content, high in soluble carbohydrate, low in crude protein (1-4%), low in fibre and fair in ash. The protein content is low in lysine, methionine, tryptophan but contain appreciable amount of valin, arginine and isoleucine. It also contains moderate amount of vitamin B complex and minerals. Yam peels are valuable as livestock feed especially in ruminant animals.

Limitation

The major limitation in the use of yam as livestock feed is the content of its major antinutritional factor (alkaloid) which can reduce the level of intake with time. It also has an itching effect on the palate. Some varieties contain tannin up to 0.4% and saponin. However, most of these antinutritional factors are destroyed during cooking and drying.

3. Cocoyam

Types of cocoyam

- Taro cocoyam, Colocasia esculenta
- Tannia cocoyam, Xanthosoma sagittfolium

Cocoyam can be fed to livestock however, cocoyam should be cooked before being fed to livestock particularly pigs since the acid (Ca – oxalate) or sap toxin contained in the corm (swollen underground stem) is irritating to the digestive tract and may even be poisonous. The pods and leaves of cocoyam are valuable feed for ruminants (cattle sheep and goats). Cocoyam are edible aroids. The big central corm is surrounded by smaller ones called cormels. The cormels are the commonly used as human food. Cocoyams are high in water and carbohydrate contents. The starch of coco yam contains predominantly amylase and small amount of amylopectin. It is low in fat (less than 0.5%) and protein content. Proteins of cocoyam have fair amount of the essential amino acids but are low in lysine and histidine. The peels are richer in oils than the inner content tuber. The leaves have higher nutrient content than the corms.

Limitations

Cocoyams are irritating to the body because of the presence of calcium oxalate in them. However, when boiled or roasted, the irritation disappears. The corms of cocoyam contain gastrogenic substance.

4. Sweet Potato

Sweet patato (Ipomoea batatas) comes in different varieties, it could be yellow or red colour.

It is cultivated in both tropical and temperate areas. Fresh potatoes contain 70-80% of water. It is low in crude fibre, fat and protein. However, the protein content have high biological value and it is rich in essential amino acid. On dry basis over 90% of sweet potatoes tuber is made up of carbohydrate. The carbohydrate is highly digestible when cooked but low when raw. Much of the starch in sweet potatoes is converted to maltose during cooking (i.e. heat, enzymatic hydrolysis and starch) and this is responsible for the sweet taste in cooked sweet potatoes.

Potato tuber is rich in carotene and ascorbic acid (especially yellow varieties) and B-vitamin. However, storage and cooking reduce the content of vitamins. It has fair amount of ash and minerals e.g. phosphorus, calcium sodium, chloride and potassium. Its leaves are rich in protein, minerals and vitamins.

Sweet potatoes are good for all classes of live stocks. The leaves and vines of potato are useful feed for ruminants. Sweet potato has been used in diets of pigs and can be used in poultry diets along with suitable protein supplements. The leaves and vines of potato are useful feed items for cattle.

Cooked Irish Cooked Irish potato can be used effectively in the diets of pigs.

3.3 Sugars and Syrups

Sugars

Sugars are cheap and easily digested forms of energy. Sugars are obtained from sugar cane and sugar beet. After extraction, the crude sugar is refined and made into cubes (crystalline sugar).

Raw sugar, obtained from chewing the cane directly, contain small amounts of protein, minerals and vitamins. Refined sugars are however essentially carbohydrates and lack every other nutrient. All white sugars i.e. crystalline table sugar, cube sugar, icing are practically 100% sucrose and are free of any toxic factors. Brown sugar is less highly refined sucrose and contains traces of other sugars, minerals and colouring matter.

Syrups

Syrups are highly concentrated solutions in which the sugar unable to crystallize out because of the presence of small qualities of other substances. Some syrups,

such as molasses and golden syrup are by-products of the manufacture of crystallize cane sugar. There syrups contain some amounts of protein (0.3%), Ca (0.03%) and Fe (1.5 mg/100g). They are devoid of any other ingredients.

Molasses

Molasses are mainly by-products of the manufacture of sugar from either sugar cane or sugar beets. Their sugar content is about 50-60% and water content is between 22% (beet molasses) and 27% (cane molasses). Beet molasses is higher in crude protein (7-11%) than cane molasses (3-4%). Molasses have a mineral content of 8-10% composed mainly of sodium(Na) and potassium (K) salts. The Calcium and Phosphorus content are 0.10 and 0.02% respectively (for beet molasses) and 0.8 and 0.8% (for cane molasses). The thiamine and riboflavin contents are each 0.05 mg/100g while the mean content is about 1.5 mg/100g. The iron (Fe) content is between 0.01 and 0.02%. The use of molasses in poultry diets is limited by its laxative effects when used at high levels. Any level above 5% is laxative. Molasses may be used to prevent dustiness in mixed feeds and in the treatment of poultry blue comb diseases because of its sugar content. Molasses can be used at a rate of 3-5% in the diet of sows to help prevent constipation and enhance feed intake. It is also used to ensile forage during silage production for ruminant animals. The difficulties in obtaining the product limit the use of molasses in animal diets.

Molasses is increasingly being used by human beings. It is sometimes used in place of honey.

Honey

Honey is made by bees. Most honeys (glucose and fructose) are known as the invert sugars. Honey also contains some protein (0.4%), minute traces of Calcium (0.005%), and small amounts of iron (0.4 mg/100g). Honey also contains thiamine 0.05 mg/100g, riboflavin 0.05 mg/100g and niacin 0.2 mg/100g. Honey is an attractive, pleasant and sweet food.

Jams

Jams are prepared by boiling fresh fruit, or a pulp preserved with Sulphur di-oxide (sulphite pulp), with sugar. Depending on the antinutritional factors present in the raw materials, pectin may or may not be added. Jam is a general name for all such products. Marmalade is synonymous to Jam in some parts of the world. Most jams contain about 65-70% sugar, 0.5% protein. It also has Calcium (0.02 – 0.04%), iron (1.2 mg), Vitamin A (2-10 mg/100g) and Vitamin C 10-45 mg/100g. Jams are pleasant, attractive and sweet foods.

3.4 Fats and oils

The term fat general, referred to a group of food or feed ingredients including animal fats, vegetable oils and related compounds. Technically, fats refer to those that are solid at room temperature for example butter, fallow and lard while oil is the term used to describe fats that exist as liquid at room temperature for example groundnut oil, corn oil, palm oil etc.

Fats and oils are concentrated sources of linoleic acid and linolenic acid (two essential fatty acids). Fats and oils may be a source of fat soluble vitamins. Most vegetable oils contain

significant amounts of vitamin E. Red palm oil is a rich source of beta carotene and hence a good source of vitamin A. corn oil contain small amounts of carotene. Fish liver oils, milk fat (butter and milk) and animal fats generally contain vitamins A, and D. Most vegetable oils do not contain vitamins A and D.

Fat commonly included in livestock feeds (for poultry and pigs) can be divided into 6 general groups

1. Animal fats:- these are rendered fats from beef or pork byproducts.
2. Blended feed grains animal fats: these may include mixtures of beef, tallow, pork lard, poultry grease and possibly restaurant grease
3. Poultry fat or grease: This is rendered fat from poultry offal.
4. Vegetable oil: these are oils derived from vegetable materials for example groundnut, soybean, palm nut etc.
5. Blended animal and vegetable fats: these may include proportions of animal and plant fats
6. Soap stocks: This is also used in the manufacture of soap: these contain products not wanted in oil meant for human consumption including free fatty acids.

The use fats and oils in poultry and pig diets would depend on their price and availability relative to other energy source. Fats should be used in diets where higher energy levels are required such as those for broiler chickens and turkey poults, weaning pigs, fast growing market hogs and lactating sows. It is not economical to add any fat at levels above 5% in poultry and all fats used in animal diet should contain an antioxidant to prevent rancidity because raw oil seeds such as groundnut and soybean may deteriorate under certain circumstances. It is wise to use artificial antioxidants for preservation.

Some artificial or synthetic antioxidants are

1. butylated hydroxyltoluence (BHT, E321),
2. butylated hydroxylanisole (BHA, E320),
3. ethoxyquin,

4. propyl galate and octylgallate.

4.0 Conclusion
Energy feedstuff forms bulk of the feed ingredient in the feed of high producing animals. They are the main source of energy for monogastric animals.
5.0 Summary
In this unit we have seen energy feed stuff contain high total digestible nutrients (TDN) and are crucial in animal production.
6.0 Tutor Marked Assignment

- Mention three categories of energy feed
- Enumerate three energy feed
- Highlight the characteristics of energy feed that make them indispensable in animal feeds

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Unit 3 Protein Supplements

CONTENTS

1.0. Introduction

A supplement feed or feed mixture is used to improve the nutritional value of the ration complementing the nutrients in the base feed. A supplement is rich in one or

more of protein, energy, vitamins or minerals, and, in combination with the base feeds, produces a more complete feed. Feed supplements are added to the main feed to supply one or more nutrients which might be lacking in the main feed. A mixed protein supplement is, by convention, a mixture of feeds which carries 30% or more of protein. Single feeds containing 20% or more of protein are included in this group.

2.0. Objectives

- Define supplement
- Explain nutritional characteristics of protein supplement
- Mention examples of protein supplement

3.0. Main Content

3.1 Protein Supplements

Protein supplements are generally expensive feeds. Feeds placed in this category contain more than 20% crude protein; some have high energy contents as well such as oil meals.

Protein supplements include feed from three major sources.

3.2 Major Sources of Protein

1. animal origin (fish meal, dried skim milk and tankage),
2. plant origin (soybean meal, cottonseed meal, and corn gluten meal)
3. nonprotein nitrogen (NPN) sources (e.g., urea, purified amino acids, and ammonium salts).

Animal Protein

1. In general, animal-based protein feedstuffs are excellent sources of protein. In comparison to plant-based protein feedstuffs, the amino acid profiles of the animal-based protein feedstuffs more closely match the amino acid profiles required by the animal. One potential issue with animal-based protein feedstuffs is quality. Protein quality will vary by source and also by processing method. The cost is also greater for animal-based protein feedstuffs compared to plant-based protein feedstuffs. In the future, the use of animal-based proteins may decline as a result of quality issues, cost, the availability of synthetic amino acids and vitamins once only available via animal-based protein feeds, and the improved protein quality of plant-based protein feedstuffs. The protein feeds of animal origin are primarily derived as end products of the meat packing, dairy processing, and marine industries. The most important of these are meat meal, bonemeal, blood meal, feather

meal, dried milk, and fish meal. The milk products are the highest quality of the end products and generally the most expensive

Plant Protein

2. The protein feeds of plant origin are primarily derived as products of the extraction of the oil from a group of seeds referred to as oilseeds because of their high fat content. These protein sources are thus referred to as oilseed meals. The most important of these sources are soybeans and cottonseed. The protein content is generally at least 40% and highly digestible and protein quality is usually good.

Nonprotein Nitrogen (NPN)

3. The NPN sources generally refer to urea and other similar products. Urea and similar products must be used with functional ruminants only—and then, very carefully. Because ruminants can convert the poorer quality proteins to higher quality microbial protein, an effective cost-reduction strategy is to feed the NPN sources and avoid the higher quality, and thus more expensive protein supplements.

3.4 Some common protein supplements

include:

1. blood meal,
2. brewers dried grain,
3. canola meal,
4. casein (dried),
5. cottonseed meal,
6. feather meal,
7. fish meal,
8. meat and bonemeal,
9. milk, whole dried;
10. soybean meal

Animal Protein Source

Fishmeal

Fishmeal is made from dried ground, whole fish, or fish cuts, offals with or without oil extraction. There are various brands of fish meal but the commonest are those with high oil including herring, menhaden, salmon and low white fish. It is a very common animal protein feed ingredient in use. It is a byproduct of fish industry. It is usually made from whole fish. However, fish offals of high quality could also be used. Local fish meal is lower in its protein content than the imported fish meal.

Crude protein content of fish meal may vary from 55 and 77% depending on the fish type use and extent of oil extraction. Calcium (3-6%) and phosphorus (1.5 – 3%) contents and micro mineral content is high (3-6% and 1.5 – 3%) respectively. Fish meal is low in fat soluble vitamin because they are extracted along with the oil. It is however, high in vitamin B complex vitamins especially vitamin B12. Its biological value is very high and usually varies from 60-80%. It is a good source of sulphur amino acid (methionine is about 1.8%). Its lysine content is about 4.5%. Fish meal must be properly stored because of its residual oil causing rancidity.

Limitation of fish meal

1. It is usually used at a level between 0 – 5% for economic reasons.
2. High levels of inclusion may make animal go off feed.
3. Fish meal flavor may also be imparted to the carcass at higher level of inclusion.
4. Fish meal must be properly stored because of its residual oil. There is also an underlying concern over dioxin levels in fishmeals.

Blood meal

It is a slaughter's house by products. It is prepared from fresh and clean animal blood free of all extraneous materials such as stomach content, hair and urine. The water in the blood is usually removed by parboiling. It is parboiled or mechanically dewatered the resulted semi solid blood mass is rapidly dried and ground to obtain meal. It is high in protein (80-88%). It is an excellent source of lysine if properly prepared. It is also rich in leucine but is low in isoleucine, ash calcium and phosphorous. The fiber content in blood meal is low. Blood meal is also low in minerals, with the exception of iron. It can partly replace fish meal in starter diets for broiler chicks and turkey but can replace all the fish meal in broiler finisher. The Nutritional value is influenced by processing. Flash drying produces the most consistent product. The crude protein content of blood meal is 80-85% on an as-fed basis.

Limitation

1. Badly processed blood meal may expose animal to the attack of salmonella organisms or create problems of flies.
2. Its amino acid content is not well balanced. It is low in sulphur containing amino acids.
3. Its biological value is low about 19%.
4. It is not usually utilized above 5% level. Higher levels make animal go off feed.

5. Overheating reduces lysine availability of protein is less digestible.

Meat and Bone Meal

It is the rendered product from animal (especially mammals) tissues including bone. It excludes blood hair, hoof horn, hide trimmings, manure, stomach and rumen content. It contains about 50% CP and it is high in fat and ash. The protein quality is variable depending on the quality of meat and amount of extraneous material. It is a good source of lysine, calcium and phosphorous but it is deficient in methionine, cystine and tryptophan.

Limitations

1. Excessive processing temperature may reduce lysine availability.
2. Too high levels of inclusion may result in undesirably high levels of calcium and phosphorous.

Meat Meal (Meat Scrap)

It is the rendered products from animal (especially mammal) tissue. It excludes bone, blood, hair, hoof, horn, hide trimmings, manure stomach and rumen content. It is similar to meat and bone meal except that it is low in calcium and phosphorous. it is classified as meat and bone meal. It is used at about 7-10 % dietary inclusion level. Meat meal is virtually nonexistent in Nigerian as virtually all parts of the animals are consumed

Meat and Bone Meal Tankage

It is similar to meat and some meal except that it may contain blood or blood meal. Meat meal/tankage and meat and bone meal/tankage are classified based on the phosphorus content. Meals containing greater than 4.4% phosphorus are classified as meat and bone meal/tankage. Tankages are classified according to the inclusion of dried blood, The labels are required to state nutrient content including minimum crude protein, minimum crude fat, maximum crude fiber, minimum phosphorus, and minimum and maximum calcium.

The crude protein contents of the various meals and tankages range from 45-60% crude protein on an as-fed basis. The protein qualities of the various products are rated as good to excellent. the crude protein is digestible and are a good energy source because of the fat content. The products are also a good source of minerals such as calcium at 6-10% and phosphorus at 3-5%. Meat and bone products are a good source of riboflavin, niacin, and vitamin B12.

Limitations

1. Meat and bone products are relatively unpalatable.
2. Meat and bone products contain a number of antinutritional factors.
3. Meat and bone products can potentially cause a calcium and phosphorus imbalance.
4. Improper processing, including inadequate heat-sterilization, can lead to contamination of the products by microorganisms.
5. Improper processing contributed to the transfer of transmissible spongiform encephalopathies (TSE). The most publicized transfer was the transfer across species to cattle. Bovine spongiform encephalopathy (BSE), also referred to as "Mad Cow Disease

Poultry By-Product Meal

It consists of the ground, dried, rendered parts of the carcass of slaughtered poultry such as heads, feet offal, undeveloped eggs and intestine. Feathers are not included. It is an excellent source of protein (about 55% CP). It is rich in lysine, tryptophan, calcium and phosphorous. It is used at about 7-10 % dietary inclusion level. Poultry by-product meal should be used in combination with other protein sources

Feather and Hair Meals

Feather and hair are not digestible however, processing of feathers significantly improves nutritional value. Commercially available feather and hair meals are often referred to as hydrolysed feather and hair meal. This is obtained by pressure streaming undecomposed clean feathers from slaughtered poultry. Excessive heat may destroy cysteine and lysine. The crude protein content is 85-90% on an as-fed basis. Hydrolyzed poultry feathers are low in methionine, lysine, histidine, and tryptophan. Hydrolysed feather is about 75% digestible. Hydrolysed feather meal is high in cystine and threonine but deficient in lysine, methionine, histidine and tryptophan. For monogastrics, hydrolyzed poultry feathers are fed in combination with complementary protein feeds. Hydrolyzed poultry feathers are also relatively unpalatable. The amount fed to monogastric animals should be limited to 5% of the ration.

Dried Poultry Manure

Dried Poultry Manure is dried poultry excreta. Its chemical contents may vary depending on the source and age of the birds from which manure is obtained. The protein content is between 25 and 29% CP, One-third of the protein is true protein and two-thirds of the protein is nonprotein nitrogen compounds. Fat content is 1.5

– 2.5% and fibre 14 – 20%. Lysine content is 0.3 – 0.5%, methionine 0.10 and 0.15%. Dried poultry manure is used in ruminant and mongastric animal feeding.

Hatching waste
This is a mixture of egg and shells, infertile and unhatched eggs curled chicken that are cooked, dried and ground prior to use.

Rendered Animal Products. Meat and bone meal, a long-time traditional ingredient and rich source of amino acids and minerals in livestock feeds worldwide, is banned in the European Union. This is due to the bovine spongiform encephalopathy (BSE) crisis and the link to the new variant Creutzfeldt - Jakob disease (vCJD) in humans

3.4 Miscellaneous Sources of Protein

1. Insect Meals

They include larva of insects, whole insects and earthworm for example edible grasshopper Black Soldier Fly, the yellow mealworm, housefly, house cricket, defatted silkworm they can replace plant protein or parts of the fishmeal used in the diet. The crude protein of insect meal especially the larva is between 55-70% however their use in animal feed is prohibited in some countries due to safety concern.

2. Leaf Protein Concentrate

Plant protein contains fair amounts of protein. The protein can be concentrated by crushing and disintegrating the leaves or by precipitating protein concentrate from the leaf juice with the aid of heat or acid. The concentrate so formed may contain up to 60% protein. It has been examined as a human or animal food source, because it is potentially the cheapest, most abundant source of available protein

3. Single Cell Protein (SCP)

Single Cell Protein refers to bacteria, yeast, fungi and algae (edible unicellular microorganisms) A biomass containing up to 50% or more can be produced from each of these microorganisms. The biomass or protein extract from pure or mixed cultures of algae, yeasts, fungi or bacteria may be used as an ingredient or a substitute for protein-rich foods and is suitable for human consumption or as animal feeds. Industrial agriculture is marked by high land use, biodiversity destruction, general environmental degradation and contributes to climate change by emission of a third of all greenhouse gases. Production of SCP does not necessarily exhibit any of these serious drawbacks. As of today, SCP is commonly grown on agricultural waste products however, SCP may also be produced entirely

independent of agricultural waste products through autotrophic growth. Thanks to the high diversity of microbial metabolism, autotrophic SCP provides several different modes of growth, versatile options of nutrients recycling, and a substantially increased efficiency compared to crops.

4. Milk and milk by product:

They include skimmed milk, condensed butter milk, dried whole milk. They are excellent source of protein but are usually too expensive to be included in the feed.

4.0. Conclusion

Protein supplements are critical to growth and reproductive process in animals though are generally costly. However, plant proteins are been used more in recent times.

5.0 Summary

Feedstuff considered in this unit are high in protein, products from animal and plant have been enumerated.

6.0. **Tutor Marked Assignment**

Briefly described two products from animal protein and state their limitation. Highlight the three types of proteins we have

7.0. **References / Further Reading**

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Unit 4 Mineral and Vitamin Supplements, Nonnutritive Additives

CONTENTS

3.3.2Factors influencing usage of feed additives
3.3.3Some commonly used feed additives
4.0. Conclusion
5.0. Summary
6.0. Tutor Marked Assignment
7.0. References / Further Reading

1.0 Introduction

Virtually all feeds contain at least some vitamins and minerals. Animals need these nutrients in much smaller amounts than they do the other nutrients, but vital to the animal therefore dietary needs must be met to achieve good animal performance and economical production. All the required minerals are needed in an animal's diet and(or) water supply, but the need for supplementation vary widely among different animals. Salt - often iodized and(or) added small amounts of other trace elements (e.g., Co, Mn, Fe, Zn, and Cu). Either as block or a loose form should be incorporated in diets.

Producers mixing their own simple rations should use supplements that contain vitamins and minerals. These supplements can easily be combined with whole grains or by-product feeds to create a balanced concentrate ration. Complete mineral mixes are recommended when grazing low quality roughages and during gestation and early lactation. The most important minerals are calcium, phosphorus, salt (NaCl) and selenium. Normally, when a well-balanced ration is fed, the only necessary supplement is salt and can be added by placing a salt block in the pasture or by providing salt in a pan or trough**.**

2.0 Objectives

- Explain the importance of vitamins and minerals supplements
- List vitamins and minerals supplements commonly used in livestock feed
- Explain the importance of Nonnutritive Additives

3.0 Main content

3.1 Some common mineral supplements include:

1. salt (often trace mineralized),
2. bone meal,
3. oyster shell,
4. calcium carbonate,
5. limestone,
6. pure forms of other specific minerals

The use of Chelates in animal feed is another advancement in animal nutrition. These are organic forms of essential trace minerals such as copper, iron, manganese and zinc.

Table 7–5
MINERAL CONTENT OF SOME REPRESENTATIVE MINERAL SUPPLEMENTS

	Calcium (%)	Total Phos. (%)	Ash (%)	Sodium (%)	Potassium (%)	Magnesium (%)	Fluorine (%)	Manganese (ppm)[1]	Iron (ppm)	Copper (ppm)	Zinc (ppm)	Selenium (ppm)
Bonemeal (steamed)	24.0	12.0	71.0	0.46	n/a[1]	0.64	n/a	30.4	840	16.3	424	n/a
Calcium carbonate	38.0	—[1]	95.8	0.06	0.06	0.5	n/a	279	336	24	n/a	0.07
Diammonium phosphate (N-18%)	0.5	20.0	34.5	0.04	—	0.45	0.2	500	15,000	80	300	n/a
Defluorinated phosphate	33.0	18.0	99.0	4.5	0.09	—	0.2	220	9,200	22	44	0.6
Dicalcium phosphate	20.0	18.5	85.6	0.08	0.07	0.6	0.18	300	10,000	80	220	0.6
Phosphoric acid, 75%	—	23.8	n/a	n/a	n/a	n/a	—	n/a	5	n/a	n/a	n/a

	Potassium (%)	Magnesium (%)	Iron (%)	Copper (%)	Manganese (%)	Zinc (%)	Cobalt (%)	Sulfur (%)	Selenium (%)	Sodium (%)
Copper sulfate ($CuSO_4 5H_2O$)	—	n/a	n/a	25.0	n/a	n/a	—	—	—	—
Ferrous sulfate ($FeSO_4 7H_2O$)	—	0.04	0.001	0.001	0.002	—	21.0	—	—	—
Manganese sulfate ($MnSO_4 H_2O$)	—	0.05	21.0	0.01	0.12	0.01	—	11.0	—	—
Magnesium sulfate ($MgSO_4$)	—	0.03	0.04	—	25.0	—	—	19.0	—	—
Potassium sulfate (K_2SO_4)	—	20.0	n/a	n/a	n/a	n/a	n/a	26.6	—	—
Sodium selenite (Na_2SeO_3)	44.8	—	—	—	—	—	—	18.3	—	—
Zinc oxide (ZnO)	—	—	—	—	—	—	—	—	45.6	26.6
Copper sulfate ($CuSO_4 5H_2O$)	—	0.5	0.8	0.07	0.01	73.0	—	1.0	—	—

[1]ppm = parts per million; n/a = data not available; — indicates that the ingredient does not contain a significant amount of nutrient.
Source: Dale, 1997. Used with permission.

Source: Damron 2013

Almost all feedstuffs contain some vitamins, but their concentrations vary widely. In plants, vitamin B concentration can be affected by harvesting, processing, and storage conditions, as well as plant species and part. In animals, the liver and kidney are generally good sources of most of the vitamins. Yeasts and other microorganisms are excellent source, especially, B vitamins. Sometimes there are Limiting vitamins in natural diets (mostly for nonruminants), thus the need for supplementation.

- Mostly for nonruminants - Vitamins A, D, E, riboflavin, pantothenic acid, niacin, choline, and vitamin B12, depending on the species & class. Also, biotin (in pigs & poultry) and vitamin K (with reduced microbial synthesis) in some instances?!

- For ruminants - Vitamin A & also $-carotene, and vitamin D & E for dairy cows? Also, thiamin and niacin in some instances.

Vitamins can be purchased individually or as a mixture. Fat-soluble vitamins need an antioxidant to retain their potency. Some water-soluble vitamins are subject to destruction by heat, moisture, light, trace elements.

3.2 Some common vitamin supplements include

1. ensiled yeast,
2. liver meal,
3. fish oil,
4. wheat germ oil,
5. purified forms of individual vitamins.

3.3 Nonnutritive Additives

This is a category of large group of feed ingredients added to the feed in small quantities for some reason other than their nutritive value.

3.3.1 Advantages of using additives

1. Non-nutritive additives are feed additives added to rations to
2. improve the efficiency of animal production
3. improvement in intake and digestion,
4. improve the health of the animal.
5. to improve manufacture and properties of the feeds
6. to improve consumer acceptance of a product.

Feed additives are utilized extensively in commercial animal production. Feed additives have been beneficial within modern animal production, allowing producers to provide safe, wholesome, cost-effective animal products to consumers. In more recent years, regulatory agencies and lawmaking bodies have started to restrict feeding of specific additives for various stated reasons.

3.3.2 Factors influencing usage of feed additives

1. specific requirements of the animal,
2. effects of other components of the ration,
3. presence of a withdrawal period,
4. effect of a withdrawal period,
5. form of additive to feed,
6. and cost-effectiveness of the feed additive.

3.3.3 Some commonly used feed additives

1. Antibiotics e.g. Terramycin, Zinc bacitracin, Flavomycin etc.
2. Enzymes e.g. Amylase, lipase, protease, pepsin etc.
3. Hormones e.g. Estrogen, progesterone, hexosterol etc.
4. Thyroprotein e.g. Iodinated casein.
5. Probiotics e.g. Microbial species. Lactobacillus.
6. Biostimulators e.g. Extracts of living organs like spleen, liver, ovary, chick embryo etc.
7. Antioxidants e.g. Vitamin E (Tocopherols), BHT (Butylated hydroxy toluene).
8. Mold inhibitors e.g. Propionic acid, acetic acid.
9. Pellet binders e.g Gur
10. Coccidiostats e.g. Amprolsol powder, Furasol powder.

4.0. Conclusion

This category of feed ingredients (Mineral and Vitamin Supplements, Nonnutritive Additives) are added to the feed in small quantities nevertheless are very important because their lack can affect production.

5.0. Summary

In this unit we have learn about various minerals and vitamin supplements that are included in feed. We have also seen other additives included for non nutritional reasons.

6.0. Tutor Marked Assignment

Mention the importance of minerals and vitamin supplements in livestock feeds.
Enumerate the two factors to consider in using feed additives.

7.0. References / Further Reading.

National Research Council NRC, (1994). Nutrient Requirements of Poultry Ninth Revised Edition National Academy Press Washington, D.C. 157pp
Lee I. C. (2009). Animal Nutrition Handbook Second Revision. unpublished

Module 3 Succulent Feed, Concentrate feeds, cereals, legumes and oil seeds

Unit 1 Succulent Feed and Concentrate feeds

CONTENTS

1.0. Introduction

Succulent foods are those that contain about 60-90 percent moisture. They are plant feed with a high content of water in a bound state and are easily digested by the animals. Succulent foods can be classified into 2 broad groups

(a) Roots and Tubers

(b) Green fodders and succulent roughages

Most green crops can be used as succulent feeds when they are young. Succulent feeds include root crops, tubers, melons, the tops of root crops and tubers, forage grasses, and ensilage. The total nutritional value of 1 kg of succulent feed ranges from 0.1 to 0.3 of a feed unit. Succulent feeds contain vitamin C, the B-complex vitamins, and, sometimes, carotene. The dry matter is rich in easily digested carbohydrates (starch and sugar) and poor in protein (with the exception of leguminous grasses). All farm animals may be fed succulent feeds because the feeds increase milk productivity. Succulent feeds are usually fed in raw form without any special preparation.

2.0 Objectives

- Explain the meaning of succulent feeds
- Explain the role of succulent feeds in feeding livestock
- List the importance of concentrates

3.0. Main Content

3.1 Advantages of Succulent feeds

1. It keeps the animal in good health and improves reproductive efficiency.

2. It is palatable and easy for digestion.
3. It has cooling effect on the body.
4. It is mild laxative, hence prevents constipation.
5. It provides fresh nutrients in their natural form.
6. It doesn't put any stress on body or organ and leads to efficient utilization of feed nutrients.

3.1.2 Examples of Succulent feeds

1. Roots and tubers such as yam cassava, cocoyam, etc
2. Vegetables such as water leaf, shoko and cabbage
3. forages such as pasture grasses and cultivated fodders
4. silage made from green fresh grass
5. Cane molasses mainly from sugar cane
6. Leaves of trees

3.1.3 Unconventional feed stuff

Unconventional feed stuff are those that are not commonly used for feeding of livestock but used during fodder scarcity or shortage. They have low to poor nutritive value

Examples of some unconventional feed stuff

1. Protein Source

Plant source – Banana peels Mango peels Avocado peels Papaya peels Papaya seeds
Animal origin – Dried poultry droppings, frog meal, crab meal etc.

2. Energy sources

Tamarind seed powder, sal seed meal, tapioca waste, mango seed kernel, Babul pods, sugarcane baggasse, sugarcane tops, sugar beet pulp, jack fruit waste etc.

3.2 Concentrate Feeds

In the feed trade, the word 'concentrate' has been used to indicate commercially prepared supplements. Feed concentrates provide nutrients that forage alone cannot provide. This is particularly true in the case of high-producing animals. At times concentrates are a more economical source of nutrients than forages. These are the feedstuffs which contain less than 18 percent crude fibre and more than 60 percent

TDN. They are less bulky and have higher digestibility. They are concentrated source of nutrients and therefore, they have higher nutritive value than roughages. There are two types of concentrate feeds: carbonaceous and proteinaceous.

3.2.1 **Proteinaceous concentrates** or "protein feeds" contain high levels of protein (>15%). Examples include soybean meal, cottonseed meal, peanuts (groundnuts), flaxseed (linseed), canola, coconuts, palm kernel cake, cotton seed cake, groundnut cake, soya beans cake, oil palm and sunflower seeds. These are animal protein concentrates such as Fish meal and blood meal.

Protein quantity is generally more important than protein quality (amino acid content) in ruminant livestock because the microorganisms in the rumen manufacture their own body protein. Livestock do not store excess protein; it is burned as energy or eliminated (as nitrogen) by the kidneys.

3.2.2 **Carbonaceous concentrates** or "energy" feeds are high in total digestible nutrient but tend to be low in protein (8-11%). They include the cereal grains -- corn, barley, wheat, oats millet, sorghum, rice and rye.

Certain concentrates are reduced to high protein content, comprising of a combination of vegetable proteins, urea, essential vitamins and minerals, rumen modifier and limestone, designed to be mixed with grain and roughage, to produce a complete ration. Such concentrates are mix 94% grain and 6% concentrate. Concentrates is not fed directly to animals.

Many feed companies offer "complete" mixes of feed, balanced for the needs of the animals of a particular age and production class. Complete feeds should not be mixed with other grain, because this may create nutritional imbalances. Complete feeds tend to be significantly more expensive than home-made concentrate rations.

4.0. Conclusion

Feeds such as succulent feed, unconventional feed and concentrates are used in order to reduce production cost.

5.0. Summary

In this unit we have explained the role of succulent feed, unconventional feed and concentrates in animal feed.

6.0. Tutor Marked Assignment

- Explain the meaning of succulent feed
- Mention one use of conventional feeds
- Explain the term concentrate feed
- List two types of concentrates

7.0. References / Further Reading

Preston T. R. (1995). Tropical Animal Feeding. FAO Animal production and health paper 50/2, 154pp

Lee I. C. (2009). Animal Nutrition Handbook Second Revision. unpublished

Unit 2 Cereals

CONTENTS CONTENTS

1.0. Introduction

Cereals play an important role in world agriculture. They contribute significantly to the global food pool in achieving food and nutritional security. Cereals that are mostly used in the tropical countries are maize, rice and guinea corn and to a less extent millet and wheat. In temperate climate, wheat, barley, oat and rye may be available for use in the diets of farm animals and human beings. Cereals are high in starches that are readily digested by animals. They are relatively low in protein content and in general are of poor quality because of the lack of balance in amino acid composition. Cereal energy constitutes below 45 - 70% of the energy in poultry, swine and rabbit diets. Cereals contain fair amount of calcium, phosphorus and iron, although the absorption of these minerals vary. Whole cereals contain useful amounts of B vitamins although most of these B vitamins are lost in the milling process to which the grains are subjected in the preparation of various foods from them. They are however totally devoid of vitamin B12 and ascorbic acid. Vitamin A in cereals is low except for yellow maize, cereals are also deficient in the amino acid such as lysine and tryptophan.

2.0. Objectives

- Explain the importance of cereals in animal production
- Describe and explain common cereals
- Explain cereal grain By-products

3.0. Main Content

3.1 Examples of some cereals and their nutritional value

Maize (Zea mays)

It is grown extensively in the country for human food as well as livestock feed. It is used for all classes of livestock. Essentially maize supply energy which is as high as 14.2 MJ/kg. It is low in protein (8-10%) depending on the variety. Its protein content is low in lysine and tryptophan. The fat content is about 4% and high in linoleic acid an essential fatty acid (about 50%). Yellow maize contains Xanthophyll which gives yellow colouration to the shank, skin, egg yolk of birds and carcass of pig fed diet containing yellow maize. Yellow maize contains carotenoids which have pro vitamin A activity 100 – 800 mg/100g. White maize is low in xanthophylls and lacking in vitamin A activity. Green leaves, palm oil or synthetic colourant can be added to white maize. Niacin in maize is in bound form and is not easily available. However, treatment with home water makes the niacin more available. Maize is used up to 60% in livestock feed. It is sometimes difficult to do 100% replacement of maize.

Sorghum (Guinea corn) Sorghum guiness

It is widely grown in several parts of the world. In Nigeria, it is grown in the Northern part of the country. Sorghum can be grown successfully on poorer soils and in drier conditions than maize. Its energy content is comparable to that from maize up to 13.79MJ/kg. Its protein content is slightly higher than that of maize. It contains low levels of xanthophylls, linoleic acid, lysine, methionine, tryptophan and fibre. It is also low in calcium but high in phosphorus. It is used to substitute maize to a reasonable extent in livestock feeding. It is also used in human food in various forms especially in the Northern part of the country. The use of sorghum in livestock feeding is limited by its content of tannin. Although low tannin sorghum has been bred to improve its utilization in poultry. Tannins are a group of compounds that bind to proteins, thus impairing protein digestion. Tannins also reduces palatability. Guinea corn leaves are used as feed for ruminant animals. However, it must be noted that young sorghum contains cyanogenic glucoside. The glucoside occurs in the germinated plant and its contents increases as the plant matures and disappears completely when grain appears, glucoside hydrolysis yields hydrocyanic acid (HCN).

Rice (Oryza sativa)

Rice is grown locally but principally as human food, though it is useful in livestock feeding. By products obtainable from rice includes rice husk, rice bran, broken rice, rice polishing and rice mill by products. Rice bran consists of the pericarp or bran layer and germ. The fat and linoleic acid contents of rice bran are relatively high. The protein content is between 12 and 13%. Rice polishing is obtained in the operation of brushing the grain to polish the rice. The protein content and linoleic content of rice polishing are higher than those of maize. The crude fibre content is low (4.1%). Its energy value is higher than rice bran. Rice mill by-products consist of rice husk, rice bran, rice polishing and broken rice grains. Its crude fibre may be higher than 32%. Rice mill by-products crude protein is low and fat content 5 – 6 %. Its high crude fibre and its low metabolizable energy (ME) values discourage its use in poultry and swine diets.

Protein and lysine content of cereal crops

Crop	Protein Content (%)	Lysine in protein (%)
Maize	8.0-11.0	1.80-2.00
Wheat	11.0-14.0	2.50-3.20
Rice	7.0-9.0	3.50-4.00
Barley	8.0-11.0	2.90-3.20
Oats	12.0-14.0	3.80-4.00
Sorghum	9.0-11.0	2.00-2.80

Limiting amino acids in cereal protein

Cereal	1st limiting	2nd limiting
Rice	Lysine	Threonine
Wheat	Lysine	Threonine
Maize	Lysine	Tryptophan
Sorghum	Lysine	Threonine
Millet	Lysine	Threonine

3.2 Cereal grain By-products

Cereals grain by- products are obtained during the processing of grains into food and drinks for human. The by-products are used mostly for feeding livestock.

Some are now processed into human foods for example oat bran and breakfast cereals.

3.2.1 Examples of cereal by-products include:
Wheat Bran
Wheat Shorts
Wheat middling
Wheat mill run
Rice Bran
Rice Polishing
Rice mill by - products
maize Gluten meal
Maize gluten feed
Maize Distillers Dried grains
Hominy feed.
Brewer's dried grains
Sorghum distillers grain
Breweries dried yeast
Torula dried yeast
Dried Bakery products

1. Wheat Bran: wheat bran consists of the coarse, outer covering of the wheat in the usual process of commercial milling of wheat. Although of low energy value, wheat bran is useful when low calorie diets are required. It is also cheap. The crude fibre level is above 9.5%
2. Wheat Shorts: Wheat shorts consist of fine particles of wheat bran, wheat germs. Wheat flour and the offal from the tail of the mill, in the usual process of milling wheat. Because of the endosperm fraction, wheat shorts contain more energy and less crude fibre than wheat bran. It has not more than 7% crude fibre.
3. Wheat Middling: wheat middling are essentially similar to wheat shorts except for the differences in crude fibre content. Wheat middling consist of fine particles of wheat bran, wheat shorts wheat germ, wheat flour and some of the offal from the tail of the mill. Has not more than 9.5% crude fibre.
4. Wheat mill Run: This consists of coarse wheat bran, fine particles of wheat bran, wheat flour and the offal from the tail of the mill. The chemical content of wheat mill run is similar to those to those of wheat shorts. Not more than 9.5% crude fibre. Wheat mill run and the other wheat by-products are ingredients that can be used but in restricted amount in poultry and swine diets.

5. Rice bran: Rice bran is the by-product of the milling of rice to produce edible rice. Rice bran consists of the pericarp or bran layer and germ of the rice, along with small quantities of hull fragments, and some chipped, broken rice and perhaps CaCO3 as is unavoidable in the rice milling process but which should usually not exceed 5%. The fat and linoleic acid contents of rice bran are relatively high. The protein content is below 12 – 13%. The oil gram rice bran is used largely in human diets. The protein content is below 12 – 13%. The oil grain rice bran is used largely in human diets. Rice bran can be used successfully to replace some part of the grain portion of some poultry and swine diets. As much as possible, rice bran should be avoided in the diets of younger poultry and pigs.
6. Rice polishing: this is a by – products of rice obtained in the milling operation of brushing the grain to polish the rice. The protein content and linoleic acid content of rice polishing are higher than those of maize. The product is characterized by relatively low crude fibre content 4.1%. Its energy value is higher than rice bran. There are no special limitations to the use of rice polishing in poultry and swine diets. It is however not as available as rice bran.
7. Rice mill by – product: this consist of rice hulls, rice polishing, and broken rice grains. Rice mill by-product is in actual fact the total offal obtained in the milling of rice. Its crude fibre content should normally not exceed 32%. Its protein content is low, with fat content of 5.6%.
8. Maize gluten meal: Maize gluten meal is the dried residue from maize after the removal of the larger part of the starch and germ, and the separation of the bran by the process employed in the wet willing manufacture of corn starch or syrup or by enzymatic treatment of the endosperm it may contain fermented corn extractive and/or maize germ meal. The amino acid contents of maize gluten meal are much higher than those of maize gluten feed. Like maize the maize by-products are deficient in lysine and tryptophan.
9. Maize Gluten feed: This is that part of the commercial shelled maize that remains after extraction of the larger portion of the starch, gluten and germ by the processes employed in the wet milling manufacture of maize starch or syrup it may or may not contain fermented Maize extractives and or maize. Contain about 21 – 23% crude protein and 9 -10% crude fibre.
10. Maize Distillers Dried Grains: These are derived from the fermentation industry particularly the alcohol industry. There are 2 types of maize distillers dried grains, with soluble and maize distiller's dried grains, both containing 27% Crude protein. The crude fibre (12%) is high and energy value relative. Generally, the distillers dried Grains and the distiller dried

soluble are by-products obtained after removal of ethyl alcohol by distillation from the yeast fermentation of grains and grain mixture.

11. Homing feed: this is a mixture of maize bran, maize germ and part of the starchy portion of the maize grain as produced in the manufacture. There have at least 5% Crude fat (ether extract). The fat of homing feed is high in lionoleic acid (3.2%) and the energy content is fairly high.
12. Brewers dried grains: this is the dried extracted residue of barley alone or in mixture with other cereal grain or grain products resulting from manufacture of beer and may contain pulverized dried spent hops in an amount not exceeding 3% evenly distributed. Because of its low energy content and high fiber content (over 18%). BDG is more suitable as cattle feed. It is also used extensively in swine production.

Table 5: Proximate composition of some brans and hulls

Products	**DM*** **g/kg**	**CP** **g/kg DM**	**EE**	**CF**	**Ash**	**NfE**
Wheat bran	861	185	59	42	31	691
Barley bran	891	97	14	217	51	623
Lentil hulls	893	189	12	277	46	476
Lathyrus pea hulls	895	130	2	356	43	466
Chick pea hulls	923	60	11	426	50	452
Faba bean hulls	929	106	7	424	37	434

**DM=Dry matter in g/kg, CP=Crude Protein, EE=Ether Extracts, CF=Crude Fibre, NfE=N-Free Extracts*

4.0 Conclusion

Cereals contribute significantly to food security and are high in starches that are readily digested by animals. The processing of cereals results in a lot of by-products. The use of these products by animal production is a form of environmental management.

5.0 Summary

In this unit we have learnt that cereals and their by-products are important in animal production however the imbalanced amino acid limits their usage.

6.0 Tutor Marked Assignment

- Highlight the reason why cereals are important in animal production
- List two common cereals in animal feeds
- Enumerate four cereal by-products you know

7.0. References / Further Reading

Harris L.E. (1980) Feedstuff : In Fishfeed Technology Lectures Presented at FAO/UNDP Training In Fishfeed Technology, Seattle Washington ADCP/REP/80/11

Preston T. R. (1995). Tropical Animal Feeding. FAO Animal production and health paper 50/2, 154pp

Unit 3 Legumes

CONTENTS

1.0. Introduction

Legumes are plant species of the family Leguminosae. They have seed pods that, when ripe, split along both sides. Legumes are a significant source of protein, dietary fiber, carbohydrates and dietary minerals; manganese. Like other plant-based foods, contains no cholesterol and little fat or sodium. Legumes are also an excellent source of resistant starch which is broken down by bacteria in the large intestine to produce short-chain fatty acids (such as butyrate) used by intestinal cells for food energy. The legume family is probably the third largest of the vascular plants. Orchid and grass families are larger. However, economically, legumes are second only to grasses in importance because of their extensive use as forages. While only about 40 legumes are significant in forage production, there are 12,000-18,000 species. Forage legumes, such as alfalfa, clovers, and trefoils are generally of high quality, and their digestibility declines less rapidly as the plant matures than that of many perennial grasses. Legumes have a longer window for best utilization, so they fit well into a feed calendar. Legumes also generally have higher levels of protein than grasses. But legumes require more management than grasses because they are more sensitive to fertility and edaphic (soil) factors. Legumes and grasses can be mixed together to take advantage of their strengths but since they have different characteristics mixtures must be more carefully managed Forage managers must learn to utilize grasses and legumes for maximum quality and yield.

The banning of meat and bone meal in animal diets has led to increased interest in vegetable protein sources. Soybean meal is the predominant protein source for

animal diets worldwide, but the increased use of genetically-modified (GMO) soybeans has resulted in an interest in alternative sources of vegetable protein, especially among organic poultry producers. Some other legumes can be used as alternative feed ingredients.

Legumes are noted for their ability to use nitrogen from the air. This ability is the result of a symbiotic relationship between the plants and bacteria (rhizobia) found in root nodules. This ability to use atmospheric nitrogen reduces fertilization costs and allows legumes to be used in crop rotation to replenish soil that has been depleted of nitrogen. Legumes break the annual cycle of cereals, reducing the buildup of cereal weeds and pests.

2.0 Objectives

- Explain importance of legumes in animal feed
- Highlight nutritional quality of legumes
- Mention examples of some legumes

3.0. Main Content

3.1 Types of legumes

1. Grain legumes refer to those crops cultivated for immature or mature grain.
2. Forage legumes refer to legumes consumed as forage. Forage legumes can also be used as a source of biomass and green manure.

3.2 Nutritional quality of legumes

Legumes have been mostly used as feeds for ruminants, although there are some reports of their inclusion in the diets of non-ruminants (pigs and poultry). The leaves, stems and fruits may be used either as a complete feed or as a supplement to other feeds.Legume seeds have twice as much protein as grains. Crude protein content of legume grains ranges from 27% in peas and faba beans to almost 50% in soybeans. The proteins are digested in the rumen to provide ammonia and amino acids for microbial cells in protein synthesis. Legume grains are also high in iron and B vitamins.

Limitations

One of the factors limiting the use of grain legumes as feed is the presence of antinutritional factors in legumes that decrease the nutritive value of the grain and, if consumed in large amounts, cause health problems for animals. These antinutritional factors include protease inhibitors, lectins, oligosaccharides, phytate, antivitamins, L-canavanine, tannins, and isoflavones.

Antinutritional factors and species where they are found

Anti-nutritional substances		Species
1.	Non-protein Amino acids	
	Mimosine	*Leucaena leucocephala*
	Indospecine	*Indigofera spicta*
2.	Glycosides	
	(A) Cyanogens	*Acacia giraffae* *A. cunninghamii* *A. sieberiana* *Bambusa bambos* *Barteria fistulosa* *Manihot esculenta*
	(B) Saponins	*Albizia stipulata* *Bassia latifolia* *Sesbania sesban*
3.	Phytohemagglutinins	
		Bauhinia purpurea
	Ricin	*Ricinus communis*
	Robin	*Robinia pseudoacacia*
4.	Polyphenolic compounds	
	(A) Tannins	All vascular plants
	(B) Lignins	All vascular plants
5.	Alkaloids	
	N-methyl-B-phen	
	Ethylamine	*Acacia berlandieri*
	Sesbanine	*Sesbania vesicaria*
		S. drummondii
		S. punicea
6.	Triterpenes	
	Azadirachtin	*Azadirachta indica*
	Limonin	*Azadirachta indica*
7.	Oxalate	*Acacia aneura*

3.3 Examples of some legumes

Soybeans

Globally, soybeans (Glycine max) are the most important feed grain legume. Soyabean is an oilseed containing about 20 percent oil. The extraxtion of oil results in a high protein cake. One of these products is soyabean meal which is one of the main protein source in animal diets. Soybean, meal is about 44 percent crude protein, while the concentrate Contains about 70% CP. Soyabean leaves and stem can be grazed, ensiled or dried to make hay. The foliage is very palatable, has a high nutritive value and highly digestible. Raw soyabeans seeds contains trypsin but leaves and stem does not.

Chick Peas

Chickpeas (Cicer arietinum) are one of the world's most important grain legumes. Like other legumes, chickpeas contain such antinutritional factors as protease and amylase inhibitors, lectins, tannins, and oligosaccharides. These antinutritional factors interfere with nutrient absorption from the digestive tract. Most of the antinutritional factors in chickpeas can be deactivated by heat treatment.

Cowpeas

Cowpeas (Vigna unguiculata), also called black-eyed peas, are an important grain legume in tropical and subtropical regions. Cowpeas are heat- and drought-tolerant crops. Cowpeas have an amino acid profile that is similar to that of soybeans. cowpea is a legume that is extensively grown, particularly throughout sub-Saharan Africa. It is a subsistence crop, often intercropped with sorghum, maize and pearl millet. The peas provide valuable protein, the leaves are used as a nutritious vegetable and the rest of the plant serves for animal feed. The plants are drought tolerant and grow well on relatively poor soils. The peas can be consumed fresh or removed from the pods and dried.

Faba Beans

Faba beans (Vicia faba) are grown in several countries, especially in the Mediterranean area. The nutrient content of faba beans makes them look like a suitable substitute for soybean meal, but the presence of antinutritional factors has limited their use in poultry diets.

Field Peas

Field peas (Pisum sativum) are grown in several countries. Field peas have been referred to as "feed peas" in Canada and as "protein peas" in Europe. The relatively low levels of antinutritional factors in pea grains eliminates the need for heat treatment of field peas prior to inclusion in poultry diets.

Lupins

Australia is the dominant world producer of lupins, accounting for around 85% of world production. Lupins are also produced in the United Kingdom and western Canada. The high price of organic feed has been hampering the development of organic poultry production. This has resulted in an increased interest in lupins, which have the advantage of not requiring roasting prior to feeding. There are two classifications lupins (Lupinus species): bitter and sweet. Bitter types are high in alkaloids, compounds that have been bred out of the sweet varieties.

Lentils

Lentils (Lens culinaris) are grown primarily for human consumption, but lentils that fail to meet food-grade standards are available for use in livestock feeds. Lentils have a relatively high protein content and few digestive inhibitors.

Vetch

Common Vetch

Common vetch (Vicia sativa) is an annual climbing legume. Common vetch originated in southern Europe but is now grown all over the world. Common vetch has many valuable agronomic characteristics: It is resistant to drought and adapted well to semiarid regions. It can also grow in poor soils. The presence of cyanoalanine toxins has limited the use of common vetch seed in poultry diets.

Other Types of Vetch

Bitter vetch (Vicia ervilia) is an old grain legume that originated in the Mediterranean and is now grown around the world. It has high yields and is resistant to droughts and insects. It is a good source of energy, and its amino acid profile is similar to that of soybeans. The seeds have been used in animal diets, but the presence of canavanine has limited the use of bitter vetch in poultry diets.

4.0 Conclusion

Legumes are important because of their extensive use as forages in ruminant nutrition. Forage legumes, such as alfalfa, clovers, and trefoils high quality protein.

5.0 Summary

We have learnt of a large group of plants known as legumes, which can be used as protein sources and forage. However, the presence of anti nutrients limits their usage.

6.0 Tutor Marked Assignment

- Describe the role of legumes in animal production
- mention one legume commonly used for animal feed in Nigeria

7.0 References / Further Reading

Shelton, H.M and Brewbaker J.L. (1998). The Role of Forage Tree Legumes in Cropping and Grazing Systems. In: Forage Tree Legumes in Tropical Agriculture (Eds) Gutteridge, R.C. and Shelton, H.M. Published by the tropical grass land society of Australia INC.

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Unit 4 Oil Seeds

CONTENTS

1.0. Introduction

Oil-bearing crops or oil crops include both annual (usually called oilseeds) and perennial plants whose seeds, fruits or mesocarp and nuts are valued mainly for the edible or industrial oils that are extracted from them. The animal feed industry productively utilizes the co-products associated with the refining of oilseeds into higher value food materials. In addition, by serving as an outlet for such by-products, the animal production industry prevents their introduction into the environment in what might be wastes

2.0. Objectives

- Explain the meaning of oilseeds
- Highlight the importance of oilseeds
- Describe oilseed cakes and meal

3.0. Main Content

3.1 Oilseed Usage

The proteins in oilseeds can be fed either as part of the oil-intact seed, or as a meal from which the oil has been removed. A relatively small proportion of oilseed production is fed to animals as the whole seed. There are both economic and nutritional reasons why this is the case. The biological availability of minerals in plant sources, such as oilseeds, are generally low, especially true for P. Depending upon the specific oilseed involved, and the type of animal being fed, special considerations must be addressed when feeding whole oilseeds. One consideration is the presence of naturally occurring toxic compounds such as the gossypol pigment present in cottonseed. While whole cottonseed should not be fed to non-ruminant animals, it can be fed to ruminants when appropriate limits are employed. Rapeseed contains erucic acid as well as glucosinolates, which are goitrogenic compounds. Oilseed and products derived from such cultivars are referred to as Canola. Soybeans contain 'anti-nutritional' factors which must be denatured through some form of heat treatment prior to feeding to non-ruminant animals. Due to their high oil content, oilseeds tend to be relatively high in nutritional energy. This can be an advantage in feed formulations which require ingredients that provide higher levels of energy. However, energy also serves as a 'cap' on the usage of whole oilseeds. Another nutritional consideration is the fatty acid profile of the oil. The impact of feeding unsaturated fats on various non-ruminant animal carcass characteristics is a concern in many production situations. However, the major consideration in the feeding of whole oilseeds is economic. Historically, the oil from oilseeds is greater when it is made available to the human food market than when it is retained in the whole seed and fed as a source of energy in animal feeds. As a result, the vast majority of oilseed is processed into oil and meal. Soybean meal for example accounts for 75 percent of all protein used in compounded livestock rations worldwide.

Only 5-6 percent of the world production of oil crops is used for seed (oilseeds) and animal feed, while about 8 percent is used for food. The remaining 86 percent is processed into oil. The fat content of oil crops varies widely. Fat content ranges from as low as 10-15 percent of the weight of coconuts to over 50 percent of the weight of sesame seeds and palm kernels. Carbohydrates, mainly polysaccharides, range from 15 to 30 percent in the oilseeds, but are generally lower in other oil-bearing crops. The protein content is very high in soybeans, at up to 40 percent, but is much lower in many other oilseeds, at 15-25 percent, and is lower still in some other oil-bearing crops.

3.1.1 Products derived from oil crops

Edible processed products from oil crops, other than oil, include flour, flakes or grits, groundnut preparations (butter, salted nuts, candy), preserved olives, desiccated coconut and fermented and non-fermented soya products.

3.1.2 Example of Oilseeds

1. Soybeans
2. Coconuts
3. Oil Palm Fruit
4. Olives
5. Karite Nuts
6. Castor Beans
7. Sunflower Seed
8. Rapeseed
9. Tiger Nuts
10. Safflower Seed
11. Sesame Seed
12. Mustard Seed
13. Melonseed
14. Tallow tree Seeds
15. Kapok Fruit
16. Linseed
17. Hempseed
18. Cottonseed
19. Peanut
20. Sunflower Seed
21. Copra
22. Palm Kernel

In terms of gross production, soyabeans are the dominant oilseed crop. More tonnes of soybeans are produced globally than all other major oilseeds combined.

3.2 Oilseed cakes and meals

Oilseed cakes and meals are the residues remaining after removal of the greater part of the oil from oilseeds. The residues are rich in protein and most are valuable feeds for livestock. According to the method of processing, the cakes are classified into

a) Ghani pressed
b) Expeller pressed and
c) Solvent extracted.

Of these, ghani pressed cakes contain the maximum amount of ether extract, while solvent extracted contain traces of oil. Conversely the protein content is higher in solvent extracted cakes and lowest in the ghani cakes.

Oilseed cakes are in general very good sources of protein and about 95% of the nitrogen is present as true protein. Vegetable proteins are generally poorer compared to animal proteins. Proteins of oil cakes have a low glutamic acid, cystine, methionine and variable but low lysine content. The meals usually have a high phosphorus content which tends to aggravate their low calcium content. They may provide good amount of B vitamins but are poorer sources of carotene and vitamin A.

3.2.1 Oilseed Processing

Processing considerations do have a direct impact on the nutritional value of oilseed meals. Some positive, others negative. As an example, the primary anti-nutritional factors in soybean meal need to be deactivated by the proper use of heat. The high temperature and pressures of the expeller process may result in a lowering of digestibility and in denaturation of the protein with a consequent lowering of its nutritive value. The high temperature and pressure also reduces most of the deleterious substances which might be present in oilcakes such as gossypol and goitrin. Some seeds such as groundnut, cottonseed and sunflower have a thick coat or husk rich in fibre, and of low digestibility which lowers the nutritive value of the material. It may be completely removed by cracking and riddling a process known as decortication. In its simplest form, oilseed processing is involved with the separation of oil from non-oil constituents. The major focus of oilseed processing has been the extraction of high quality oil. The meal and other co-products were typically regarded as ‘by-products’ and thus of lesser interest. Over the course of time, market pressures have required an increasing focus on meal quality. When soybean meal is evaluated and compared with canola and sunflower meals in the context of those amino acids which tend to be most limiting, it is, with the exception of its sulphur bearing amino acids, typically superior. In general, soybean meal also tends to be higher in energy than the other protein meals. This is of particular importance in feeding situations where higher nutrient densities are desirable.

3.2.2 Factors to consider in oilseed meals

1. Amino acid availability. The above values are on the basis of total levels present. In reality, not all of the protein that is present can be digested and thus beneficially utilized by an animal. Protein availability varies with native protein characteristics as well as processing induced changes.

2. Toxic and ant nutritional factors. As mentioned, certain whole oilseeds contain toxic and/or ant nutritional factors. The presence of these compounds in the meal must be evaluated and considered.
3. Functional considerations. Physical characteristics can be an issue in certain applications, such as when the feed is to be pelleted. In this situation, nutritional considerations may be outweighed by inappropriate levels of fibre and fat, which limit its practical use in certain applications.
4. Palatability of an ingredient or lack thereof, is also a factor.
5. Wholesomeness. Meals should be free of mycotoxins and other harmful materials.
6. In addition, the residual oil in a meal should not be rancid.
7. Consistency. An important assumption in modern feed formulation is that the nutritionist can accurately describe the nutritional characteristics of the ingredients used. When an ingredient is subject to wide fluctuations in composition, it greatly complicates the process and ultimately adds cost.

3.2.3 Examples of Oil seed Cakes and Meal

1. Cake of Soya Beans
2. Cake of Groundnuts
3. Cake of Coconuts
4. Cake of Palm Kernels
5. Cake of Sunflower Seed
6. Cake of Rapeseed
7. Cake of Safflower
8. Cake of Sesame Seed
9. Cake of Mustard
10. Flour of Mustard
11. Cake of Cotton Seed
12. Cake of Linseed
13. castor seed meal.
14. Soya Beans meal

Table 3: Proximate composition of selected oil seed cakes

Product	**DM* g/kg**	**CP g/kg DM**	**EE**	**CF**	**Ash**	**NfE**
Cotton seed cake	893	320	120	220	64	273
Linseed cake	918	347	97	150	76	330
Noug seed cake	928	303	83	273	113	229
Rapeseed cake	936	356	93	120	99	333
Soybean seed cake	953	401	81	66	62	392
Sesame seed cake	897	328	188	96	91	297

**DM=Dry matter in g/kg, CP=Crude Protein, EE=Ether Extracts, CF=Crude Fibre, NfE=N-Free Extracts*

4.0. Conclusion

Oil seed meals and cakes are importance sources of energy in animal feed. Some of these feed ingredients contain naturally occurring toxic substances and anti nutritional factors. The use of oilseeds and cake should be with caution despite their high protein content.

5.0. Summary

In this unit we have learnt about the nutritional quality of oilseeds and that the proteins in oilseeds can be fed either as oil-intact seed, or as meal or as cake. We have also learnt there are factors to consider in using oilseed meal and cake.

6.0. Tutor Marked Assignment

describe the nutritional quality of soyabean
mention two oilseed cake commonly used in animal feed
highlight the factors to consider before using oilseed

7.0. References / Further Reading

OECD/FAO (2016). Oilseeds and Oilseed Products: In OECD-FAO Agricultural Outlook 2016-2025, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/agr_outlook-2016-8-en

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Module 4 Nutritive values of some Nigerian grasses, storage and quality control of feedstuff

Unit 1 Chemistry and nutritive values of some Nigerian grasses

CONTENTS

5.0. Summary
6.0. Tutor Marked Assignment
7.0. References / Further Reading

1.0. Introduction

Grasses, even when dormant, are fair to good sources of energy for ruminant animals, but other nutrients, especially crude protein and carotene, are likely deficient when plants are dormant. Grasses are plants with jointed stems. The stems are normally hollow between the joints (node). Leaves are in two rows on the stem. Veins in the leaves are parallel. About 75% of forage consumed in the tropics is grass.

2.0. Objectives

- Explain the role of grasses in ruminant nutrition
- Nutritional quality of grasses

3.0. Main Content

3.1 Nutritional quality of grass

The performance of livestock grazing grasses is directly related to the quantity and quality offered. There are many factors that influence intake of grass, the most important being digestibility and crude protein. Digestibility is a measure of the proportion of grass that can be utilized by an animal. Grasses that are green, leafly and actively growing will have a higher digestibility than those that have dried. The crude protein of early to late vegetative stage is higher than late flowering stage. Young growing grasses have a crude protein value of 8-16 percent but most matured grasses have 3.5-8 percent.

Most tropical grasses only have energy and crude protein for maintenance only. Thus, growing and lactating animals who require higher levels of protein in their diet must have protein rich supplements included in their diets

3.2 The quality problem of tropical grasses

1. do not meet the nutritional requirements of ruminants for maximum production.
2. availability of green feed for at least half of the year in seasonally dry regions,
3. and low nutritive value during most of the season of active growth."
4. including presence of material which is unpalatable because of senescence.

3.3 Some Important Forage Species in Nigeria

Botanical Name	Common Name
Andropogon gayanus (Kunth)	Gambia grass
Cenchrus biflorus (Roxb)	-
Cenchrus Ciliaris (Linn)	Buffel grass
Pennisetum pedicellatum (Trinn)	-
Cymbopogon giganteus	-
Digitaria decumbens	Pangola grass
Digitaria smutsii	wolly finger grass
Hyparrhenia spp. (Nees) Stapf	-
Brachiaria brizantha	-
Echinocloa colonum (L.) Link.	Jungle rice
Pennisetum polystachion (Linn.) Schult	
Setaria sphacellata	Golden blue grass
Andropogonn tectorum Schum. & Thon	Giant blue stem
Cymbopogon giganteus	-
Megastachya mucronate	-
Panicum phragmatoides	-
Pennisetum purpureum Schumach	Elephant grass
Panicum maximum Jacq	Guinea grass

source

4.0 Conclusion

Grasses comprise of 75 % of forages in the tropics but need to be supplemented with protein rich diet for growing and lactating animals.

5.0 Summary

In this unit we have learnt about the nutritional value of grasses and some important Nigerian grass species have been listed.

6.0. **Tutor Marked Assignment**

- Mention two factors affecting the use of tropical grasses
- Enumerate three examples of Nigerian grasses

7.0. **References / Further Reading**

Speedy, A. and Sansoucy, R. (1991). Feeding Dairy Cows in the Tropics. Proceedings of the FAO Expert Consultation Bangkok 7-11 July 1989. FAO Animal Production and Health Paper 86

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Unit 2 Storage and Quality control of feeding stuffs and forage

CONTENTS

1.0. Introduction

Losses normally occur during storage of feeds which could be weight loss, quality loss, health risk or economic loss. These losses are caused by insects, micro organisms, animals, improper handling, physical and chemical changes. Intense insect infestation results in the growth of moulds which poses a serious health risk to animals consuming the feed. Sometimes inadequately processed feed ingredients is the cause of spoilage. Also, there is lack of quality standards for feed ingredients in most developing countries.

2.0 Objectives

- Explain the importance of storage in feedstuff and forage
- Describe quality control of feedstuff and forages
- Describe the types of processing method
- List Common Processing Methods for Roughage

3.0. Main Content

3.1 Importance of storage of feedstuff

1. It prevents contamination by insects and microorganisms eg fungi which cause staleness and mycotoxin production, discolouration
2. It prevents destruction of the grain by pest
3. It prevents quality loss of feedstuff
4. It prevents rancidity of fat components of feed e.g. fishmeal

In order to ensure good feed quality, feedstuffs need to be monitoured. Quality control involves the verification of the quality standards established for each feed ingredient. One of the advantages of quality control is that it provides knowledge of exact composition of raw materials

3.2 Quality control of feedstuff and forages

1. Visual inspection:

To ascertain level of moisture, mould infestation, presence of foreign bodies for example (scrap metals, stone) non-biological contaminants, presence of insects, signs of stale or poorly preserved ingredients, heat damage and spoilage.

2. Analyse incoming ingredients check for moisture, color, odour and texture
3. Establish rejection criteria for incoming ingredients
4. Prevent contamination of feeds
5. Frequently sample both ingredients and mixed rations
6. Check if analysis matches ration formulation
7. The mixer scale should be checked for accuracy
8. Bunker forages should be tightly packed to minimize spoilage
9. Water must be kept clean
10. Reduce bunk shoveling with good bunk management

3.3 Processing of feeds

Processing is done to

1. alter the physical form or particle size,
2. prevent spoilage,
3. improve palatability,
4. increase surface area,
5. obtain a uniform mixture of various ingredients,
6. avoid sorting by animals,
7. increase digestibility by subjecting to pre-digestion (e.g., heat processing),

3.3.1Types of processing method

This can be classified into dry and wet processing or cold and hot processing.

- cold processing methods

1. grinding:

The particles may be finely, moderately or coarsely ground. However, fine ground may lead to wind loss, tends to form ball in the GIT when mixed with saliva, reduces palatability in cattle, and reduces digestibility and absorption due to faster rate of passage in GIT. May cause ulcer in pig, feed bloat in cattle. Moderately ground feed is good for pig and poultry. Grinding of grains for cattle may probably not be necessary but sorghum has to be crushed coarsely because its waxy coats may prevent digestions. Fine ground grains for diary cattle will result in low butter, fats and milk.

2. rollermill grinding

Rollermills act on grain by compressing it between two corrugated rolls that can be screwed together to produce smaller and smaller particles. Rollermills are not used with roughages.

3. hammermills

A hammermill processes feed with the aid of rotating metal bars (hammers) that blow the ground product through a metal screen. The size of the product is controlled by changing the screen size. These mills will grind anything from coarse roughage to any type of grain. The products size will vary from particles similar to cracked grain to a fine powder. For nonruminants smaller particle size however ruminants prefer coarsely ground grains.

4. soaked grain

Grain is soaked for 12-24 hours. The soaking, sometimes with heat, softens the grain which swells during the process making a palatable product that should be rolled before using in finishing rations.

5. reconstitution

It is similar to soaking and involves adding water to mature dry grain to raise the moisture content to 25-30 percent. This procedure works well with sorghum.

6. high moisture grain

Grain is harvested at a high moisture content of (25-35%) and stored in a silo or treated with chemical to avoid spoilage. It may be ground before ensiling or

ground or rolled before feeding. This is an important method when weather conditions do not allow sun drying.

- hot processing methods

Most of these methods are associated with high cost and maintenance problem of equipment.

1. steam rolling

The steaming is accomplished by passing steam through a tower above the roller mill. The grains are subjected to steam for only a short time (3-5minutes) prior to rolling. Most results had only little or no improvement on animal performance as compared to dry rolling but use of steam does allow production of larger particles and fewer fines.

2. steam flaking

Grain is subjected to high moisture steam for a sufficient time to raise the water content to 18-20%, and the grain then rolled to produce a flat flake. This process is beneficial in term of weight gain efficiency.

3. Roasting

Maize is usually the target. The maize is passed through a roaster. The moisture constant will be reduced to about 5% but the bulkiness is increased by 15%. Results of livestock feeding trials with roasted maize used for pigs consistently shown an improvement in the rate of grain to about 812% and improvement in feed efficiency to about 9-10%.

4. cooking

It is usually done for two reasons:
To destroy the antinutritional factors in feed stuffs and to increase the utilization of starch granules present.

5. pelleting

Pelleting is accomplished by grinding the feed and then forcing it through a thick die. Feedstuffs are usually but not always steamed to some extent prior to pelleting. Pellets can be made in different diameters, lengths and harnesses and are commercially available. It is good for pig and poultry.

6. Extruding

By passing the feed through a machine with a spiral screw that forces the feed through a tapered head. Feed is ground, heated, and extended, producing a

ribbonlike product. It is being used to process whole soybean seeds or other oil seeds. Heating is enough to destroy anti-nutritional factors in soybean.

3.3.2 Common Processing Methods for Roughage

1. Bailing - Still one of the most common methods of handling roughage, and large bales are becoming more common.
2. Chopping or grinding - Provide more uniform product & can reduce feed refusal and wastage.
3. Pelleting - Usually consumed readily by ruminants, horses, and rabbits, and improve animal performance more with "low-quality" roughage.
4. Cubing - Hay is forced through dies that produce a square product (about 3 cm in size) of varying lengths & hardness. Often used for dairy cattle.
5. Dried/dehydrated, e.g., alfalfa - A substantial amount of alfalfa meal is produced. The cost is relatively high, thus used in limited amounts in pig or poultry diets as a source of carotene and vitamins.

3.4 Toxicity

This may seem a strange term to use in conjunction with feed stuffs. However, there are harmful substances which, when used at certain levels, are harmful enough to be classed as toxic. Urea is an example of a feed stuff that is potentially toxic if too much is fed at one time. If the correct amount of urea is fed, the feed stuff is very valuable. The term 'toxic' must not be confused with 'poison'.

Mycotoxins are toxic to animals, and are produced on plants by fungi, particularly during weather stress during the growing or harvest seasons or during feed storage (e.g., vomitoxin, zearalenone, aflatoxin and T-2, etc).Feed ingredients liable to have antinutritonal factors must be checked for trypsin inhibitiors and urease in soyabean products, gossypol in cotton seed, aflatoxin in corn and ground nuts , rancidity in fats.

3.5 Additives and Residues

Many feed additives must be withdrawn from feeds to ensure residue-free carcasses, and withdrawal periods before slaughter vary among additives. The main concern is sulfa residues. Some people are hypersensitive to sulfa and can develop allergic reactions.

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FAO is concerned to implement the relevant standards and guidelines of the Codex Alimentarius which relate to the safety of animal feed in these matters. Relevant Codex standards include:

- Contaminants and Toxins in Food
- Maximum Residue Limits (MRLs) for Pesticides, etc.
- Maximum Residue Limits (MRLs) for Veterinary Drugs
- International Code of Practice for Control of the Use of Veterinary Drugs
- Aflatoxins in Raw Materials and Supplemental Feeding Stuffs for Milk Producing Animals
- Labelling of Pre-Packaged Foods and the forthcoming Code of Practice for Good Animal Feeding

To this may be added the issue of environmental pollution, particularly by intensive livestock. In Europe, there is a demand for reduction in Nitrogen (and Phosphorus) excretion, which has implications for animal nutrition, particularly in the use of protein feeds.

4.0. **Conclusion**

It is important to maintain the qualtity of feed ingredients by ensuring proprer storage. Unwholesome feed ingredients will produce low quality feeds which can be harmful to the animal and man which is the end user.

5.0. **Summary**

In this unit we have learnt about the importance of storage and maintaining good quality feed ingredients. We also explained the different processing method, toxicity and residues.

6.0. **Tutor Marked Assignment**

- Explain three importance of storage in feedstuff and forage
- Briefly describe quality control of feedstuff and forages
- Mention two main types of processing method
- Define the term toxicity and feed additive residue

7.0. **References / Further Reading**

Lee I. C. (2009). Animal Nutrition Handbook Second Revision. Unpublished

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.

S/NO	Name of Feedstuffs	C.P	EE	CF	NFE	ASH
A	GREEN ROUGHAGES B	C	D	E	F	G
1	Amaranthus	11.8	4.5	22.7	49.6	11.5
2	Barley (Hardium vulgare) One month old	15.8	3.1	19.1	45.4	16.6
3	Two months old	6.6	2.4	31.1	49.1	10.6
4	Three months old	5.4	2.5	27.0	57.3	7.8
5	Cabbage leaves (Brassica oleracea var capitata)	20.0	3.5	10.3	38.9	27.2
6	Centrosema pubescens	11.8	0.7	33.8	44.7	9.0
7	Cowpea (Vigna sinesis) average	18.2	2.6	25.3	39.6	14.2
8	large variety	28.1	3.0	26.7	33.1	9.2
9	small variety	16.5	3.0	30.9	39.4	10.3
10	Crotolaria medica	19.7	-	-	-	-
11	Glycine javanica	10.1	0.7	32.7	47.8	8. 6
12	Indigofera endecaphylla	12.3	0.8	38.4	36.9	11.7

13	Ipomea pestigridis early cut	11 .4	2.2	23.8	50.4	12.2
14	late cut	12.3	3.0	26.2	48.2	10.3
15	smaller variety	10.5	3.3	25.6	47.8	13.1
16	Black gram Phaselous mungo Lucerne (Medicago sativa)	13.0	3.7	2.9	51.0	11.4
17	maximum	25.8	3.1	35.2	39.9	11.8
18	minimnm	16.8	1.3	27.0	30.2	9.4
19	average	20.2	2.3	30.1	36.6	10.7
20	1st cut	20.8	3.4	22.9	40.6	12.3
21	2nd cut	18.1	2.6	24.9	43.5	10.9
22	3rd cut	20.4	2.7	22.8	44.2	9.7
23	4th cut	20.7	3.2	18.4	47.5	10.3
24	flowering	16.9	3.5	29.0	41.8	8.8
25	1st month	24.5	2.6	16.2	41.0	15.7

26	2nd month	20.3	3.1	25.7	36.1	14.8
27	3rd month	16.0	3.5	29.7	40.1	10.7
28	Maize (Zea mays)	7.2	1.8	30.8	51.6	8.6
29	Average	12.1	1.1	29.6	44.2	13.0
30	January	8.2	0.9	27.2	51.9	11.8
31	February	6.4	0.9	29.9	51.2	11.6
32	March dough stage	5.1	1.5	26.9	59.3	7.3
33	Oats (Avena sativa) young	14.6	2.1	32.9	36.4	13.9
34	milk stage	6.4	2.3	28.7	53.2	9.3
35	ripe	9.2	1.8	34.8	44.8	9.4
36	flowering	10.8	1.8	31.0	45.9	10.4
37	green	5.3	2.5	34.2	47.1	10.9
38	1st month	18.8	3.6	18.0	37.5	22.1

39	3rd month	5.2	3.5	27.3	55.9	8.1
40	Paddy (Oryza sativa) young	7.0	1.8	25.9	47.3	18.0
41	dough stage	5.8	2.2	29.5	41.7	18.3
42	Paspalum Scrobiculatum	11.4	1.4	28.8	44.2	14.3
43	young	6.7	1.2	36.5	43.8	11.9
44	flag leaf dough stage	6.7	1.5	31.6	49.1	12.1
45	Pea (Pisum sativum) podding	11.8	1.0	29.8	48.7	8.7
46	11 1/2weeks	16.7	2.4	22.6	54.4	3.9
47	Pennisetum polystachium	5.3	2.0	34.6	45.7	12.1
48	Phaseolus aconitifolius average	11.0	1.5	31.3	43.6	12.6
49	Phaseolus calcaratus	14.5	1.1	32.2	41.6	10.8
50	Phaseolus sublobatus	13	1.1	32.8	42.9	10.1

51	Phillipesara (Phaseolus trilobus) October	17.4	1.6	23.6	45.7	14.8
52	November Ragi (Eleusine coracana)	16.3	1.5	25.0	41.6	15.7
53	Young	7.6	1.1	33.6	42.6	15.1
54	dough stage	6.4	2.1	28.8	50.3	12.4
55	Rawan (Dolichos lablab) average	16.5	3.3	25.9	41.2	13.1
56	Soybean (Glycine max) syn. G. hispida (average)	13.0	1.7	31.3	45.3	8.8
57	(G!ycine javanica)	10.1	0.7	32.7	47.9	8.6
58	Stylosathes bojeri	10.1	1.2	38.4	8.6	41.7
59	Sunflower (Helianthus annuus)	11.0	3.4	24.0	45.3	15.4
60	Sunhemp (Crototaria juncea) average	14.2	2.5	33.3	38.6	8.0
61	Sweet potato (Ipomea batatas)	17.2	3.4	19.3	43.4	16.7
62	Teosinte (Euchlaena mexicana)	4.5	1.2	32.2	51.3	10.8
62	Trifolium resupinatum	21.5	1.9	16.9	42.0	17.7
64	Trigonella foenumgraeceum	15.7	2.1	13.1	42.4	8.8

65	Velvet bean (mucuna cochinchinensis)	15.1	2.1	19.3	48.5	14.9
66	Water hyacinth (Eichhornia species) average					
67	Triticum aestivum syn. T. vulgare non-irrigated	7.3	1.3	34.7	48.0	8.7
68	Milk stage	11.2	2.6	25.7	49.9	10.6
69	Dough stage irrigated	9.3	2.3	15.3	65.8	7.4
70	Young	23.3	3.4	21.5	40.2	11.6
71	milk stage	11.8	2.0	31.8	41.4	12.9
72	dough stage	6.4	1.4	26.3	56.3	9.7
73	Aeluropus lagopoides Non saline area	5.7	2.3	33.2	44.4	14.4
74	October-saline area	4.6	2.3	29.7	47.7	15.7
75	September	5.1	2.2	29.7	17.2	15.8
76	African couch (Panicum muticum),	10.2	2.2	23.6	47.3	16.7
77	African foxtail (Cenchrus diiaris Young	7.4	-	-	-	17.1

78	Prime	8.2	-	-	-	-
79	Ripe	5.5	-	-	-	-
80	Maximum	12.0	2.3	43.6	56.8	20.8
81	Minimum	3.0	1.0	25.3	39.0	9.1
82	Average	8.4	1.7	30.5	43.3	16.1
83	Amphilophis glabra Young	5.1	3.0	30.7	51.0	10.2
84	pre flowering	5.1	2.9	32.8	47.1	12.2
85	Flowering	4.7	2.8	33.2	44.1	15.2
86	ripe	3.7	2.5	35.8	47.1	12.8
87	Amphilophis odorata Young	4.4	2.8	33.8	49.1	9.1
88	pre-flowering	3.6	3.0	31.6	52.2	10.6
89	Flowering	3.5	2.9	32.6	49.6	11.5

90	Ripe	2.3	2.6	35.4	49.5	10.3
91	Anabis multiflora average	10.9	1.6	31.4	45.5	10.7
92	Andropogon muricatus syn. of (Vetiveria zizanioldes) ripe	4.8	1.2	36.6	44.8	12.6
93	Andropogon taniger	6.1	1.8	30.5	49.2	12.3
94	Apluda aristate long variety	6.0	0.9	36.2	47.2	9.7
95	short variety	4.2	0.8	40.8	37.8	16.6
96	November	4.1	1.4	32.3	47.0	15.2
97	Apluda digitata	8.0	1.0	33.8	45.2	13.0
98	Apluda mutica 1st cut	10.2	2.0	32.3	37.0	18.5
99	2nd cut	4.6	1.2	33.6	40.7	19.2
100	3rd cut	4.1	1.7	40.2	42.0	12.1
101	Aristida depressa average	5.0	1.5	37.1	39.9	12.0
102	Aristida funiculata	2.4	1.1	33.2	53.8	9.5

103	Arundo donax	13.2	1.9	28.2	41.3	15.1
104	Australian blue stem (Bothriochloa intermedia)1st cut	3.9	1.3	38.9	40.4	9.5
105	2nd cut	3.7	1.1	37.6	48.2	9.2
106	3rd cut	2.1	1.3	37.8	50.3	8.5
107	Batiki blue (Ichaemum aristatum)	5.1	1.2	38.2	48.8	6.3
108	Bermuda grass (Cynodon dactylon)	21.9	2.7	18.6	44.1	12.6
109	Young	10.0	1.4	31.9	44.0	12.6
110	Prime ripe	4.9	1.2	39.7	46.1	8.1
111	average	10.5	1.8	28.2	47.3	11.8
112	Blue buffel grass	11.0	2.5	30.8	43.7	12.0
113	Blue panic grass (Panicum anidotale 1^{st} cut	13.9	2.7	34.6	36.4	12.2
114	2^{nd} cut	10.4	1.8	35.5	40.9	13.3
115	Boer love (Eragrostis chloromelas)	6.8	1.4	37.0	48.4	6.4

116	Brachiaria erusiformis	6.5	1.1	38.2	40.1	14.2
117	Brachiaria ramose	6.5	1.1	38.2	40.1	14.2
118	Average	6.4	1.0	32.0	47.1	13.6
119	September cut	10.7	2.0	38.2	40.1	14.2
120	October cut	14.6	1.8	29.5	42.7	11.4
121	November cut	11.7	1.1	30.0	46.2	10.0
122	Canary young grass (Phalaris minor)	10.0	3.7	21.2	38.5	17.5
123	Flowering	13.9	5.2	9.9	31.3	19.7
124	Chionachne koenigii	7.3	1.4	34.6	45.9	11.7
125	Chloris virgata	6.4	1.6	32.1	42.2	17.4
126	Chrysopogon fulvus syn. (C. montanus) 1st cut	6.1	1.2	36.8	46.1	9.7
127	2nd cut	4.6	1.2	36.7	48.8	8.7
128	3rd cut	4.4	1.2	31.6	51.6	8.7
129	Conyolvulus arvensis	13.2	2.5	20.7	55.8	7.8

130	Cymbopogon caesius average	5.9	5.2	37.1	47.0	9.4
131	Cyperus rotundus	8.9	2.4	26.7	49.4	13.0
132	Cyperus iria, ripe	6.0	0.9	32.8	51.6	8.6
133	Dactyloctenium aegypium 1st cut	8.3	2.5	35.2	40.6	13.5
134	Milk stage	7.2	1.2	33.7	45.3	12.5
135	Dactyloctenium aegyotium	5.7	1.2	27.8	49.6	15.6
136	Dallis (Paspalum dilatatum)	10.0	1.2	34.9	41.8	12.2
137	Desmodium uncinatum	12.8	3.4	29.6	45.2	9.1
138	Desmostachya bipinnata October	4.5	2.2	33.3	50.5	9.0
139	November	3.2	2.0	30.4	53.2	10.2
140	December	4.2	2.2	30.9	51.0	11.7
141	Digitaria longiflora	6.0	0.8	24.6	46.3	22.4
142	Digitaria marginata	7.1	1.2	33.6	45.0	13.3

143	Echinochloa colonum	5.2	1.8	34.8	45.7	12.4
144	Eleusine flagellifera	5.6	1.7	29.2	51.4	12.0
145	Erianthus longisetosus Early cut	8.0	2.3	35.0	45.6	9.2
146	Late cut	7.5	3.4	32.2	48.8	9.2
147	Eriochloa procera	5.8	0.6	25.3	50.9	17.4
148	Finbristylis quingu angularis	9.2	1.6	30.6	45.1	11.6
149	Giant star grass (Cynodon plectostachyus) 1st cut	12.2	1.7	26.6	45.7	11.9
150	2nd cut	9.4	0.9	30.4	48.1	11.2
151	3rd cut	7.2	0.9	32.7	51.0	8.2
152	4th cut	5.4	0.9	37.6	45.2	10.2
153	Green panic grass	10.8	1.3	44.1	34.2	9.6
154	Guinea grass (Panicum maximum)Minimum	14.4	2.7	41.8	50.0	16.1
155	Average	4.7	0.7	31.6	35.6	11.4

156	Young(average)	7.7	1.2	36.4	37.0	15.5
157	Hurricane grass (Bothrichloa pertusa)	7.9	1.2	36.4	37.0	15.5
158	1st cut	5.4	1.2	36.5	44.6	12.3
159	2nd	3.9	1.1	35.7	48.0	11.3
160	3rd cut	3.2	1.3	36.5	47.8	11.3
161	Hymenachne amplexicanlis (flowering stage)	9.4	2.3	22.1	54.3	12.2
162	Imperata cylindrical	7.0	3.3	34.0	47.6	8.3
163	Young	5.5	3.2	32.4	47.6	8.3
164	Prime ripe	3.5	1.6	39.4	48.7	6.8
165	Irrigates mayor	11.6	2.5	31.7	43.8	6.8
166	Ischaemum pilosum	7.8	1.3	43.2	39.1	10.7
167	Ischaemum rugosum	7.1	2.5	29.8	50.5	10.1
168	Iseilema anthaphoriodes	2.6	2.1	34.1	50.9	11.2
169	Iseilema laxum before flowering	5.1	1.4	31.2	47.7	11.6
170	in flowering					

		3.7	1.0	38.8	46.7	9.8
171	in seed	2.8	1.1	34.5	49.8	11.0
172	Iseilema wightii early	6.0	1.4	36.6	45.8	10.2
173	Before flowering	4.2	1.0	38.9	39.6	10.3
174	in flowering	4.1	1.1	41.1	44.5	9.4
175	in seed	3.2	1.1	37.4	47.7	10.6
176	Johnson grass (Sorghum halepense) 1st cut	10.3	2.2	35.8	43.5	8.2
177	2nd cut	5.1	1.5	36.4	47.5	9.4
178	Kikuyu grass	7.8	1.7	27.6	40.6	14.8
179	Lawn grass	7.8	2.1	25.3	53.1	11.5
180	Leersia hexandra	5.8	2.1	28.4	43.4	16.7
181	Marvel grass (Dichanthium annulatum)October cut	1.7	1.8	37.1	45.5	8.8
182	November cut	3.2	2.2	33.4	54.6	6.5
183	December cut	2.3	1.8	36.8	49.4	9.6
184	1st cut	5.2	1.6	31.4	49.7	11.8
185	2nd cut	3.8	1.2	35.0	50.1	9.9
186	3rd cut	2.7	1.0	33.3	52.8	10.3

187	Early	8.8	1.7	33.0	46.1	10.4
188	flowering	4.7	1.3	41.1	43.8	9.1
189	pre milk stage	3.1	1.1	35.2	50.5	10.0
190	milk stage	4.7	1.3	40.7	42.3	10.9
191	ripe stage	4.8	0.8	36.3	48.3	9.8
192	Micrstegium ciliatum	6.0	1.8	37.5	45.0	9.7
193	Napier, syn. Elephant grass (Pennisetum purpureum)	6.2	2.3	28.1	47.5	16.0
194	Vegetative	15.6	1.2	27.4	36.7	19.1
195	October cut	14.5	2.2	27.9	38.2	17.1
196	November cut	9.2	1.9	29.2	43.2	16.6
197	Pennisetum polystachyon October cut	11.2	2.6	28.4	41.5	16.3
198	November cut	10.2	1.8	38.5	37.4	11.7
199	1st cut	17.4	1.4	23	42.3	15.9
200	2nd cut	12.2	1.7	31.4	44.2	10.4
201	4 weeks	6.4	1.1	28.6	46.2	17.6

202	6 weeks	4.9	0.9	29.9	49.7	14.6
203	8 weeks	5.4	0.8	33	47.2	13.5
204	Napier Hybrid	10.2	2.1	30.5	41	16.2
205	Orohanchanceae sp.	8.9	1.7	11.3	68.2	9.9
206	Panicum sp.	8.0	1.4	34.8	42.7	13.1
207	Pennisetum padicellatum cut August	5.5	2.8	33.0	47.0	11.7
208	Pennisetum purpureum vegetative	15.6	1.2	27.4	36.7	19.1
209	Panicum laevifolium	5.4	1.5	40.2	42.4	10.5
210	Para grass (Brachiria mutica) in running water	12.0 6.9	2.9 0.8	28.2 35.4	45.7 46.1	11.2 10.8
211	Waterlogged	15.4	1.2	32.3	38.0	13.1
212	Paspaldium flavidum	9.1	1.2	35.8	44.8	11.3
213	P. snagainale	6.5	1.7	34.8	44.8	12.2
214	Pennisetum orientale	8.2	3.2	27.9	44.7	16.1
215	P. peciiceIlatum	7.4	2.8	22.2	49	18.6

216	Perotis indica average	2.9	1.6	35.3	44	10.1
217	Pusa giant Napier grass	2.9	1.8	37.2	52.5	7.0
218	Rhodes grass (Chloris gayana) October cut	11.9	1.5	33.5	43	10.1
219	November cut	8.5	1.7	34.7	45.1	10.0
220	Chloris gayana August	4.2	2.0	34.9	51.7	7.2
221	Cynodon dactylon	14.4	1.6	27.2	45.8	11.0
222	Rye (Lolium perenne)	1.2	3.6	13.3	63.2	7.8
223	Desrncdium scorporus August cut	15.5	3.0	29.3	42.5	9.7
224	Stylosanthes gracilis August cut	13.4	1.7	32.3	38.2	14.2
225	Hyperrhenia rufa August cut	4.4	1.8	32.3	42.0	19.5
226	Centrosema pubescens July cut	14.9	3.0	33.5	40.3	8.3
227	Setaria intemedia	8.6	1.0	37.2	39.9	13.3
228	September cut	14.5	2.0	28.1	40.1	15.3
229	October cut	12.0	2.2	33.4	37.5	14.8

230	November cut	13.6	2.0	24.5	40.9	19.0
231	Shade grass	13.3	2.5	27.5	39.1	17.5
232	Spear grass (Heteropogon controtus) average	5.2	1.8	33.8	50.1	9.1
233	Sporobolus arabicus lst cut	9.1	1.4	31.5	48.6	9.4
234	2nd cut	8.0	1.9	33.9	46.7	9.6
235	3rd cut	4.6	1.0	34.6	51 .9	7.8
236	Andropogon gayanus July cut	6.5	3.1	29.6	50.9	9.9
237	(Sorghum sudenese)	5.7	1.9	27	51	14.4
238	Festuca	8.9	4.2	24	53.7	9.2
239	Themeda cymbaria Prime	4.6	21.	37.8	49.4	9.1
240	Ripe	2.4	1.9	37.1	49.4	9.2
241	Themeda tromula	9.0	3.5	3.9	46	10.8
242	Torpedo grass (Panicum repens)	8.5	3.2	27.4	48.2	12.8
243	Tricholaena rosaea (Natal grss)	6	1.3	38.8	45.5	8.4

244	Tuber grass Urochloa pullulans	15.9	3.2	15.4	54.7	10.8
245	July cut	13.4	-	-	-	-
246	September	5.0	-	-	-	-
247	October cut	3.9	-	-	-	-
248	November cut	3.5	-	-	-	-
249	Urochloa stolonifera 1st cut	13.9	-	-	-	-
250	2nd cut	9.8	-	-	-	-
251	3rd cut	13.2	-	-	-	-
252	Veldt love (Eragrostis superba)	5.3	1.1	39.4	47.3	6.9
253	Vine (Apluda varia)	8.1	2.4	32.6	42.2	14.7
254	Weeping love (Eragrostis curvula)	5.2	1.7	36.4	45.6	11.1
255	Yellow blue stem (Andropogon ischaemum)	3.9	1.5	38.5	46.0	10.1
256	Grass mixture (average) Flowering Mature	7.0 9.0 4.9	1.2 2.1 1.7	30.2 30.1 32.4	49.0 45.9 51.5	12.6 12.9 9.4

257	Green gram (P haseolus aureus syn. P. radiates) average	13.7	2.1	28.8	46.4	8.9
258	Groundnut (Arachis hypogeal) average	9.8	0.7	34.1	48.1	7.3
	LEAVES & SHRUBS					
259	Acacia catechu	13.0	4.6	22.6	51.0	9.8
260	Acacia nilotica Average	11.0	3.8	26.7	31.4	7.1
261	Adina cord folia	9.5	4.88	14	64	7.6
262	Aegle marmelos	15.1	1.5	16.4	52.4	14.1
263	Agathi (Sesbonia grandiflora)	37.3	5.5	6.4	41	9.8
264	Albiza lebbeck (average)	21.7	3.7	31.4	36.1	9.3
265	Alfalfa leaves	28.2	2.7	14.7	39.8	14.6
266	Allmania modiflora	10.3	2.8	25.8	55.6	5.5
267	Amorphophallus campanullatus	15.3	3.3	14.2	50.9	16.2
268	Amaranthus leaves	11.8	4.5	22.7	49.6	11.5
269	Anogeissus letifolia	7.4	3.6	24.2	55.4	9.5

270	Neem Zadirachta indica (average)	17.4	3.8	17.5	51.3	10.0
271	Bamboo (dendrocalamus strictus) average	14.6	1.6	25.6	43.1	15.2
272	Banyan (Ficus benghalensis) average	9.8	2.7	21.9	53.0	12.5
273	Bassia latifolia (syn. Madhuca indica) average	9.5	3.9	19.5	60.0	7.3
274	Baubinia variegate (average)	15.7	1.8	31.9	40.8	9.7
275	Browse plant (Indigofera endecaphhylla)	8.3	1.0	42.2	35.4	13.1
276	Careva arborea	10.4	7.7	24.9	42.6	7.5
277	Castor (Ricinus conumunis)	24.3	5.4	10.3	47.1	12.4
278	Chiionachene koenigii	21.3	5.2	13.9	48.9	10.7
279	Choonkura leaves	4.3	2.5	30.7	56.6	5.9
280	Cordial dichotoma (syn. C. oblique)	15.1	1.5	16.4	52.8	14.1
281	Dalbergia sisso average	9.6	3.2	27.7	48.8	10.8
282	Date palm leaves	11.6	1.6	27.7	51.1	H8.0
283	Diospyros tementosa	7.1	2.2	25.3	56.0	9.4

284	Ehretia leavis	13.5	6.0	18.0	51.0	11.4
285	Eugenia jambolena syn. Syzygium cumini	8.8	3.1	19.8	62.5	5.8
286	Ficus glomerate	11.2	2.4	12.3	59.0	15.1
287	Ficus lacor (syn. F. infectoria) young	11.2	2.2	27.2	51.3	7.7
288	Mature	12.5	3.5	20.0	49.9	13.1
289	Autumn	7.3	2.7	25.5	50.2	14.9
290	Ficus religiosa (pipal)	9.7	2.7	27.0	45.8	14.9
291	Fig (Ficus sycomorus) average	13.3	2.9	20.6	44.9	18.1
292	Grewia oppositifolia maximum	24.9				
293	Minimum	13.1				
294	Average	20.2	3.2	21.4		
295	Holoptelea integrifolia	13.7	1.9			14.5
296	Ipomea spp	12.5	2.2	12.2	55.8	17.4
297	Jack (Artocarpus heterophyllus A. integrifolia) average	12.8	2.9	19.9	52.3	11.7

298	Kydia calycina	12.5	3.3	23.7	46.1	14.4
299	Lagerstroemia parviflora	7.8	5.7	17.3	58.2	11.1
300	Larnea coromandelica (syn.L. grandis)	11.4	4.2	16.1	59.1	9.2
301	Leucaena leucocephala (syn.L. glauca)	16.7	7.1	12.6	51.1	12.5
302	Lotus leaves	2.4	2.9	10.4	74.3	10.1
303	Mallotus philippinensis	13.4	3.6	29.7	44.6	8.9
304	Mango (Mangifera indica)	9.3	2.6	23.7	52.6	11.8
305	Mlletia auriculate	22.7	4.6	32.5	30.9	9.3
306	Mimusops hexandra	9.4	6.1	23.1	55.0	7.4
307	Moringaollifera lank (entire leaves)	17.8	5.1	9.7	56.8	10.6
308	Morinda tinctoria	15.1	2.9	22.7	47.8	11.5
309	Morus alba	15	7.4	15.3	48	14.3
310	Mytragyna parviflora	7.7	3.3	19.6	60.7	8.7
311	Nagarjuna	27.8	1.5	12	49.4	9.3

312	Odaimaram leaves	11.7	7.7	18.1	49.7	12.9
313	Onion leaves	9.5	2.6	34.6	43.9	9.4
314	Moringa oleifera	15.6	4.4	17.9	48.7	13.4
315	Plantain (Musa ssp) leaves	9.5	5.6	23.1	48.5	13.3
316	Stem	2.8	1.2	13,8	66.7	15.6
317	Bulb	8.7	2.8	2.4	47.2	17.1
318	Phyllanthus reticulatus	17.3	4.4	9.7	50.7	17.9
319	Poincia elata	25.6	7.5	7.2	46.5	13.2
320	Potato leaves	10	2.3	26.6	52.6	8.6
321	Prosopsis spcigera	15.3	3.2	17.5	54.1	10
322	Quercus dilatata	9.6	4.5	29.1	51.8	5.1
323	Quercus galuca	9.6	4.1	29.1	49.6	7.6
324	Quercus incana	10.2	4.8	31.3	48.4	5.2
325	Rubber tree	13	4.4	32.2	3.2	7.3

326	Saurania mapaulenesis	12.2	4.2	18.4	51.6	13.5
327	Shcleichera oleosa	10.4	1.9	32.3	49.2	6.2
328	Shorea robusta	10.1	3.2	27.4	55.4	3.9
329	Sugar canspith leaves	2.9	7.3	36.3	48.8	4.7
330	Sunhemp leaves	32.6	7.3	14.3	33.6	12.2
331	Tapioca (Manihot esculenta) leaves	23.0	4.8	24.4	36.2	11.6
332	Tamarindus (Tamarindus indica)	13.4	7.0	17.7	52.4	9.5
333	Monsoon lopped	11.2	5.9	18.7	55.4	8.8
334	Winter lopped	12.9	8.2	14.2	51.9	13.1
335	Summer lopped	15.2	7.2	21.4	48.5	7.8
336	Terninalia bellirica	8.6	4.7	18.6	60.1	8.0
337	Ternialia tomentosa	8.6	4.9	21.8	54.1	10.3
338	Tinosposa cordifolia	11.2	2.5	17.5	61.2	7.8
339	Wattle plant leaves	4.7	2.7	12.0	77.3	3.3

340	Ziziphus mauritiana mature Average of all seasons	8.6 15.4	1.7 2.7	30.1 14.2	48.8 56.7	10.7 10.2
341	Ziziphus mummulasia	11.5	1.6	33.8	46.8	6.2
	SILAGE					
342	Dal grass (Hymenachne amplexicaulis)	6.9	1.9	27.8	44.5	17.9
343	Grass	7.8	1.5	33.8	42.6	14.4
344	Guinea grass (Pannicum maximum)	5.2	1.5	38.7	44.6	9.9
345	Lower (Sorghum vulgare) average	5.9	1.8	37.3	44.4	10.6
346	Maize (Zea mays)	7.9	1.1	24.6	55.1	11.3
347	Oat (Avena sativa)					
348	Acid brown	7.3	1.6	40.8	40.6	9.7
349	Fruity green	8.1	3.0	39.8	39.6	9.5
350	Ragi straw (Eleusine corcane)	3.6	1.5	38.8	46.7	9.6
351	Rice straw (Oryza sativa)	5.9	1.7	30.0	47.5	11.4
352	Sisham leave (Dalbergia sissoo)	3.2	3.3	27.7	51.6	14.4

353	Spear grass (Hereropogon contortus) young prime	6.6 6.6	1.3 1.6	36.8 32.8	43.1 43.67	12.2 15.5
354	Teosinte	5.6	4.6	31.5	46.3	10.2
355	Water hyacinth silage	7.3	1.2	5.4	25.9	60.3
356	Wheat straw (Triticum aestivum)	3.5	0.5	39.4	42.1	14.6
	HAYS`					
357	African foxtail (Cenchrus ciliaris)	4.9	0.8	32.9	51.2	10.2
358	Young	16.9	1.4	28.5	40.8	10.2
359	Prime	10.0	1.2	35.3	42.6	12.7
360	Ripe	6.4	0.7	33.3	49.7	10.9
361	Post flowering	5.5	0.9	35.2	45.7	9.9
362	Alfalfa hay	14.1	1.8	31.7	41.6	10.8
363	Anthistiria anathera	1.6	1.8	39.8	49.6	7.2
364	Apluda mutica (syn. A. aristata) average	5.5	1.0	34.8	39.2	7.7

365	Australian blue stem flowering stage	4.2	1.5	43.2	42.0	9.2
366	Babbar hay	2.3	2.3	32.1	56.9	6.4
367	Bermuda grass (Cyanodon dactylon average)	8.4	1.4	20.2	56.5	11.6
368	Bolarum hay	2.8	1.4	37.0	45.4	13.3
369	Young	5.1	1.2	36.0	44.8	13.0
370	Prme	3.8	1.2	37.0	45.6	12.5
371	Ripe	2.0	1.9	38.3	48.4	9.4
372	Chloris barbata pre-flowering	6.0	1.4	30.9	48.8	11.9
373	Chrysopogon lancearius	4.7		27.6		16.3
374	Chrysopogon montanus (syn. of C. fulvus) preflowering	5.9	1.6	34.1	48.6	9.7
375	Post flowering	4.6	1.1	36.6	48.9	8.6
376	Elionerus hirsutus post flowering	5.9	0.3	38.0	44.7	11.0
377	Erianthus rovennae flowering	1.9	1.6	43.9	45.6	6.9
378	Eulaliopsis binata preflowering	4.1	1.6	38.3	49.3	7.7

379	Giant star grass hay (Cynodon plectostachys)	5.4	0.9	37.6	45.2	10.8
380	Pre-flowering	6.4	0.6	35.6	50.6	6.8
381	Guinea grass (Pannicum maximum) flowering stage	7.6	1.2	38.1	37.1	16.0
382	Hay flowering stage	4.8	1.2	42.1	39.9	12.3
383	Sporobolus arabicus hay	6.1	1.0	34.4	49.6	8.8
384	Sugar cane (Saccherum officinarum) leaves	2.6	1.4	37.2	52.7	6.1
385	Wheat (Teiticum aestivum) hay	5.1	2.3	35.1	51.3	7.2
	LEGUME HAY					
386	Barseem (Trifolim alexandinum)	14.7	1.6	30.6	41.0	12.1
387	Cajanus cajan hay	9.3	2.5	29.7	49.3	9.3
388	Cluster bean hay	25.2	0.9	13.8	43.6	16.5
389	Cowpea (Vigna Sinensis) hay	15.3	1.1	34.8	35.4	13.3
390	Cowpea large variety without pods	11.7	1.4	32.8	45.9	8.5
391	Cowpea small variety.	11.7	1.4	41.4	35.4	10.1

392	Dolichas biflorus hay	10.6	1.8	16.2	58.3	13.1
393	Gram hay (average)	12.2	2.3	33	41.8	10.2
394	Groundnut hay	21.5	1.0	245	38.2	14.8
395	Kudzurine (Pueraria lobata) hay	17.7	0.6	23.4	24.3	34.1
396	Lucerne hay	21.3	1.4	29.4	35.2	12.7
397	Pea (Pisum sativum)	10.9	1.9	29.2	50.3	7.7
398	Phaseolus aconitifolius hay	10.6	1.9	26.8	47.1	13.8
399	Soyabean hay	15.0	1.3	29.1	42.6	12.0
	STRAWS					
400	Bajra (Pennisetum typhoides) straw average	3.3	1.1	37.8	47.7	9.8
401	Bargudi bhoosa	9.7	0.7	26.9	53.7	9.0
402	Barley staks	3.0	1.0	38.6	51.3	6.1
403	Barley straw	3.2	0.9	47.4	41.4	8.1
404	Bata sad straw	6.5		47.4	41.4	8.1

405	Black gram (Phaseolus mumgo) bloom	10.1	0.4	28.8	46.7	14.2
406	Cumbu straw	1.7	1.6	23.5	52.3	10.9
407	Fleusine caracana straw average	3.7	1.1	33.0	51.2	10.7
408	Eulalia cumingil	6.9		38.7		8.5
409	Gram stalk bhoosa average	4.8	1.0	44.6	40.9	8.7
410	Groundnut straw	8.1	1.0	40.6	39.4	8.7
411	House gram straw	10.5	1.2	44.8	38.1	5.3
412	Jowar (Sorghium vulgare) straw average	3.8	1.3	35.6	51.0	8.3
413	Maize Kadbi (straw)	3.6	0.8	51.9	10.5	10.5
414	Oplismenus burmanni	1.3		20.7		14.9
415	Paddy straw, average	3.4	1.2	33.6	42.6	18.4
416	Panicum miliaceum straw average	4.5	1.2	33.1	45.8	15.3
417	Paspalum sorobiculatum straw average	2.3	1.4	34.3	48.3	12.6
418	Phaseolus aureus bhoosa	12.5	1.0	25.4	47.0	14.0

419	Phrgmites karka straw	3.8	0.8	31.1	52.0	10.8
420	Rottboellia exaltata straw	5.3	0.8	31.1	52.0	10.8
	CONCENTRATES, GRAINS, SEEDS					
421	Acacia nilotica pods average	14.1	1.9	14.9	62.4	6.2
422	Bajra (Pennisetum typhoides) graing average	11.7	5.5	1.1	78.9	2.8
423	Barley	10.1	2.0	5.0	79.4	3.5
424	Barley heads	9.9	1.1	20.2	65.1	4.7
425	Bargudi average	26.2	1.0	5.8	62.1	4.9
426	Phaseolus aureus with pods	8.9	2.8	28.0	48.0	13.1
427	Grains average	26.0	1.1	5.2	62.9	4.8
428	Phaseolus tribolus	10.0	1.0	31.2	43.4	14.4
429	Plantago ovate	20.9	2.4	31.9	36.8	8.0
430	Ragi (Elusine coracata) grains	10.3	1.2	3.7	81.0	3.9
431	Rape (Brassica compestris) grains	21.8	37.3	6.9	27.7	5.4

432	Rice	8.3	0.9	0.4	89.1	1.3
433	Rice broken	7.0	0.4	0.6	87.4	4.6
434	Samolian	11.3	0.9	0.2	86.9	0.7
435	Sesame indicum seeds	19.9	51.3	1.6	21.3	5.8
436	Sesbania bispinosa seeds	32.7	2.9	10.7	48.8	5.8
437	Soybean seeds	41.6	17.4	6.0	28.8	6.1
438	Tamarind (Tamarindus indica) seeds	18.3	7.4	26.4	44.4	3.5
439	Trigonella foenumgraecum	23.5	5.8	6.3	58.3	6.2
440	Vigna sinensis seeds	26.4	0.9		64.8	7.9
441	Wheat average	10.4	2.6	2.0	82.6	2.4
442	Wheat average	9.5	3.2	1.8	82.5	3.0
	CAKE&MEALS					
443	Cashew oil cake	23.0	3.6	1.3	80.2	7.4
444	Coconut cake (country mill pressed)	23.4	13.0	12.9	42.3	8.4

445	Coconut expeller pressed average	23.5	9.6	10.2	49.6	6.8
446	Cotton seed cake, average	40.5	9.4	18.4	38.4	10.4
447	Gingelly oil cake	34.6	7.8	6.7	37.7	13.2
448	Groundnut cake decorticated average	47.0	6.6	6.1	33.1	7.5
449	Linseed cake average	28.2	5.1	9.5	47.4	9.7
450	Linseed meal	29.9	4.1	9.8	49.4	6.3
451	Maize cake average	21.4	18.7	8.7	45.2	2.9
452	Mahua (Madhuca butyracea) cake	17.9	17.2	5.6	50.2	9.0
453	Rape (Brassioca compestris) cake, average	35.0	10.0	7.9	38.0	9.0
454	Safflower cake	42.8	8.5	15.2	26.6	6.8
455	Sesame cake (Sesamum indicum) average	42.7	6.5	5.1	33.1	12.6
456	Sesame ghani pressed	36.4	11.2	10.7	35.7	15.9
457	Soybean cake	40.9	14.4	6.1	31.3	7.3
458	Toria (Brassica compestris var. toria) cake	33.8	12.5	11.2	34.1	7.5

	BY PRODUCT					
459	Arhar (Cajanus cajan) husk average	6.3	2.1	41.5	45.3	5.0
460	Bagasse	3.1	4.2	45.1	44.7	3.0
461	Bajra (Pennisetum typhoides) husk	5.8	1.0	29.9	52.4	10.9
462	Banana stem	2.4	3.2	20.5	60.4	14.3
463	Banana sucker	7.7	5.8	48.2	22.2	16.2
464	Beef meal	80.1	10.9	0.5	35.5	3.0
465	Black gram (Phaseolus mumgo) husk average	17.0	0.7	24.6	47.2	11.0
466	Blood meal	91.2	0.6	0.6	1.6	6.0
467	Bone (Acid digested)	29.6	2.0	0.4	2.6	65.4
468	Bone meal	21.4	4.4		3.9	70.3
469	Brewery grain	19.2	3.8	13.5	59.3	4.2
470	Broth meal residue	89.3	8.3	0.0	0.0	2.4
471	Cotton pod shell powder	5.5	1.6	27.4	56.6	9.0

472	Cotton seed hull	4.4	1.0	38.0	53.9	2.3
473	Cow dung meal	15.0	4.3	12.1	45.0	23.7
474	Cowpea husk	7.4	4.7	24.6	51.3	12.2
475	Distiller grain	20.0	5.4	16.8	53.3	12.2
476	Feather meal	88.1	1.5	0.7	9.7	2.9
477	Filter press M V D sugar cane	13.6	6.0	11.8	32.6	36.0
478	Dried catfish milled	65.5	6.1	0.1	6.0	22.2
479	Dried tilapia milled	57.3	7.8	3.3	6.7	40.9
480	Spoilt fish mixed	39.9	21.8	2.3	3.0	27.1
481	Gram (Cicer arietinum) dust	17.5	2.5	27.0	47.4	5.6
482	Gram husk average	4.9	0.7	49.0	39.1	6.3
483	Groundnut husk	17.8	16.7	12.1	46.3	7.1
484	Groundnut stem average	6.2	2.4	45.7	34.6	11.1
485	Guar powder	42.2	3.7	12.3	35.1	5.9

486	Guar (Cyamposis tetragonoloba) gum	6.1	1.0	47.6	40.7	4.7
487	Hatchery waste	8.0	1.7	0.7	3.8	85.7
488	Hide fleshing	89.4	18.3	0.2	29.8	4.2
489	Intestine meal	47.6	18.3	0.2	29.8	4.2
490	Jack fruit outer coating	7.0	8.0	17.6	59.5	7.9
491	Lemon fruit peel	5.9	2.0	13.5	71.8	6.8
492	Liver meal	68.2	2.4	0.0	19.8	9.6
493	Liver residue meal	75.1	16.2	0.0	5.5	3.5
494	Maize bran	11.9	1.7	10.5	75.2	0.8
495	cobs	2.1	0.8	36.4	57.9	2.8
496	germ oil residue	7.4	36.5	0.2	55.0	0.8
497	germ oil residue	8.9	10,6	5.3	73.2	2.1
498	gluten	48.2	8.6	0.2	40.5	2.3
499	husk	8.1	1.5	15.7	72.5	2.3
500	Malt sprout	22.0	2.0	0.0	53.0	13.0
501	Mango seed kernel	6.5	11.0	4.0	77.1	2.2
502	Meat and bone meal	55.3	6.1	0.0	5.8	32.8
503	Milk tuber	8.9	8.9	36.4	38.8	7.1

504	Molasses (Khandasari)	0.9	1.2	-	93.1	2.3
505	Mung(Phaseolus aureus) husk average	13.5	1.7	20.1	52.7	12.5
506	Papayas flowers	10.0	1.3	21.2	60.0	9.4
507	Papayas male flowers	22.8	1.5	8.0	49.6	18.1
509	Penicillum mycellium residue	27.4	1.7	2.2	52.2	16.4
510	Philipesara shell	10.0	1.0	10.7	75.5	5.9
511	Plantain leathery bract	5.5	2.3	10.7	75.5	5.9
512	Plaintain flower (Musa paradesica)	9.2	5.8	9.2	64.6	11.2
513	Plantains fruit peels	7.9	5.0	8.1	77.5	0.6
514	Plain sheeth	2.8	1.1	17.4	69.2	19.6
515	Prawn head meal Prawn meal on fresh basis	30.6 45.4	9.7 -	0.3 -	2.5 -	57.0 22.1
516	Pulse bran	19.4	2.6	18.5	48.8	10.6
517	Pulse husk	11.2	1.6	26.6	47.6	13.0
518	Ragi husk	6.2	2.0	20.8	53.4	18.0
519	Ragi damaged grain	8.6	1.1	1.0	75.9	13.5
520	Rice bran average	10.4	7.5	22.6	38.1	21.5
521	Rice bran boiled (Chamba variety)	12.6	12.2	11.9	47.0	16.3
522	(Vasaramadam variety)	17.4	60.0	13.3	35.5	17.9
523	Rice bran polish average	6.1	4.5	27.4	42.0	19.9
524	Rice germ	17.8	24.0	4.1	47.5	6.7
525	Rice grit	7.8	0.5	1.6	87,7	2.3
526	Rice grit husk average	3.2	1.4	32.7	38.7	23.6.

527	Rice polish	11.6	18.9	2.1	55.6	11.8
528	Samolian	11.3	0.9	0.2	86.9	0.7
529	Silk worm pupae with filament	63.8	23.2	3.7	3.1	6.2
530	without filament	32.7	22.8	2.8	36.0	5,8
531	Skim milk powder	36.9	0.2	-	54.1	8.1
532	Snail meal	7.0	2.4	1.0	28.7	61.1
533	Spent lemon grass	6.6	1.4	34.3	51.4	6.3
534	Tapioca (Marithot esculenta) cassava	15.2	3.7	9.9	63.2	7.9
535	chips	2.9	0.4	10.9	76.2	9.5
536	flour meal	2.2	0.8	2.4	70.4	2.9
537	Wheat bran average	12.8	3.2	11.1	64.3	8.4
538	wheat husk	11.9	1.6	22.8	35.6	28.2
539	Yeast	62.4	1.3	0.1	26.8	9.46
540	extract	9.9	1.7	0.2	27.4	60.8
541	sludge	14.6	0.5	0.1	28.4	56.5
542	spent	13.9	0.2	0.0	67.4	18.5
543	yolk meal	63.8	25.7	1.0	3.4	6.1
544	Local Groundnut Cake (Kulikuli)	40.5	19.0	6.03	20.65	6.20
545	Dried Poultry litter	11.0	2.1	8.3	38.60	28.0
546	Broil. Starter cage Manure 1-5 wk	26.9	13.5	7.5	33.60	26.0

547	finisher cage manure 6-12 wk	27.2	8.9	9.50	34.0	26.0
548	Pullets/Cockerel Chicks 1-8 wks	24.2	13.0	6.00	33.00	24.5
549	Laying Chickens (20- 30 wk above	20.3	5.53	13.1	34.90	20.0
550	Extruded Soybean meal	41.5	24.3	4.90	-	3.0
551	Tilapia meal (Sarotherodon galilaeus)	57.7	1.81	5.18	-	33.6
552	Wheat flour Starch	16.00	5.6	5.00	75.00	1.20
553	Cassava tuber /Starch Starches from dehulled grains	4.80	5.10	5.00	87.60	5.00
554	Yellow Maize Starch	5.50	4.10	3.50	84.0	1.00
555	Guinea Corn	6.8	2.48	2.32	74.0	1.71
556	Cane Molasses	3.80	10.00	2.32	74.00	1.75
557	Whole Lemna paucicostata (Duckweed)	45.12	4.0	8.10	25.0	13.5
558	Saccharomyces cerevisiae Bakers Yeast)	48.25	9.00	8.90	32.00	9.7
559	Clupelds Fish Meal P. afzeluiisl	71.50	7.0	1.50	26.56	21.0