Course Name	National Diploma: Animal Production NQF 5 (249 Credits) SAQA ID: 49011
Module Name	Module 6: Livestock Production Learner Guide
Unit Standards	116430, 116382
NQF Level	5

LEARNER GUIDE

Livestock Production

Part II Animal Nutrition

Table of Contents

Dear Learner

This Learner Guide contains all the information to acquire all the knowledge and skills leading to the unit standard:

Unit standard ID:	Unit Standard Title:
116430	Apply and plan Animal Nutrition
116382	Manage an Input Chain

You will be assessed during the course of your study. This is called formative assessment. You will also be assessed on completion of this unit standard. This is called summative assessment. Before your assessment, your assessor will discuss the unit standard with you.

It is your responsibility to complete all the exercises in the Assessor Guide. The facilitator will explain the requirements of each exercise with you. You will also be expected to sign a learner contract in your assessor guide. This contract explains responsibility and accountability by both parties.

On the document "Alignment to NQF", you will find information on which qualification this unit standard is linked to if you would like to build towards more credits against this qualification.

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KEY TO ICONS

	**Important Information**
	**Quotes**
	**Personal Reflection**
	**Individual Formative Exercise**
	**Group Formative Exercise**
	**Summative Exercise**
	**Activity**

Alignment to NQF

Element of Programme	
Name of programme	Livestock Production II
Purpose of the programme	Form part of the qualification to equip learners in Livestock Production
Duration of the programme	4 days of formal facilitation; 180 notional hours
NQF level	5
NQF credits	18
Specific outcomes	See Unit Standard Guide
Assessment criteria	See Unit Standard Guide
Critical cross-field outcomes	See Unit Standard Guide
Learning assumed to be in place	See Unit Standard Guide
Essential embedded knowledge	See Unit Standard Guide
Range statement	See Unit Standard Guide

Recognition of Prior Learning (RPL)	RPL can be applied in two instances: • Assessment of persons who wish to be accredited with the learning achievements • Assessment of learners to establish their potential to enter onto the learning programme.
Learning Materials	Learner Guide, Assessor Guide, Facilitator guide, Learner PoE Workbook, US Guide
Links of the programme to registered unit standards, skills programmes, or qualifications	Registered qualification: Title: National Diploma: Livestock Production ID: 49011 NQF: Level 5 Credits: 249

Unit 1

Animal Nutrition

Unit Standard	
116430	**Apply and Manage Animal Nutrition**
Specific Outcomes	
SO1: Nutrition Theory: Understand the metabolism of nutrient components and factors influencing it. SO2: Nutrition Theory: Understand the principles of qualifying nutrient requirements. SO3: Nutrition Theory: Understand evaluation criteria for feed ingredients. SO4: Nutrition Theory: Understand and apply feed formulation principles. SO5: Nutrition Theory: Calculate feeding levels for different animal species and categories. SO6: Feed Technology: Understand en determine quality control and corrective measures in feed conservation. SO7: Feed Technology: Interpret analysis, supply and availability of ingredients and feeds in animal maintenance, stimulation and production and feed flow management. SO8: Nutrition Management: Interpret feed evaluation results for use in animal production and feed flow management.	

Learning Outcomes		
By the end of this module you will demonstrate an understanding of: • The metabolism of nutrients • The principles of nutritional requirements • The application of feed formulation principles • The analysis of ingredients in feed • Feed flow management systems		
Identifying Working Organise	Collecting Science Communicating	Demonstrating Contributing

1. NUTRIENT COMPONENTS OF FEED STOCK

1.1. INTRODUCTION

There are five board groups of essential nutrients:

- Water is involved in chemical reaction and transport of nutrients in the animal's body
- Energy feeds comprise two groups, carbohydrates and fats
- Protein feeds are essential for growth, preproduction and milk production
- Minerals for 3% of the animal's body, with phosphorus and calcium being the most important, and
- Vitamins are usually available I sufficient quantities to grazing animals

1.2 WATER

Water, the elixir of life. By far the largest percentage of the animal body, all living organisms and goring plants, consists of moisture. Even their shape or form is attributing to their moisture content. Water is of such importance to the animal that it will succumb sooner from a lack of water or thirst than from hunger. All body cells and interstitial spaces contain moisture acting as vehicle for nutrients in the body. In the same way, water or moisture in the roots of plant is the vehicle for the absorption of minerals from the soil.

The complicated biochemical reactions of bodily functions, digestion and absorption, depend upon the moisture content of plant and animal. From 75 – 85% of an animal's mass may be attributed to water, while green plants contain 70 – 90% moisture.

1.2.1 Animal Water Needs

So many factors influence water consumption by animals that accurate data for daily intake is not practical. Rough estimates are, however, necessary for the purpose of making provision for adequate supplies. Actual consumption of water would depend on the temperature, type, size or mass of the animal and its production of work and whether feed is green with high moisture content or dry with low moisture content. Water deprivation to the degree of cellular dehydration would seriously affect mass gains and feed efficiency. Young calves that have suffered from an attack of diarrhoea are classical examples of dehydration. The other extreme would be an excess of water to the degree of cerebral oedema. Disturbances may also be seen, such as laminitis in horses. The daily consumption of large amounts of feed demands a relatively greater quantity of water to be consumed by the animal for optimum function of its digestive processes. This important physiological balance may be observed in cattle grazing on poor dry veld in winter, where daily water consumption appears to be surprisingly low.

The daily intake of water was always lower in winter or dry pasture than in summer on green pasture. See table 1 below:

1. Environmental conditions in terms of temperature, humidity as well as feed succulence, can vary water consumption substantially.

2. Lactating cows consume more water proportional to their production.

3. Water conservation of mature sheep results a reduction in requirements as compared to younger animals.

Species	**Live Mass kg**	**Water Consumption Litre per day**
Cattle	160	5 -20
	340	45 - 70
	450	90 -
Horses	450	25 - 40
Sheep	10	2.5
	25	1.3
	50	1.2
Pigs	10	2
	45	4
	90	7
Poultry	100 mature birds	14

Table 1 - Approximate Water Consumption of Livestock per day

1.2.2 Water Risks

Although water is of such vital importance in nutrition it is not considered a true nutrient. Actually, pure water (H_2O) is not found as such in nature, as all ground and surface water contain impurities. The mounting problem of water pollution and its effects on animal health and production warrants intensified study.

Attention is also drawn to some of the infections that may be carried by water or dusts, such as leptospirosis, salmonellosis, hog cholera, mastitis, foot and mount disease, tuberculosis, brucellosis, histoplasmosis, ornithosis, infectious bronchitis, Newcastle disease, anthrax, blackleg foot rot, coccidiosis, blackhead of turkeys, erysipelas and transmissible gastroenteritis.

Although all coliform bacteria are not pathogens, their count in water has for many years ben used as indication for infectious bacterial potential.

The sulphates, fluorine, nitrates and chlorine have probably received most attention in subterranean water supplies.

Water for animal consumption should not contain more than 5000 ppm total dissolved solids (TDS);

Na^+2000,	$NO\text{-}_3$400
Ca^{++}1000	CI^-3000
Mg^{++}500	$So_4$1000
$Hco^-_3$500	F^-6,0 ppm

$MgSO_4$ and Na_2SO_4 may not be more than 50% of the TDS. Even these levels are excessive for certain situations.

Upper limits according to the species are quoted in Table 2. When water contains more than 5000 ppm (0.5% of TDS), it becomes less acceptable to animals and is actually liable to upset the electrolyte balance, with consequent productive performance.

	Human	Livestock	Poultry	Units
Alkalinity	30 - 500	<2000		mg//
Aluminum	<0,2	<5,0	<5,0	mg//
Ammonia (as N)	<0,5			mg//
Antimony	<0,0002			mg//
Arsenic	<0,05	<0,05	<0,02	mg//
Barium	<1,0	<1,0		mg//
Boron	<5,0	<5,0		mg//
Cadmium	0.001	<0,01		mg//
Calcium	200	<1000	35 - 600	mg//
Cesium – 137	<50			Bg/l
Chloride	<250	<1000	<14 - 200	mg//
Chromium	<0,05	<0,05		mg//
Cobalt		<1,0		mg//
Copper	<1,0	<1,0	<0,6	mg//
Cyanide	<0,20	<0,20		mg//
Fluoride	<1,5	<1,2	<2,0	mg//
Hardness ($CaCO_3$)	180	<2000	<2000	mg//
Iodine		<1,0		mg//
Iodine -131	<10			Bg//
Iron	<0,3	<0,4	<0,4	mg//

Lead	<0,05	<0,05	<0,1	mg//
Magnesium	150	<1000	<35 - 350	mg//
Manganese	<0,05	<0,05	<0,05	mg//
Mercury	<0,001	<0,003		mg//
Molybdenum	<0,25	<0,06	<0,25	mg//
Nitrogen (from NO_2+NO_3)	<10	<23	<11	mg//
Nitrate (NO_3)	<44	<100	<50	mg//
pH	6,5 - 8,3	5,5 - 8,3	6,4 - 8,0	unit
Phosphate (total P)	<0,1	<0,7		mg//
Potassium	<10	<20	<300	mg/4
Radium	<1,0			Bg//
Residue – total	<1000	<7000	<1000	mg//
Total fixed	<1000	<7000	<1000	mg//
Filterable	<1000	<7000	<1000	mg//
Selenium	<0,01	<0,01		mg//
Silver	<0,05			mg//
Sodium	<10	<800	<50	mg//
Specific conductance		<3000	<1000	µs/c
Strontium – 90	<10			Bg/4
Sulphate	<250	<500	30 - 50	mg//
Sulphide (as H_2S)	<0,05			mg//

Uranium	<0,02			mg//
Vanadium		0,1		mg//
Zinc	<5,0	<5,0	<2,5	mg//

Table 2: Drinking Water Quality – Recommended Maximum Levels

Source: Animal Nutrition, Concepts and Applications, PA Boyazoglu, Revised Edition

1.3. PROTEIN

The most important requirements of animals are the supply of Energy and Protein. Protein is broken down and absorbed in the digestive tract of the animal in a simpler form, the amino acids. The amino acids are the building blocks of specific proteins and the DNA of a cell determines the ratio and quantities of amino acids that are needed to build each specific body protein. Before a protein can be built by a cell, the correct quantities and ratios of amino acids must be available to that cell to build the protein. If one of the amino acids needed is not available, the protein will not be produced, and the remaining amino acids will be broken down and used as energy.

1.3 1 Crude Proteins

True protein refers to substances which as chemically pure such as amino acids but does not include non-protein nitrogen compounds such as urea, ammonia and nitrates. The total or crude protein content of feeds is a useful indication of their nutritional value, especially as the protein in nitrogenous feeds such as oilcake meals, fish-meal, milk powders, legumes and cereals are more readily available to the animal than the lower digestibility generally obtained in proteins from fibrous roughages, often encased in lignine.

1.3.2 Amino Acids

All peptides and polypeptides are polymers of alpha-amino acids. There are 20 alpha-amino acids that are relevant to the makeup of mammalian proteins. Several other amino acids are found in the body free or in combined states. These non-proteins associated amino acids perform specialized functions. Several of the amino acids found in proteins also serve functions distinct from the formation of peptides and proteins for example tyrosine is important in the formation of thyroid hormones or glutamate acts as a neurotransmitter. The alpha-amino acids in peptides and proteins (excluding proline) consist of a carboxylic acid (-COOH) and an amino (-NH2) functional group attached at the same tetrahedral carbon atom. This carbon atom is the alpha-carbon atom. Therefore, the twenty amino acids are called the alpha-amino acids (It is not necessary to know the structures of the amino acids.) The important aspect that must be known is that there are amino acids and that these amino acids are roughly classified into essential and non-essential amino acids.

Although there are more than 20 amino acids the important ones in the rations of animals are the ones needed to build the different proteins in the body or body structure, as well as the functions that build protein out of these amino acids.

Essential Amino Acids

These are the amino acids that mono-gastric animals need in their ration to satisfy the amino acid requirements of their diet. It is important that these amino acids be included in the correct ratios to make sure that the amino acid "building blocks" are available to build certain proteins. For instance; if a wool fiber is manufactured by the cell it needs the sulphur containing amino acid methionine as a building block. So, if the diet of the animal does not supply the amino acid then wool protein cannot be formed. The essential amino acids play an important role in the synthesis of several proteins and are needed in the correct quantities in the rations of mono-gastric animals. However, although the ruminant has the same amino acid requirements, the way the ration of a ruminant is digested is different. The ruminant does not only make use of his or her own enzymes for digestion but also uses microbial digestion. The microbes in the rumen can synthesize certain amino acids out of non-protein nitrogen sources. This enables the animal (ruminant) to be less dependent on external essential amino acids in their diet. The essential amino acids are:

Valine	Methionine
Leucine	Arginine
Isoleucine	Lysine
Threonine	Histidine
Phenylalamine	Tryptophan

There are also two amino acids that some people consider as also essential or that may be essential for some animals and these are:

Cysteine	Tyrosine

Non-Essential Amino Acids

The other eight alpha-amino acids are:

Glycine	Asparagine
Alanine	Glutamic acid
Serine	Glutamine
Aspartic acid	Proline

These alpha amino acids are also important building blocks of proteins, but the body can modify the structure of the essential amino acids to form the non-essential amino acids. The feeds of pigs, poultry and other mono-gastric animals are supplemented with the necessary amino acids when an imbalance or shortage is found in a mixed feed. Pure amino acids are expensive so the person compiling a ration will make use of natural protein rich feed sources and supplements for the initial balancing and will only supplement the pure amino acids in small quantities where it can play a big role. This is done merely to make the feed as inexpensive as possible (This is called "least cost" feed formulation). The amino acids that are supplemented will be small amounts and are mixed with the minerals and vitamins that are also small amounts. Do you remember how to mix small amounts of feed ingredients into large amounts of mixed feed?

1.3.3 Protein Concentrates

There are a lot of feeds that are considered "protein rich". However, they differ in quality. As a rule, you can consider any protein feed of animal origin such as fishmeal, carcass meal and blood meal as protein supplements with a high-quality protein. The presence of essential amino acids in them is good. Dry milk powder is also a protein supplement with a good quality protein.

Protein supplements of animal origin are more expensive and also less abundant. There are also very good protein supplements available of plant origin. In the processing of certain grains and plant seeds for oil a by-product is produced that is a good protein supplement. These plant protein sources are mostly cheaper and more available than animal protein supplements. Examples include:

- Soya bean oil cake meal
- Peanut oil cake meal
- Sunflower oil cake meal
- Canola oil cake meal; and
- Other oilcake meals like cottonseed oil cake meal.

There are also other by-products with protein content higher than 10 % but these have a lower quality protein. These include the by-products of the milling companies such as wheaten bran and pollard.

1.3.4 Non-protein Nitrogen

The micro-organisms in the rumen of ruminants have the ability to synthesize amino acids and therefore, proteins out of non-protein nitrogen sources such as urea. Urea supplies the nitrogen needed by the micro-organisms to synthesize amino acids. Only small amounts of urea should be added to a mixed ration since there are limits to the amount of protein that can be replaced by non-protein nitrogen. Also, urea can be poisonous if too much is used in the ration and also if the ration gets wet in rainstorms. The urea in the ration can dissolve very easily in the water and if the animal drinks the water it may die of urea poisoning. Due to the action of the ruminal microbes, ruminants are efficient at utilizing the protein within high quality roughages such as Lucerne and other legume roughages. Most of their protein requirements can be met through such roughage rations.

1.3.5 Alternative Protein Sources

Chicken litter is sometimes used as a protein source for ruminants because of its high urea content. However, this practice is not recommended unless the feed is sterilized, and the ruminant herd has been vaccinated against botulism.

1.4. ENERGY

Carbohydrates, fats and lipids are the main sources of energy of farm animals. The animal needs energy for maintenance, growth and production functions.

1.4.1 Carbohydrates

Carbohydrates are found in very small quantities in animals. Most animals store carbohydrates in the cells of the liver in the form of glycogen. Plants however are a very rich source of carbohydrates. The most common place where a lot of carbohydrates are found is in the seeds of the plants in the form of starch. Some plants like sugar cane, sugar beet and even the sweet maize plant contain high quantities of sugars in their stems. Carbohydrates include:

- Starch
- Glycogen
- Cellulose
- Hemicellulose
- Sugars:
  - Mono-saccharides (glucose, fructose, galactose)
  - Di-saccharides (sucrose, maltose, lactose)
  - Poly-saccharides (hexose, pentose)

Cellulose and hemicelluloses are resistant to digestive processes and their energy content is locked up and can only be utilized by animals that use microbes to help them with their digestion. Fermentation in the rumen of ruminants and the caecum and colon of horses and rabbits' results in the production of short-chain fatty acids (acetate, propionate, and butyrate). These end products also result from the fermentation of sugars and polysaccharides. Fatty acids are absorbed by the reticulo-ruminal epithelium (stomach lining). Acetic acid is absorbed most rapidly, followed by propionic and butyric acids. Volatile fatty acids contribute approximately 60% of all the energy metabolised by the ruminant animal. The volatile fatty acids enter into the metabolism in various ways. Propionic acid is converted into glucose and stored as glycogen. Acetic acid may be formed into body fat, oxidised to provide energy, or converted to glucose and stored as glycogen.

Butyric acid and acetic acid are important sources of milk fat. The sugars and starches also supply energy to the farm animal (Less than 5% of the metabolizable energy is derived from these sources). As mentioned above, sugars and starches are also broken down in the rumen by microbial fermentation and volatile fatty acids are formed.

Since the microbes are responsible for digestion in the rumen, it should be remembered that it is actually the micro-organisms that are being fed rather than the animal. This is often forgotten in the feeding management of ruminants. When changes in the feed occur, the microbial population in the rumen changes. Some micro-organisms increase in number if the feed source that they prefer is provided while others will decrease in number since their feed source is not being supplied. Because of this continuous adaptation of the microbial population to the feed provided, it should be remembered that new feeds should be introduced to ruminants over a week to two-week period. This allows the microbial population time to adapt to the new feed source. If sudden complete shifts are made in the diet, the microbial population will die. Acidosis is a disease condition resulting from poor feed management. Lactic acid bacteria occur in the rumen naturally but in very small numbers (about 0.01% of all the rumen bacteria). If a large amount of a concentrate feed (such as maize) is fed suddenly, then the lactic acid bacteria multiply very rapidly, reaching numbers as high as 30% of the total rumen microbial population. This leads to the production of excesses of lactic acid and reduces the pH in the rumen to less than 5. This massive increase in acidity leads to several metabolic disturbances in the animal such as dehydration, acidic body fluids, rumen stasis, the death of all the other rumen micro-organisms, damage to the rumen wall and hemorrhaging, abscesses in the liver, formation of endotoxins, and inflammation of the intestinal tract. The mono-saccharides are readily absorbed by simple diffusion in the small intestine. The amylase enzymes are responsible for hydrolyzing the more complex sugars to their simple free derivatives. Thus, the disaccharide sucrose is converted to fructose and glucose, maltose is converted to glucose, and lactose is converted to galactose and glucose. The amylase enzymes found throughout the digestive tract digest the polysaccharides such as starch and glycogen. However, as mentioned above, cellulose and hemicellulose has beta-linked glucose units or pentose and hexose units, respectively, but no animal secretes the enzyme which can hydrolyze these beta-linkages. Thus, digestion of cellulose and hemicellulose in ruminants is dependent on microbial action.

1.4.2 Fats

Fat digestion begins in the duodenum (small intestine) when the triglycerides come into contact with pancreatic lipase and bile-salts. Triglycerides (the most abundant of the dietary lipids) are emulsified to glycerol and monoglycerides, free fatty acids and diglycerides. The monoglycerides and fatty acids combine with bile salts and sodium to form a micellar solution in the lumen of the small intestine. The lipid micelles enter the inter-microvillar spaces of the intestinal tract allowing the monoglycerides and fatty acids to enter the cells. Once inside the intestinal mucosal cells, the long-chain free fatty acids and monoglycerides are re-esterified back into triglycerides. They are then coated with a layer of lipoprotein, cholesterol and phospholipid to form chylomicrons which are carried away by the lymph system. Short-chain fatty acids merely pass from the mucosal cells directly into the portal blood where they are transported to the liver as free fatty acids.

Definition:

Hydrolyzed: Hydrolyzed means the breaking of a chemical bond by addition of a water molecule.

1.5. MINERALS

Mineral imbalances and deficiencies can cause sub-optimal production and reproduction even when there is an abundant feed supply. At least 15 mineral elements are nutritionally essential for ruminants. There are seven major or macro minerals (Ca, P, K, Na, Cl, Mg and S) and eight trace or micro minerals (Fe, I, Zn, Cu, Mn, Co, Mo and Se). An excess of Cu, F, Mn, Mo or Se can also cause toxicities. Toxicities can also occur where excess arsenic, lead, cadmium, mercury or aluminium, occurs. The macro elements like calcium, phosphorus and magnesium forms the structural part of the skeleton of an animal. Phosphorus also has a central role in the energy metabolism of the animal. Copper is essential for the functioning of a wide variety of enzymes and a shortage thereof results in symptoms that vary from anaemia to a lowering of fertility to a loss of crimp in wool. Cobalt forms part of Vitamin B12 which is essential for the utilization of propionic acid.

Group Activity 1:

The class will be divided into two equal-sized groups. One group of learners will research the role of minerals in the functioning of the body and the other group will research the role of vitamins in the body. Each group must name and describe the roles of each nutrient, as well as symptoms of their deficiency. **A representative from each group will present the group findings in class at a date to be decided.**

The following is a list of the essential minerals and their approximate concentrations in the body:

Macro Elements		Micro Trace Elements	
Calcium Phosphorus	1,55%	Iron	20 - 80 ppm
Potassium Sodium	1,00%	Zinc	10 - 50 ppm
Chlorine	0,20%	Copper	1 - 5 ppm
Sulphur Magnesium	0,16%	Manganese	0.2 - 0.5 ppm
	0,11%	Iodine	0.3 - 0.6 ppm
	0,15%	Cobalt	0.02 - 0.1 ppm
	0,04%	Molybdenum	1 - 4 ppm
		Selenium	

1.6 VITAMINS

The vitamins are a group of organic substances found in feeds and which are essential for health. The quantities required vary between microgram and milligram sixes and some of them are synthesised in the body to satisfy part or all of the body requirements.

1.6.1 Essential Vitamins

Some vitamins play a major role in mineral metabolism. For example, Vitamin D is important for the mineralization of calcium into the bone structure. Phosphorus plays an important role in the transfer of energy in the body. It is also a very important part of the skeleton and along with calcium forms the main mineral components of bone. The following is a list of the important known vitamins. They are divided into two groups:

Fat Soluble Vitamins	Water Soluble Vitamins
Vit A	Vit B1 (Thiamine)
Vit D	Vit B2 (Riboflavin)
Vit E	Vit B6 (Pyridoxine)
Vit K	Niacin Pentatonic acid
	Biotin Folic acid
	Vit 12 (siano cobalimine)
	Inositol
	Vit C (Ascorbic acid)

The animal body can synthesize some vitamins. These include Vitamin K and the B vitamins. All other vitamins need to be supplied via external sources. Humans, apes, other primates and guinea pigs especially have an important Vitamin C requirement, which if left unchecked can lead to a condition called scurvy.

The vitamins commonly recognised as being of biological significance to domestic animals are tabulated in the table 3 below to clarify nomenclature and to indicate the site of activity.

Alphabetic Classification	Chemical Classification	Site of Action
Vitamin A_1	Retinol	Epithelia and rod vision
Vitamin A_2	Dehydroretinol	
Vitamin D_2	Ergocalciferol	Skeletal development
Vitamin D_3	Cholecalciferol	

Vitamin E	Alpha tocopherol	Anti-oxidant in cell metabolism fertility
Vitamin K_1	Phylloquinone	Haemorrhage prevention
Vitamin K_2	Farnoquinone	
Vitamin K_3	Menadione	
Vitamin B_1	Thiamine (aneurine)	Energy metabolism
Vitamin B_2	Riboflavine	Energy metabolism
Vitamin PP	Nicotinomide / Nicotinic acid	Energy metabolism
Vitamin B_5	Pantothenic acid	Anti-dermatitis and other epithelia
Vitamin B_6	Pyridoxine	Energy metabolism / Blood formation
Vitamin B_9	Folic acid / Pteroylglutamic acid	Red-cell formation
Vitamin B_{12}	Cyanocobalamin	Red-cell formation
Vitamin B_{12b}	Hydroxocobalamin	
Vitamin B_{12c}	Nitritocobalamin	
Vitamin B	Choline chloride	Lipotropic
Vitamin B	Para-aminobenzoic acid	Growth of micro-organisms
Vitamin B	Inositol	Lipotropic
Vitamin H	Biotin	Protein and energy metabolism
Vitamin C	Ascorbic acid	Intercellular bonding

Table 3: Vitamin Nomenclature and Site of Activity

Source: Animal Nutrition, Concepts and Applications, PA Boyazoglu, Revised Edition

1.6.2 Vitamin A

Vitamins are used extensively in balanced rations and are available from chemical and microbiological production procedures in a stabilized form. The increasing production and reproduction capabilities expected from the intensive farming of livestock have accentuated their needs. Addition rates however still remain at levels measured in micrograms and milligrams per kg of body mass per day.

There is no vitamin A in plant material. Pro-vitamin A, better known as beta-carotene is found in green plants in variable amounts with a limited shelf-life during hay-making and storage. This pro-vitamin act as an antioxidant which functions increases the animal's resistance to infectious diseases. Prolonged deficiency will disadvantage fertility by lowering oestrus intensity, delaying ovulation and precipitating embryo death and desorption. The requirements are usually adequately supplied by the dietary intake of green grass by herbivores. Carotenoids also act as pro- vitamin A sources and are found as lutein and zeaxanthin, the yellow pigments of maize and green feeds.

When inadequate, growth is retard and epithelia become dry and lose suppleness. Reproduction is disadvantaged, and infectious disease susceptibility is increased. Daily requirements are dependent on the level of productivity but could be 100 - 200 IU/kg body mass. Surplus intake or surplus conversion from carotene to vitamin A results in storage in the liver.

Some specific diseases and parasites which have been found to disturb vitamin A metabolism are:

- Infectious diseases: foot and mouth, tuberculosis, fowl cholera, Newcastle disease; Cosyza; fungal diseases.
- Parasitic diseases: protozoal diseases - lamblia, plasmodia and coccidia. Worms - ascaridia, lung worm, liver fluke etc.
- Other diseases - liver and kidney diseases, intoxications, hyperkeratosis, acetonemia, gastro-intestinal inflammation or catarrh.

1.6.3 Vitamin D_3

Natural Sources are sun-dried green roughage (D_2) and irradiation from the sun on the animal body (D_3).

Vitamin D is essential for the absorption of dietary calcium and phosphorus from the intestine, their metabolism and deposition in the skeletal structure and excretion ***via*** the kidneys. When inadequate young growing animals develop rachitis adult's osteoporosis, growth disorder of its and tooth defects.

1.6.4 Vitamin E

Vitamin E is a vitamin of significance, regulating the metabolism of carbohydrates, creatine, muscle and glycogen, gonad development, reproduction, anterior pituitary hormone production, immunoglobulin response to disease challenge and liver protection. Of special note is its antioxidant action which stabilises fatty acids in cellular metabolism and is synergistic and protective of vitamin A and the pro-vitamin As. With some species differences as to their relative efficacy, this antioxidant effect of vitamin E is significant on the cellular membrane whereas selenium incorporated glutathione peroxidase is found intracellular and also acts as an antioxidant.

Deficiency symptoms of vitamin E are varied appearance. Degenerative myopathy of locomotory muscles in lambs and calves has been the symptom which led to the naming of the condition as "white muscle disease". Damage to the myocardium can result in sudden cardiac arrest with subendocardial haemorrhages which describe the condition as "mulberry heart disease" in pigs. Fertility of male and female animals is decreased is the hatchability of eggs.

1.6.5 Vitamin K_3

This is also known as the anti-haemorrhagic vitamin. Synthesis of menaquinone (K_2) takes place by the bacteria in the digestive tract. Synthetic menadione (K_3) is a stable form used in animal feeds.

Its actions are linked with blood coagulation, maintaining normal prothrombin formation and cellular metabolism. When inadequate the animal is prone to haemorrhage due to delays in clotting time.

1.6.6 Vitamin B_1

Thiamine is also known as the anti-beriberi factor. It is found in cereals and their by-products, milk and yeast. It is commercially available as thiamine hydrochloride. It is a regulator of carbohydrate metabolism, the neural tissue and myocardium, is beneficial to the gastro-intestinal tract and its functions. Deficiency retards growth produces nervous symptoms and results in cerebro-cortical necrosis in lambs and calves. Requirements range 2 - 4 mg/ kg of feed, with higher levels being appropriate in high energy rations as in feedlots.

1.6.7 Vitamin B_2

Riboflavin is present in feed ingredients of animal origin and yeast but not in by-products. It is beneficial in the metabolism of proteins and fats. Inadequate dietary presence retards growth and in poultry results in curled toe paralysis. Dietary needs are 4 -12 mg/kg with the higher levels appropriate for energy rations.

1.6.8 Vitamin B_6

Pyridoxine is present in substantial quantities in grains, their by-products and yeast but not in animal products. It is of importance in the metabolism of protein, fat and carbohydrates, as minerals.

When inadequate there is growth retardation, inflammation of the skin and central nervous symptoms. In poultry, egg production and hatchability are reduced. Feed supplementation is 3 – 6 mg per kg feed. Suiphonamides and antibiotics elevate the dietary needs.

1.6.9 Vitamin B_{12}

Cyanocobalamin is the animal protein factor available in a synthetic powder form. It is present in feedstuffs of animal origin and yeast culture. Together with folic acid it plays an important role in red-blood cell synthesis and protein metabolism. When inadequate, growth is retarded, and anaemia is evident. Whereas adult bovines synthesise adequate cyanocobalamin in the rumen when cobalt is present, the rate of synthesis is inadequate for calves as many cyanocobalamin-like substances are also synthesised which use up cobalt. Requirements range between 15 and 30 µg per kg feed.

1.6.10 Biotin

Vitamin H is found in a range of feed ingredients such as soya beans, animal proteins and maize. It is associated with fatty acid synthesis, gluconeogenesis and protein synthesis. When inadequate there is retardation of growth and reproduction poor feathering, fatty liver and inflammation of the beak, toes and shanks of poultry. Inflammation and cracks of hooves in pigs and horses.

Requirements of biotin are 100 — 350 µg per kg feed. Ruminants, however, synthesise this vitamin adequately in the rumen and do not need supplementation as do poultry, pigs and dogs. Horses hooves are also reputed to benefit from biotin supplementation under certain conditions.

1.6.11 Folic Acid

Vitamin B_9 or pteroyl glutamic acid is present in most feed ingredients and especially in yeast, lucerne, soya beans and fish-meal. It plays an important synergistic role with B_{12} and C in red-blood cell and haemoglobin synthesis as well as immunoglobulin formation. Deficiency symptoms in poultry are slowed growth, poor feathering and reduced hatchability. Perosis and crossed beaks. Anaemia is seen in other species. Supplementation of 0, 5 - 1 mg per kg feed is generally effective. Folic acid synthesis in the rumen meets the nutrient needs from endemic sources.

1.6.12 Nicotinic Acid

Niacin is also known as the anti-pellagra factor and is found in most feedstuffs of plant origin, yeast, and green feed and animal protein. Small quantities are synthesised in the digestive tract and from the conversion of L-tryptophan. As a Constituent Of coenzymes, it is involved in the metabolism of carbohydrates, fats and proteins of all cells. It is also involved in skin and the digestive system disorders. When deficient there are skin and digestive system disorders. Poultry have feather development deviations, reduced egg production and poor ferity, inflammation of mucosa and ulceration. Poultry also develop perosis and dogs' black tongue. These are preventable by 30 - 80 mg addition of niacin per kg of feed. Additions are recommended to all domestic animal diets.

1.6.13 Choline

This is an essential nutrient available as choline chloride and though discussed with the vitamins is classified by some nutritionists separately. It is found in virtually all feed ingredients but especially in animal proteins, yeast and oilcakes. It is necessary for the synthesis of phospholipids and fat metabolism. Its role in acetyl choline synthesis links it to the functioning of the nervous system. It is a methyl group donor like the amino acids, lysine and methionine, and can be synthesized from serine and methionine in the presence of B_{12} and folic acid.

Symptoms of deficiency are found on high fat, high-energy rations and include fatty liver, skeletal malformations, perosis in poultry, splayed legs in pigs and growth retardation. Nutrient needs are met by 1000 – 2000 mg/kg feed.

In the concentrated form it has a destructive effect on other vitamins and premix manufacturers are prone to package it separately.

1.6.14 Vitamin C

Ascorbic acid is found in green feed and is also synthesised by farm livestock. It is however a labile vitamin being broken down readily by trace minerals acting as catalysts. In the body it acts in hydrogen transfer for oxidation reduction. It is active in the synthesis of steroid hormones and blood clotting. It is reputed to improve resistance to infectious diseases and stress. It benefits the well-being of collagenous tissues. When inadequate it reduces growth rate and reproduction, susceptibility to infections increases and there is weakening of mucosal intercellular cement resulting in spontaneous bleeding.

Supplementation of vitamin C to farm animal rations is not normally recommended. With severe heat stress laying hens may benefit from supplementation with 50 mg per kg feed.

2. NUTRIENT REQUIREMENTS OF FARM ANIMALS

2.1 INTRODUCTION

The nutrient requirements (quantity and quality) of different animals differ depending on:

- Their species
- Their breed
- Their age
- Their sex
- Their production potential
- Their stage of production
- Whether they are ill or healthy
- The product they produce (whether wool, meat, milk etc.)

These factors will influence the nutrient requirements of animals throughout their lives. In general, nutrient requirement tables indicate the nutrient requirements of different age animals for their maintenance requirements as well as for different levels of production. Production indices could include growth, milk production, gestation (pregnancy) or fibre production.

2.2 FEED FORMULATION

The cost of feed generally makes up approximately 70% of the costs of a livestock operation. Whether the farmer is producing the feed on the farm or purchasing the feed from outside sources, feed provision to the herd carries a cost. Feed formulation is the process whereby the farmer estimates the nutrient requirements of his animals, and then determines which feeds are required to provide for those requirements at the least possible cost. To do this the farmer will obviously need to know:

- What feeds he currently has available?
- The quantity and quality of the available feeds.
- The nutrient requirements of his/her animals.
- The stage of production and level of production of his/her animals (high milk producers vs. low milk producers or dams carrying singles or dams carrying twins).
- The shortages in nutrients that may occur.
- Which feed resources can be used to supplement the shortages?
- The costs of feed production, mixing, supplementation or outright purchase (including costs of transport and storage).
- The seasonality of feed production and seasonality of feed purchase.

Since feed is the greatest input cost in a livestock operation, one of the main management functions of a livestock farmer is to manage, control and monitor the management of feed to ensure efficient utilisation with little wastage at minimum cost and highest production. Feed management is not a once off event but a daily management task on the livestock operation. To effectively control the costs of this input every farming enterprise should have a well-designed feed flow program in place.

Definition

A maintenance ration: A maintenance ration is one, which provides sufficient nutrients for the maintenance of the essential processes of life. The animal will remain in good health without a decrease or increase in body mass. Maintenance requirements are mainly dictated by the body mass of the animal.

A production ration: A production ration is one which provides nutrients over and above the maintenance ration to ensure the production of a certain product. Products include growth (meat), milk, young and fibre.

Various "Nutrient Requirement" tables are available. These differ mainly in the manner in which the nutrient requirements of the various animals were determined but are essentially the same. The feeding standards presently used include the:

- National Research Council (NRC) USA.
- Agricultural Research Council (ARC) Britain.

To interpret the tables, the farmer needs to know how old the animal is, how much it weighs, and its stage of production. For example, the animal in question may be a mature ewe, weighing 60 kg, with twins in the first 8 weeks of gestation. The tables will provide the nutrients (dry material, metabolizable energy, and crude protein) required by the animal at the specific stage of production. The required nutrients may be given as:

- Quantity per animal per day.
- Percentage of the total ration.
- Quantity per kg of the ration.

While reading and interpreting Nutrient Requirement tables is an important skill, a farmer should inherently know that there are certain periods of an animal's life when improved nutrition is required. Such periods include:

- During mating
- In order to obtain a high conception rate or increased multiple offspring the female should be in good condition during the mating season. Flush feeding assists to increase the ovulation rate (multiple ova are released).
- The last six weeks of gestation - The nutritional requirements of the female increase drastically during this period because most of the development of the foetus occurs during this time. Poor nutrition during this period may lead to metabolic disturbances such as ketosis (domsiekte) in the female or the birth of small lambs/calves which are weaker.

- The first eight weeks of lactation - The female has the greatest nutrient requirements during this time since the young is almost totally dependent on the female during this period.
- Active growth stage of the young animal - A high quality feed should be fed to young animals because the requirements for growth are high and the rumen capacity at this stage is still a limiting factor. Poor nutrition during this stage can lead to permanent stunting of the animal. Differences of nearly 20 percent in mature body mass were obtained as a result of differences in nutritional treatment prior to four months of age. Also, the influence of pre- and postnatal treatments were additive. This means that if the mother is fed well in the last few weeks of pregnancy, and the young that are born are strong, then, if the young are also fed well up to weaning, the final result will be even stronger and healthier offspring.

Although it may seem logical that some periods of an animal's life have lower nutrient requirements, do not be fooled! For example, during the dry period a pregnant dairy cow needs to build up reserves in the form of fat, muscle, tissue and bone for the stressful high production period to follow. Also, although the production of fibre does not necessarily require increased nutrient supply, feed provision/nutrient supply should be **constant** to avoid breakages or weak areas in the fibre. Since sudden changes in weather can negatively affect feed intake, fibre producing animals should be fed slightly above maintenance requirements to ensure a buffer for sudden stressful periods which may negatively influence fibre quality.

In Nutrient Requirement Tables the Units for Protein and Energy are expressed as follows:

Crude Protein

Crude Protein is an estimate of the percentage of protein that is contained in a feed based on the analysis of N contained therein. Some tables also present protein as Digestible Protein. That is the part of the ration that is assimilated by the animal when the food is digested. This value will usually be lower than the estimate of Crude protein, since some protein may not be nutritionally available to the animal, although it is present in the feed. Digestible protein is of particular importance to dairy farmers who need more accurate estimates of a feed's protein content, since milk production is dependent on adequate protein provision.

Energy

Energy values of food are presented as either total digestible nutrients (TDN) or Metabolizable Energy ME. The TDN is expressed as a percentage of the ration. Energy is expressed in (ME) Mega Joules per kilogram of metabolizable energy.

2.3 NUTRIENT REQUIREMENTS

Sheep and goats are kept primarily under extensive farming conditions, making use of lower-cost roughage sources which fluctuate substantially in production according to area and rainfall. Management styles are very different when comparing the arid Karoo, with its typical short bush an interspersed grasses dependent on 250 mm rain and less, to management styles used in the eastern Highveld, with its extensive grasslands and grain production capabilities due to a rainfall of 600 mm and over in normal years.

The majority of sheep and goat producing farms are based on low-cost pastoral grazing. It is obvious, therefore, that a satisfactory return on investment would be achieved only where land price and productivity are proportionately competitive.

2.3.1 Digestive System of Sheep

The digestive tract in the pig and dog is comparatively simple, although differences occur in digestive juice secretions.

However, in both species' saliva is secreted by the parotid gland, submaxillary and sublingual glands. The saliva contains the starch-splitting enzyme ptyalin. Gastric juices in the stomach are secreted by the pyloric and fundus glands which form a villous coating.

The digesta is strongly acid and contains lactic and afterwards, hydrochloric acid. Breakdown is accomplished by the action of enzymic hydrolysis. Monogastrics are less versatile in assimilating food and are dependent on regular intakes of a complete range of nutrients.

Pepsin is secreted in the mucus membranes of the stomach to hydrolyse proteins. From the pancreas is secreted trypsin and chymotrypsin, carboxypeptidase, amino peptidase and di-peptidase from the small intestine, all for protein hydrolysis.

Fats are hydrolysed by stomach lipase and pancreatic lipase.

Glucosides are hydrolysed by such enzymes as maltase, lactase, sucrase and glucosidase from the small intestine.

Most of the digestion in these animals takes place in the stomach, and the overflow in the small intestine. While the starches and sugars are digested first, the proteins take longer to be digested. The chief area for absorption is the small intestine. Actually, fibre is poorly utilised by pigs, dogs and cats.

The pig is, however, capable of limited bacterial fermentation in order to cope with grazing and a limited consumption of lucerne hay.

2.3.2 Water Needs for Sheep

The daily access to water for drinking purposes is a basic need not infrequently neglected, especially in the semi-arid sheep country. Judging from appearances, it would sometimes seem as if the only available water to sheep in the area is the morning dew.

The water consumption of sheep is influenced by many factors, such as ambient temperature, rainfall, activity, wool covering, age, succulence of feed, plane of nutrition and lactation. Sheep that suffer from thirst will eat less, lose mass and naturally produce less milk for their lambs.

Pregnant ewes, fed on a high plane of nutrition twice as much water as ewes fed at a maintenance level.

When on dry winter-veld grazing the water consumption of sheep is much less than when the same sheep receive adequate rations. However, a good policy is to provide about 5 l of water per sheep per day.

Due to the possibilities of internal parasitic infections, open, muddy watering places should be avoided. In the arid sheep areas it is advisable to have the borehole waters checked in order to ascertain whether harmful mineral salts are present.

2.3.3 Feeding Sheep

Because wool growth is a continuous process, maintenance and sub maintenance feeding would apply only in abnormal circumstances where it has been decided to forfeit the fleece and try to save the animal from dying of poverty. These terms would, therefore, be more applicable to mutton types of sheep or valuable breeding animals.

It appears that the daily total protein needed by Merino ewes weighing 35 kg would be about 75 - 80 g. The digestible protein level would be about 55 g per day.

The digestible energy need is approximately 2.5 – 3.0 MCal per day. Actually, ordinary mature flock sheep fare satisfactorily on a daily intake of 1.5 MCal.

The daily phosphorus requirements as given in the NRC tabulations are considered to be liberal as 1 – 1.5g P per sheep per day gives best results locally.

If it is assumed that a small flock Merino ewe weigh 32 kg and produces a fleece of 3.6 kg per annum, or about a yield of 6 g clean wool per day, plus a lamb for which she gives 1l milk daily, her daily nutritional needs would be met by 68 g of crude protein, 3 MCal, 1 g of phosphorus (P), 8 g of common salt (NaC1). The requirements, however, escalate in bigger framed sheep with a higher growth and reproductive capacity.

The increase in requirements of the ewe, from maintenance to pregnancy and eventually to lactation, escalates the requirements manifold. Furthermore, the lamb, at half the body mass of the ewe, at maintenance level, has nutrient requirements which are more than double per kg of body mass.

Under maintenance conditions for ewes, the nutrients supplied by natural grasses are adequate or almost adequate. However, when production and reproduction requirements are taken into consideration, the situation changes substantially. Either these increases in requirements are met or productivity declines.

On pasture or veld grazing a lack of energy is to occur. This is due to various factors such as insufficient feed intake during winter or droughts, unacceptability of hard, lignified, low-quality roughage, even if a sufficient amount of such poor roughage were to be consumed, its lower digestibly would result in an energy deficiency in the animal.

In the case of sheep that are required to walk while grazing on pastures or in the veld, the energy requirement is estimated to be 24 — 77% (NRC) higher than for stall-fed sheep.

A low level of energy intake is probably one of the main causal factors for the general light mass of Merino sheep on the open range. Such low energy levels result in low fertility, weak lambs, poor milking ability of ewes and their frequent refusal to suckle their lambs. Susceptibility to disease infection and internal parasite infections is also more common in underfed sheep.

In stressing the value of energy supplementation, a warning should be sounded that in doing so the level of other nutrients should be raised as well for best results to be obtained. From observation and experience sheep, are able to subsist on 112 g of maize for a comparatively long period during a drought.

The above simple formulation is mixed with a shovel on a concrete floor and placed in cut-drums in the camps for easy access by the grazing sheep. The inclusion of the small amount of molasses or maize meal is to assure acceptability. A rate of voluntary intake of approximately 20 g per sheep is anticipated.

When the pasture declines, due to colder months and lowered rainfall, it becomes necessary to increase the supplementation rate by reducing the salt content and increasing the number of ingredients.

2.3.4 Ration Balancing for Sheep

The following calculation shows how to balance a ration for sheep by utilising low quality roughage and a high protein concentrate. We are interested in formulating a ration for an ewe that is in her first eight weeks of lactation with a single born

Definition:

HPC: HPC stands for High protein concentrate.

For the purposes of the calculation presented here a number is provided (in brackets) associated with each value. Let the facilitator help you with that when you do the activity. The ration should include HPC40 if the preliminary ration does not include at least 60% of a legume roughage (see tip for selecting of preliminary ration). Utilise Table 1 The Nutrient Requirements of sheep and Table 2 Composition of Feedstuffs.

Feed Tables

Table 1:

Daily nutritional requirements of sheep, NRC standards (1975)

Body Mass (Kg)	Increase or Decrease (g/d)	Dry Material Intake (kg)	Crude Protein (%)	TDN (%)	Metabolizable Energy (ME)(MJ/kg)
Ewes Maintenance					
50	10	1.0	8.9	55	8.2
60	10	1.1	8.9	55	8.2
70	10	1.2	8.9	55	8.2
80	10	1.3	8.9	55	8.2
Non-lactating and first 15 weeks of pregnancy					
50	30	1.1	9.0	55	8.2
60	30	1.3	9.0	55	8.2
70	30	1.4	9.0	55	8.2
80	30	1.5	9.0	55	8.2
Last 6 weeks of pregnancy or last 8 weeks of lactation of ewes with one lamb (1)					
50	175 (+45)	1.7	9.3	58	8.7
60	180 (+45)	1.9	9.3	58	8.7
70	185 (+45)	2.1	9.3	58	8.7
80	190 (+45)	2.2	9.3	58	8.7

First 8 weeks of lactation of single lamb ewes or last 8 weeks of lactation for ewes with multiple lambs (2)					
50	-25 (+80)	2.1	10.4	65	9.7
60	-25 (+80)	2.3	10.4	65	9.7
70	-25 (+80)	2.5	10.4	65	9.7
80	-25 (+80)	2.6	10.4	65	9.7
First 8 weeks of lactation for ewes with multiple lambs					
50	-60	2.4	11.5	65	9.7
60	-60	2.6	11.5	65	9.7
70	-60	2.8	11.5	65	9.7
80	-60	3.0	11.5	65	9.7

In brackets is applicable to last 8 weeks of lactation of single lamb ewes.

In brackets is applicable to last 8 weeks of lactation for multiple lamb ewes.

Table 2: Feed Composition Tables

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Alfalfa cubes	91	57	18	29	46	2
Alfalfa dehydrated 17% CP	92	61	19	26	45	3
Alfalfa fresh	24	61	19	27	46	3
Alfalfa hay early bloom	90	59	19	28	45	2.5
Alfalfa hay midbloom	89	58	17	30	47	2.3
Alfalfa hay full bloom	88	54	16	34	52	2
Alfalfa hay mature	88	50	13	38	59	1.3
Alfalfa seed screenings	91	84	34	13		10.7
Alfalfa silage	30	55	18	28	49	3
Alfalfa silage wilted	39	58	18	28	49	3
Alfalfa leaf meal	89	60	26	16	34	3
Alfalfa stems	89	47	11	44	68	1.3
Almond hulls	89	56	3	16	36	3.1
Ammonium chloride	99	0	163	0	0	0
Ammonium sulfate	99	0	132	0	0	0
Apples	17	70	3	7	25	2.2

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Apple pomace wet	20	68	5	18	36	5.2
Apple pomace dried	89	67	5	18	38	5.2
Artichoke tops (Jerusalem)	27	61	6	18	41	1.1
Avocado seed meal	91	52	20	19		1.2
Bahiagrass hay	90	53	6	32	72	1.8
Bakery product dried	90	90	11	3	30	11.5
Bananas	24	84	4	4		0.8
Barley hay	90	57	9	28	65	2.1
Barley silage	35	59	12	34	58	3
Barley silage mature	35	58	12	30	50	3.5
Barley straw	90	44	4	42	78	1.9
Barley grain	89	84	12	5	20	2.1
Barley grain, steam-flaked	85	90	12	5	20	2.1
Barley grain steam-rolled	86	84	12	5	20	2.1
Barley grain 2-row	88	84	12	5	20	2.2
Barley grain 6-row	87	84	11	6	20	2.2
Barley grain lt.wt. (42-44 lb/bu)	88	78	13	9	30	2.3

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Barley feed pearl byproduct	90	74	15	12		3.9
Barley bran	91	59	12	21	36	4.3
Barley grain screenings	89	71	12	9		2.6
Beans navy cull	90	84	24	5	20	1.4
Beans pinto	90	75	25	5	7	1.5
Beet pulp wet	17	77	9	20	45	0.7
Beet pulp dried	91	76	9	21	46	0.7
Beet pulp wet with molasses	24	77	11	16	39	0.6
Beet pulp dried with molasses	92	77	11	17	40	0.6
Beet foot (sugar)	23	80	4	5	16	0.4
Beet tops (sugar)	19	58	14	11	25	1.3
Beet top silage	25	52	12	12		2
Bermudagrass coastal dehydrated	90	62	16	26	40	3.8
Bermudagrass coastal hay	89	56	10	30	73	2.1
Bermudagrass hay	89	53	10	29	72	1.9

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Bermudagrass silage	26	50	10	28	71	1.9
Birdsfoot trefoil fresh	22	66	21	21	47	4.4
Birdsfoot trefoil hay	89	57	16	31	50	2.2
Biuret	99	0	248	0	0	0
Blood meal, wwine/poultry	91	66	92	1	10	1.4
Bluegrass KY fresh early bloom	36	69	15	27	60	3.9
Bluegrass straw	93	45	6	40	78	1.1
Bluestem fresh mature	61	50	6	34		2.5
Bone meal steamed, swine/poultry	95	16	13	1	0	11.6
Bread byproduct	68	90	14	1	3	3
Brewers grains wet	23	85	26	13	45	7.5
Brewers grains dried	92	84	25	14	49	7.5
Brewers yeast dried	94	79	48	3		1
Bromegrass fresh immature	30	64	15	28	54	4.1
Bromegrass hay	89	55	10	35	66	2.3

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Bromegrass haylage	35	57	11	36	69	2.5
Buckwheat grain	88	75	12	13		2.8
Buttermilk dried	92	88	34	5	0	5
Cactus, prickly pear	23	61	5	16	28	2.1
Calcium carbonate	99	0	0	0	0	0
Canarygrass hay	91	53	9	32	67	2.7
Canola meal, solv. ext.	91	71	40	12	27	2.7
Carrot pulp	14	62	6	19	40	7.8
Carrot root fresh	12	83	10	9	20	1.4
Carrot tops	16	73	13	18	45	3.8
Cattle manure dried	92	38	15	35	55	2.5
Cheatgrass fresh immature	21	68	16	23		2.7
Citrus pulp dried	90	78	7	13	21	2.9
Clover ladino fresh	19	69	25	14	35	4.8
Clover ladino hay	90	61	21	22	36	2
Clover red fresh	24	64	18	24	44	4
Clover red hay	88	55	15	30	51	2.5

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Clover sweet hay	91	53	16	30	50	2.4
Coconut meal, mech. ext.	92	76	21	13	56	6.8
Coffee grounds	88	20	13	41	77	15
Corn whole plant pelleted	91	63	9	21	40	2.4
Corn fodder	80	65	9	25	48	2.4
Corn stover mature (stalks)	80	54	5	35	70	1.3
Corn silage milk stage	26	65	8	26	54	2.8
Corn silage mature well-eared	34	72	8	21	46	3.1
Corn silage sweet corn	24	65	11	20	57	5
Corn grain whole	88	88	9	2	10	4.2
Corn grain rolled	88	88	9	2	10	4.2
Corn grain, steam-flaked	85	93	9	2	9	4.1
Corn grain high moisture	74	93	10	2	9	4
Corn gGrain, high oil	88	91	8	2	8	6.9
Corn grain hi-lysine	92	87	12	4	11	4.4
Corn and cob meal	87	82	9	9	26	3.7

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Corn cobs	90	48	3	36	88	0.6
Corn screenings	87	87	9	3	10	3.8
Corn bran	91	76	11	10	51	6.3
Corn germ meal	90	74	27	11	50	3
Corn germ, full-fat	93	135	12	6	36	44.9
Corn gluten feed	90	80	23	10	37	3.2
Corn gluten meal 41% CP	86	56	46	5	30	3.2
Corn gluten meal 60% CP	91	89	67	3	10	2.4
Corn cannery waste	29	68	8	28	59	3
Cottonseed, whole	91	93	23	26	47	19.8
Cottonseed, whole, delinted	90	95	24	19	40	22.9
Cottonseed, whole, extruded	92	87	26	32	53	9.5
Cotton gin trash (burrs)	91	42	9	35	70	2
Cottonseed hulls	90	45	4	48	89	1.7
Cottonseed meal, solv. ext. 41% CP	90	77	46	13	28	1.6

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Cottonseed meal, mech. ext. 41% CP	92	79	46	13	31	5
Crab waste meal	91	29	32	11		3
Crambe meal, solv. ext.	91	81	31	25	47	1.4
Crambe meal, mech. ext.	92	88	28	24	42	17
Cranberry pulp meal	88	49	7	26	54	15.7
Crawfish waste meal	94	25	35	12		
Curacao phosphate	99	0	0	0	0	0
Defluorinated phosphate	99	0	0	0	0	0
Diammonium phosphate	98	0	115	0	0	0
Dicalcium phosphate	96	0	0	0	0	0
Distillers grain, barley	90	75	30	16	44	8.5
Distillers grain, corn, dry	91	95	30	8	44	9.5
Distillers grain, corn, wet	36	96	30	8	44	9.5
Distillers grain, corn with solubles	91	96	31	9	30	10.8
Distillers grain, corn with solubles, low oil	90	92	31	10	31	7.4

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Distillers dried solubles	93	87	32	4	22	13
Distillers corn stillage	7	92	22	8	21	8.1
Distillers grain, sorghum, dry	91	84	33	13	44	10
Distillers grain, sorghum, wet	35	86	33	13	43	10
Distillers grain, sorghum with solubles	92	85	33	12	42	10
Elephant (napier) grass hay, chopped	92	55	9	24	63	2
Fat, animal, poultry, vegetable	99	195	0	0	0	99
Feather meal hydrolyzed	93	67	87	1	42	7
Fescue KY 31 fresh	29	64	15	25	64	5.5
Fescue KY 31 hay early bloom	88	60	18	25	64	6.6
Fescue KY 31 hay mature	88	52	11	30	73	5
Fescue (red) straw	94	43	4	41		1.1
Fish meal	90	74	66	1	12	9
Flax seed hulls	91	38	9	32	50	1.5

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Garbage municipal cooked	23	80	16	9	59	20
Glycerol (glycerin)	88	90	0	0	0	0
Grain screenings	90	65	14	14		5.5
Grain dust	92	73	10	11		2.2
Grape pomace stemless	91	40	12	32	54	7.6
Grass hay	88	58	10	33	63	3
Grass silage	30	61	11	32	60	3.4
Guar meal	90	72	39	16		3.9
Hominy feed	89	89	11	6	19	5.8
Hop leaves	37	49	15	15		3.6
Hop vine silage	30	53	15	21		3.1
Hops spent	89	35	23	26		4.6
Kelp dried	91	32	7	7		0.5
Kenaf hay	92	48	10	31	56	2.9
Kochia fresh	29	55	16	23		1.2
Kochia hay	90	53	14	27		1.7
Kudzu hay	90	54	16	33		2.6

FEEDSTUFF	**DRY MATTER %**	**ENERGY TDN %**	**PROTEIN CP %**	**FIBER CF %**	**NDF %**	**EE %**
Lespedeza fresh early bloom	25	60	16	32		2
Lespedeza hay	92	54	14	30		3
Limestone ground	98	0	0	0	0	0
Limestone dolomitic ground	99	0	0	0	0	0
Linseed meal, solv. ext.	91	77	39	10	26	1.9
Linseed meal, mech. ext.	91	82	37	10	24	6
Meadow hay	90	50	7	33	70	2.5
Meat meal, wwine/poultry	93	71	56	2	48	10.5
Meat and bone meal, swine/poultry	93	72	56	1	34	10
Milk, dry, skim	94	87	36	0	0	0.9
Mint slug silage	27	55	14	24		1.8
Molasses beet	77	75	8	0	0	0.2
Molasses cane	77	74	6	0	0	0.5
Molasses cane dried	94	74	9	2	7	0.3
Molasses, cond. fermentation solubles	43	69	16	0	0	1

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Molasses citrus	65	75	9	0	0	0.3
Molasses wood, hemicellulose	61	70	1	1	4	0.6
Monoammonium phosphate	98	0	70	0	0	0
Mono-dicalcium phosphate	97	0	0	0	0	0
Oat hay	90	54	10	31	63	2.3
Oat silage	35	60	12	31	59	3.2
Oat straw	91	48	4	41	73	2.3
Oat grain	89	76	13	11	28	5
Oat grain, steam-flaked	84	88	13	11	30	4.9
Oat groats	91	91	18	3		6.6
Oat middlings	90	91	16	4		6
Oat mill byproduct	89	33	7	27		2.4
Oat hHulls	93	38	4	33	75	1.6
Orange pulp dried	89	79	9	9	20	1.8
Orchardgrass fresh early bloom	24	65	14	30	54	4

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Orchardgrass hay	88	59	10	34	67	3.3
Pea vine hay	89	59	11	32	62	2
Pea vine silage	25	58	16	29	55	3.3
Pea vine straw	89	51	7	41	72	1.4
Peas cull	88	85	23	7	12	1.4
Peanut hulls	91	22	7	63	74	1.5
Peanut meal, solv. ext.	91	77	51	9	27	2.5
Peanut skins	92	0	17	13	28	22
Pearl millet grain	87	82	13	2	18	4.5
Pineapple greenchop	17	47	8	24	64	2.4
Pineapple bran	89	71	5	20	66	1.5
Pineapple presscake	21	71	5	24	69	0.8
Potato vine silage	15	59	15	26		3.7
Potatoes cull	21	80	10	2	4	0.4
Potato waste wet	14	82	7	9	18	1.5
Potato waste dried	89	85	8	7	15	0.5
Potato waste wet with lime	17	80	5	10	16	0.3

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Potato waste filter cake	14	77	5	2		7.7
Poultry byproduct meal	93	79	62	2		14.5
Poultry manure dried	89	38	28	13	35	2.1
Prairie hay	91	50	7	34	67	2
Pumpkins, cull	11	80	15	14	30	8.9
Rice straw	91	40	4	38	72	1.4
Rice straw ammoniated	87	45	9	39	68	1.3
Rice grain	89	79	8	10	16	1.9
Rice polishings	90	90	14	4		14
Rice bran	91	71	14	13	24	16
Rice hulls	92	13	3	44	81	0.9
Rice mill byproduct	91	39	7	32	60	5.7
Rye grass hay	90	58	10	33	65	3.3
Rye grass silage	32	59	14	22	59	3.3
Rye straw	89	44	4	44	71	1.5
Rye grain	89	80	14	3	19	2.5
Safflower meal, solv. ext.	91	56	24	33	57	1.3

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Safflower meal dehulled, solv. ext.	91	75	47	11	27	0.8
Safflower hulls	91	14	4	58	90	3.7
Sagebrush fresh	50	50	13	25	38	9.2
Sanfoin hay	88	61	14	24		3.1
Shrimp waste meal	90	48	50	11		5.5
Sodium tripolyphosphate	96	0	0	0	0	0
Sorghum stover	87	54	5	33	65	1.8
Sorghum silage	32	59	9	27	59	2.7
Sorghum grain (milo) ground	89	82	11	3	17	3.1
Sorhum grain (milo) flaked	82	90	11	3	17	3.1
Soybean hay	89	52	16	33	55	3.5
Soybean straw	88	42	5	44	70	1.4
Soybeans whole	88	92	41	8	15	18.8
Soybeans whole, extruded	88	93	40	9	15	18.8
Soybeans whole, roasted	88	93	40	9	15	18.8
Soybean hulls	89	74	12	40	65	1.7

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Soybean meal, solv. ext. 44% CP	89	84	49	7	15	1.5
Soybean meal, solv. ext. 49% CP	89	87	54	4	10	1.1
Soybean mill feed	90	50	15	36		1.9
Spelt grain	88	75	13	10	21	2.1
Sudangrass fresh immature	18	70	17	23	55	3.9
Sudangrass hay	88	57	9	36	67	1.8
Sudangrass silage	31	58	10	30	64	3.1
Sunflower meal, solv. ext.	91	64	39	20	36	2
Sunflower meal with hulls	91	57	32	27	45	1.9
Sunflower seed hulls	90	40	4	52	73	2.2
Sugar cane bagasse	91	39	1	49	86	0.6
Tapioca meal, cassava byproduct	89	82	1	5	34	0.8
Timothy fresh pre-bloom	26	64	11	31	59	3.8
Timothy hay early bloom	88	59	11	32	63	2.7
Timothy hay full bloom	88	57	8	34	65	2.6

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Timothy silage	34	59	10	34	70	3.4
Tomatoes	6	69	16	9		4
Tomato pomace dried	92	64	23	26	55	10.6
Triticale hay	90	56	10	34	69	
Triticale silage	34	58	14	30	56	3.6
Triticale grain	89	85	14	4	22	2.4
Turnip tops (purple)	18	68	18	10		2.6
Turnip roots	9	86	12	11	44	1.6
Urea 46%N	99	0	288	0	0	0
Vetch hay	89	58	18	30	48	1.8
Wheat fresh, pasture	21	71	20	18	50	4
Wheat hay	90	57	9	29	66	2
Wheat silage	33	59	12	28	62	3.2
Wheat straw	91	43	3	43	81	1.8
Wheat sraw ammoniated	85	50	9	40	76	1.5
Wheat grain	89	88	15	3	14	2.8
Wheat grain hard	89	88	14	3	14	2

FEEDSTUFF	DRY MATTER %	ENERGY TDN %	PROTEIN CP %	FIBER CF %	NDF %	EE %
Wheat grain soft	89	88	12	3	12	2
Wheat grain, steam-flaked	85	91	14	3	12	2.3
Wheat grain sprouted	86	88	12	3	13	2
Wheat bran	89	70	17	11	46	4.4
Wheat middlings	89	75	17	9	38	4.7
Wheat mill run	90	76	17	9	37	4.5
Wheat shorts	89	78	19	8	30	5.3
Wheatgrass crested fresh early bloom	37	60	11	26	50	1.6
Wheatgrass crested fresh full bloom	50	55	10	33	65	1.6
Wheatgrass crested hay	92	54	10	33	65	2.4
Whey dried	94	82	14	0	0	0.9
Yeast, brewer's	92	79	47	3		0.9

Source: http://beefmagazine.com/nutrition/2015-feed-composition-tables-know-nutritional-value-your-feed

Table 3: Maximum percentage low energy roughage (7.5 MJ/Kg ME) in ration when the ration more or less provides in the energy requirements.

Energy Requirement		
ME MJ/KG	PERCENTAGE ROUGHAGE	
7.5	100	**N.B.** When HPC 60 is used, use 5% less roughage in ration. When using higher energy roughage e.g. Eragrostis hay, use 5% more roughage in the ration.
7.75	95	
8.0	90	
8.25	85	
8.5	80	
8.75	75	
9.0	70	
9.25	65	
9.5	60	
9.75	55	
10.0	50	
10.25	45	
10.5	40	
10.75	35	
11.0	30	
11.25	25	
11.5	20	

PRACTICAL APPLICATION

Step 1:

What are the nutrient requirements of this sheep? Look in Table 1. Nutrient requirements of sheep.

A sheep of 50kg in her first 8 weeks of lactation with a single lamb requires:

Crude protein requirement = 10,4 % **(1)

Energy requirement = 9,7 MJ/KG ME **(2)

Step 2:

Look at the nutritive value of feedstuffs (Table 2)

Feedstuff	**Crude Protein Content**	**Energy Content MJ/KG ME**
Maize Stover (roughage 1)	4 ** (3)	7.5 (4)
Maize Stover (roughage 2)	- (5)	0.0 (6)
HPC (with urea) 60	60 (7)	5.3 (8)
Maize meal	9 (9)	12.5 (10)
HPC (without urea) 40	40 (11)	9.0 (12)

Step 3:

Select a preliminary ration and determine its nutritive value.

Total roughage content of preliminary ration (See Table 3: App A) 50%

Ratio of roughage 1	50 % (13)
Ratio of roughage 2	-- % (14)
Ratio of HPC (6,5 of 10%)*	6.5 % (15)
Ratio of maize meal: 100 – (50(13) + .?. (14) + 6.5(15))	43,5 % (16)

Composition and nutritive value of preliminary ration A

Feedstuff		% CP
Maize Stover (roughage 1)	50 (13) ÷ 100 x 4 (3)	2.0 (17)
HPC 1 60	- (14) ÷ 100 X – (5)	0.0 (19)
Maize meal	6.5 (15) ÷ 100 X 60 (7) OR (11)	3.9 (21)
Total	43.5 (16) ÷ 100 x 9	3.92 (23)
		9.82 (25)
Feedstuff		**ME MJ/KG**
Maize Stover (roughage 1)	50 (13) ÷ 100 x 7.5 (4)	3.75 (18)
HPC 1 60	- (14) ÷ 100 X – (6)	0.0 (20)
Maize meal	6.5 (15) ÷ 100 X 5.3 (8) OR (12)	0.34 (22)
Total	43.5 (16) ÷ 100 x 12.5	5.44 (24)
Metabolisable Energy		9.53 (26)

Deficit							
Crude protein deficit	10.4	(1)	-	9.82	(25)	=	0.58% (27)
Energy deficit	9.7	(2)	-	9.53	(26)	=	0.17% (28)

Step 4:

Correct energy deficit of preliminary ration and test its nutritive Value %

Maize Meal replacing roughage with lowest energy content: 0.17 (28) x 100 ÷ (12.5 - 7.5 (4)) = 3.4% (29)

Quantity roughage with lower energy content 50.0 (13) – 3.4 (29) = 46.6% (30)

Quantity maize meal 43.5 (16) + 3.4 (29) = 46.9% (31)

Nutritive value of preliminary ration B

Feedstuff		**% CP**
Maize Stover (roughage 1)	46.6 (30) ÷ 100 x 4 (3)	1.86 (32)
Maize Stover (roughage 2)	- (14) ÷ 100 X – (5)	0.0 (19)
HPC 1 60	6.5(15)	3.90 (21)
Maize Meal	46.9 (31) ÷ 100 x 9	4.22 (34)
Total		9.98 (36)
Feedstuff		**ME MJ/KG**
Maize Stover (roughage 1)	46.6 (30) ÷ 100 x 7.5 (4)	3.50 (33)
Maize Stover (roughage 2)	- (14) ÷ 100 X – (6)	0.0 (20)
HPC 1 60	6.5(15)	0.34 (22)
Maize meal	46.9 (31) ÷ 100 x 12.5	5.86 (35)
Total		9.70 (37)

Deficit:	Crude protein deficit	10.4 (1)	-9.98 (36)=0.42%	(38)
	Energy deficit	9.7 (2)	-9.70 (37)=0 MJ/KG	(39)

Step 5:

Correct the protein of the preliminary ration and test and test its nutritive value % Urea free HPC replacing roughage with lowest energy content

0.42 (38) x 100 ÷ (40 (11) - 4 (3)) = 1.2% (40)

Quantity roughage with lower energy content

46.6 (30) - 1.2 (40) = 45.4% (41)

Composition and nutritive value of final ration

Feedstuff		**% CP**
Maize Stover (roughage 1)	45.5 (41) ÷ 100 x 4 (3)	1.82
Maize Stover (roughage 2)	- (14) ÷ 100 X – (5)	0.0 (19)
HPC 1 60	6.5(15)	3.90 (21)
Maize meal	46.9 (31)	4.22 (34)
HPC 2 (Urea free)	1.2 (40) ÷ 100 x 40 (11)	0.48
Total		10.42
Feedstuff		**ME MJ/KG**
Maize Stover (roughage 1)	45.5 (41) ÷ 100 x 7.5 (4)	3.41
Maize Stover (roughage 2)	- (14) ÷ 100 X – (6)	0.0 (20)
HPC 1 60	6.5(15)	0.34 (22)
Maize meal	46.9 (31)	5.86 (35)

HPC 2 (Urea free)	1.2 (40) ÷ 100 x 9 (12)	0.11
Total		9.72

Tips for the Selection of a Preliminary Ration

Legume hay more than 50% of roughage: Leave HPC from preliminary ration. Legume hay only source of protein:

- Legume hay should then constitute at least 60% of the roughage.
- Legume hay replaces urea free HPC in step 5. Add calculations 14 and 40.

Hay other than legume hay:

- Include HPC in preliminary ration.
- HPC with urea, use a maximum of 6.5% HPC.
- HPC without urea, use 10% HPC.

Preliminary estimation of energy in ration: Table shows the low energy content roughage (7.5 MJ/kg ME) in the ration with corresponding expected energy content of the ration.

- When HPC 60 is used, use 5% less roughage.
- When higher energy content roughage (8.1 + MJ/kg ME) is used, use 5% more roughage.
- Prevent disturbances: Roughage should preferably be not less than 40% and definitely not below 20%.
- Protein and energy should rather be slightly over supplied rather than under supplied.

When silage is given to sheep:

- Calculate the ration on a dry basis.
- Multiply the quantity (%) by three to get it on an as fed basis.
- The ratios will then be in kg and not percentage.
- Silage should preferably not be more than 40% of the roughage on a dry basis.

2.4 NUTRIENT REQUIREMENTS FOR CATTLE

2.4.1 Digestive System of Cattle

Digestion in ruminants differs markedly from that of other animals, since cattle, sheep, goats, antelope, buffalo and camel are equipped with a large forestomach or paunch which acts as a fermentation vat.

In mature cattle the rumen or paunch holds as much as 182l. A large amount of roughage is swallowed and retained in the rumen. When liquid is swallowed it passes the rumen *via* the oesophageal groove into the reticulum or honeycomb compartment and from there into the omasum (or manyplies) and finally to the abomasum or true stomach.

For efficient digestion ruminants do not rely on digestive juices. Actually, the secretion of large amounts of ptyalin in the abundant supply of saliva in cattle would cause the formation of chronic bloat.

In the rumen many millions of micro-organisms set to breaking down the fibrous material, which process is facilitated by the rumenal churning movements. For ideal growth and function these organisms need a 6,8 to 7 pH medium in the paunch, as well as an optimum nutrient medium consisting of proteins, sugars and minerals, especially phosphorus and copper - all substances known to promote fermentation.

After 24 hours of rumen fermentation and the secretion of as much as 5 kg saliva, the ingesta is regurgitated for re-chewing of the cud before swallowing in sufficiently liquifled form to pass *via* the oesophageal groove to the reticulo-omasal orifice. The chief function of the reticulum omasum is to complete the work initiated in rumen. The saliva contains considerable quantities of $NaHCO_3$, mucin and NaC_1. Secretion of saliva is stimulated by coarse roughage.

In the process of cellulose digestion of roughage by the micro-organisms, the inherent nutrients in the plant material are not only liberated to become available to the animal, but the organisms themselves are carried through to the small intestine to be digested. The protein obtained from millions of digested organisms is of high bi-logical value and contains the vitamins of the complex, as well as vitamin K.

Starches are hydrolysed in the rumen to dextrose, sugars and eventually such important energy-producing volatile fatty acids as acetic, propionic and butyric acids. Relatively little digestion takes place in the large intestine, but large quantities of water can be absorbed, especial in sheep. Undigested residue is voided as faeces.

Converting Grass to Animal Products

1) Low-quality plant material such as grass can't be used as food for people. Most of the country is covered by grassland and the only way in which to use this resource is to farm with grass-eating (ruminant) animals.

2) Ruminant livestock (animals that have a big stomach called / the rumen) can use and digest grass through a distinct process.

3) In the big stomach (rumen) there are billions of microorganisms (bacteria and yeast).The grass fibres are digested by enzymes produced by these organisms as an animal's own enzymes cannot digest grass.

4) This releases the individual nutrients in the grass (energy, protein, minerals and vitamins). These nutrients are then used by the organisms as food, and they grow and multiply.

5) One of the important nutrients released from the digested grass is protein.

6) The organisms in the rumen need protein form the grass to grow fast and multiply.

7) If protein in the grass is high, digestion will take place at a high rate.

8) These organisms are then digested in the milk stomach by enzymes produced by the animal; this releases the nutrients and allows them to be absorbed in the small intestine of the animal.

9) The rumen will empty faster, which results in the cow eating more.

10) When good-quality grazing (high protein) is available, the adult cow will eat an amount of grass (on a dry-out basis) equal to or larger than 2% of her body weight.

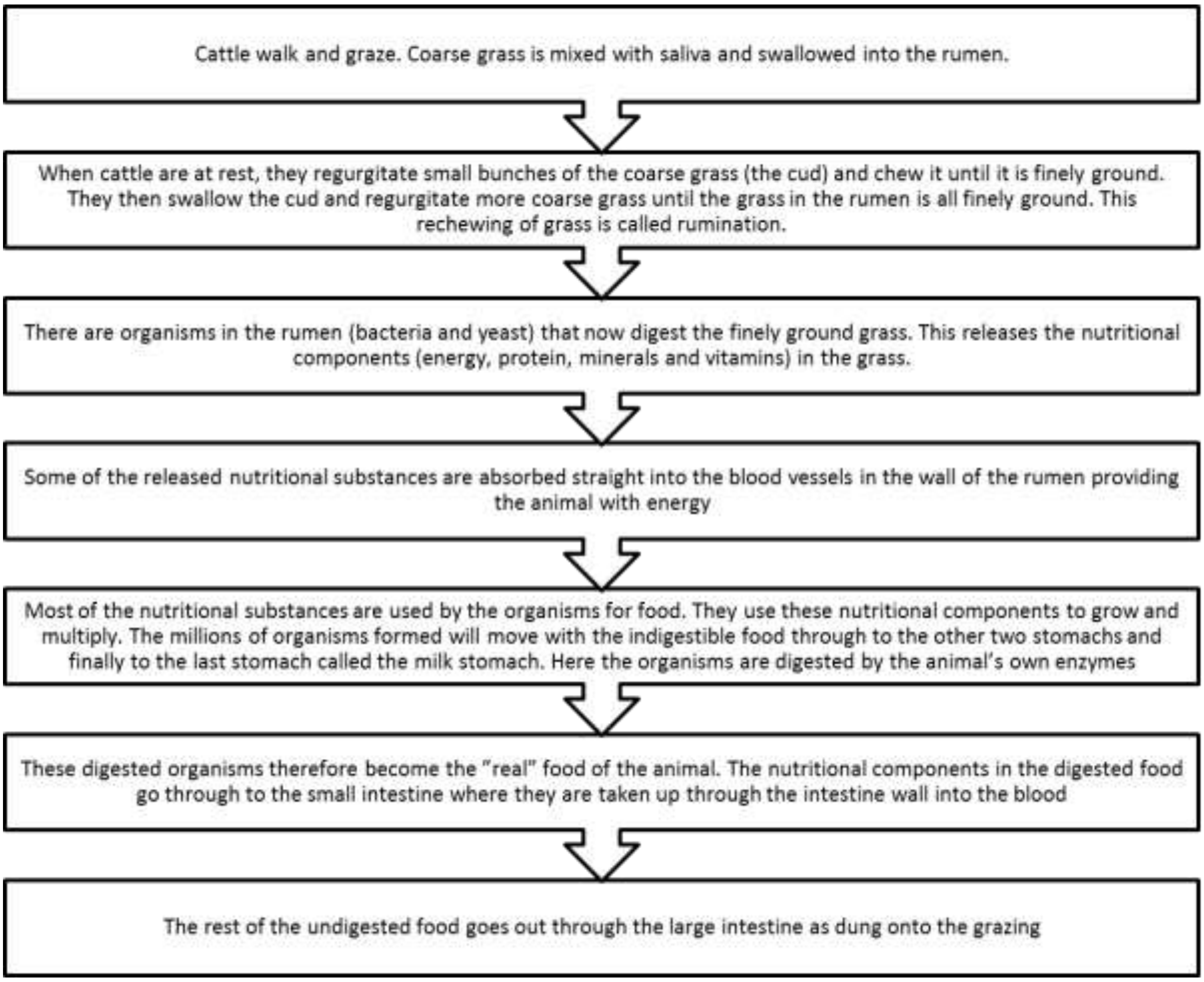
11) For a cow weighing 450 kg, it amounts to+- 9 kg of dry grass per day.

12) By using the unique ability of ruminant animals, low-quality plant material can be converted into a saleable product to provide an income.

13) The market place will determine the price for live animals as well as animal products. The farmer must provide the product that is needed by the market.

Digestion Process

Let us illustrate this distinct digestion process by showing and explaining what happens in the rumen and milk stomach.



2.4.2 BEEF CATTLE NUTRITION

Cattle farming is primarily conducted on an extensive basis, making use of natural grazing as the main feed source. This natural feed source varies, however, both in quality and quantity, as a result of seasonal changes, as well as regional influences. Improved knowledge of these variations enables us to supplement economically, the nutrient inadequacies. It is estimated that as much as two-thirds of the final mass of beef in this country is produced from the veld while close on a million head are processed by feedlots. The aim in ranching being to produce a beast weighing about 500 kg on the hoof at 2 ½ years, yielding a carcase of 280 kg.

This immediately places the emphasis in beef production on veld management, but the ideal target can seldom be reached without some form of supplementation of veld grazing. In the larger ranching areas, on mixed and sweet veld, with an annual rainfall of approximately 300 – 450 mm is generally estimated that the stocking intensity would be approximately 5 -7 ha per Large Animal Unit (LAU). In sparser rainfall areas (200 - 300 mm) 8,5 - 13,0 ha is considered necessary per LAU. The Large Animal Unit (LAU) or Mature Animal Unit (MAU) is defined as:

- 1 mature cow or bull, or
- 2 heifers less than 2 years old, or
- 3 calves

According to the rough guide indicated, the aim is to obtain the highest possible sustainable carrying capacity without causing irreparable deterioration of the pasture and consequent stock losses. The carrying capacity should, therefore, be assessed on the winter low and not, is often the case, on the summer peak grazing when with reasonable rainfall, there is adequate grass growth to supply the total energy requirements of animals. The green colour of the plant growth (arotene), supplies the pro-vitamin A requirements while the surplus is stored in the liver for use at times of inadequacy in the dry, winter months. Ideal spring and summer conditions, with good rains, yield adequate protein levels of the natural feed sources. During this time, it is however necessary, to think in terms of mineral (calcium / phophate, trace element) and salt supplementary feeding.

An important basic requirement is sufficient grazing or feed for the requirement of cows capacity of producing sufficient milk to give the young calves a good start. A high degree of fertility in the herd is of paramount economic importance as the larger the batch of calves produced annually from the particular herd, the lower the cost of production and consequently the price per weaner.

Bone-meal or calcium phosphate is a good source of phosphate and is recommended in the ratio of 1 calcium phosphate : 1 salt.

Blending of 10 l of molasses to very 100 kg lick is recommended. The molasses can be diluted 50 : 50 with water to facilitate even distribution. Alternately, the addition of 10% maize meal will improve acceptability.

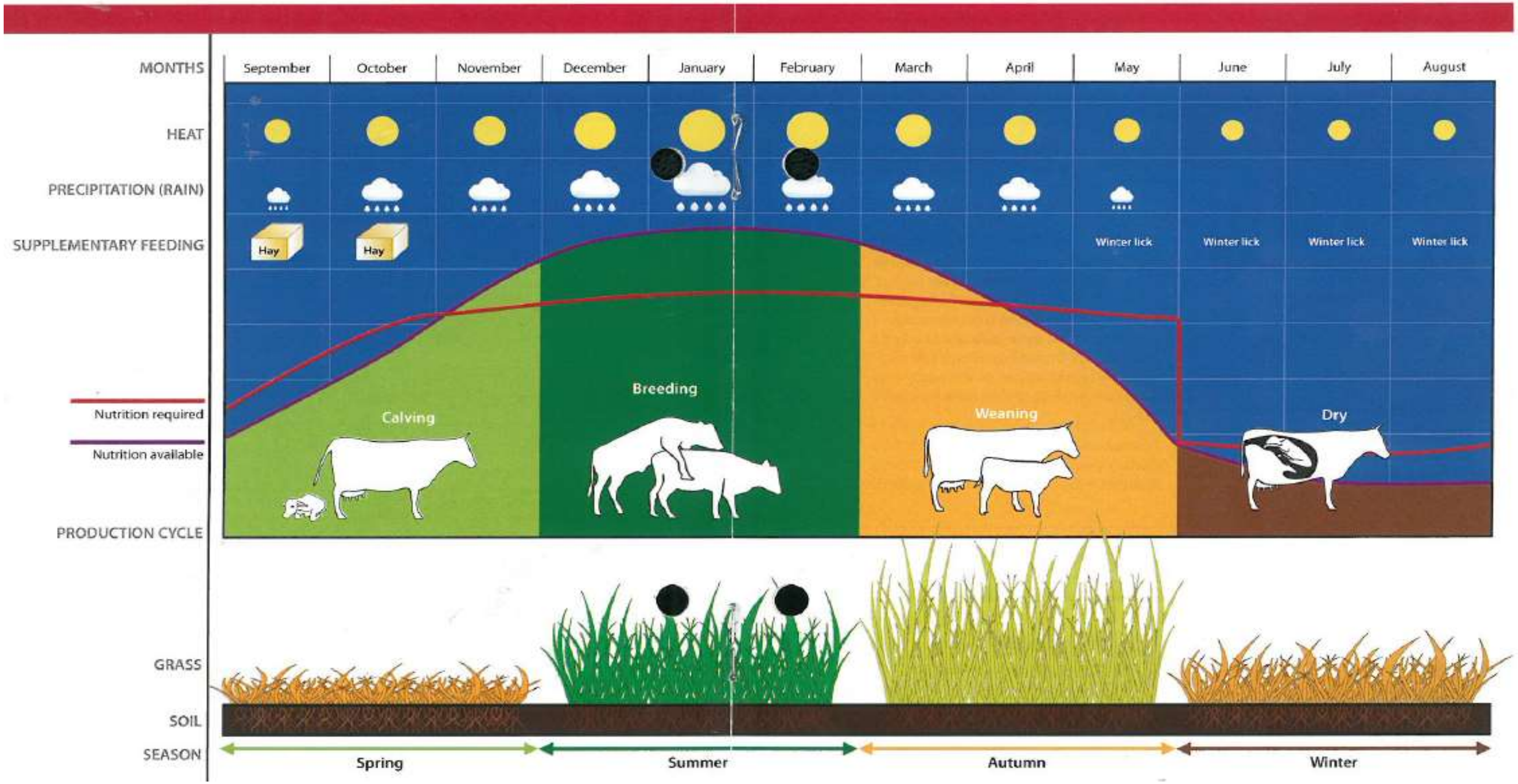
The lick mentioned thus far will be taken in at rate of 100 g per bovine per day during the spring summer months. The licks should be placed near the water source where they will be better utilized as the cattle will be in the vicinity of the water at least once a day. The advantage associated with the supplementation of the mineral requirements are an accelerated growth of young animals, a better utilization of the forage and a higher conception percentage. If maximum efficiency is to be achieved, the micro-nutrient requirements of the region should be considered and supplemented accurately.

Environmental Cycle – Nutrition Available

The grass growth rate depends on the environmental conditions. There is a significant difference in the amount, digestibility and protein content of available grass during the four seasons. See next diagram.

Production Cycle – Nutrition Required

The nutritional needs of a cow producing one calf a year differs depending on her stage of production during 12 – month production cycle. See next diagram.

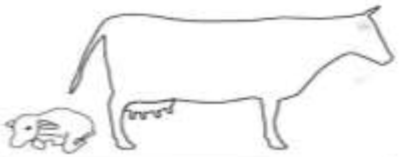


Source: Animal Nutrition, Concepts and Applications, PA Boyazoglu, Revised Edition

12-MONTH PRODUCTION CYCLE FOR COWS CALVING AT THE START OF THE WET SEASON

Practical explanation of the nutritional needs during the four different stages of production

Period 1: Calving and preparation for breeding



The reproductive tracts must return to normal and the cows must come on heat again to rebreed after three months. Cows must also reach peak milk production to support calf growth. **This is the most important nutritional period for the beef cow.**

Cows must be supplemented with stored feed (such as hay) after calving if enough grazing is not available.

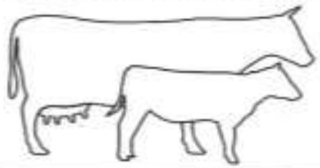
Provide trace minerals before the start of breeding (see back page).

Period 2: Breeding and pre-wean growth of calves

The bull will mate with cows showing standing heat; therefore, cows should be gaining weight during the breeding period. **The best grazing possible must be available at the start of breeding.** Cows will be in the early stages of the next pregnancy while giving milk for the calves.

Phosphate can be supplemented during the breeding season for optimal weight gain during breeding.

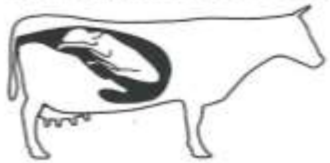
Period 3: Weaning of the calves and pregnancy diagnosis



Up to weaning, the cow will start to lose weight owing to the falling nutritional value of the grass. Low levels of protein supplementation can be started as soon as the cows start to loose condition. If a cow's condition score falls below 2,5, calves must be weaned.

High levels of protein supplementation must be provided from the beginning of the dry season to maintain high intake of dry grass.

Period 4: Dry cow management and preparation for calving



The dry cow must now build up fat reserves before calving. In addition 70 to 80% of the total foetal growth occurs during this period. **This is the second-most important nutritional period during the beef cow year.**

Continue with high level of protein supplementation.

Provide cows in low condition (<3) with an additional energy supplement.

Provide trace minerals and vitamin A 30 - 60 days before the start of calving.

4 Stages of the production process

The nutritional needs of a cow during peak milk production, especially the daily amount of protein needed, is double the amount needed by a dry cow.

1 to 1,5 kg of protein per day.

Most cows (> 90%) in the herd should be in a body condition score (BCS) of 2,5 at the beginning of mating (breeding) season and increase in condition during this period.

BCS 2,5 – The eye muscle is half full and the bone ends feel well rounded.

The nutritional needs of the dry cow are much lower after weaning but the digestibility of the grass also decrease drastically at the start of the dry season.

0,5 to 0,6 kg of protein needed per day.

Most cows (> 90%) in the herd should be in a condition score of 3 or more, 30 days before the first calves are born.

BCS 3 – The eye muscle is full and the bone ends can only be felt with pressure.

Source: Animal Nutrition, Concepts and Applications, PA Boyazoglu, Revised Edition

2.4.3 PROTEIN FEEDS FOR RUMINANTS

Ruminants do not need such high quality protein feeds. The micro-organisms in the rumen will degrade the feed protein and built it into their own bodies. Therefore, if you feed high quality protein feeds to ruminants you must protect these protein sources from the micro-organisms in the rumen, allowing them to pass undigested into the abomasums where they will be digested by enzymes followed by absorption of these amino acids in the small intestine. Usually the ration of a ruminant will be balanced with protein supplements that are cheaper or with inexpensive non-protein supplements such as urea.

The amount of protein (protein percentage) in the grass is the first limiting factor in dry grass. Because there is only dry grass available for six months or longer during the year, a disease condition called dry gall sickness can develop if the nutritional shortage is not supplemented by providing a protein lick.

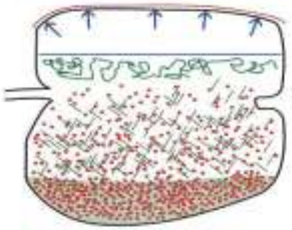
Development of dry gallsickness caused by a protein shortage

Starts as a result of low-quality grazing

At the start of the dry season, the crude protein percentage in the grass will start to fall below 10%.

BCS – 2,5 

The eye muscle is half full and the bone ends feel well rounded. 2 to 5 mm of fat can be felt under the skin over the pin bone.



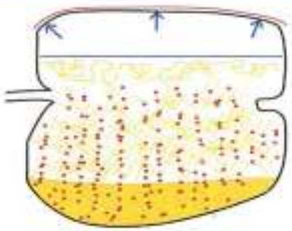
Protein is the first limiting nutrient in natural grazing. The protein needs of the organisms are not provided by the grazing. The organisms in the rumen become less because they do not have enough protein to multiply at a fast rate. This directly reduces the food supply of the cow because there are less organisms to digest. Owing to the fact that cattle are pregnant but still producing milk for the calf, they will start to lose weight.

1 to 3 months later

The crude protein percentage in the grass is now 7% and below.

BCS - 2 

Eye muscle is very indented but the bone ends just feel rounded. 1 mm of fat can be felt under the skin over the pin bone.



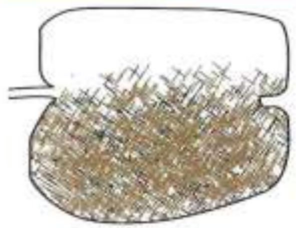
When the protein in the grass falls to 7% and below the number of organisms that must digest the grass becomes even less. These organisms need enough protein otherwise they can't multiply. Now the grass will be digested even slower, and the cattle will eat much less (1,5% of body weight) because undigested grass remains for a longer time in the rumen. Even if the calves are weaned the cows will still lose condition because of the very slow rate of digestion.

4 to 5 months later

The crude protein percentage in the grass is now 4% and below.

BCS - 1 

No eye muscle can be felt and the bone ends are very sharp. No fat can be felt under the skin and the skin is stuck to the pin bone.



When it is completely dry and very cold, the grass becomes very hard and the protein can fall to 4% and even lower. By now, the organisms in the rumen stop multiplying and die. The grass in the rumen can't be digested any more.

Cattle will rapidly lose weight when this starts to happen. They will get to the point that they are too weak to walk and will lie down. Once cattle lie down they will die in a few days and in most cases they can't be rescued, even if they are provided with good feed at this stage.

Examination of dead cattle

When a veterinarian cuts open the dead animal, they will find that the different stomachs of the cow contains very dry grass and the gallbladder is enlarged. In cattle that haven't eaten for a few days the gallbladder will be bigger so it is not a sign of a specific disease.

The animal will also not have any fat reserves specifically around the kidney which is a sign of starvation.

Diagnosis of protein shortage in the live animals.

There is no specific test to make a diagnosis of a long-term protein shortage. The veterinarian will base their findings on the time of year, available grazing, pregnancy status and condition of the cattle.

This condition will occur in most areas of South Africa where a protein supplement is not provided during the dry season.

The digestibility of dry grass becomes too low to maintain good production and the goal of producing one calf every 12 months cannot be obtained without a protein supplement.

Source: Animal Nutrition, Concepts and Applications, PA Boyazoglu, Revised Edition

The Supplementation of Amino Acids for Dairy Cows

In modern ruminant rations for high producing dairy cows the nutritionist includes amino acids in the ration. This is because the high producing dairy cow is not able to ingest enough of certain amino acids via her normal ration because the requirements for her production are very high and her body is physically not large enough to eat more. Because all the cows do not all produce such high yields of milk, it would be a waste to also supplement the lower producers with expensive supplementary amino acids. This creates a feed management problem in that different cows need to be fed different feeds. One way to manage this is to break the whole herd into smaller groups of cows with similar production yields. In this way the farmer can then feed the different groups of cows feeds according to their production.

Another modern method of feeding individual cows is an automated system where the individual cows ration is mixed by a computer just before the milking process starts. The cow's individual body mass and production is measured twice a day and the computer determines the mixture required. This feed is mixed as soon as the cow enters the milking stall, and is delivered to the feed bin in the milking stall while the cow is being milked. Although such systems are highly effective, they are also very costly.

2.5 NUTRIENT IMBALANCES

Nutrient Imbalances

To maintain the health, vigor and productive ability of animals, a farmer needs to manage those factors which can challenge the health of the animal. There are four factors which need to be managed correctly to reduce the chance that diseases will occur.

- Poor nutrition: A well-fed animal has a much better chance of fighting off disease and can convert nutrients in excess of maintenance requirements into products.
- Stress: Any stress placed on an animal will make it more susceptible to disease (e.g. Pasteurella). Stress includes factors such as parturition, fatigue from walking or being transported long distances, poor housing, excessive cold (especially when combined with damp), excessive heat, high humidity, and dehydration.
- Lack of tolerance: Animals in some areas are more tolerant to certain diseases because they have built up a resistance for those factors through being exposed to them for many generations. For example: Goats are browsers, and thus less susceptible to picking up internal parasites from grazing infected pastures. Thus, if you then put a goat onto pastures he will pick up internal parasites more easily.
- Lack of immunity: It is important to maintain an animal's immunity levels. There are two ways, one is allowing the newborn to receive colostrum in the first few days after birth, and the other is through vaccination.

In general, long-term stress causes an increase in the production of cortisol by the adrenal cortex around the kidneys. Persistently elevated levels of cortisol in the blood causes the cells to develop a resistance to the function of insulin (which is to allow the entry of glucose into cells). Thus, glucose cannot enter cells and cannot be utilized by the cells to function normally, since glucose is the basic energy source for life. Elevated cortisol levels due to stress also cause reduction in levels of FSH, LH, growth hormone thus directly impairing reproduction and growth. Also cortisol induces protein catabolism (breakdown) thus inducing muscle weakness.

All processes within the body rely on the supply of nutrients. These nutrients include proteins, energy, vitamins, minerals and water in the correct quantities and ratios. If any of these elements are not supplied in the correct quantities then malnutrition or starvation ensues. In some circumstances, where some nutrients are supplied in lieu (instead of) others the body may be able to manufacture the limiting nutrient. For example: an excess of protein can be converted into energy. However, when this occurs other organs and processes in the body can be negatively affected. For example: when an excess of protein and inefficient energy is supplied, the kidneys are placed under strain to excrete the excess amounts of urea. Some vitamins, minerals, amino acids and fatty acids are considered "essential" or 'indispensable" and cannot be manufactured/synthesized by the body and must be ingested from an external source.

2.5.1 Malnutrition: Minerals

Although the animal body contains less than 5% in mass of mineral elements, some of these being present in minute traces only, their functional importance in the metabolism of the animal is considerable. Together with the vitamins, these elements are responsible for a major contribution towards the health and production of the animal. It is no wonder then that the majority of unsoundness in animals is attributed to an inadequate supply or imbalance of one or more minerals or vitamins.

Mineral deficiency is generally attributed to seasonal climatic variations in the larger stock-raising areas where long, dry winters occur, when veld grass leaches and becomes white, tough and unacceptable, and low in nutritional value. In addition, large areas are subject to periodic droughts when grazing becomes sparse and even unavailable. Dry winters chiefly apply to the summer-rainfall areas and in these areas lowered phosphorus levels act as a sensitive barometer of the nutritional status of the natural grazing. The deficiency can be so acute as to practically cause a disappearance of phosphorus after the first winter frosts, a factor which contributes towards the unreliability of veld-pasture analyses. In the winter-rainfall areas, which includes the Western and South Western coastal strip, the dry period starts in late summer and is not as severe or as long as it is in the summer-rainfall areas. However, a large variety of imbalances appear to be present, especially of trace elements such as copper, zinc, magnesium manganese.

It is apparent, therefore, that for maximum productive performance, animals in all areas should have regular access to carefully balanced mineral compounds, in which special attention has been paid to phosphorus and salt as a base. The frame or skeletal development of an animal may be considered the foundation upon which the rest of the body develops.

Calcium

A calcium deficiency is more likely to make its appearance in the prolonged presence of low calcium and high phosphorus. Although mild cases of Ca deficiency are not easily detected in cattle and sheep, a condition known as "camped-under" is thought to be associated with a Ca deficiency. Cattle tend to place their hind limbs too far under the body, the result is that they stand on their heels and the hoof grows out long. In such circumstances bone fractures become common.

Phosphorus

However, unless animals have access to phosphatic supplements they lose condition and frequently develop a stiff gait and arched back. Many cases are evident where the hocks appear to be placed excessively far back in cattle. The end of the tail usually hangs between the hocks and the latter is frequently stained by faeces. In certain coastal areas where the interplay of certain trace elements may be more evident, calves show a peculiar stiffness in the forequarters prior to assuming a kneeling position. The condition is commonly referred to as stiff-sickness ("stywesiekte") and is actually a form of osteomalacia or rickets. This condition may become progressively worse as the joints of animals become more painful and handicap them in their ability to cover distances for grazing. In the veld, mortality is often the sequel to bone-fracture disablement. "Stywesiekte" caused by a phosphorus deficiency must not be confused with three-day stiff-sickness, which has an insect vector.

Magnesium

Cases of magnesium deficiency have been described in young pigs and in calves as showing weakness of the pasterns, particularly in the forelegs, causing backward bowing of the legs, sickle hocks, arching of the back, hyper-irritability, muscle tremor, reluctance to stand, continual shifting of mass from limb to limb and eventually tetany and death.

Blood and Henderson (1971) describe three closely related syndromes associated with hypomagnesaemia:

i. Hypomagnesaemic tetany of calves, thought to be a deficiency disease, as calves fed solely on whole milk or milk replacers can contract the condition in two to four months.

ii. Lactation tetany. Grass Staggars, or wheat pasture poisoning. This condition occurs mostly on lush green pastures, and

iii. Usually in cattle grazing on poor pastures and after a sudden cold spell in climate. Grashuis (1960) associates the onset of hypomag-nesaemia with:

   a) An alkalosis due to excess fertilization of pasture with K and NH_3

   b) Low external temperatures

   c) Digestive disturbances due to the formation of amines, e.g. histamine.

Source: Animal Nutrition, Concepts and Applications, PA Boyazoglu, Revised Edition

Sodium (Na) and Chlorine (CI)

Animals suffering from a salt deficiency manifest an intense craving for salt, loss of appetite haggard appearance, rough coat and lustress eyes. There is a rapid decline in milk flow and high producers may collapse and die. In advanced stages cows may show neuromuscular abnormalities such as shivering.

A sudden excess of salt may result in toxicity, especially after animals have experienced a salt hunger, or insufficient water is available. However, when animals are accustomed to the conditions, large amounts of salt given with the object of controlling intake of licks, will prove relatively safe.

Potassium (K)

If animals were adequately fed, therefore, especially if sufficient roughage were available, there would normally be no deficiency of potassium.

The potassium, together with NaCI, has an important body function in controlling osmotic pressure and acid-base equilibrium which is responsible for the passage of nutrients into the body cells and also for water metabolism. All tissues contain intracellular potassium. Muscular tissue such as the heart is especially high in K content. A deficiency of potassium has been experimentally produced in dogs, pigs, calves and rats. Pathological findings according to King (1961) are: a necrosis of the myocardial fibers of the heart and of the renal tubular epithelium of the kidneys, and in dogs, in addition, paralysis had been observed. Cases are on record where administration of potassium salts affected improvement and cure of rheumatism.

Iron (Fe)

Iron forms an integral part of haemoglobin which in its turn act as the carrier of oxygen and the activator of several enzymes. The normal haemoglobin content of blood is 10 – 18 g per 100 ml.

Sulphur (S)

The body contains about 0.15% sulphur, chiefly present in keratin in the horns, claws, feathers, hair and wool.

The inclusion of 1 -2 % of flowers of sulphur in stock licks has for this reason been found to be valuable antidote against “geilsiekte”.

Fluorine (F)

In the body, traces of fluorine present chiefly in the skeletal material and teeth, where the very low concentration of 1 ppm total dry matter intake per day appears to be desirable. Although fluorine is present in all soft-body tissue and is excreted in urine and faeces, excessive intake over prolonged periods accumulates in the bones and teeth. The result is a mottling of the tooth enamel, which shows erosion and pitting, loss of appetite and emaciation, infertility and low production. A condition of typical osteoporosis develops in which bones show softening and knobbly lesions.

2.5.2 METABOLIC DISEASES

Disease conditions that manifest themselves due to an imbalance of nutrient ratios are known as metabolic diseases. Some well-known metabolic diseases include:

2.5.2.1 METABOLIC DISEASES IN CATTLE

These are diseases of livestock caused by productivity practices when the body reserves on calcium, magnesium or energy cannot meet the metabolic needs. They are very important in places where high producing animals are required, e.g. in diary industry. In cattle, metabolic diseases include ketosis, milk fever, fat cow syndrome, and hypomagnesaemia. All these can produce an acute, temporary, but potentially fatal deficiency. Correcting the diet for cows during the period from late pregnancy to peak lactation is crucial in preventing these diseases.

Prevention

All the above diseases result from nutritional deficiencies during the crucial period from late pregnancy to peak lactation when body reserves on calcium, magnesium or energy cannot meet the metabolic needs. Correcting the diet for cows during this crucial period is the key to the prevention of these diseases. If metabolic diseases occur frequently, it is essential to seek professional veterinary and nutritional advice

Ketosis

Ketosis usually occurs within a few days to a few weeks after calving. It is characterised by a sudden drop in appetite and milk yield, constipation, mucus covered faeces, depression, a staring expression, loss of weight, and a humped back suggesting mild abdominal pain. Some animals may develop nervous signs such as salivation, chewing, incoordination, blindness and aggression.

Effective treatment can be achieved if it is administered in time. Ketosis can be treated by intravenously injecting 500 ml of 40% glucose, plus twice daily oral dosing of 150 ml of propylene glycol (a glucose precursor) for 4 days.

Milk Fever

Milk fever usually occurs one or two days before or after calving. Loss of appetite and a slight drop in temperature are the first signs of milk fever. Later, the animals may exhibit some unsteadiness as they walk. More frequently, a sick animal may be found lying on her sternum with her head resting on the shoulder. The eyes are dull and staring and the pupils dilated. If untreated, the cow becomes comatose and dies within a day of the appearance of the first signs.

Effective treatment can be achieved if it is administered in time. Milk fever can be treated with slow intravenous infusion of 600-800 ml of 20% calcium borogluconate.

Fat Cow Syndrome

Fat cow syndrome most commonly occurs in fat cows which were heavily fed in early pregnancy, but suffer severe nutritional stress during the 2 months before calving. After calving, the affected cows lose their appetite and become weak. The pulse is small and fast, and droppings are small and firm. Sternal recumbence follows. There is a greater than normal clear nasal discharge. The respiration is rapid and grunting. About a week after the first signs appearing, the cows become comatose and die quietly.

Effective treatment can be achieved if it is administered in time. Fat cow syndrome, treatment is generally ineffective, especially if the cows are already recumbent. Anabolic steroids and supportive therapy with glucose, fluids and electrolytes IV, and propylene glycol, fluids and electrolytes orally is recommended.

Hypomagnesaemia

Hypomagnesaemia occurs most commonly in adult cows which are lactating heavily and are grazing on lush grass pastures, and in calves reared predominantly on a diet of milk. In peracute form of the disease, affected animals may be grazing normally, but suddenly develop staggers, fall and undergo severe paddling convulsions. These convulsion periods may be repeated at short intervals and death quickly follows. In many cases, animals at pasture may be found dead without illness having been observed. Acute cases are similar apart from the animals survive a few hours during which periods of convulsion followed by quiet periods. In subacute cases, affected animals may progress to the acute or peracute, convulsive stage after a period as long as 2 to 3 days. All cases of hypomagnesaemia are characterised by loud heart sounds and rapid heart rate.

Effective treatment can be achieved if it is administered in time. For cases of hypomagnesaemia, use the same treatment as for milk fever, plus subcutaneous injection of 200 ml of 50% magnesium sulphate.

Grass Staggers

Characterised by convulsive seizures where the animal lies down and paddles wildly. Caused by magnesium deficiency. Can be reversed by intravenous administration of magnesium compounds.

2.5.2.2 METABOLIC DISEASES IN SHEEP

Diseases affecting the sheep's nervous system can affect sheep at all ages and points in the production cycle, presenting with a number of different signs including: blindness, depression, nervousness, scratching, circling or difficulty walking or standing.

The most common and significant neurological disorder, metabolic disease tends to affect adult sheep, particularly around lambing time. Early treatment improves the outcome. Having a standard on farm treatment protocol is important. If the animal does not respond to treatment seek veterinary assistance. The three diseases below are often difficult to distinguish, particularly close to lambing.

Pregnancy toxaemia/Twin lamb disease

Occurs in late pregnancy in ewes carrying multiple lambs and usually affects thinner ewes that have not received enough concentrate. First signs are usually loss of appetite, a ewe separating herself from the flock, standing still and seeming blind. The appearance of twin-lamb in one ewe is an indication that flock nutrition levels may be a problem and should be assessed in addition to individual treatment. Many cases are difficult to treat without aborting the lambs. To control, condition score ewes, scan for lamb numbers and plan appropriate diet based on forage analysis Feed according to the number of lambs carried and the ewes condition score.

Hypocalcaemia

In contrast to the equivalent condition in cattle (milk fever), Hypocalcaemia tends to be seen in late pregnancy rather than early lactation. Ewes in any condition can be affected, particularly following stress e.g. gathering for housing/vaccination. Ewes have difficulty walking or lie down, are depressed and may develop bloat. Control can be difficult – watch the flock closely after gathering and have calcium injection handy

Hypomagnesaemia

Hypomagnesaemia nearly always occurs at peak lactation. Lush grass is low in magnesium so ewes are at risk when grazing this pasture type. Signs: excitability, shaking and convulsions. Death follows rapidly (ewes are often found dead). Watch the flock closely after moving onto lush pasture. Have magnesium injection handy. In high risk flocks, magnesium supplementation can be given by enriched cake, rumen bullets or licks.

Scrapie

This infectious, untreatable, fatal brain disease is a Transmissible Spongiform Encephalopathy (TSE) and is in the same group as BSE in cattle. Resistant to all disinfectants, Scrapie can persist in the environment for years.

Tending to arise in older animals with only one or two sheep being affected at any one time, clinical signs include scratching, nervousness, weakness and weight loss. The eventual outcome is death.

Genetics determine how likely an individual is to develop scrapie. By breeding only from the more resistant genotypes, the national flock will eventually become less at risk.

Swayback

Swayback affects lambs when ewes have had low copper concentrations in late pregnancy through insufficient copper in food or pasture, or copper being 'locked up' by other minerals in grass/soil. Suspected copper deficiency must be treated with caution as too much copper is poisonous.

Border Disease/Hairy Shaker Lambs

The classic example of this viral infection is the 'Hairy Shaker' lamb.

Lambs have a long hairy coat, trembling muscles and most grow slowly and fail to thrive. Hairy Shaker lambs result from ewes meeting the Border Disease virus for the first time in early pregnancy. Most commonly this results in abortion, occasionally unborn lambs survive becoming persistently infected (PI) which are likely to be weak, and will continually shed virus. Not all PI's are weak and hairy – they may go on to breed, perpetuating the problem.

Eradication can be attempted; however, it may be more practical to deliberately expose all future breeding stock to the virus. This is a crude form of vaccination, achieved by carefully mixing future breeding stock with Hairy Shakers.

Group Activity 2:

The class will be divided into groups of 3 or 4 people. The facilitator will give go through the Feed Formulation calculation provided above. This will be done step by step so that all learners understand the procedure involved.

3. FEED MANUFACTURING AND PROCESSING

3.1. INTRODUCTION

The principal objective in feed mixing is to assure that an animal receives all of its formulated nutrient allowances every day. Uniformity of particle size and number of particles per unit weight are important considerations for assessing mixing accuracies of the various micro ingredients. Many of the micro ingredients (particularly feed additives) are expensive and elevated levels may be toxic. Thus, a small uniform particle size is a very important criterion in the selection of micro ingredients.

3.2. ADJUSTMENTS REQUIRED FOR MIXING FEEDS

Many of the problems in feed mixing are due to differences among feed ingredients in particle shape, size, and density. Feed ingredients with similar sizes and densities tend to blend easily and quickly. For example, ground or cracked grains have densities similar to that of the oilseed meals. Consequently, there is usually very little difficulty in obtaining a uniform blend of these feed ingredients. Minerals on the other hand have densities which are vastly greater than that of grains and oilseed meals. Feed additives have intermediate densities, but very fine particle sizes. Forages have low densities, and highly varied particle shapes and sizes. This diversity of physical form and density of individual feed ingredients complicates the preparation of uniform feed mixes.

Feed additives and vitamins pose a special problem for obtaining a uniform feed mix. Their densities are more similar to that of ground grain and oilseed meals. Thus, uniform mixing should not be so problematic. However, they are included in the mix at very low levels.

This presents a unique problem with respect to spacial distribution. Following a few simple guidelines in feed formulation can minimize the risk of inadequate spacial distribution of critical micro ingredients.

Guidelines for Mixing Feed

Premix

Premix micro ingredients such as feed additives, vitamins, and trace minerals with a suitable diluent prior to their inclusion in a supplement. Diluents serve to dilute the micro ingredient and thereby facilitate the rate of mixing.

Examples of suitable diluents include the macro minerals typically incorporated in a feed mix (i.e. salt, limestone, di-calcium phosphate, magnesium oxide). Diluents should be dry in order to permit a more uniform dispersion of individual micro ingredient particles. Moisture must be avoided as it may cause entrainment and clumping (hygroscopic compounds such as urea are not suitable diluents). The premix (micro ingredients plus diluent) should represent 3%, by weight, of the supplement. Premixing may be done by hand in a large container. However, it can be performed more easily and efficiently by means of a small portable cylinder mixer (cement mixer). Protective clothing, gloves and dust mask should be worn when handling micro ingredients.

Supplement

Prepare a supplement. This supplement will contain the premix, a suitable carrier, and the remaining minor dry ingredients in the diet including minerals, urea, and supplemental protein sources.

Carriers are feed ingredients, which combine, with the micro ingredients in the premix to alter their physical characteristics. By adsorbing to the carrier, the very fine particles of the micro ingredients are allowed to move more rapidly and uniformly through the mix. This rapid movement of micro ingredients through the mix is important to assure adequate distribution prior to addition of molasses.

Carriers should have physical properties comparable to ground grain or oilseed meals. Indeed, both of these may be used as carriers. However, the adsorptive properties of ground grain and oilseed meals are low. This limitation may be overcome by first combining 2% fat to the ground grain or oilseed meal before blending with the premix. The thin film of fat covering the carrier will facilitate adsorption of the micro ingredients in the premix.

Excellent carriers for micro ingredients include poultry litter, rice hulls, wheat bran, vermiculite, alfalfa meal, ground maize cobs, and beet pulp. The amount of carrier to include in the supplement will depend on the "space" available in the diet formulation. The supplement should comprise a minimum of 3% by weight of the finished feed.

In preparing the supplement, first add the carrier, and then add other major ingredients until they reach the central shaft line, then add the premix and other minor ingredients, and finally add the remaining major ingredients. Mixing volume and mixing time will depend on the specifications of the particular mixer being used. Although some mixers will mix feed very efficiently at low volumes, most do not. Review the literature regarding your mixer and then see that the volume of feed being mixed and mixing times are optimal for the mixer. Be careful not to under fill or overfill the mixer.

Finished Feed: Finished Feed may be Prepared as Follows

- Add the grain portion of the diet to the mixer;
- Add the dry supplement (remember that the supplement should comprise a minimum of 3% of the finished feed) to the centre of the mixer (if possible, add supplement on the opposite end of the mixer to where the feed is discharged);
- Allow feed to mix for a minimum of 1 minute;
- Add forage component of the diet;
- Add fat component of the diet;
- Add molasses or liquid component of the diet;
- Allow to mix for the time specified for the mixer (usually not less than 8 minutes).

Note: As previously explained, the reason that the supplement is added to the grain portion of the diet prior to the addition of forage is because the grain and supplement have similar particle size and densities. Accordingly, the supplement will distribute itself quickly through the grain. This increased dilution of the supplement prior to the addition of forage and liquid feeds will enhance the spacial distribution of micro ingredients in the complete feed while shortening mixing time.

Adding Molasses

Molasses is a common ingredient in diet formulations. However, it is highly viscous and this presents several problems in feed mixing. Indeed, if added to the diet improperly it can cause marked increases in the variation of the equal distribution the micro ingredients through the feed mix.

Molasses should be added to the mixer as the last step in formulation. If the molasses is added to the mixture before the supplement has had a chance to mix with the other major ingredients in the diet it may result in entrainment of sequestering of the micro ingredients. This will increase what is called the "Poisson Error" or the variance associated with decreased spacial distribution of micro ingredient particles.

Furthermore, if molasses is added to the mixer before it is adequately filled, it will come in contact with the mixer itself, adhering to the sides of the mixer and moving parts, thereby decreasing mixer efficiency and, necessitating more frequent cleaning. Whereas the obvious challenge with molasses addition to the mix is the formation of feed balls or clumps, the more real problem in terms of animal performance is the potential increase in poor distribution of the micro ingredients if the molasses is not added in the proper order.

Black strap molasses (standardized at 80E Brix) is particularly viscous. The efficiency of mixing black strap molasses with other dietary ingredients will be enhanced if it is first diluted with water (i.e. dilute to 70E Brix).

The viscosity of molasses is markedly reduced by heating. For example, raising the temperature of molasses from 23E C to 27E C (an increase of only 4%) will reduce the viscosity of molasses 50%. Molasses should not be heated to temperatures in excess of 43E C, except for very short periods of time, as this may cause caramelisation.

3.3. THE OPERATION OF FEED MANUFACTURING EQUIPMENT

Good mixing begins with an understanding of the equipment used. Feed mixing equipment can be divided into two broad types: continuous and batch. The continuous mixing systems used on farms are metering mills. These mills meter ingredients into a mixing auger in set proportions. Batch mixing systems mix a set amount depending on their capacity. Most continuous systems are stationary, while batch systems can be stationary or portable. Mixing procedures are totally different for batch and continuous systems.

Continuous Mixing Systems

The big advantage of a continuous mixing system is its automatic operation. Once you start the mill, it mixes until it runs out of ingredients, fills a finished feed bin, or is turned off. The main unit of this system is the proportioner, which controls the volume of each ingredient added. This proportioner must be routinely calibrated for the proper mix. Changes in ingredient density (that is, changes in test weight) will change the proportions by weight and therefore the nutrient content of the mix. For example, if you calibrate a mill for maize weighing 56 kg per bag, and the next load of maize weighs only 54 kg per bag, the diet that should have 1,700 kg of maize only contains 1,640 kg.

These mills are calibrated by two simple methods. The first method consists of weighing the amounts of each of the ingredients being metered in simultaneously. Place a weighed container under each ingredient auger. Divert the ingredients into the container, and then run the mill. When you collect an ample supply of the least ingredient (2 to 5 kg), turn the mill off. Weigh each ingredient, and then subtract the weight of the containers. Add the weights of each ingredient together, and then divide that number into 2,000. This gives a factor to use in correcting the amounts collected to a ton basis. Multiply this correction factor by the weight of each ingredient collected. The resulting number is the amount of that ingredient being added to a ton of feed.

Example:

Amounts collected:	5 kilograms of base mix
	55 kilograms of maize
	40 kilograms of soybean meal
Total collected =	100 kilograms

The feed formula is for 2,000 kilograms, so divide 2,000 by 100 for a conversion factor of 20. Multiply the weight of each ingredient collected times 20 to get the amount per ton:

5 base mix x 20 =	100 kilograms of base mix
55 maize x 20 =	1,100 kilograms of maize
40 soybean meal x 20 =	800 kilograms of soybean meal
Total =	2,000 kilograms

Compare the amount per ton for each ingredient with the formula and make needed adjustments.

The second method works best when there is a wide range in ingredient levels. Run each ingredient for the same length of time. When each ingredient has been collected, determine the weight of the ingredient less the weight of the container. Add the ingredient weights and divide into 2,000 (same correction factor as above). Multiply each weight by the correction factor. This gives the diet formula in kilograms per ton.

In both cases, the adjustments depend on the make and model of the machine. The adjustments needed are in the owner's manual. If one is not on the farm, contact the equipment dealer or company representative.

Continuous mixing systems are only as good as the operator. Every part of the system must be working properly to produce quality feed. You must carefully calibrate the mill, analyze samples of mixed feed, and frequently check the system to produce quality feed.

Batch Mixing Systems

Batch systems take more time but generally are more accurate because each ingredient is weighed. Vertical mixers are more popular than horizontal mixers because they take less space. Horizontal mixers typically provide a better mix and have a shorter mixing time. Some stationary systems combine both a horizontal mixer for combining ingredients used in small amounts and a vertical mixer for mixing the complete feed.

The mixing accuracy of a horizontal mixer is because of its mixing action. Horizontal mixers have one of two mixing mechanisms--a ribbon (Figure 1) or paddle (Figure 2). Both will provide a good mix, but the ribbon provides a more uniform final mix.

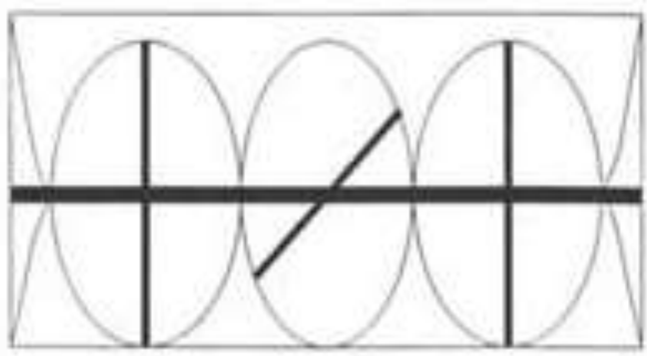


Figure 1: Horizontal mill with ribbon mixing.

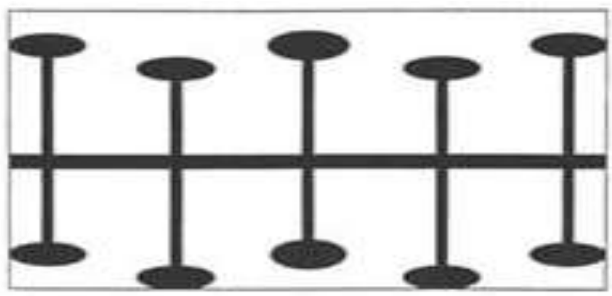


Figure 2: Horizontal mill with paddle mixing.

Ribbon and auger mixers operate most efficiently if they are filled to 70 to 90% of capacity. With paddle mixers, satisfactory mixing may be obtained at much lower levels of loading (25% of capacity). However the application of fat and/or molasses to mixers that are not adequately loaded may cause coating of the sides of the mixer and mixer bars, resulting in decreased mixer efficiency and contamination. The mixer should not be overloaded. Overloading the mixer will cause some of the feed to float above the mix and not blend properly. With paddle and ribbon mixers the mixer bars should rise at least 12 cm above the level of the mix.

Improper mixing can also occur if the tolerances between the mixer bars and the sides of the mixer are not set properly. Mixers are factory-set with an agitator clearance of .3 to .9 cm. If that clearance increases to 1.3 cm, mixer efficiency will be impaired. Mixers should be visually inspected periodically. Establish a set schedule for inspecting the mixer. Worn paddles and ribbons should be replaced.

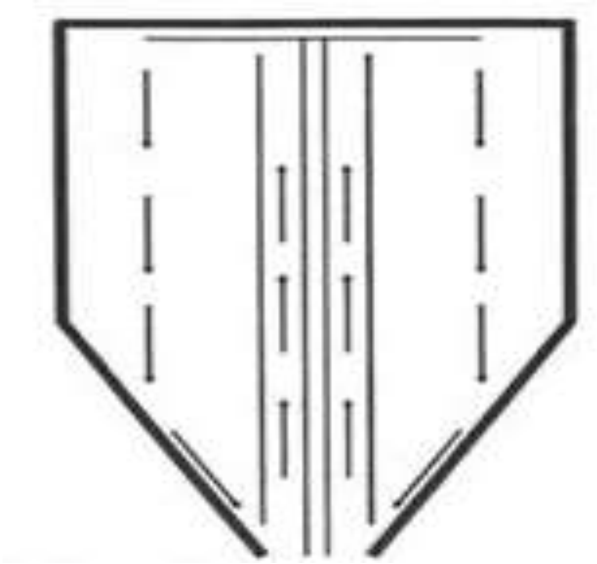


Figure 3: Mixing action of a vertical feed mill.

The chances for mixing errors are usually greater when using vertical mixers. Figure 3 is a simplified drawing of a vertical mixer at work. Ingredients enter the mixer, are carried to the top, and then dropped into the mixing area. This action makes it difficult to properly mix ingredients added in small amounts (40 kilograms per ton or less). Blend these ingredients with another ingredient (grain, soybean meal) before mixing.

Because of the design, 10 to 20 kilograms of the first ingredient added to the mixer may never be mixed because the mixing auger never picks it up. Two additional steps to the process solve this problem. First, avoid adding ingredients used at 200 kilograms or less to an empty mixer. Then, just before mixing is complete, auger out about 50 kilograms and put it back in the mixer. These two practices will reduce the chances of a feeder being filled with straight premix, base mix, soybean meal, etc.

Portable mixers and stationary mixers in some conditions pose other problems. It is tempting to weigh all ingredients except the grain, put them in the mixer, and then fill the mixer with grain. It is impossible to measure weight by measuring volume in grain. Another problem is running the mixer until the grain is ground and then shutting the mixer off. The feed must mix at least 5 minutes after the last of the grain is in the mixer. For most mixes, the time should be 7 to 10 minutes, depending on the model of the mixer and the amount of feed being mixed. Over-mixing can lead to feed separation in some farm conditions. More importantly, it increases the amount of fuel or electricity used, therefore increasing the cost of mixing.

Do not deviate from proper mixing times. If possible have mixing time controlled by a timer. Mixing time increases with the level of liquid feed added to the mix. This is because the mix becomes more viscous, slowing down the flow of ingredients through the mix. This problem accentuates when the level of molasses added to the mix exceeds the absorptive capacity of the mix. Thus, the level of molasses employed in a diet formulation should be considered not only with respect to relative cost of the molasses, but also with respect to practical mixing time and the acceptable distribution of the limiting micro ingredient throughout in the mix.

Still another problem is scales. Many portable mixers do not have scales. Scales are expensive and require frequent maintenance. However, the cost of scales is more than offset by the improved quality of feed when scales are used. Balance manual and electronic scales frequently. Scales for portable mills are designed for rough conditions, but they are still delicate instruments. Check the accuracy by adding a known weight of ingredients. If scales are not weighing accurately, have them repaired.

PRACTICAL 1:

To be able to understand the working of an animal feed factory it is necessary to visit a factory so that everything can be explained, observed and questioned. By arrangement, the facilitator will take you to an animal feed factory. Be attentive; ask questions, make sketches of the equipment that you see, draw process flow diagrams to illustrate the movement of feed ingredients through the entire process.

For assessment purposes you need to answer the questions provided in your assessment pack.

4. THE PRINCIPLES OF FEED PRESERVATION

4.1. INTRODUCTION

South Africa is known for seasons where abundant feed production takes place, and seasons where high quality feed is scarce. It stands to reason then that feed should be collected and preserved during the seasons of plenty so that ample feed is available during times of scarcity.

In general, South African livestock farming, especially ruminant production, takes place under extensive conditions. It is in these farming systems that feed preservation is most often practised. In South Africa the most common forms of feed preservation are the making of hay or silage.

In contrast, the production systems of pigs and poultry are intensive. In these systems the feeds provided to mono-gastric animals are manufactured either by the farmer or commercial feed manufacturers. This has allowed the formulation of feeds for mono-gastric animals to the level of precision where particular amino acids are perfectly balanced to meet the requirements of mono-gastric animals at a particular level of production.

4.2. FACTORS INFLUENCING FEED PRESERVATION OR SPOILAGE

The success of haymaking depends on the rapid and almost complete removal of moisture from plant material. It is thus highly dependent on hot, dry weather. Several factors influence the final quality of hay. These include:

- The type of material from which the hay is produced. Hay made from legumes is obviously higher in protein than hay made from grass or grain materials.
- The growth stage at which the material is harvested. As a plant matures its dry matter content increases, its fibre content increases and its digestibility decreases.

- The method used to make the hay. Methods include, sun-drying, drying in a shed with warm air, drying in a shed with cool air or artificial drying.

- The form in which the hay is fed to the animal. More wastage and poorer intake occurs with hay in the long form, versus hay which has been chopped, ground and pelleted. Hay fed in the long form is also often prone to selection by the animal (in other words the animal selects the tastier bits and leaves the bits that are less palatable). Chopped and pelleted hay also takes up much less storage space.

- When feeding hay, the farmer should always be on the look-out for moulds (perhaps if the bale was accidentally wet during storage). Moulds are particularly dangerous to pregnant animals and horses.

The success of silage making depends on the ability to preserve plant material in a wet form. It does not depend on the weather for its success. Several factors influence the final quality of silage. These include:

- The type of material from which the silage is produced.

- The dry matter content of the material that is ensiled.

- The rate at which the required pH is reached.

- Whether anaerobic conditions in the silage is maintained.

- Whether the silage is protected from rain and sun.

- The size of the particles that are ensiled since this influences the degree to which the material can be compacted and thus has a direct influence on the anaerobic circumstances in the silo.

4.3. FEED QUALITY

Feed quality is dependent on both the original plant material and also how the material has been processed to arrive at the final feed.

Problems that Might Arise in Rations Include

Mold growths that can grow on feed crops before or after harvest and on feeds during storage. These may result in the production of mycotoxins (the most important being aflatoxin). Sometimes molds form in feeds such as maize, peanuts, cottonseed and ryegrass. Some animals such as cattle can tolerate a little mold in their rations but molds are particularly toxic to horses and pregnant animals.

The presence of anti-nutritional factors. These may include:

- Factors affecting protein utilisation and digestion e.g. tannins, anti-vitamins and others such as saponins (lucerne), cyanogens, alkaloids, photosensitizing agents, isoflavone
- Contamination with poisons or poisonous plants such as oleander can cause problems in mixed or complete feeds.
- When plant material is harvested mechanically small animals such as frogs, mice and even snakes may get killed in the process. They end up in the bulk feed bins and are processed along with the feed.
- If the quality of the original plant material is poor then the preserved feed, or the mixed feed ration manufactured there from will also be of poor quality. In this sense poor quality feed may include a raw material like lucerne that is harvested at a mature stage, when it is very dry and has already lost most of its leaves.

4.4. FEED PRESERVATION TECHNIQUES

Silage

The normal process of making silage depends on the transformation of soluble carbohydrates in the plant (or which are added to the silage) into lactic acid so that the pH of the silage drops to approximately 3.8 to 4.2. Well-made silage has a lactic acid content of approximately 8 to 12% of dry matter. Silage at a pH of 4 is stable and can be preserved indefinitely as long as the anaerobic conditions in the silo are maintained. If rain enters the silage or if the lactic acid concentration is too low, then a secondary clostridium-type fermentation ensues where lactic acid is converted into butyric acid. Silage in which this spoilage has occurred has a pH higher than 5 and has a bad taste and smell. Because this secondary type of fermentation can only take place in the presence of moisture, it is often recommended to wilt the plant material before ensiling and in this way reducing the moisture content of the plant material to between 65 and 70%. If the plant material, which is to be ensiled, does not contain enough carbohydrates (for example, if lucerne is to be ensiled versus the more common maize silage), then external carbohydrates can be added. This can be done by adding 2 to 3 percent molasses to the mixture and mixing well (20 to 30 kg of molasses per ton of silage) or by adding 45 to 55kg of maize meal to the mixture and mixing well. A well-made silage smells of fresh apples.

Any moisture rich material can be ensiled if adequate carbohydrates are available. Also, the material must be chopped fine enough to allow effective compaction to ensure that anaerobic circumstances are maintained in the silo. Materials as diverse as the leaves and trunks of banana trees, a mixture of oranges and cabbage, cosmos flowers, sugar cane tops, citrus pruning, and mango pruning have been successfully ensiled during research aimed at small scale farming at the Animal Nutrition and Products Institute of the Agricultural Research Council at Irene.

Drying

Plant material should be cut several times during the growing season. The quality of the hay is directly dependant on the stage of maturity of the plant when harvested: the younger the plant the higher the final hay quality will be. However, it must be remembered that younger plants are higher in moisture and thus that the drying process will take longer. Drying takes place on hot, sunny days, and ideally with a light breeze. The hay rows should be turned on the land several times to allow the hay to dry on all sides. When the hay is completely dry it can be raked and baled. Hay should be stored out of direct sunlight and away from moisture and pests such as birds and rodents.

5. QUALITY CONTROL MEASURES THAT AFFECT FEEDS

5.1. FEED STANDARDS

The quality and standards of Feed in South Africa is controlled by the Fertilizers, Farm feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act no. 36 of 1947). This act is available on the Agricultural Feed Manufacturers Association website at www.afma.co.za. Obtain a copy of this act for this Session.

Compare the quality of feed ingredients and complete feeds with the standards described in the Farm Feed Act (Act 36 of 1947)

The Farm Feed Act gives specific requirements regarding:

- The registration of farm feeds (application, duration of registration, and renewals of registration.
- Conditions for the registration of farm feeds.
- Requirements for custom mixes.
- Marking and labeling of Animal Feeds.
- Invoicing.
- Registration requirements for feed ingredients.
- Registration requirements for enzymes, micro-organisms and their preparation.
- Publication or distribution of false or misleading advertisements.
- Harbors and ports through which imports may occur.
- Practices to be followed at establishments.

- General requirements for establishments.
- Keeping of records.
- Substances whose use is prohibited in mixed animal feeds.
- Ingredients allowed in mixed animal feeds.
- Undesirable substances with limited use in animal feeds.
- Maximum and minimum levels of additives in animal feeds.
- Additives in supplementary and concentrated animal feeds.
- Maximum and minimum levels of stock remedies in animal feeds.
- Stock remedies in supplementary and concentrated animal feeds.
- Sampling of animal feeds.
- Analysis methods.
- Tolerances.
- Offences and penalties.
- Payment of fees.

5.2. DEVELOPING ON-FARM NUTRIENT VARIABILITY STANDARDS

As a farmer or farm manager it is your task to ensure that any feeds that you mix yourself or which you acquire from a feed manufacturing company complies with the legislation. This is to ensure the health of animals, but more importantly the health of the public that consumes the products from the livestock. Also, international sanitary regulations are becoming very strict especially regarding the use of feed additives. It would be irresponsible to use a feed ingredient which is prohibited by law and in doing so jeopardising the good standing of South African livestock products internationally.

Remember, legislation does not only serve a prohibitory purpose; laws also provide Good Practice principles which are useful guidelines to apply to your own farming operation.

Activity 3

Obtain the Farm Feed Act of 1947 (Act no 36) and Notice 498 of 2006 **Annexure A "South African Policy on Animal Feeds" from the AFMA website** (www.afma.co.za).

Study these documents carefully have a classroom discussion of those aspects that will have practical implications for mixing of feed on your own production unit. For example, if the feed you are mixing is for your own use only, the feed labelling regulations may not be relevant to your situation. However, the use of certain feed additives is prohibited and you will not be able to use these additives in your rations since your livestock or livestock product will be sold for public consumption.

Note: The implications of the Farm Feed Act will be completely different between a farm which mixes its own feed for own use and a feed manufacturing company that manufactures farm feeds for sale.

5.3. FEED EVALUATION AND FEEDING MANAGEMENT

Although Nutrient Requirement tables and Feed Composition tables (as supplied in Appendix A) provide volumes of information that is useful in feed formulation, it should be understood that the farm manager has a more comprehensive set of feed management "tools" at his/her disposal. These "tools" can assist the farmer on a daily basis to improve the feed management on the farm.

Remembering that feed is the most expensive input in a livestock production operation, it makes sense that different methods should be employed to obtain the most benefit out of feeds at the lowest cost.

5.4. DATA REQUIRED FOR NUTRITION MANAGEMENT DECISIONS

Several data types can be utilised by the farmer to make feed management decisions. These include:

- Feed conversion ratios. Feed conversion ratios indicate the amount of product produced per weight of feed consumed. To calculate feed conversion ratios the daily weight gain of the animal should be measured and the weight of feed consumed by an animal on a daily basis should be measured.
- Feed intake values. If an animal can be stimulated to consume a large amount of feed, growth will obviously be enhanced. However, there are health and physical (anatomical) limitations to the amount of feed that an animal can consume.
- Growth rate values. No production system can claim to be a production facility if production is not measured (monitored) on a regular basis. Growth rates can be measured weekly or monthly depending on the labour requirements, the facilities available and the type of operation. Feedlot steers are often weighed when they arrive at the feedlot, and they are measured again at sale. Their daily gain is estimated from previous experience and their market readiness is also measured subjectively by experienced feedlot operators. However, where this "experienced eye" is lacking, animals should be weighed at regular intervals to check progress.

- Nutrient composition of feeds and feed ingredients: It is good practice to send feed ingredients for analysis on a regular basis. The nutrient composition of purchased feeds can be determined from their labels, but feeds grown on the farm need to be analysed.

5.5. INTERPRETING THE DATA

Feed Conversion Ratios

A feedlot steer may consume 15 kg of complete feed per day, whilst gaining 2.5 kg per day. The feed conversion ratio in this instance is thus 6.8. In other words the steer consumes 6.8 kg of feed for every 1 kg of live weight gain. If this live weight gain is translated into carcass weight gain (one can assume a dressing percentage of 65%), then 1 kg of live weight gain translates into 650 g of carcass weight. Thus, for every 15 kg of feed consumed 1.625 kg of carcass is produced.

Let us see whether this is a profitable situation. Let us assume that the feed costs R1200 per ton. Thus, the feed costs for the feedlot steer is R18 per day (we are not including the other costs of the feedlot such as labour, electricity, water, etc). If the feedlot operator obtains R13.00 per kilogram live weight for his steer, the Rand per kilogram carcass weight translates into R20. The feedlot operator can expect to make R2 per kilogram of carcass weight gained by the steer. It is thus important that the feedlot operator tries and obtains an optimal weight gain for the least amount of feed. He cannot starve his animals (this would result in little weight gain) so he must ensure that the feed conversion ratio is as low as possible. For example, a chicken has a feed conversion ration of approximately 2! This means that the chicken consumes 2 kg of feed for every 1 kg of weight gained. Imagine the fantastic future feeds necessary if a feed conversion ratio of 2 could be obtained for feedlot steers.

Feed Intake

Even when animals are fed in groups, estimates of feed intake per animal can still be made. This is done by measuring the amount of feed provided to the group, measuring the amount of feed left over by the group, and dividing the amount consumed by the number of animals in the group. If animals are grouped according to similar sizes and types then an assumption can be made that feed consumption of individuals within the group are roughly the same.

Several methods can be used to stimulate intake of feed. Such methods include pelleting of the ration (which reduces selection), adding palatable substances such as molasses, reducing the stressors in the environment of the animal (for example removing animals that bully, allowing enough crib space, ensuring the health of the animal) and reducing the dustiness of the feed.

Growth Rates

If regular weighing is done and all animal weights recorded it is possible to determine whether there is a problem in the herd. For example, if your animals are grazing on pasture with a feed supplement provided, and excellent weight gains are obtained in the month of November, but poorer weight gains are obtained in the month of December, this may be an indication that the grazing quality is reducing and an adjustment must be made to the feed supplement. Or, it may be an indication that the animals are experiencing an increased parasite load (e.g. tape worm), and that they should be treated with anthelminthics.

Nutrient Composition of Feeds and Feed Ingredients

If feed ingredients grown on the farm are analysed on a regular basis (monthly), then it is possible to adjust the feed supplementation required (if any is required) to match the nutrients already provided by the grazing. This manner of feed management will provide the farmer with the best growth rates since he/she is not overfeeding or underfeeding the herd. This is also a good method to manage the costs of feed supplementation since supplementation will only be done when absolutely necessary.

6. FEED FLOW PLANNING

It is all very well to know how much feed an animal or a herd of animals needs. It is also useful to know how to formulate rations for these requirements and to know how to mix such rations. However, if feed is the most expensive input in a livestock production system then the management of the feed throughout the production cycle, where the correct nutrients are provided to the herd on an on-going basis, becomes crucial. This is known as "feed flow". How does the farmer plan this annual feed flow?

6.1. SEASONAL PRODUCTION OF FEED INGREDIENTS

In South Africa there is no area where feed from the natural veld is available in the right quantities and quality all year round. However, with correct pasture management, this feed resource is the most inexpensive feed resource and should be used optimally. Where deficiencies in this resource occur, the farmer needs to supplement those nutrients that are lacking. It should also be remembered that the natural veld resource should be managed sustainably. That is why the word "optimal" is used and not "maximum". You cannot expect to extract the maximum from the veld pasture without ruining it for the future. Thus, the correct stocking rates, camp rotation and resting should be used to manage the natural pasture resource for the future.

6.2. FEED FLOW FOR ANIMAL REQUIREMENTS FOR MAINTENANCE AND PRODUCTION

Determining the Nutrient Requirements of the Production Herd

When planning the feed flow for an operation it is first necessary to determine the production cycle of the animal. In this way it becomes possible to ascertain the general requirements of the herd over time. This can then be matched to the provision of nutrients from the natural pasture at that same period and shortfalls can be determined.

There are five important periods that need special attention during the production cycle of a female small stock animal (sheep and goats):

Dry

This is the period between weaning the offspring and being bred. During this period, the female is regaining the weight lost while nursing the offspring. She must reach a satisfactory condition score before being bred again. However, the nutrient demand here is the lowest.

Mating

Flushing can be used to increase ovulation rate. Flushing involves providing supplementary feeding 3 weeks before the male is introduced, and 3 weeks after they were introduced. If the herd is on the veldt, flushing can be accomplished by putting the females onto lush pasture, or by feeding pellets or grain.

Early Gestation

(1st 100 days): foetus growth is slow during this period. A maintenance diet is enough and no ill effects will be found if the females are grazing veldt.

Late Gestation

(Last trimester): foetal growth is very rapid and the foetuses gain 70% of their birth weight in this 50-day period. Protein and energy requirements increase dramatically. In adverse weather conditions the farmer should provide adequate feed for the pregnant females, to avoid losing offspring, or to have offspring born in poor condition. During the 5th month of the gestation period, daily gains of the female should range from 0.1 to 1.2 kg.

Lactation

This is the most critical period. It is vital that the female's requirements are met, as the production of sufficient milk of good quality ensures that the offspring are healthy, grow fast, and at the end of the day they produce more meat, which means more money in the farmer's pocket.

Active Growth Stage of the Young Animal

A high quality feed should be fed to young animals because the requirements for growth are high and the rumen capacity at this stage is still a limiting factor. Poor nutrition during this stage can lead to permanent stunting of the animal. Differences of nearly 20 percent in mature body mass were obtained as a result of differences in nutritional treatment prior to four months of age. Also, the influence of pre- and postnatal treatments were additive. This means that if the mother is fed well in the last few weeks of pregnancy, and the young that are born are strong, then, if the young are also fed well up to weaning, the final result will be even stronger and healthier offspring.

Determining the Nutrient Provision of the Pasture

It is now necessary to match these to the nutritive value of the natural pasture and see if any gaps occur.

If we assume that the small stock herd mentioned above is being produced in a summer rainfall area such as the Northern parts of South Africa, the following pattern emerges:

January	Pastures of high quality	High protein and energy	High parasite load
February	Pastures of high quality	High protein and energy	High parasite load
March	Pastures starting to deteriorate	Decrease in protein	Parasite load reduced
April	Pastures deteriorating	Potential for frost damage	Decrease in protein
May	Pastures of poorer quality	Pastures of poorer quality	
June	Pastures of poor quality	Energy content dropping	Higher cellulose and hemicellulose
July	Pastures of poor quality	Energy content dropping	Higher cellulose and hemicellulose

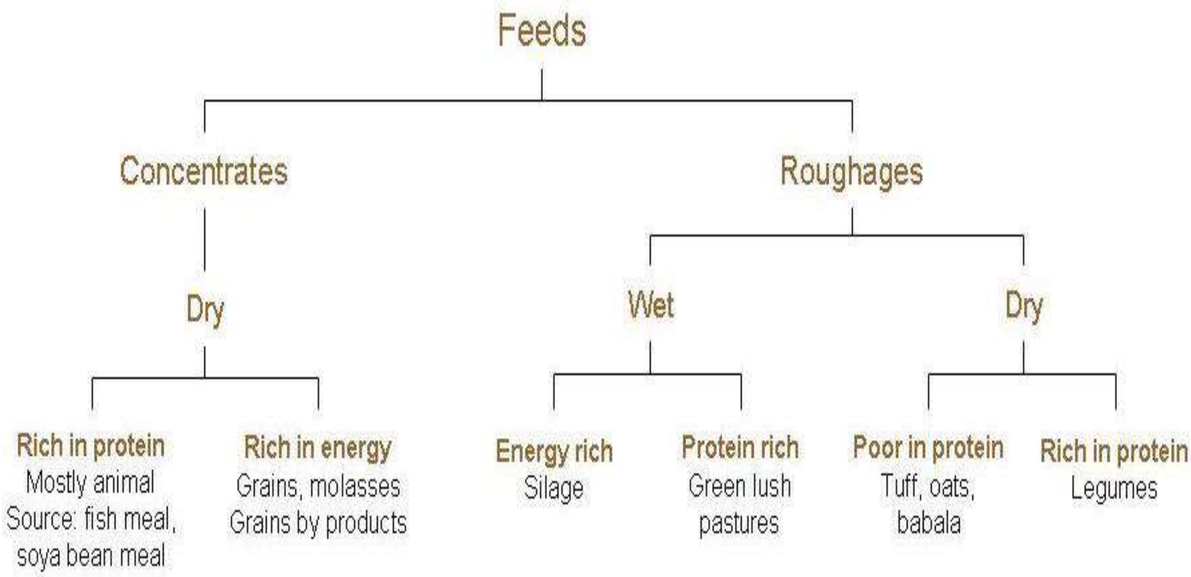
August	Pastures of poor quality	Energy content dropping	Higher cellulose and hemicellulose
September	Very poor pastures		
October	First rains – new growth - rich in protein	Energy may be limiting	
November	High quality pastures rich in protein	Energy may be limiting	Increase in parasite load
December	High quality pastures		High parasite load

Determining the Nutrient Provision of the Pasture

The nutrient requirements of the herd and the nutrient provision of the natural pasture is now super-imposed on each other. Where a shortfall of nutrients occurs, the pasture can be supplemented with either energy rich licks, or protein-rich licks as required. As a general rule a salt lick containing minerals should be provided all year round.

Keep in mind that with ruminants the farmer is actually feeding the micro-organisms in the rumen and not the ruminant animal itself. Therefore all feed management decisions should keep the livelihood of the micro-organisms in mind. For example, any changes in feed should be done slowly over at least a seven day period. Furthermore, inexpensive Non-protein Nitrogen sources such as urea (or sterilised chicken litter) can be used instead of expensive protein resources such as lucerne, fish meal etc. This is because the micro-organisms are capable of using these Non-Protein Nitrogen resources in the synthesis of amino acids and proteins.

SUMMARY TABLE OF FEED COMPOSITION



2A. Group Formative Exercise: Nutrition Questionnaire

2B. Individual Formative Exercise: Livestock nutrition: visit to a feed factory

Unit 2

Flow Chain of Agricultural Inputs

Unit Standard			
116382	**Manage an Input Chain**		
Specific Outcomes			
SO1: Plan the flow chain of agricultural inputs. SO2: Implement a plan on the flow of agricultural inputs. SO3 (Part of Farm Staff management module 3, pg 115) SO4: Evaluate and resolve eventualities that emerge during the flow of agricultural inputs. SO5: Give accurate reports on the agricultural input flow chain.			
Learning Outcomes			
At the end of this module you will have an understanding of: • The correct feed storage procedures on a farm • Feed stock control and record systems • Feed losses if incorrect storage systems are used			
Identifying Working	Communicating Demonstrating	Contributing Organise	Science Collecting

2.1 CORRECT FEED STORAGE PROCEDURES

Introduction

Animal feed is the one item that needs to be stored well, or it spoils. Storing hay to maintain its quality can be done in several different ways; the main thing to remember is that you want it covered. Tarps work and they're cheap, but they aren't a good long-term option. They tear, or blow away, unless very well secured in the first place; and sunlight eventually rots them, so they only last a season or two. One thing that can help is weighing tarps down well with old tires or blocks, or using tent stakes to tie them down. When using tarps, don't tightly enclose your whole pile of hay, or any moisture that is in the bales will cause them to rot in no time. Hay needs to have some air movement in and around the pile. Small hay piles benefit from being stacked on wooden pallets; this keeps soil moisture from ruining the bottom bales.

If you are dealing with large quantities of hay, a pole shed with just a roof, or a roof and one wall that blocks the predominant wind, protects hay well yet lets the air move around it. These structures are also relatively inexpensive to build. Hoop houses are also good for hay storage. Hay that is being stored in any type of enclosed structure must be adequately dry, or it may start on fire. As the hay cures, it heats up, and sometimes it can heat up enough to spontaneously combust!

Livestock kept with grass-farming strategies don't generally need grain in such large quantities that bulk storage space is necessary. The best way to store the small amounts of grain is in garbage cans or 55-gallon (208 l) drums. (Metal or plastic is fine, but make sure the drum contained food-grade materials before: You don't want to poison your stock.)

As with hay, grain must be well dried before it goes into storage. Dampness breeds mold (and possibly mycotoxins) and fire. Grain or premixed feeds that are being purchased from a reputable feed dealer should always be adequately dry, and most of the time area farmers whom you buy from directly won't be selling you wet feed. But when you buy grain at harvest time, make sure the grain has been tested for moisture. Most feed stores can provide this service, or you can test your own sample.

Haystacks Covered with a Tarp

2.2 APPLY STOCK CONTROL AND RECORDS OF ANIMAL FEED

As feed often makes up to between 60% and 70% of the costs of a farming operation, it is critically important that it is correctly stored and used.   It is very important that you make sure that you understand the control of feed on a farm.   The farmer must always know the rate of the feed-flow on the farm.   In other words, the farmer must have full control of the use and supply of feed on his farm.   Keeping that in mind, it is important that the people who practically feed the animals on the farm must regularly report to the farmer or manager on the use and stock of feed.

2.3 WHAT LOSSES CAN BE SUFFERED IF FEED IS NOT CORRECTLY STORED

Quantity

- Birds and rodents will eat the feed or, carry it away.
- Loose roaming animals might eat the feed.
- Human theft.
- Fire could destroy feed that are not stored away.
- Insects can turn grains into dust.
- Wind blows loose meal away.

Quality

- Birds, rodents and other animals eating freely will contaminate the feed with a danger of disease transmission to livestock.
- If the feed gets wet, it will become mouldy and is then dangerous to feed to pregnant animals. It is likely that it will need to be discarded or used to make compost
- High temperatures can turn oily / high fat feeds rancid.
- Open containers of molasses attract rodents that may fall into it and drown.
- If feed storage is such that the identity of the feed / mix is lost, it means that the feed may have to be discarded if it contains potentially dangerous substances such as antibiotics or urea.
- Always work on a FIFO (First in - first out) basis, so that feeds do not become too old.

What Can Be Done To Ensure Proper Storage of Feeds

- Ensure that feed storage areas are waterproof.
- If feed is stored loose, ensure that area is protected from wind, rain and pests/loose roaming animals.
- Store high cost feeds / supplements that can easily be loaded, in an area that can be safely locked.
- Small quantities of feed can be stored in plastic bins or drums.
- Make sure that fire control apparatus is available and working.
- Stack bags / bales in such a manner that cats can get to the rodents, but that the rodents do not have "nice" hiding places.
- Ensure an active rodent control program (use cats, dogs, baited traps, eco-friendly poison).
- Always keep stock control sheets up to date.

2.4 RECORDS TO BE KEPT

- All feeds that are regularly stored should appear as an item on a stock control sheet. Before any new consignment of feed arrives, the existing levels of stock need to be controlled and an area prepared for the new consignment. Do not load fresh food on top of old food.

- All consignments of feed delivered to the farm need to be checked, as it is off-loaded on the farm. Check that the label corresponds to that on the delivery note. Check the condition of the bags (are they torn, punctured or badly worn?) Count / weigh the feed as it is off-loaded and jot the actual number /weight received down next to the amount on the delivery note. Make a note on the delivery note of any problems encountered. Once the entire load has been checked, the delivery note is signed and a copy is kept for the farm records.

- Whenever feed is taken out to be used in a mix or to be fed, the amount of stock that is removed from the store needs to be jotted on the stock control sheet.

- The stock levels need to be controlled on a regular basis and maintained at a specific level. This is done as follow:

  - Take the last actual count / weight of bags / bales / feed.
  - Add all deliveries / new mixes made.
  - Subtract all stock used.
  - Jot down figure calculated - this is the Expected Stock Level.
  - Now do an actual count / weigh and compare it to the expected stock level.
  - The Stock Control sheet indicates what the minimum acceptable level of every item is. Once stock levels have been checked, follow workplace procedure to order stock that is below the minimum required level.
  - Whenever stock levels are checked, a check on quality can also be done. Check e.g. for signs of mould, rancidity, wet, dung contamination, separation of components.
  - Report any signs of quality problems on the stock control sheet.

2C. Group Formative Exercise:

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