

COURSE CODE:	ANN 508
COURSE TITLE:	Non-Ruminant Animal Nutrition
NUMBER OF UNITS:	3 Units
COURSE DURATION:	3 Hours

COURSE DETAILS:

Course Coordinator:	Dr. Adeboye olusesan Fafiolu
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Other Lecturers:	Prof. Olutosin Oduguwa, Dr Olusegun Mark Obafemi Idowu, Dr. Oluwakemi Irekhore

COURSE CONTENT:

Principles of poultry nutrition. Nutrient requirements for various classes and species of poultry. Pig nutrition and the feeding of various classes of pigs. Rabbit nutrition and the feeding of rabbits. Nutritional/metabolic disorder in non-ruminant.

COURSE REQUIREMENTS:

This is a compulsory course for all final year students in the college of Animal science and livestock Production. This course is being offered in lecture format on-campus for 14 weeks, students are expected to attend lectures and practical classes, 3 hours of lecture per week. Students are expected have minimum of 75% attendance to be able to write the final examination.

The course grade will be based on 1 exams, CAT and practical work.

READING LIST:



LECTURE NOTES

ANN 508: Rabbit Nutrition & Feeding

RABBITS FEEDING AND NUTRITION

I. INTRODUCTION

- A. Rabbits are monogastric (single stomach), herbivorous (eat plant material) animals.
- B. They need nutrients (such as proteins, carbohydrates, lipids or fats, minerals and vitamins) in specific amounts to grow and perform at their best.
 - 1. Feed is very important when raising rabbits, because it accounts for about 75 percent of your production costs.

2. In the wild, rabbits eat a variety of grains, greens, roots, and roughages.
 3. Most domestic rabbits eat a pelleted feed made to meet their nutritional needs.
 - a. Rabbit pellets consist mostly of ingredients from plants (primarily alfalfa meal and wheat middlings).
 - b. Pelleted rabbit feeds are available from many companies and are easy to feed and store.
- C. Some rabbit raisers prefer to formulate (mix) their own rabbit diet.
1. Rabbit feeds can be prepared from many readily available ingredients.
 2. The following feedstuffs are commonly used in diets for rabbits.
 - a. Green feeds -- growing plants such as grasses, weeds and leafy vegetables.
 - b. Root crops -- carrots, sweet potatoes, turnips and beets.
 - c. Cereal grains -- oats, wheat, barley,, grain sorghums, corn and rye.
 - d. Milled feed -- bran, middlings and shorts.
 - e. Hays -- alfalfa, clover, lespedeza and timothy.
 - f. Protein supplements -- soybean meal, peanut meal and dried milk products.
 - g. Salt.

II. FEEDING.

- A. Feeding has a strong influence on breeding, fertility, conception, kindling, nursing, growth, and resistance to disease.
1. Young rabbits begin to consume feed when they are approximately three weeks of age.
 2. A well balance, palatable ration should be available to them at all times in amounts which will adequately supply their nutritional needs.
 3. Special "milk supplements" are not needed.

4. The following table shows the amounts of feed which should be fed daily for young rabbits and other rabbits in various stages of the life cycle.

<u>Age or Condition</u>	<u>Amount to Feed Daily</u>
Growing rabbits (After weaning)	3 to 4 ounces
Resting Does	2 to 5 ounces
Does in Gestation	4 to 8 ounces
Nursing Does (until litter is 3 weeks of age)	6 to 8 ounces
Does with litter of 7 or 8 (3 to 8 weeks)	1 to 2 pounds

- B. Feed requirements for rabbits will vary with individual animals.
 1. Proper amounts should be fed to keep the animal in good physical condition without allowing it to become overly fat.
 2. Fat rabbits should have feed reduced; thin rabbits should have feed increased.
 - a. The most important thing is to feed only fresh, high quality pellets.
 - (1) The way a pelleted feed is put together is important.
 - (2) The pellets should be firm and not broken into small particles (fines).
 - (3) Rabbits tend to only eat the solid pellets and will not consume the fines.
 - (4) Look at the end of the pellet.
 - (5) The firm pellets will have squarer ends.
 - (a) If the ends of the pellet are extremely ragged, this may indicate a softer pellet which will produce a greater amount of waste due to fines.
 - b. Feed every animal over 3 weeks of age one small handful of legume hay every day.
 - c. Pellets or hay should never be fed if moldy.

3. **Some special feeding of nursing does is sometimes required.**
 - a. The doe's ration is normally reduced to one-half the usual amount on the day she kindles.
 - b. From the second to the seventh day, the amount of feed is gradually increased daily.
 - c. After the first week, feed should be kept before the nursing doe and her litter at all times.
 - d. When hay, greens, or root crops are fed, the amount of grain can be reduced.
 - e. When feeding greens, introduce small amounts at a time to rabbits, increasing total amount fed gradually to prevent diarrhea.
 - f. Salt can be provided either by mixing into the feed at one percent or in the form of commercial salt cakes.
 - g. Vitamins.
 - (1) Vitamin A is available from root crops and hay.
 - (2) Vitamin B is found in greens and crude roughage.
 - (3) It is also synthesized in the rabbit's cecum and is obtained by the rabbit's re-ingesting its droppings.

III. COPROPHAGY (ka-prof-a-gee).

- A. Rabbits are unique in that they produce two types of fecal material, a hard, dry fecal pellet and a soft of "night" feces.
 1. The soft feces are produced in the cecum (a pouch located between the small and large intestines) and are consumed by the rabbit directly from its anus as they are excreted.
 2. This practice is called coprophagy or cecotrophy and usually takes place when the animal is alone.

- B. Some feces contain a mucus coating and are excreted in a cluster rather than as single pellets as with hard feces.
 - 1. Coprophagy is a natural process which provides the rabbit with B-vitamins which are synthesized (produced) by bacteria in the cecum and excreted in the soft feces.
 - 2. Night or soft feces are much higher in protein and water and lower in fiber than hard feces.

IV. KEEP THESE POINTS IN MIND WHEN FEEDING RABBITS

- A. Breeding does and bucks should be kept in good condition. Many breeding failures are caused by does being overweight. In general, it is best to have a doe a little lean rather than a little fat.
- B. Pregnant does and lactating does require more feed. Consult an experienced breeder and/or a rabbit feed salesperson to help determine the amount of increase needed.
- C. Reduce the amount of feed given to a doe 24 to 48 hours before she kindles to help prevent caked mammary glands. After kindling gradually increase to full feed in 7 days.
- D. Growing young rabbits should have as much feed as they can eat; however, DO NOT let stale or mouldy feed accumulate in the feeder.
- E. Provide only as much feed as your rabbits will eat between feedings; any excess left in the feeder is usually wasted.

V. TIPS TO REMEMBER WHEN FEEDING RABBITS.

- A. Use a good quality, commercially prepared, pellet rabbit feed.
- B. Use a suitably sized container to measure you feed. (A 6-ounce tuna fish can holds about 5 ounces of pellets if shaken off level).
- C. To lower feed costs, feed a small amount of good, clean hay every day.
- D. DO NOT feed young rabbits cabbage, lettuce, or green grass.

RABBIT NUTRITION

They are not rodents, but are included in a family called Lagomorphs. They are strict herbivores and have continually growing incisors and molars that are designed to tear and macerate very tough leafy foods. The teeth rub against each other and are worn down by the action of eating. Rabbits require a large percentage of fiber in their diet to maintain normal gastrointestinal motility. Rabbits are monogastric animals with enlarged caeca. They are medium sized hopping mammals with long legs, long ears and short tails. Rabbits are mainly reared for their meat and fur. Rabbit meat is normally regarded as a white meat. Rabbits kept as a source of meat and/or a source of income. The nutrition of rabbit is an important aspect of production. Rabbit is also a small non-ruminant herbivore with an enlarged hind gut. It is a monogastric or single stomachs animal.

The digestive system consists of:

- Mouth & teeth.
- stomach & small intestine
- Caeca & large intestine

The Mouth and rabbit's teeth.

Digestion begins in the mouth, where food is mashed up by the teeth and mixed with saliva. Enzymes in the saliva begin the process of breaking down food into pieces small enough to move into the blood. When food is broken up and moist, the rabbit swallows and the food enters the stomach.

Dental formula	1 :2/1	C 0/0	pm 3/2	m 3/3
	Incisors	canine	premolar	molars.

Total number of teeth is 28.

The mouth part of rabbit is adapted for cutting and chewing.

The incisors are for cutting. The front surface of the incisors has a thick layer of enamel which forms a sharp edge at the cutting point of the teeth.

The incisors are open rooted, meaning that they continue to grow throughout the rabbit's life as they worn down by chewing. Premolars and molars are for grinding.

Stomach and Small intestine

The stomach of rabbit weights about 20g and the contents weight about 90 – 100g. The pH is between 1.5 and 2.0. The food in the stomach is exposed to acidity and some enzyme digestion begins. The weak muscular contractions in the stomach push the ingested feed into the first loop of the small intestine. The small intestine is about 310 – 350 cm long and has a weight of about 60+ 3 g. The contents of small intestine ranges between 18-42 g depend of on diet density and bulkiness. The pH of small intestine is 7.2 or slight alkaline. The first loop of the small intestine is called duodenum, Here the ingesta is bath in bile which is released into the GIT via bile duct. The bile is produced in the liver and is stored in the gall bladder. Next to the duodenum is the pancreatic loop which produces pancreas via the pancreatic duct. In the stomach the food is mixed with stomach acid and different enzymes continue the process of digestion. Once food has been broken into even smaller pieces by the stomach, it moves into the small intestine. Small water-soluble nutrients such as sugars, amino and nucleic acids, and non water soluble fats are absorbed in this region. Larger indigestible molecules such as fiber are passed into the large intestine. Once in the large intestine the material is sorted by size. Smaller fragments are moved backwards into the caecum for use by the cecal bacteria. Larger fiber fragments are passed to the large intestine and then excreted as fecal pellets.

Caecum and large intestine

Rabbits are referred to as hind – gut fermenter that is feed is broken down by bacteria at the end of the digestive system. The major site of breakdown in the caecum. The caecum is between small and large intestines and is about 45cm long, 25-30g in weight while the content vary between 120-140g. The pH is 6.0. The caecum has absorbing and secretory cell. Its end there is a small closed sac called appendix. A rabbit's cecum maintains a delicate mix of protozoa, yeast and *good bacteria*, which is crucial to keeping your rabbit healthy. If something upsets the delicate bacterial balance (such as stress; some oral antibiotics such as penicillin & related drugs; a high fat, low fiber diet; too many carbohydrates, etc.), *bad bacteria* will begin to grow. These bad bacteria produce toxins that can be harmful or fatal to your rabbit. On the other hand, the products of *good* cecal fermentation are crucial to healthy gut flora, because they break

down, or "ferment" the fiber the rabbit cannot digest, through coprophagy, the oral re-ingestion of the cecal pellets produced by this fermentation process, the rabbit can absorb by normal digestion the special nutrients and vitamins contained in the cecal pellets.

The bacteria use the energy generated during fermentation to grow. By products of fermentation include VFA like acetic acid of monophonic butyric acid, bacteria, B. vitamins, gas like methane, bacteria protein and essential amino acids, all of which can be used by the rabbit. Volatile fatty acids are absorbed directly into the bloodstream through the lining of the cecum and provide approximately 30% of the energy required by the animal. Nutrients that cannot be absorbed directly into the bloodstream pass through the large intestine and are excreted as "cecal pellets" Cecal pellets are different from the round rabbit droppings that are left in the litter boxes; they are soft, grapelike clusters that have a distinctive smell

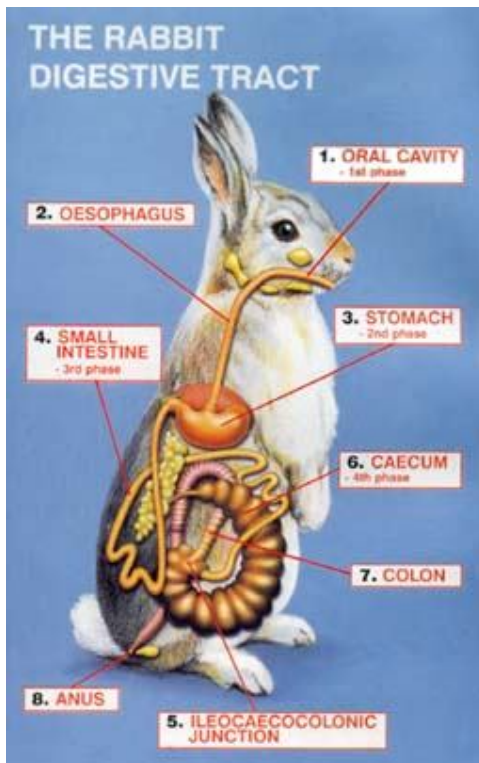
The content of the caecum are digest a, VFA like acetic acid of monophonic butyric acid, bacteria, B. vitamins, gas like methane. Bacteria in the caecum cause fermentation are digesta to produce B-vits, e.g. thiamine, bacteria protein and gases.

Note: That when a rabbit is treated with antibiotic for bacterial diseases, the cecal bacteria may also be killed. This often led to disturbances in the digestive system. Water is reabsorbed throughout the caecum of large intensive. This results in relatively hard, dry facial pellets.

Digestive tract and caecotrophy

Feed eaten by the rabbit quickly reaches the stomach. There it finds an acid environment. It remains in the stomach for a few hours (three to six), undergoing little chemical change. The contents of the stomach are gradually "injected" into the small intestine in short bursts, by strong stomach contractions. As the contents enter the small intestine they are diluted by the flow of bile, the first intestinal secretions and finally the pancreatic juice.

After enzymatic action from these last two secretions the elements that can easily be broken down are freed and pass through the intestinal wall to be carried by the blood to the cells. The particles that are not broken down after a total stay of about one and a half hours in the small intestine enter the caecum. There they have to stay for a certain time, from two to 12 hours, while they are attacked by bacterial enzymes. Elements which can be broken down by this new attack (mainly volatile fatty acids) are freed and in turn pass through the wall of the digestive tract and into the bloodstream.



The digestive system of the rabbit

The contents of the caecum are then evacuated into the colon. Approximately half consists of both large and small food particles not already broken down, while the other half consists of bacteria that have developed in the caecum, fed on matter from the small intestine.

So far, the functioning of the rabbit's digestive tract is virtually the same as that of other monogastric animals. Its uniqueness lies in the dual function of the proximal colon. If the caecum contents enter the colon in the early part of the morning they undergo few biochemical changes. The colon wall secretes a mucus which gradually envelops the pellets formed by the wall contractions. These pellets gather in elongated clusters and are called

soft or night pellets (more scientifically, caecotrophes). If the caecal contents enter the colon at another time of day the reaction of the proximal colon is entirely different.

Successive waves of contractions in alternating directions begin to act; the first to evacuate the contents normally and the second to push them back into the caecum. Under the varying pressure and rhythm of these contractions the contents are squeezed like a sponge. Most of the liquid part, containing soluble products and small particles of less than 0.1 mm, is forced back into the caecum. The solid part, containing mainly large particles over 0.3 mm long, forms hard pellets which are then expelled. In fact, as a result of this dual action, the colon produces two types of excrement: hard and soft. Table 14 shows the chemical composition of these pellets.

The hard pellets are expelled, but the soft pellets are recovered by the rabbit directly upon being expelled from the anus. To do this the rabbit twists itself round, sucks in the soft faeces as they emerge from the anus, then swallows without chewing them. The rabbit can retrieve the soft pellets easily, even from a mesh floor. By the end of the morning there are large numbers of these pellets inside the stomach, where they may comprise three quarters of the total contents.

From then on the soft pellets follow the same digestive process as normal feed. Considering the fact that some parts of the intake may be recycled once, twice and even three or four times, and depending on the type of feed, the rabbit's digestive process lasts from 18 to 30 hours in all, averaging 20 hours.

The soft pellets consist half of imperfectly broken-down food residues and what is left of the gastric secretions and half of bacteria. The latter contain an appreciable amount of high-value proteins and water-soluble vitamins. The practice of caecotrophy therefore has a certain nutritional value.

The composition of the soft pellets and the quantity expelled daily are relatively independent of the type of feed ingested, since the bacteria remain constant. In particular, the amount of dry matter recycled daily through caecotrophy is independent of the fibre

content of the feed (Table 7-15). The higher the crude content of the feed and/or the coarser the particles, the sooner it passes through the digestive tract.

On the other hand, this particular function requires roughage. If the feed contains few large particles and/or it is highly digestible, most of the caecal contents are pushed back to the caecum and lose elements which nourish the "normal" bacteria living in the caecum. This would appear to increase the risk of undesirable bacteria developing in this impoverished environment, some of which might be harmful.

It is thus advisable to include a minimum of roughage in the feed, enabling the rabbit's digestive process to be completed fairly rapidly. In theory, roughage is provided by the crude-fibre content of the feed, as this is normally rather hard to digest. However, certain fibre sources (beetroot pulp, fruit pulp in general) are highly digestible (digestibility of crude fibre varies from 60 to 80 percent). Recommendations now made on quantities of indigestible crude fibre to be fed are therefore given below. Table 16 gives the chemical composition of various raw materials which can be fed to rabbits.

Caecotrophy regulation depends on the integrity of the digestive flora and is governed by intake rate. Experiments have shown that caecotrophy starts eight to 12 hours after the feeding of rationed animals, or after the intake peak of animals fed ad lib. In the latter case, the intake rate and hence the function of caecotrophy are governed by the light regime to which the animals are subjected.

Caecotrophy also depends on internal regulatory processes as yet not understood. In particular, the removal of the adrenals halts caecotrophy. Cortisone injections of animals without adrenals causes the resumption of normal behaviour. The digestive process of the rabbit appears to be highly dependent on adrenalin secretions. Hypersecretion associated with stress slows down digestive activity and entails a high risk of digestive ailments.

Composition of hard and soft faeces: averages and range for ten different feeds

Components	Hard pellets		Soft pellets	
	Average	Range	Average	Range
	<i>(Percentage)</i>			
Moisture	41.7	34-52	72.9	63-82
Dry matter	58.3	48-66	27.1	18-37
	<i>(Percentage of dry matter)</i>			
Proteins	13.1	9-25	29.5	21-37
Crude fibre	37.8	22-54	22.0	14-33
Fats	2.6	1.3-5.3	2.4	1.0-4.6
Minerals	8.9	3.1-14.4	10.8	6.4-10.8
Nitrogen-free extract	37.7	28-49	35.1	29-43

Source: Proto, 1980.

Intake and excretion of dry matter by growing rabbits eating isonitrogenous feeds containing two levels

	Experimental feeds	
	Low fibre content	High fibre content
Straw content (%)	5	20
Crude-fibre content (%)	10.8	16.8
Daily dry-matter intake (g)	60±28	67±28
Dry matter excreted each day in:		
hard pellets (g)	20±5	33±8
soft pellets (g)	10±4	10±5

of straw in place of maize starch

Source: C. Dehalle, personal communication, 1979.

Caecotrophy first starts to function in young rabbits (domesticated or wild) at the age of about three weeks, when they start eating solid feed in addition to mother's milk.

Feeding behaviour

Feeding behaviour studies have basically involved rabbits receiving balanced concentrates or fed ad lib on dry feed (cereals, straw, dry forage).

The feeding pattern of newborn rabbits is imposed by the dam. A doe feeds her young only once every 24 hours (although some does will nurse their young twice). Suckling lasts only two or three minutes. If there is not enough milk the young try to feed every time the doe enters the nest-box, but she will hold back her milk. This behaviour signals insufficient milk production in the doe.

From the third week of life the young rabbits begin to move about, taking a few grams of mother's milk and a little drinking water if available. In a few days the intake of solid feed and water will exceed the milk intake. During this period the changes in feeding behaviour are remarkable: the young rabbit goes from a single milk feed a day to a large number of alternating solid and liquid feeds distributed irregularly throughout the day: 25 to 30 solid or liquid meals every 24 hours.

The number of feeds during light periods drops and the morning "feeding rest" tends to lengthen. The feeding habits of wild rabbits are even more nocturnal than those of domesticated rabbits.

The Importance of Fiber in rabbit nutrition

Many different types of microorganisms (bacteria and protozoa) normally live in the rabbit intestine and cecum and aid tremendously in fermentation and digestion of foods. Fiber is required for these microorganisms to function properly and stay in balance. Fiber also stimulates motility of the gastrointestinal tract and helps keep food moving properly so that normal digestion and absorption of nutrients can take place. Without

fiber, gut motility slows down, the normal bacterial population is disrupted, and changes in gut pH and fermentation occur. This dangerous cascade of events can lead to indigestion or gut stasis, and can make a rabbit very ill. Rabbits experiencing this type of illness, called ileus, may show a decreased appetite, decreased fecal production, decreased size of fecal balls, softer feces, weight loss, increased gas production, and possibly diarrhea or other life-threatening disease. Ileus is frequently misdiagnosed as a “hairball” stomach obstruction.

High fiber is also necessary to keep the teeth in normal wear. A rabbit’s teeth grow continuously throughout its lifetime. In the absence of a high fiber diet, the teeth tend to overgrow, and complications can result including incisor or molar malocclusion, molar points, or tooth root and facial abscesses. When your rabbit is fed an improper diet that is, one that does not contain an adequate amount of [indigestible] fiber or one that is too high in carbohydrates the Gastro-Intestinal (GI) tract cannot function properly and it begins to shut down, causing various degrees of what is called GI stasis.

What is GI stasis?

When the speed with which material moves through the GIT is altered it can affect how quickly the stomach and cecum empty. When this happens we often see a dramatic decrease in the rabbit's appetite for both food and water, which only furthers the problem: The body still needs water to function so it takes it from the stomach and cecum, causing the contents of the entire GI tract (food, hair from grooming, etc.) to become further dehydrated and impacted. The bunny is then unable to pass the mass of food/hair in the stomach, feels full, uncomfortable and often gassy (due to the build-up of the bad bacteria in the cecum), which only adds to his "I don't want to eat" mentality! A rabbit in GI stasis will often stop eating, become anorexic and die. When a rabbit dies from GI stasis and its related problems it is most often due to hepatic *lipidosis* or Fatty Liver Disease, which is caused by the toxins produced by the bad bacteria in the cecum.

In most cases, especially those caught early-on by observant owners, GI stasis can be reversed with time, *patience* and good advice from your rabbit vet. But our goal is to prevent it from happening at all.

What Causes GI Stasis?

A rabbit's intestine can become static for a variety of reasons, including

(1) stress (2) dehydration (3) pain from another underlying disorder or illness (such as gas, dental problems, infections, or urinary tract disorders)

(4) an intestinal blockage or (5) insufficient dietary crude fiber. Left untreated, the slowdown or complete cessation of normal intestinal movement (peristalsis) can result in a painful death, in a relatively short period of time.

An intestinal slowdown can cause ingested hair and food to lodge anywhere along the GI tract, creating a potential blockage. Also, because the cecum is not emptying quickly enough, harmful bacteria such as *Clostridium* species (related to the ones that cause botulism and tetanus) can proliferate, their numbers overwhelming those of the normal, beneficial bacteria and fungi in the cecum. Once this overgrowth occurs, gas emitted by the bacteria can cause extreme pain. Some *Clostridium* species also produce potentially deadly toxins. It is the liver's job to detoxify these poisons, at a high cost to that all-important organ. Damage to the liver can be a serious--even life-threatening--side effect of GI stasis.

Rabbits can be fed on four major types of feed

- | | |
|-----------------|---------------------------------|
| 1) Grass | 2) Weeds |
| 3) Leaves | 4) Agro- industrial by products |
| 5) Concentrates | |

GRASSES

- | | |
|------------------------|----------------|
| 1) Elephant grass | 2) Spear grass |
| 3) Guinea grass | |

WEEDS

- *Tridax procumbens* - *Asphilia africana* - *Syndrella nodiflora*

- *Milk weed* - *Talinum triangulare*

LEAVES

1) Sweet patoto leaf 2) Pawpaw leaf 3) Cowpea leaf 4) Plantain leaf

AGRO-INDUSTRIAL BY PRODUCT

- Maize milling waste - Ground nut haulms
- Maize chaff - Rice milling waste

TYPICAL RABBIT CONCENTRATE

Ingredients	%composition
Maize	45.00
Soya bean meal	10.00
Ground nut cake	10.00
Palm kernel cake	10.00
Wheat offal	19.50
Bone meal	2.00
Oyster Shell	1.50
Premix	0.25
Salt	<u>0.25</u>
	<u>100.00</u>

M.E=2.55 KCAL/G

CP= 18%

CF = 15%

CONCENTRATE FEEDING IS THE MANAGEMENT OF CHOICE

Because -Concentrate feed is in form of mash

- It is easy to serve.**
- Left over does not stink**
- It supplied the necessary nutrients**
- It encourage and maintain sanitation and cleanliness in farm**

A recommended level of 50-100g concentrates daily depending on age and physiological status Concentrates are supplied in concrete feeders of varying height

- Clean water is supplied in drinkers daily**
- Wash feeders every other day to prevent mouldiness**

Adaptation of Rabbits to forage based- diets

The caecum is the major site of microbial growth and fermentation. So small herbivores like rabbit have evolved a unique digestive strategy that allows them to utilize a forage- based diets. The followings are noted in rabbit:

- (i) The digestive system involves selective separation of fibre particles from non- fibre components (stomach) for fermentation in the caecum.
- (ii) The selective separation and excretion of fibre is accomplished by muscular activities of the portioned colon. Fibre particles are less dense than other components of a forage, so they tend to segregate out in solution. The separated fibre particles are moved rapidly by peristaltic action to the colon, forming the faecal pellet (hard feces)
- (iii) Reverse peristalsis moves the non- fibre components (starch, granules, proteins, hides) from the proximal colon to the caecum where they undergo microbial fermentation. Colon is emptied completely every 24hrs of hard faeces and the soft faeces or chemotropism are excreted. In this process, the caecum contracts to move the caecal content into the proximal colon. Mucus is separated by goblets cells into the lining of proximal colon, covered or coated the cecotropes, which resembles grapes in appearance. These are moved true the colon by peristaltic action and are consumed directly from the anus by the animal.

PELLETS

The recommendations for feeding pellets to rabbits have changed dramatically over the past 5-10 years. Pelleted rabbit feed used to be recommended as a complete diet for rabbits with little other supplementation necessary. However, pelleted diets were originally formulated for the rapid growth of the meat, fur production, or laboratory rabbit. Most of these rabbits were not meant to live out their full life span. The breeding rabbit, with an average life span of 5 to 10 years, needs a balanced, low-energy, consistent diet with plenty of fiber primarily in the form of hay. Pelleted diets are typically made up of chopped, compressed hay, various grains, molasses, and other added nutrients. Grains can be quite high in calories (starches and fats) and lower in fiber than hay, and disrupt the microbial balance when eaten in significant quantities. The hay in pellets is chopped, compressed, and heated, and thereby loses a lot of its fiber quality. A high-quality pellet should be chosen that contains over 20% fiber and less than 16% protein. Avoid pellet mixes that contain too much seeds or grains such as corn .

Feeding a high quality diet comprised of hay, fresh vegetables, and limited quantities of pellets is key to optimal rabbit health and good preventative medicine. Many common diseases of rabbits are related to improper nutrition and can be prevented by learning about their nutritional requirements, consistency in the diet, and maintenance on a well-balanced high-fiber ration.

Nutrient Requirement of Rabbits

Carbohydrates

Carbohydrates provide energy for the rabbit.

Types

- Simple sugars (a.k.a. monosaccharides):
glucose, fructose (fruit sugar), corn syrup, high fructose corn syrup, dextrose
- Complex sugars (a.k.a. polysaccharides):
starch

Source

- Grains - Concentrated Starch
- Pellets - Concentrated Starch
- Fruit - Fructose

Needs

Carbohydrates are the primary energy source in the rabbit's diet. Therefore, the rabbit's need for carbohydrate is dictated by their energy level. Rabbits with higher energy demands, such as nursing mothers, growing bunnies, rabbits with some types of cancer, and those on certain drugs, may require more carbohydrates in the diet. Spaying and neutering decreases the need for energy and intake should be modified accordingly.

Dangers

Too much starch or sugar can contribute to obesity because the rabbit will convert the excess energy to fat. Enterotoxemia can be caused by too much carbohydrate in the diet. This is because the excess carbohydrate travels to the cecum where the extra energy can cause the wrong populations of bacteria to grow and produce toxins.

Fiber

Function

- Drives digesting food through the digestive tract (breaks digested food/feces into smaller masses)
- Is the best source of energy for bacteria living in the cecum (eg. fiber is converted into volatile fatty acids)
- Protects against diet induced enterotoxemia (maintains the cecal bacteria balance)
- Protects against GI stasis and helps prevent blockages due to hair
- Adds water and bacterial bulk to the feces (makes defecation easier)
- Helps retain water in the digestive tract.

Protein

Function

Protein is essential to make a bunny.

- Proteins help make bone and muscle and fur, they also are responsible for turning food into energy.
- Proteins are important for the proper functioning of the cecal bacteria

Fats

Function

- Provide energy
- Facilitate absorption of fat soluble vitamins

Source

- Grains
- Nuts
- Pellets
- Oils (flax seed oils and vegetable oils)

Needs

- Rabbits require approximately 1-1.5% of the total caloric intake to be fats.
- There is also a requirement for essential fatty acids, linoleic and linolenic acids.

- Eicosanoid hormones are essential for blood pressure control, blood clotting, muscle contractions and memory. Precursors for these hormones (omega 3 and omega 6 fatty acids) are essential and must be supplied by the diet.

Vitamins

Function

- Are important to help release energy from food and energy stores
- Act as hormones to regulate metabolism
- Act as antioxidants to prevent cellular damage

Source

- The water soluble vitamins and vitamin K are synthesized by the cecal bacteria and obtained by coprophagy.
- Carotenes (plant pigments) are converted to Vitamin A in animal tissues.
- Pre-vitamin D is found in sun-dried hay and can be synthesized by the skin after exposure to UV light.
- Vitamin E is found in vegetable oils and cereal grains.

Needs

- Rabbits do have an absolute requirement for all the vitamins except C.
- However, the vitamin K and the B-vitamins are provided by the cecal bacteria and therefore may not need further supplementation until the cecum is disturbed or the cecal pellets are not consumed.
- Rabbits receiving pellets as part of the diet should be receiving sufficient amounts of vitamins D, A, and E. For rabbits receiving no pellets, it is possible that D and E would become deficient after a long time (many years). Carrots, of course, are rich in vitamin A.
- Extreme excesses of Vitamin C can cause kidney damage.
- Excess vitamin D can cause calcium deposits in tissues (joint, kidneys, etc.).
- Excess vitamin A causes neurological and skin damage.

Minerals

Function

- Are important for bone structure (calcium, phosphorus, magnesium).
- Bind oxygen and carry it through the blood stream (iron).
- Act as antioxidants to prevent cellular damage (selenium).
- Help to release energy from foods and stores (iodine, cobalt, chromium).
- Participate in blood pressure control (sodium, potassium)

Source

- Many plants concentrate minerals therefore there is not a big risk that rabbits fed a varied diet including lots of vegetables would develop deficiencies.
- Pellets are a good source for minerals.

Excess minerals can be toxic, however, this should not be a concern with most minerals. The one exception is calcium. Rabbits metabolize calcium very differently from other animals. Rabbits absorb calcium from the intestine very efficiently (60-80% of ingested calcium is absorbed into the blood stream), and the major way for them to get rid of this calcium is through the urine.

FEEDING MANAGEMENT OF PIGS

Pigs (swine) are essentially kept for meat (pork) production. Pigs are born alive. Pigs are usually fed managed from birth until they are disposed of. Feed constitutes the largest single expense of any swine operation. For convenience feeding management of pigs may be divided into 4:

1. Feeding the nursing pig.
2. Feeding the weaned pig.
3. Feeding the market pig.
4. Feeding the breeding herd.

Feeding the Nursing (Suckling) Pig

Milk Feeding

The first successful step in feeding pigs is to ensure that they have access to their mothers' milk within 24 hours of birth. This is to ensure that each newborn gets an adequate supply of **colostrums**, the first milk produced by the sow after giving birth (parturition). Colostrum helps to increase disease resistance by providing immunization with proteins known as **gamma globulins**. Colostrum also provides glucose for the pigs which have low reserves of glycogen at birth. Colostrums also provides nutrients and other essential substances in highly concentrated forms. If pigs fail to get colostrums after birth, they may not survive. Since piglets rapidly lose their ability, with time, to absorb gamma globulins and the fact that the gamma globulin content of sow's milk declines rapidly after birth, it is very important that piglets (young pigs) suckle their mother during the first 24 hours of life. Weak piglets should be moved closer to the sow's udder in order to suckle their mother.

Piglets should continue to suckle their mother until they are weaned at 3 weeks, or at most, 6 weeks of age. The mother may not produce sufficient milk to take care of the excess pigs from large litters or the mother may die after farrowing, leaving behind orphan pigs. In such situations, a **milk replacer** may be fed at the rate 10ml. Milk replacer per piglet, 4 to 6 times daily until they are weaned. Milk replacers can be obtained commercially. A milk replacer may also be made by blending the following:

1000ml or cc (one litre) of cow's milk plus one raw egg, 2 tablespoons of sugar and some commercial iron.

Sow's milk is generally deficient in iron. Consequently, to prevent anemia and to ensure good growth, supplementary iron is necessary. It has been estimated that for optimal growth, piglets require 7mg of iron per day. Therefore for pigs weaned at 3 weeks of age, a single injection (preferably in the neck) of 100-150 mg of iron, as **iron dextran**, is sufficient. However, if pigs are weaned after 3 weeks of age. For oral treatment, the first

one should be given 1 to 3 days after birth and then weekly. Sprinkling a little soil in the pen, preferably sterilized by heat to avoid infection, may be an effective and cheap alternative to injection or oral administration of iron.

Creep Feeding

Maximum milk production of the sow is attained during the third and fourth week and declines steadily thereafter. Milk therefore, does not provide all the needed nutrients of the piglets before weaning. Therefore, supplementary feed must be supplied the suckling piglets. This feed is known as **creep feeding**. Piglets should be started on creep feed at about seven days of age. At first, the creep feed should be placed on a dry section of the floor at the rate of 20-25 g/litter/day and should not be given within a few hours of the sow being fed since most of the piglets will be sleeping or sucking and may not notice the creep feed. This practice should be continued for 3 or 4 days or until the piglets are obviously consuming the feed. After this period, the feed should be placed on a shallow feeder, large enough to allow as many pigs to feed together. For the first few days, creep feed should be fed often and a little at a time. This would ensure that the feed is always fresh. This practice also helps to encourage consumption since piglets tend to be curious when any new material is introduced into the pen. Any stale feed should be discarded daily. Some pig diets are shown in Table 1

Table 1. Percentage composition of pig creep and starter diets.

Ingredients	Creep diets (1-10kg)			Starter diets (for 10-20kg pigs)				
	1	2	3	4	5	6	7	8
Maize (corn)	61.70	57.50	56.60	61.70	58.85	60.55	-	67.30
Guinea corn	-	-	-	-	-	-	61.95	-
Groundnut meal	29.00	39.00	-	20.50	27.50	-	-	-
Soybean meal	-	-	39.50	-	-	28.00	27.60	29.25
Wheat bran	-	-	-	10.00	10.00	8.00	6.00	-
Fish meal	7.00	-	-	5.00	-	-	-	-
Fat or oil	-	-	0.70	-	-	-	1.00	-
Bone meal ¹	1.50	2.00	2.00	1.50	2.00	2.00	2.00	2.00
Periwinkle shell ²	0.25	0.65	0.65	0.60	0.75	0.75	0.75	0.75
Common salt	0.35	0.35	0.35	0.50	0.50	0.50	0.50	0.50
Methionine	-	0.10	-	-	0.05	-	-	-

Lysine	-	0.20	-	-	0.15	-	-	-
Premix ³	0.2	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Calculated composition								
Crude protein (%)	24.20	24.10	24.10	20.30	20.20	20.10	20.20	20.10
ME, kcal/kg diet	3510	3500	3507	3360	3360	3368	3350	3440
Lysine (%)	1.23	1.20	1.57	1.03	1.00	1.25	1.22	1.24
Meth.+cyst. (%)	0.66	0.65	0.71	0.60	0.56	0.62	0.61	0.60
Calcium (%)	0.90	0.91	0.94	0.92	0.93	0.95	0.96	0.94
Total phosphorus (%)	0.74	0.71	0.72	0.73	0.74	0.72	0.74	0.70

¹ Dicalcium phosphate can be used in the place of bone meal

² A good quality limestone or oyster shell can be used in place of the periwinkle shell

³ Premix supplied the following per kg diet: vitamin A, 20,000 i.u.; vitamin D₃, 2000 i.u.; vitamin E, 25 i.u.; vitamin K, 3.0mg; thiamine, 1.3mg; riboflavin, 5.0mg; niacin, 30mg calcium pantothenate, 17.5mg; biotin, 0.06mg; vitamin B₆, 2.5mg; choline chloride, 125mg; folic acid, 0.5mg; vitamin B₁₂, 0.02mg; vitamin C, 25mg; manganese, 25mg; zinc 146 mg; copper, 25mg; iron, 125mg; iodine, 0.8mg; cobalt, 0.9mg; selenium, 0.1mg.

The introduction of solid feed at the suckling stage helps to get used to solid feed and promotes the development of the necessary digestive enzymes. For piglets weaned after 4 weeks, creep feeding results in 10-15% heavier weight at weaning. With creep feeding, piglets tend to suckle less, leaving sows in a better body condition. This results in higher conception rate and the shortening of the weaning to breeding intervals

Feeding the Weaned Pig

Piglets are weaned anytime between 3 and 6 weeks. Weaning is stressful to the pig. The earlier the pig is weaned, the greater the stress. The weight of the piglet at weaning would depend on the age at weaning and management during the suckling period. The average weaning weight may vary between 4 and 7 kg.

To reduce stress after weaning, the animals should be properly fed. The creep diets should continue to be fed to the pigs until they attain an average weight of 10kg per pig. The creep diets at this stage (post weaning) may be referred to as **pre-starter** diets. Once the pigs has attained 10kg weight, they should be provided with a **starter** diet. Some sample pig starter

diets are also shown in Table 1. The starter diet should be fed up till approximately 20kg weight. Weanling pigs appear to perform better of pelleted diet and crumbles than on mash diet.

To maximize the benefit from a good starter, weaning pigs should be provided adequate feeder and floor spaces. A feeder space of 6-7 cm per weanling pig is recommended. A floor space allowance of 0.25m² per pig is recommended up to 20 kg. alternatively the floor space per pig may be phased out as follows:

- up to 14kg – 0.15m² (1.6 sq. feet);
- 14 to 18kg – 0.20m² (2.2sq. feet);
- 18 to 20kg – 0.25m² (2.7 sq. feet).

In addition, overcrowding of pigs should be avoided. It is good practice to house all pigs from a single litter in one pen.

Performance of Starter Pigs

Performance targets should be set for any pig enterprise. Table 2 provides some useful information on the performance of weaning pigs. From Table 2, it can be calculated that it takes 24 (best) 28 (better) and 33 (good) days from 7 to 20 kg weight at total feed intake of 18.5 kg; 20.0 kg and 21.1 kg, respectively, per pig.

Table 2 – Performance of Weanling Pigs from 7 to 20 kg Body Weight

	Good	Better	Best
Average daily gain	400	475	550
Average daily feed (g)	640	715	770
Feed conversion (g feed/g gain)	1.6	1.5	1.4
Mortality (%)	2.5	1.5	0.5

Data were adapted from “Swine Nutrition Guide” by J.F. Patience and P. A. Thacker, 1989.

Feeding Management of Market Pigs

Pigs are switched from starter diets to grower/finisher diets when they attain 20 kg live weight. The pigs are fed and managed until they attain market weight. Market weight varies from 60 kg to about 100 kg. In well managed piggeries, pigs are sold at weights of 90 to 100 kg. these weights are achievable in less than 200 days from birth. Both **boars** (males) and **gilts** (females) are reared for the market. However because males have some boar taint, they are normally castrated at 2-3 weeks of age. **Castration** (removal of the testicles) of pigs intended for slaughter may be done later, at 6 weeks of age. Castration should however not be done within one week of weaning. Castration prevents the development of boar taint. Such castrated young males are known as **barrows**. Boars grow faster and are leaner than gilts, which in turn, grow faster and are leaner than barrows. Boars also tend to convert feed about 3% more efficiently than gilts and about 7% more efficiently than barrows.

Feeding of Market Pigs

About 60% of the total cost of pork production is incurred during the period between 20 kg and market weight. The traditional system of feeding employs one grower diet from about 20 kg to a market weight of 105 kg. Another diet option is to feed more than one diet from 20 kg to market weight. The second option is the one recommended here. In this option, a grower diet is fed from 20 kg to 60 kg and then another grower/fattener diet is fed from 60 kg until market weight. Some typical grower diets are shown in Table 3. these diets are intended for pigs reared from 20 to 60 kg. Table 4 shows the composition of typical diets which can be used for pigs from 60 to 100 kg weight. These diets are intended as guides only. Usually pigs are fed to appetite (*ad libitum*); that is they are allowed continuous access to feed. Some operators practice the limit feeding system. In this system, the pigs are fed only a fraction of their *ad libitum* intake. Limit feeding system has been shown to improve feed efficiency by 5-10%, reduce carcass fat by 2-4% but reduce growth rate by 5-10%. If practiced, feed restriction should not exceed 10% of *ad libitum* intake and should not be practiced at any weight below 60 kg live weight.

The overall objective of a market pig enterprise is profitability. The cheapest or most expensive or the feed that gives the best efficiency is not necessarily the most profitable feed. This fact should be borne in mind. Feed should not be considered in isolation of other management factors. All pigs should also get continuous access to fresh, cool and clean water and must be in good health always. Over-crowding should be avoided. To get maximum benefit from any feed, sufficient feeder and floor spaces should be provided. As a guide, a floor space of 0.7 square metres per pig should be provided from 20-105kg. The floor space may be phased according to pig weight as follows:

20 – 35 kg	0.35m ² (4 sq. feet).
35 – 70 kg	0.55m ² (6 sq. feet).
70 – 105 kg	0.75m ² (8 sq. feet).

Table 3. Percentage Composition of Pig Grower Diets (for 20-60 kg pig)

Ingredients	1	2	3	4	5	6	7	8
Maize (corn)	47.00	47.40	51.50	52.00	-	75.30	75.30	37.65
Guinea corn	-	-	-	-	53.00	-	-	-
Groundnut meal	15.50	-	12.50	-	-	21.65	-	21.65
Soybean meal	-	16.00	-	13.00	16.00	-	21.65	
Wheat bran	34.70	33.80	-	-	28.20	-	-	-
Brewers dried grain	-	-	33.05	32.05	-	-	-	-
Palm kernel meal	-	-	-	-	-	-	-	37.65
Bone meal ¹	1.00	1.00	1.75	1.75	1.00	2.00	2.00	2.00
Limestone ²	1.10	1.10	0.50	0.50	1.10	0.35	0.35	0.35
Common salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Premix ³	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
<i>Calculated composition</i>								
Crude protein (%)	17.10	17.20	17.20	17.20	17.10	17.20	17.10	21.90
ME, kcal/kg diet	3109	3108	3110	3112	3107	3456	3441	3075
Lysine (%)	0.78	1.00	0.79	0.97	0.88	0.69	1.00	1.83
Meth.+cyst. (%)	0.52	0.59	0.67	0.72	0.54	0.44	0.53	0.66
Calcium (%)	0.77	0.78	0.78	0.79	0.78	0.76	0.77	0.92
Total phosphorus (%)	0.67	0.67	0.65	0.65	0.66	0.65	0.65	0.77

See Table 1

Premix supplied the following per kg diet: vitamin A, 12,000 i.u.; vitamin D3, 1200 i.u.;; vitamin E, .. i.u.; vitamin K, 1.8 mg; thiamine 0.8mg; riboflavin, 3.0 mg; niacin, 18 mg; calcium pantothenate, 5mg, biotin, 0.0375mg; vitamin B6, 1.5mg; choline chloride, 75mg; folic acid, 0.3mg; vitamin B12, 12mg; vitamin C, 15mg; manganese, 15mg; zinc, 87.6mg; copper, 15mg; iron, 75mg; iodine, ...mg; cobalt, 0.54mg; selenium, 0.06mg.

Table 4. Percentage Composition of Pig Grower Diets (for 60-105 kg pig)

Ingredients	1	2	3	4	5	6	7	8
Maize (corn)	36.55	37.05	44.30	-	-	32.30	80.30	44.30
Cassava meal	-	-	-	36.30	36.30	-	-	-
Groundnut meal	7.50	-	2.00	6.50	-	3.50	-	2.00
Soybean meal	-	7.50	-	-	6.50	-	16.80	-
Wheat bran	53.50	53.00	-	-	-	41.75	-	-
Brewers dried grain	-	-	51.00	54.50	54.50	-	-	-
Palm kernel meal	-	-	-	-	-	20.00	-	51.00
Bone meal ¹	0.25	0.25	1.50	1.50	1.50	0.25	2.00	1.50
Limestone ²	1.50	1.50	0.50	0.50	0.50	1.50	0.20	0.50
Common salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Premix ³	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
<i>Calculated composition</i>								
Crude protein (%)	15.10	15.00	15.00	15.10	15.00	15.20	15.20	15.70
ME, kcal/kg diet	2902	2901	2900	2904	2900	2906	3440	2914
Lysine (%)	0.74	0.84	0.74	0.78	0.87	0.67	0.84	0.53
Meth.+cyst. (%)	0.54	0.57	0.77	0.72	0.75	0.50	0.57	0.60
Calcium (%)	0.70	0.70	0.71	0.73	0.73	0.76	0.76	0.67
Total phosphorus (%)	0.63	0.63	0.60	0.60	0.60	0.62	0.63	0.78

See Table 2

Performance of Market Pigs

Some typical performance data for market pigs are presented in Table 5. These data are intended as guides only to help monitor any market pig flock. They should not be regarded as definitive. However if performances vary too much below the data given in Table 5, then solution to the problems must be sought. For example for the 20-105 kg pigs, average daily gain of 0.85-0.95 kg and feed efficiency of 2.7-3.0 can be achieved with overall excellent management. However the bottom line in any pig enterprise is profitability. This must always be borne in mind.

Some additional information can be calculated from Table 5 for the 20-105 kg pig as follows:

Weight gain	=	85 kg (105-20 kg)
Feed conversion	=	3.3
Total feed consumed	=	$8.5 \times 3.3 = 280.5\text{kg}$
Creep feed consumed	=	0.3kg
Starter feed consumed	=	21.25 kg
(See Table 6-27)		
Total feed consumed	=	$280.5 + 0.3 + 21.25 = 302.25$
Days from 20kg to 105kg	=	110
Days on starter feed	=	33
Days to weaning	=	28
Total days to market	=	171

Generally, total feed from birth to market may vary between 265 and 340 kg. Age from birth to market varies from 160 to 200 days depending on management and weight at slaughter. Weight at slaughter varies between 75 and 110kg.

Table 5. Performance of Market Pigs from 20 to 105 kg weight

	Weight Range of Pigs		
	20-60 kg	60-105kg	20-105kg
Average daily gain (kg)	0.605	0.825	0.776
Average daily feed (kg)	1.66	3.00	2.52
Feed conversion (kg feed/kg gain)	2.74	3.64	3.25
Days to market	-	-	105-125
Hot dressed percentage	-	-	75-80
Lean meat yield (%)	-	-	52-61
Back fat thickness (cm)	-	-	3.0-3.6

Data are for Large White x Landrace crosses

Feeding Management of the Breeding Herd

The breeding herd is made up of both females and males. The females are known as **gilts** before their first litter and **sows** after a first litter. The males are known as **boars**. The pregnancy period is known as the **period of gestation** and pregnant animals are known as **gestating pigs**. The gestation period is an average of 114 days (range of 112 to 115 days) or 3 months, 3 weeks and 3 days. Female pigs that are producing milk are said to be in lactation and are known as **lactating animals**.

Feeding of Gilts During Gestation

The breeding herd is kept solely for the production of young pigs (**piglets**). Traditionally, gilts intended for breeding are selected at market weight and are kept till they reach 120kg or more by which time they are 8 to 9 months old before breeding. It is however recommended that all replacement gilts be selected before market weight (say one month before) for proper gilt management. It is also more profitable if gilts are bred at an earlier age, and many producers are now successfully doing this. The level of feed intake affects the age at which a gilt reaches puberty, that is the age at which the reproductive organs become operative.

All gilts intended for breeding purposes should be fed *ad libitum* until they are bred by artificial insemination or by mating them with a boar. After service, feed intake should be reduced to about 2.0-2.7 kg per pig per day.

Sample gestation diets are shown in Table 6. The diet is fed from the time gilts are selected as breeders and through pregnancy.

Feeding of Sows during Gestation

The threshold level of feed intake/pig/day is about 1.5 kg. Above this level, feed intake has very little effect on litter size. Therefore, sows should be fed restrictedly. In general for pregnant sows, feed allocation should be restricted to 2.0-2.7 kg per animal per day. This level of feed intake should be maintained throughout pregnancy up to farrowing time (i.e. time of birth). Feed intake above this level is not much beneficial and result in increased feed cost. In addition, at higher level of feed intake, the sow may become over fat and litter size may increase without increasing birth weight. There is also some evidence that embryonic survival, and thus litter size, may be increased by restricting level of feed intake during gestation. As the level of feed intake during gestation increases, the level of feed intake during lactation decreases. This may result in the sow depleting its body reserves and consequent loss in body conditions during lactation.

To prevent sows getting overweight, a good rule is to feed 2.0 to 2.2 kg of feed per pig per day at 120 kg weight and increase this amount by 0.2 kg for every 20 kg increase in weight. The gilt or sow would gain weight during pregnancy. This weight gain consists of the net weight in gain by the sow (estimated at 10-15kg net weight gain per sow up to the fifth litter) and the weight of the foetal tissues (about 25 kg up to the fifth litter). After the fifth litter, sow weight gain should be nil. Thus the gilt or sow should be weighted at intervals to obtain the weight and the feed intake adjusted accordingly. A daily weight gain of 0.2 kg is considered normal.

Sows which are housed and fed in group be given 10-15% feed allowances above that of sows fed individually. This is to ensure that less aggressive sows also get feed that is

sufficient to prevent reproductive failure. For both gilts and sows, the amount of feed recommended for use during pregnancy should be taken as a guide only. This is because the actual amount of feed provided during gestation would depend on a number of factors. These factors include condition and size of the animal, method of feeding and housing, standard of management, health of the herd, environment, and productivity level.

Sows are also fed similar gestation diets as gilts (see Table 6).

Table 6. Percentage Composition of Gilt and Sow Gestation Diets

Ingredients	1	2	3	4	5	6	7	8
Maize (corn)	37.25	37.75	44.50	-	-	79.50	79.50	-
Guinea corn	-	-	-	-	-	-	-	81.00
Cassava	-	-	-	57.00	57.00	-	-	-
Groundnut meal	8.00	-	3.00	19.30	-	16.80	-	-
Soybean meal	-	8.00	-	-	19.30	-	16.80	15.30
Wheat bran	51.50	51.00	-	-	-	-	-	-
Brewers dried grain	-	-	49.00	20.00	20.00	-	-	-
Bone meal ¹	1.25	1.25	2.60	3.00	3.00	3.00	3.00	3.00
Limestone ²	1.30	1.30	0.20	-	-	-	-	-
Common salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Premix ³	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
<i>Calculated composition</i>								
Crude protein (%)	15.10	15.00	15.10	15.10	15.00	15.20	15.20	15.10
ME, kcal/kg diet	2905	2905	2904	3280	3266	3432	3420	3328
Lysine (%)	0.73	0.84	0.74	0.70	0.97	0.60	1.84	0.71
Meth.+cyst. (%)	0.54	0.57	0.75	0.44	0.51	0.41	0.48	0.42
Calcium (%)	0.91	0.91	0.91	1.04	1.04	0.91	0.91	0.91
Total phosphorus (%)	0.80	0.80	0.80	0.80	0.80	0.81	0.81	0.80

¹ Dicalcium phosphate can be used in the place of bone meal

² A good quality periwinkle shell or oyster shell can be used in place of the limestone

³ Premix supplied the following per kg diet: vitamin A, 12,000 i.u.; vitamin D₃, 2000 i.u.; vitamin E, 35 i.u.; vitamin K, 3.5mg; thiamine, 1.0mg; riboflavin, 5.0mg; niacin, 15mg calcium pantothenate, 15mg; biotin, 0.150mg; vitamin B₆, 2.0mg; choline chloride, 200mg; folic acid, 0.5mg; vitamin B₁₂, 0.015mg; manganese, 20mg; zinc 58.5mg; copper, 10mg; iron, 50mg; iodine, 0.3mg; cobalt, 0.35mg; selenium, 0.15mg.

Feed Restriction during Gestation

Feed restriction can be effected by either of four methods.

1. Individually feeding each pig the recommended amount of feed every day. This is the easiest method and provides the most effective control over the feed intake of gilts and sows. It is however labour intensive and may require individual housing.
2. Skip method. In this method, gilts or sows are allowed access to feed for 6-8 hours per day for only 3 to 4 days in the week. For the remaining 3 to 4 days, pigs are allowed access to water but no feed.
3. Diet dilution method. In this method, energy intake is restricted by diluting the diet with a high fibre ingredient. This method is less labour intensive. However it may cost more to maintain the sow and it is very difficult to prevent sows from getting fat. Making high fibre diets may sometimes be quite expensive. There are other problems associated with this method of feed restriction.
4. By using the electronic sow feeder in which several pigs can be group fed from one feeding area. In this method, the amount of feed each sow gets each day is programmed into the computer. Devices are put in place to prevent other pigs from getting at the feed specifically released for any particular sow. This method is attractive but is expensive.

Feeding the Sow during Lactation

There is a direct relationship between the amount of feed consumed by the sow during lactation and the amount of milk produced. As the level of feed intake increases, the level of milk production also increases and consequently, the growth rate of suckling piglets also increases. Insufficient feeding during lactation would result in the sow drawing on its body reserves causing an appreciable loss in body weight. This may result to depleted back fat reserves, longer weaning to conception intervals, low rates of conception and premature culling. Therefore sows should be given additional feed to meet the needs for milk production. Under normal conditions, the sow produces about 7 kg of milk daily during lactation.

Sows should also be fed according to the size of the litter. A good rule is to allow 2.2 to 2.5 kg of feed per day for the sow and additional 0.5kg for each pig in the litter. For example, to calculate the feed required per day by a sow nursing 10 piglets, proceed as follows:

Sow feed allowance = 2.2 to 2.5kg
Piglet feed = (0.5 x 10) = 5.0kg
Total feed allowance = 7.2 to 7.5 kg
(That is 7.2 – 7.5 kg of feed/sow/day).

There are several ways of maximizing feed intake during lactation. One way is to give the feed wet. Sows appear to consume more of a wet feed than they will of a dry feed. The feed can be made wet by simply sprinkling some water on the feed allocation for any period. A second method is to feed 2 or more times a day. It has been demonstrated that sows will consume more feed if fed two or more times a day as compared to feeding once daily. The use of pelleted feed has also been shown to increase the feed intake of sows. Pelleted feed should thus be used when available. Day length has also been shown to influence the amount of feed consumed by the animal. Where possible, day length period in the sow pen should be increased to about 15 hours by artificial lighting (use electric or kerosene lamps) to stimulate further consumption of feed. In addition, sows in lactation must be allowed continuous access to clean and fresh water at all times. The sow's daily water consumption is high. It may be as much as 15-25 litres per sow per day. Inadequate consumption of water may result in reduced feed intake by the sow. Sample sow lactation diets are given in Table 7.

Table 7. Percentage Composition of Sow Lactation Diets

Ingredients	1	2	3	4	5	6	7	8
Maize (corn)	42.50	43.00	-	-	77.00	77.00	-	-
Guinea corn	-	-	-	-	-	-	78.25	78.05
Cassava	-	-	61.00	61.00	-	-	-	-
Groundnut meal	12.00	-	25.20	-	19.10	-	-	18.00
Soybean meal	-	12.50	-	25.30	--	19.30	18.00	-
Wheat bran	42.20	41.20	-	-	-	-	-	-
Brewers dried grain	-	-	10.00	10.00	-	-	-	-

Bone meal ¹	1.50	1.50	3.00	3.00	3.00	3.00	3.00	3.00
Limestone ²	1.10	1.10	-	-	-	-	-	-
Common salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L-lysine	-	-	-	-	0.10	-	-	0.15
DL-methionine	-	-	0.10	-	0.10	-	0.05	0.10
Premix ³	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Calculated composition								
Crude protein (%)	16.10	16.20	16.10	16.00	16.10	16.10	16.20	16.20
ME, kcal/kg diet	3008	3010	3400	3382	3438	3424	3336	3338
Lysine (%)	0.75	0.93	0.72	0.06	0.75	0.92	0.86	0.75
Meth.+cyst. (%)	0.53	0.58	0.50	0.50	0.52	0.50	0.50	0.50
Calcium (%)	0.91	0.91	1.05	1.05	0.91	0.92	0.93	0.92
Total phosphorus (%)	0.80	0.80	0.80	0.80	0.82	0.82	0.85	0.84

¹ Dicalcium phosphate can be used in the place of bone meal

² A good quality periwinkle shell or oyster shell can be used in place of the limestone

³ Premix contained the following per kg diet: vitamin A, 12,000 i.u.; vitamin D₃, 2000 i.u.; vitamin E, 35 i.u.; vitamin K, 3.5mg; thiamine, 1.0mg; riboflavin, 5.0mg; niacin, 15mg calcium pantothenate, 15mg; biotin, 0.1505mg; vitamin B₆, 2.0mg; choline chloride, 200mg; folic acid, 0.5mg; vitamin B₁₂, 0.015mg; manganese, 20mg; zinc 58.5mg; copper, 10mg; iron, 50mg; iodine, 0.3mg; cobalt, 0.35mg; selenium, 0.15mg.

Feeding the Sow between Weaning and Rebreding

The level of feeding just before weaning should be maintained for about a week. Thereafter, feed should be provided at the rate of 2.7 kg per day. Gilts that have just weaned their first litter are sometimes difficult to rebreed due to poor body condition. For such gilts, a high level of feed of 3.5 to 4 kg per day (known as **flushing**) should be provided in order to improve the number of days from weaning to rebreeding and to improve the conception rates. Flushing is not necessary for older sows. After breeding, feed levels should be reduced to 2.0-2.7 kg per pig per day. Diets for dry sows are similar to those for the 60-120 kg pig.

Feeding Boars

Boars are first used for breeding at 8 to 9 months of age. Boars should be individually fed twice per day, at the level of 2.3 to 3.0 kg per day. Any of the diets recommended in Table 6-29 for the 60-105 kg pigs is suitable for boars. Over feeding of boars may reduce **libido**

(sexual drive), increase the size of the bear so that it become incompatible with the sows in the herd, result in early culling of the boars.

Performance of Gilts and Sows

The reproductive performance of swine breeding herd is shown in Table 8. these values are only guides and performances above the values stated in Table 6-33 are not uncommon.

Table 8. Reproductive Performance of Swine Breeding Herd

	Temperate ¹	Nigerian ²	Nigerian ³
Age at first breeding – sows (months)	8-9	8-9	10.00
Number of piglets born alive	9.8	9.8	9.4
Number of piglets weaned per litter	8.4	8.1	8.1
Mortality before weaning (%)	14.0	17.4	14.0
Weight per piglet at birth (kg)	1.4	1.5	N/A
Weight per piglet at weaning (kg)	6.4	6.6	5.7
Age of piglets at weaning (weeks)	3-4	3-4	5-6
Number of litters/year	1.8-2.3	1.8-2.3	1.5-2.3
Number of pigs weaned/sow/year	15-19	15-19	12-19

¹Summarized data of research conducted in temperate regions

²Summarized data from Nigeria for large white x landrace crossbreds

³Summarized data from field survey of pig farms in Nigeria (LIMECU, Federal department of livestock and pest control services, Abuja, 1992).

GENERAL COMMENTS ON FEEDING MANAGEMENT OF PIGS

All the diet formulations shown are examples only and other combinations are possible. Manufactured feeds should not be stored longer than four weeks at a time. Feed wastage must be prevented. Feed should be provided in an area separate from the watering area. The watering and feeding system must be adequate and clean. Only up-to-date feeding programmes should be used. Unproductive animals should be culled. In addition, animals

must be kept healthy. Pig pens should be scrubbed daily and disinfected as often as possible.

FEEDING MANAGEMENT OF PIGS

Pigs (swine) are essentially kept for meat (pork) production. Pigs are born alive. Pigs are usually managed from birth until they are disposed of. Feed constitutes the largest single expense of any swine operation. For convenience feeding management of pigs may be divided into 4:

5. Feeding the nursing pig.
6. Feeding the weaned pig.
7. Feeding the market pig.
8. Feeding the breeding herd.

Feeding the Nursing (Suckling) Pig

Milk Feeding

The first successful step in feeding pigs is to ensure that they have access to their mothers' milk within 24 hours of birth. This is to ensure that each newborn gets an adequate supply of **colostrum**, the first milk produced by the sow after giving birth (parturition). Colostrum helps to increase disease resistance by providing immunization with proteins known as **gamma globulins**. Colostrum also provides glucose for the pigs which have low reserves of glycogen at birth. Colostrum also provides nutrients and other essential substances in highly concentrated forms. If pigs fail to get colostrums after birth, they may not survive. Since piglets rapidly lose their ability, with time, to absorb gamma globulins and the fact that the gamma globulin content of sow's milk declines rapidly after birth, it is very important that piglets (young pigs) suckle their mother during the first 24 hours of life. Weak piglets should be moved closer to the sow's udder in order to suckle their mother.

Piglets should continue to suckle their mother until they are weaned at 3 weeks, or at most, 6 weeks of age. The mother may not produce sufficient milk to take care of the excess pigs from large litters or the mother may die after farrowing, leaving behind orphan pigs. In such situations, a **milk replacer** may be fed at the rate 10ml. Milk replacer per piglet, 4 to 6 times daily until they are weaned. Milk replacers can be obtained commercially. A milk replacer may also be made by blending the following:

1000ml or cc (one litre) of cow's milk plus one raw egg, 2 tablespoons of sugar and some commercial iron.

Sow's milk is generally deficient in iron. Consequently, to prevent anemia and to ensure good growth, supplementary iron is necessary. It has been estimated that for optimal growth, piglets require 7mg of iron per day. Therefore for pigs weaned at 3 weeks of age, a single injection (preferably in the neck) of 100-150 mg of iron, as **iron dextran**, is sufficient. However, if pigs are weaned after 3 weeks of age. For oral treatment, the first one should be given 1 to 3 days after birth and then weekly. Sprinkling a little soil in the pen, preferably sterilized by heat to avoid infection, may be an effective and cheap alternative to injection or oral administration of iron.

Creep Feeding

Maximum milk production of the sow is attained during the third and fourth week and declines steadily thereafter. Milk therefore, does not provide all the needed nutrients of the piglets before weaning. Therefore, supplementary feed must be supplied the suckling piglets. This feed is known as **creep feeding**. Piglets should be started on creep feed at about seven days of age. At first, the creep feed should be placed on a dry section of the floor at the rate of 20-25 g/litter/day and should not be given within a few hours of the sow being fed since most of the piglets will be sleeping or sucking and may not notice the creep feed. This practice should be continued for 3 or 4 days or until the piglets are obviously consuming the feed. After this period, the feed should be placed on a shallow feeder, large enough to allow as many pigs to feed together. For the first few days, creep feed should be fed often and a little at a time. This would ensure that the feed is always fresh. This practice also helps to encourage consumption since piglets tend to be curious when any new

material is introduced into the pen. Any stale feed should be discarded daily. Some pig diets are shown in Table 1

Table 1. Percentage composition of pig creep and starter diets.

Ingredients	Creep diets (1-10kg)			Starter diets (for 10-20kg pigs)				
	1	2	3	4	5	6	7	8
Maize (corn)	61.70	57.50	56.60	61.70	58.85	60.55	-	67.30
Guinea corn	-	-	-	-	-	-	61.95	-
Groundnut meal	29.00	39.00	-	20.50	27.50	-	-	-
Soybean meal	-	-	39.50	-	-	28.00	27.60	29.25
Wheat bran	-	-	-	10.00	10.00	8.00	6.00	-
Fish meal	7.00	-	-	5.00	-	-	-	-
Fat or oil	-	-	0.70	-	-	-	1.00	-
Bone meal ¹	1.50	2.00	2.00	1.50	2.00	2.00	2.00	2.00
Periwinkle shell ²	0.25	0.65	0.65	0.60	0.75	0.75	0.75	0.75
Common salt	0.35	0.35	0.35	0.50	0.50	0.50	0.50	0.50
Methionine	-	0.10	-	-	0.05	-	-	-
Lysine	-	0.20	-	-	0.15	-	-	-
Premix ³	0.2	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Calculated composition								
Crude protein (%)	24.20	24.10	24.10	20.30	20.20	20.10	20.20	20.10
ME, kcal/kg diet	3510	3500	3507	3360	3360	3368	3350	3440
Lysine (%)	1.23	1.20	1.57	1.03	1.00	1.25	1.22	1.24
Meth.+cyst. (%)	0.66	0.65	0.71	0.60	0.56	0.62	0.61	0.60
Calcium (%)	0.90	0.91	0.94	0.92	0.93	0.95	0.96	0.94
Total phosphorus (%)	0.74	0.71	0.72	0.73	0.74	0.72	0.74	0.70

¹ Dicalcium phosphate can be used in the place of bone meal

² A good quality limestone or oyster shell can be used in place of the periwinkle shell

³ Premix supplied the following per kg diet: vitamin A, 20,000 i.u.; vitamin D₃, 2000 i.u.; vitamin E, 25 i.u.; vitamin K, 3.0mg; thiamine, 1.3mg; riboflavin, 5.0mg; niacin, 30mg calcium pantothenate, 17.5mg; biotin, 0.06mg; vitamin B₆, 2.5mg; choline chloride, 125mg; folic acid, 0.5mg; vitamin B₁₂, 0.02mg; vitamin C, 25mg; manganese, 25mg; zinc 146 mg; copper, 25mg; iron, 125mg; iodine, 0.8mg; cobalt, 0.9mg; selenium, 0.1mg.

The introduction of solid feed at the suckling stage helps to get used to solid feed and promotes the development of the necessary digestive enzymes. For piglets weaned after 4 weeks, creep feeding results in 10-15% heavier weight at weaning. With creep feeding, piglets tend to suckle less, leaving sows in a better body condition. This results in higher conception rate and the shortening of the weaning to breeding intervals

Feeding the Weaned Pig

Piglets are weaned anytime between 3 and 6 weeks. Weaning is stressful to the pig. The earlier the pig is weaned, the greater the stress. The weight of the piglet at weaning would depend on the age at weaning and management during the suckling period. The average weaning weight may vary between 4 and 7 kg.

To reduce stress after weaning, the animals should be properly fed. The creep diets should continue to be fed to the pigs until they attain an average weight of 10kg per pig. The creep diets at this stage (post weaning) may be referred to as **pre-starter** diets. Once the pigs has attained 10kg weight, they should be provided with a **starter** diet. Some sample pig starter diets are also shown in Table 1. The starter diet should be fed up till approximately 20kg weight. Weanling pigs appear to perform better of pelleted diet and crumbles than on mash diet.

To maximize the benefit from a good starter, weaning pigs should be provided adequate feeder and floor spaces. A feeder space of 6-7 cm per weanling pig is recommended. A floor space allowance of 0.25m² per pig is recommended up to 20 kg. alternatively the floor space per pig may be phased out as follows:

up to 14kg – 0.15m² (1.6 sq. feet);

14 to 18kg – 0.20m² (2.2sq. feet);

18 to 20kg – 0.25m² (2.7 sq. feet).

In addition, overcrowding of pigs should be avoided. It is good practice to house all pigs from a single litter in one pen.

Performance of Starter Pigs

Performance targets should be set for any pig enterprise. Table 2 provides some useful information on the performance of weaning pigs. From Table 2, it can be calculated that it takes 24 (best) 28 (better) and 33 (good) days from 7 to 20 kg weight at total feed intake of 18.5 kg; 20.0 kg and 21.1 kg, respectively, per pig.

Table 2 – Performance of Weanling Pigs from 7 to 20 kg Body Weight

	Good	Better	Best
Average daily gain	400	475	550
Average daily feed (g)	640	715	770
Feed conversion (g feed/g gain)	1.6	1.5	1.4
Mortality (%)	2.5	1.5	0.5

Data were adapted from “Swine Nutrition Guide” by J.F. Patience and P. A. Thacker, 1989.

Feeding Management of Market Pigs

Pigs are switched from starter diets to grower/finisher diets when they attain 20 kg live weight. The pigs are fed and managed until they attain market weight. Market weight varies from 60 kg to about 100 kg. In well managed piggeries, pigs are sold at weights of 90 to 100 kg. these weights are achievable in less than 200 days from birth. Both **boars** (males) and **gilts** (females) are reared for the market. However because males have some boar taint, they are normally castrated at 2-3 weeks of age. **Castration** (removal of the testicles) of pigs intended for slaughter may be done later, at 6 weeks of age. Castration should however not be done within one week of weaning. Castration prevents the development of boar taint. Such castrated young males are known as **barrows**. Boars grow faster and are leaner than gilts, which in turn, grow faster and are leaner than barrows. Boars also tend to convert feed about 3% more efficiently than gilts and about 7% more efficiently than barrows.

Feeding of Market Pigs

About 60% of the total cost of pork production is incurred during the period between 20 kg and market weight. The traditional system of feeding employs one grower diet from about 20 kg to a market weight of 105 kg. Another diet option is to feed more than one diet from 20 kg to market weight. The second option is the one recommended here. In this option, a grower diet is fed from 20 kg to 60 kg and then another grower/fattener diet is fed from 60 kg until market weight. Some typical grower diets are shown in Table 3. these diets are intended for pigs reared from 20 to 60 kg. Table 4 shows the composition of typical diets which can be used for pigs from 60 to 100 kg weight. These diets are intended as guides only. Usually pigs are fed to appetite (*ad libitum*); that is they are allowed continuous access to feed. Some operators practice the limit feeding system. In this system, the pigs are fed only a fraction of their *ad libitum* intake. Limit feeding system has been shown to improve feed efficiency by 5-10%, reduce carcass fat by 2-4% but reduce growth rate by 5-10%. If practiced, feed restriction should not exceed 10% of *ad libitum* intake and should not be practiced at any weight below 60 kg live weight.

The overall objective of a market pig enterprise is profitability. The cheapest or most expensive or the feed that gives the best efficiency is not necessarily the most profitable feed. This fact should be borne in mind. Feed should not be considered in isolation of other management factors. All pigs should also get continuous access to fresh, cool and clean water and must be in good health always. Over-crowding should be avoided. To get maximum benefit from any feed, sufficient feeder and floor spaces should be provided. As a guide, a floor space of 0.7 square metres per pig should be provided from 20-105kg. The floor space may be phased according to pig weight as follows:

20 – 35 kg	0.35m ² (4 sq. feet).
35 – 70 kg	0.55m ² (6 sq. feet).
70 – 105 kg	0.75m ² (8 sq. feet).

Table 3. Percentage Composition of Pig Grower Diets (for 20-60 kg pig)

Ingredients	1	2	3	4	5	6	7	8
Maize (corn)	47.00	47.40	51.50	52.00	-	75.30	75.30	37.65
Guinea corn	-	-	-	-	53.00	-	-	-
Groundnut meal	15.50	-	12.50	-	-	21.65	-	21.65
Soybean meal	-	16.00	-	13.00	16.00	-	21.65	
Wheat bran	34.70	33.80	-	-	28.20	-	-	-
Brewers dried grain	-	-	33.05	32.05	-	-	-	-
Palm kernel meal	-	-	-	-	-	-	-	37.65
Bone meal ¹	1.00	1.00	1.75	1.75	1.00	2.00	2.00	2.00
Limestone ²	1.10	1.10	0.50	0.50	1.10	0.35	0.35	0.35
Common salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Premix ³	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Calculated composition								
Crude protein (%)	17.10	17.20	17.20	17.20	17.10	17.20	17.10	21.90
ME, kcal/kg diet	3109	3108	3110	3112	3107	3456	3441	3075
Lysine (%)	0.78	1.00	0.79	0.97	0.88	0.69	1.00	1.83
Meth.+cyst. (%)	0.52	0.59	0.67	0.72	0.54	0.44	0.53	0.66
Calcium (%)	0.77	0.78	0.78	0.79	0.78	0.76	0.77	0.92
Total phosphorus (%)	0.67	0.67	0.65	0.65	0.66	0.65	0.65	0.77

See Table 1

Premix supplied the following per kg diet: vitamin A, 12,000 i.u.; vitamin D3, 1200 i.u.;; vitamin E, .. i.u.; vitamin K, 1.8 mg; thiamine 0.8mg; riboflavin, 3.0 mg; niacin, 18 mg; calcium pantothenate, 5mg, biotin, 0.0375mg; vitamin B6, 1.5mg; choline chloride, 75mg; folic acid, 0.3mg; vitamin B12, 12mg; vitamin C, 15mg; manganese, 15mg; zinc, 87.6mg; copper, 15mg; iron, 75mg; iodine, ...mg; cobalt, 0.54mg; selenium, 0.06mg.

Table 4. Percentage Composition of Pig Grower Diets (for 60-105 kg pig)

Ingredients	1	2	3	4	5	6	7	8
Maize (corn)	36.55	37.05	44.30	-	-	32.30	80.30	44.30
Cassava meal	-	-	-	36.30	36.30	-	-	-
Groundnut meal	7.50	-	2.00	6.50	-	3.50	-	2.00
Soybean meal	-	7.50	-	-	6.50	-	16.80	-
Wheat bran	53.50	53.00	-	-	-	41.75	-	-
Brewers dried grain	-	-	51.00	54.50	54.50	-	-	-
Palm kernel meal	-	-	-	-	-	20.00	-	51.00
Bone meal ¹	0.25	0.25	1.50	1.50	1.50	0.25	2.00	1.50
Limestone ²	1.50	1.50	0.50	0.50	0.50	1.50	0.20	0.50
Common salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Premix ³	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
<i>Calculated composition</i>								
Crude protein (%)	15.10	15.00	15.00	15.10	15.00	15.20	15.20	15.70
ME, kcal/kg diet	2902	2901	2900	2904	2900	2906	3440	2914
Lysine (%)	0.74	0.84	0.74	0.78	0.87	0.67	0.84	0.53
Meth.+cyst. (%)	0.54	0.57	0.77	0.72	0.75	0.50	0.57	0.60
Calcium (%)	0.70	0.70	0.71	0.73	0.73	0.76	0.76	0.67
Total phosphorus (%)	0.63	0.63	0.60	0.60	0.60	0.62	0.63	0.78

Performance of Market Pigs

Some typical performance data for market pigs are presented in Table 5. These data are intended as guides only to help monitor any market pig flock. They should not be regarded as definitive. However if performances vary too much below the data given in Table 5, then solution to the problems must be sought. For example for the 20-105 kg pigs, average daily gain of 0.85-0.95 kg and feed efficiency of 2.7-3.0 can be achieved with overall excellent management. However the bottom line in any pig enterprise is profitability. This must always be borne in mind.

Some additional information can be calculated from Table 5 for the 20-105 kg pig as follows:

Weight gain	=	85 kg (105-20 kg)
Feed conversion	=	3.3
Total feed consumed	=	$8.5 \times 3.3 = 280.5\text{kg}$
Creep feed consumed	=	0.3kg
Starter feed consumed	=	21.25 kg
(See Table 6-27)		
Total feed consumed	=	$280.5 + 0.3 + 21.25 = 302.25$
Days from 20kg to 105kg	=	110
Days on starter feed	=	33
Days to weaning	=	28
Total days to market	=	171

Generally, total feed from birth to market may vary between 265 and 340 kg. Age from birth to market varies from 160 to 200 days depending on management and weight at slaughter. Weight at slaughter varies between 75 and 110kg.

Table 5. Performance of Market Pigs from 20 to 105 kg weight

	Weight Range of Pigs		
	20-60 kg	60-105kg	20-105kg
Average daily gain (kg)	0.605	0.825	0.776
Average daily feed (kg)	1.66	3.00	2.52
Feed conversion (kg feed/kg gain)	2.74	3.64	3.25
Days to market	-	-	105-125
Hot dressed percentage	-	-	75-80
Lean meat yield (%)	-	-	52-61
Back fat thickness (cm)	-	-	3.0-3.6

Data are for Large White x Landrace crosses

Feeding Management of the Breeding Herd

The breeding herd is made up of both females and males. The females are known as **gilts** before their first litter and **sows** after a first litter. The males are known as **boars**. The pregnancy period is known as the **period of gestation** and pregnant animals are known as **gestating pigs**. The gestation period is an average of 114 days (range of 112 to 115 days) or 3 months, 3 weeks and 3 days. Female pigs that are producing milk are said to be in lactation and are known as **lactating animals**.

Feeding of Gilts during Gestation

The breeding herd is kept solely for the production of young pigs (**piglets**). Traditionally, gilts intended for breeding are selected at market weight and are kept till they reach 120kg or more by which time they are 8 to 9 months old before breeding. It is however recommended that all replacement gilts be selected before market weight (say one month before) for proper gilt management. It is also more profitable if gilts are bred at an earlier age, and many producers are now successfully doing this. The level of feed intake affects the age at which a gilt reaches puberty, that is the age at which the reproductive organs become operative.

All gilts intended for breeding purposes should be fed *ad libitum* until they are bred by artificial insemination or by mating them with a boar. After service, feed intake should be reduced to about 2.0-2.7 kg per pig per day.

Sample gestation diets are shown in Table 6. The diet is fed from the time gilts are selected as breeders and through pregnancy.

Feeding of Sows during Gestation

The threshold level of feed intake/pig/day is about 1.5 kg. Above this level, feed intake has very little effect on litter size. Therefore, sows should be fed restrictedly. In general for pregnant sows, feed allocation should be restricted to 2.0-2.7 kg per animal per day. This level of feed intake should be maintained throughout pregnancy up to farrowing time (i.e. time of birth). Feed intake above this level is not much beneficial and result in increased feed cost. In addition, at higher level of feed intake, the sow may become over fat and litter size may increase without increasing birth weight. There is also some evidence that embryonic survival, and thus litter size, may be increased by restricting level of feed intake during gestation. As the level of feed intake during gestation increases, the level of feed intake during lactation decreases. This may result in the sow depleting its body reserves and consequent loss in body conditions during lactation.

To prevent sows getting overweight, a good rule is to feed 2.0 to 2.2 kg of feed per pig per day at 120 kg weight and increase this amount by 0.2 kg for every 20 kg increase in weight. The gilt or sow would gain weight during pregnancy. This weight gain consists of the net weight in gain by the sow (estimated at 10-15kg net weight gain per sow up to the fifth litter) and the weight of the foetal tissues (about 25 kg up to the fifth litter). After the fifth litter, sow weight gain should be nil. Thus the gilt or sow should be weighted at intervals to obtain the weight and the feed intake adjusted accordingly. A daily weight gain of 0.2 kg is considered normal.

Sows which are housed and fed in group be given 10-15% feed allowances above that of sows fed individually. This is to ensure that less aggressive sows also get feed that is

sufficient to prevent reproductive failure. For both gilts and sows, the amount of feed recommended for use during pregnancy should be taken as a guide only. This is because the actual amount of feed provided during gestation would depend on a number of factors. These factors include condition and size of the animal, method of feeding and housing, standard of management, health of the herd, environment, and productivity level.

Sows are also fed similar gestation diets as gilts (see Table 6).

Table 6. Percentage Composition of Gilt and Sow Gestation Diets

Ingredients	1	2	3	4	5	6	7	8
Maize (corn)	37.25	37.75	44.50	-	-	79.50	79.50	-
Guinea corn	-	-	-	-	-	-	-	81.00
Cassava	-	-	-	57.00	57.00	-	-	-
Groundnut meal	8.00	-	3.00	19.30	-	16.80	-	-
Soybean meal	-	8.00	-	-	19.30	-	16.80	15.30
Wheat bran	51.50	51.00	-	-	-	-	-	-
Brewers dried grain	-	-	49.00	20.00	20.00	-	-	-
Bone meal ¹	1.25	1.25	2.60	3.00	3.00	3.00	3.00	3.00
Limestone ²	1.30	1.30	0.20	-	-	-	-	-
Common salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Premix ³	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
<i>Calculated composition</i>								
Crude protein (%)	15.10	15.00	15.10	15.10	15.00	15.20	15.20	15.10
ME, kcal/kg diet	2905	2905	2904	3280	3266	3432	3420	3328
Lysine (%)	0.73	0.84	0.74	0.70	0.97	0.60	1.84	0.71
Meth.+cyst. (%)	0.54	0.57	0.75	0.44	0.51	0.41	0.48	0.42
Calcium (%)	0.91	0.91	0.91	1.04	1.04	0.91	0.91	0.91
Total phosphorus (%)	0.80	0.80	0.80	0.80	0.80	0.81	0.81	0.80

¹ Dicalcium phosphate can be used in the place of bone meal

² A good quality periwinkle shell or oyster shell can be used in place of the limestone

³ Premix supplied the following per kg diet: vitamin A, 12,000 i.u.; vitamin D₃, 2000 i.u.; vitamin E, 35 i.u.; vitamin K, 3.5mg; thiamine, 1.0mg; riboflavin, 5.0mg; niacin, 15mg calcium pantothenate, 15mg; biotin, 0.150mg; vitamin B₆, 2.0mg; choline chloride, 200mg; folic acid, 0.5mg; vitamin B₁₂, 0.015mg; manganese, 20mg; zinc 58.5mg; copper, 10mg; iron, 50mg; iodine, 0.3mg; cobalt, 0.35mg; selenium, 0.15mg.

Feed Restriction during Gestation

Feed restriction can be effected by either of four methods.

5. Individually feeding each pig the recommended amount of feed every day. This is the easiest method and provides the most effective control over the feed intake of gilts and sows. It is however labour intensive and may require individual housing.
6. Skip method. In this method, gilts or sows are allowed access to feed for 6-8 hours per day for only 3 to 4 days in the week. For the remaining 3 to 4 days, pigs are allowed access to water but no feed.
7. Diet dilution method. In this method, energy intake is restricted by diluting the diet with a high fibre ingredient. This method is less labour intensive. However it may cost more to maintain the sow and it is very difficult to prevent sows from getting fat. Making high fibre diets may sometimes be quite expensive. There are other problems associated with this method of feed restriction.
8. By using the electronic sow feeder in which several pigs can be group fed from one feeding area. In this method, the amount of feed each sow gets each day is programmed into the computer. Devices are put in place to prevent other pigs from getting at the feed specifically released for any particular sow. This method is attractive but is expensive.

Feeding the Sow during Lactation

There is a direct relationship between the amount of feed consumed by the sow during lactation and the amount of milk produced. As the level of feed intake increases, the level of milk production also increases and consequently, the growth rate of suckling piglets also increases. Insufficient feeding during lactation would result in the sow drawing on its body reserves causing an appreciable loss in body weight. This may result to depleted back fat reserves, longer weaning to conception intervals, low rates of conception and premature culling. Therefore sows should be given additional feed to meet the needs for milk production. Under normal conditions, the sow produces about 7 kg of milk daily during lactation.

Sows should also be fed according to the size of the litter. A good rule is to allow 2.2 to 2.5 kg of feed per day for the sow and additional 0.5kg for each pig in the litter. For example, to calculate the feed required per day by a sow nursing 10 piglets, proceed as follows:

Sow feed allowance = 2.2 to 2.5kg
Piglet feed = (0.5 x 10) = 5.0kg
Total feed allowance = 7.2 to 7.5 kg
(That is 7.2 – 7.5 kg of feed/sow/day).

There are several ways of maximizing feed intake during lactation. One way is to give the feed wet. Sows appear to consume more of a wet feed than they will of a dry feed. The feed can be made wet by simply sprinkling some water on the feed allocation for any period. A second method is to feed 2 or more times a day. It has been demonstrated that sows will consume more feed if fed two or more times a day as compared to feeding once daily. The use of pelleted feed has also been shown to increase the feed intake of sows. Pelleted feed should thus be used when available. Day length has also been shown to influence the amount of feed consumed by the animal. Where possible, day length period in the sow pen should be increased to about 15 hours by artificial lighting (use electric or kerosene lamps) to stimulate further consumption of feed. In addition, sows in lactation must be allowed continuous access to clean and fresh water at all times. The sow's daily water consumption is high. It may be as much as 15-25 litres per sow per day. Inadequate consumption of water may result in reduced feed intake by the sow. Sample sow lactation diets are given in Table 7.

Table 7. Percentage Composition of Sow Lactation Diets

Ingredients	1	2	3	4	5	6	7	8
Maize (corn)	42.50	43.00	-	-	77.00	77.00	-	-
Guinea corn	-	-	-	-	-	-	78.25	78.05
Cassava	-	-	61.00	61.00	-	-	-	-
Groundnut meal	12.00	-	25.20	-	19.10	-	-	18.00
Soybean meal	-	12.50	-	25.30	--	19.30	18.00	-
Wheat bran	42.20	41.20	-	-	-	-	-	-
Brewers dried grain	-	-	10.00	10.00	-	-	-	-
Bone meal ¹	1.50	1.50	3.00	3.00	3.00	3.00	3.00	3.00
Limestone ²	1.10	1.10	-	-	-	-	-	-
Common salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L-lysine	-	-	-	-	0.10	-	-	0.15
DL-methionine	-	-	0.10	-	0.10	-	0.05	0.10
Premix ³	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Calculated composition								
Crude protein (%)	16.10	16.20	16.10	16.00	16.10	16.10	16.20	16.20
ME, kcal/kg diet	3008	3010	3400	3382	3438	3424	3336	3338
Lysine (%)	0.75	0.93	0.72	0.06	0.75	0.92	0.86	0.75
Meth.+cyst. (%)	0.53	0.58	0.50	0.50	0.52	0.50	0.50	0.50
Calcium (%)	0.91	0.91	1.05	1.05	0.91	0.92	0.93	0.92
Total phosphorus (%)	0.80	0.80	0.80	0.80	0.82	0.82	0.85	0.84

¹ Dicalcium phosphate can be used in the place of bone meal

² A good quality periwinkle shell or oyster shell can be used in place of the limestone

³ Premix contained the following per kg diet: vitamin A, 12,000 i.u.; vitamin D₃, 2000 i.u.; vitamin E, 35 i.u.; vitamin K, 3.5mg; thiamine, 1.0mg; riboflavin, 5.0mg; niacin, 15mg calcium pantothenate, 15mg; biotin, 0.1505mg; vitamin B₆, 2.0mg; choline chloride, 200mg; folic acid, 0.5mg; vitamin B₁₂, 0.015mg; manganese, 20mg; zinc 58.5mg; copper, 10mg; iron, 50mg; iodine, 0.3mg; cobalt, 0.35mg; selenium, 0.15mg.

Feeding the Sow between Weaning and Rebreding

The level of feeding just before weaning should be maintained for about a week. Thereafter, feed should be provided at the rate of 2.7 kg per day. Gilts that have just weaned their first litter are sometimes difficult to rebreed due to poor body condition. For such gilts, a high level of feed of 3.5 to 4 kg per day (known as **flushing**) should be provided in order to improve the number of days from weaning to rebreding and to improve the conception rates. Flushing is not necessary for older sows. After breeding, feed levels should be reduced to 2.0-2.7 kg per pig per day. Diets for dry sows are similar to those for the 60-120 kg pig.

Feeding Boars

Boars are first used for breeding at 8 to 9 months of age. Boars should be individually fed twice per day, at the level of 2.3 to 3.0 kg per day. Any of the diets recommended in Table 6-29 for the 60-105 kg pigs is suitable for boars. Over feeding of boars may reduce **libido** (**sexual drive**), increase the size of the bear so that it become incompatible with the sows in the herd, result in early culling of the boars.

Performance of Gilts and Sows

The reproductive performance of swine breeding herd is shown in Table 8. these values are only guides and performances above the values stated in Table 6-33 are not uncommon.

Table 8. Reproductive Performance of Swine Breeding Herd

	Temperate ¹	Nigerian ²	Nigerian ³
Age at first breeding – sows (months)	8-9	8-9	10.00
Number of piglets born alive	9.8	9.8	9.4
Number of piglets weaned per litter	8.4	8.1	8.1
Mortality before weaning (%)	14.0	17.4	14.0
Weight per piglet at birth (kg)	1.4	1.5	N/A
Weight per piglet at weaning (kg)	6.4	6.6	5.7
Age of piglets at weaning (weeks)	3-4	3-4	5-6
Number of litters/year	1.8-2.3	1.8-2.3	1.5-2.3
Number of pigs weaned/sow/year	15-19	15-19	12-19

¹Summarized data of research conducted in temperate regions

²Summarized data from Nigeria for large white x landrace crossbreds

³Summarized data from field survey of pig farms in Nigeria (LIMECU, Federal department of livestock and pest control services, Abuja, 1992).

GENERAL COMMENTS ON FEEDING MANAGEMENT OF PIGS

All the diet formulations shown are examples only and other combinations are possible. Manufactured feeds should not be stored longer than four weeks at a time. Feed wastage must be prevented. Feed should be provided in an area separate from the watering area. The watering and feeding system must be adequate and clean. Only up-to-date feeding program should be used. Unproductive animals should be culled. In addition, animals must be kept healthy. Pig pens should be scrubbed daily and disinfected as often as possible.

POULTRY FEEDING AND NUTRITION

POULTRY FEEDING AND NUTRITION

Digestive System

- Chicken's Body Length to the Digestive Tract ratio (1:4)
- Mouth contains no teeth
- Tongue consist of (top beak, tongue, Bottom beak)
- Tongue works off of a lever action concept

Parts

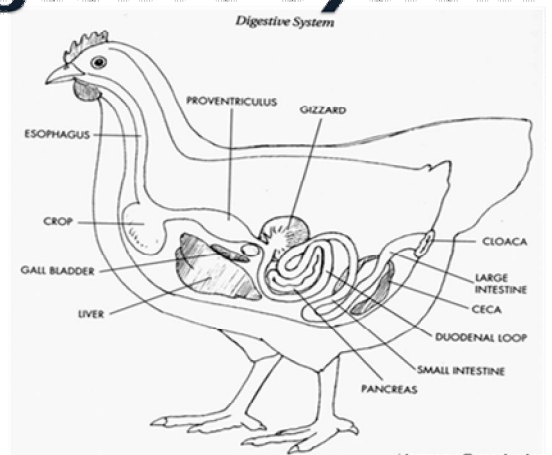
- Proventriculus
 - Secretes hydrochloric acid
- Gizzard
 - Crush or grind the food (seed, grits)
- Pancreas
 - Lies in the duodenum neutralizes the acid secretions of the proventriculus secretes enzymes that hydrolyzes protein, starches and fats
- Duodenum

Greatest site of absorption (loop)

How long does it take for a chicken to digest a meal?

About 3 hours

Digestive System



Source: Chicken Health Handbook, by Gail Damerow, Storey Publications.

Feeding systems:

1-Whole grain method

2-Grain & mash

3-All mash: fed at first 8W

4-Wet mash feeding (more palatable)

5-Pellets

- With grain fed must used insoluble grit
- Also fresh green feed is fed to poultry.

Feeds and Feedings in Poultry Production

Poultry feeding is a major item of cost in poultry production. It is producing eggs and poultry meat. Adequate nutrition is essential in profitable chicken production enterprises. When chickens are provided with high quality feed at the required quantity, it promotes body maintenance, growth, improves egg production, and it gives energy, good health and vigour. Maintenance of the body is the first consideration in good feeding. Under normal conditions, production follows after the body needs are supplied. Considerable feed is required to build and maintain the body to the point of production. Actual production of eggs requires but a comparatively small amount of food in addition. Profit comes from growth or production of meat or eggs. About three-fourth of the total feed consumed is used for maintenance when a fowl is in laying condition.

Terms which should be defined before the principles of feeding are discussed further.

Nutrient is any feed constituent or group of feed constituents of the same general chemical composition or a pure chemical compound that aids in the support of life. These consist of carbohydrates, protein, minerals, vitamins and water.

Feedstuff is synonymous with feed, food or fodder although it is broader, covering all materials included in the diet because of their nutritional properties. It includes natural feeds of animal origin, synthetic and other pure nutrients which are added in the natural feeds.

Feed is a mixture of feedstuff blended/processed in a form which is acceptable to animals. It is merely the carrier of nutrient and potential energy in a ration.

Supplement is a feed/feed mixture used with another feed to improve the nutritive balance of total ration and it is intended to be fed undiluted as a supplement to other feeds. It could be:

- Offered free choice with other parts of the rations separately available
- Further diluted and mixed to produce a complete feed.

A **ration** is an allowance of feed given to an animal over a specified period of time, e.g. daily ration or weekly ration. It should furnish the entire nutrient required in adequate amount.

Diet connotes a feed which is offered to an animal over a non-specified period of time. It is formulated for special purposes– experimentation, special physiological conditions (sick, production); a ration is part of a diet.

Protein-energy ratio means the amount of protein in the feed or group of feeds as compared with the combined carbohydrates and fat. When we say a ration has a protein – energy ratio of 1 to 5, we mean that it contains one part of protein to every five parts of carbohydrates and fat.

$$\text{Feed conversion (FC)} = \frac{\text{Feed intake (g or kg)}}{\text{Weight gain (g or kg)}}$$

Factors affecting feed conversion:

- 1-Type of feed fed
- 2-Strain of the birds
- 3-Environmental temperature
- 4-Age and weight of the birds
- 5-Diseases and condemnations
- 6-Rodent & flying bird control in feeding area
- 7-Antibiotics and medications ⇒improve FC
- 8-Debeaking & size of baby chicks
- 9-Feed wastage
- 10-Form of the feed

Ad Libitum Feeding

This practice means feed must be available to the birds at all times. This method of feeding allows the poultry to consume feed to appetite or want. Birds raised for meat (broilers) are preferably fed ad libitum.

Advantages:

- More uniform body weight attainment at maturity.
- Feed management technique is less complicated as compared to feeding regimen in feed restriction programmes.
- Birds that feed themselves at will are less stressed up.

Disadvantages

- Birds overeat and increase feed cost during the rearing period.
- Meat type (broiler) breeders tend to overeat and grow excessively, thus compromising production efficiency and profitability (more small/peewee eggs prolapse etc).
- Overweight broiler breeders are prone to prolapse, reduced fertility, hatchability and reproductive failures.

Controlled Feeding

In this practice feed is supplied to the birds in limited quantity and/quality. The strains of birds must be grown on the controlled feeding programme to limit weight, particularly with broiler breeder strains. The female feed intake may be adjusted to delay egg at sexual maturity to maintain desired body weight and reduce prolapses. If the birds are overweight, some form of feed restriction may be imposed. It is advisable to start the restricted feeding programme from 6 weeks of age, although some breeders recommend earlier ages (2–3 weeks of age).

Advantages

- Reduction in the cost of feeding the birds during the growing period.
- Feed restriction results in later maturing birds that lay larger eggs at the initial period.
- The birds are less fat, thus protecting the birds from breeding problems due to excess fat.
- It leads to the production of more hatchable eggs during the laying year.

Disadvantages

- Management of the restricted feeding programme is more complicated than ad libitum feeding.
- Birds may be more uneven in body size mainly because of the differential feed intake of “boss” vs “timid” birds.
- It is more troublesome to feed the birds because they fight among themselves in a bid to get at the feed.
- Increase in cannibalism and mortality problems.

Facts should be considered when computing ration for poultry:

- 1-Feed must contain all essential nutrients in right amounts & proportion required.
- 2-Different standards per age should be followed.
- 3-Palatability of the ingredients which used.
- 4-Unlike ruminants, poultry completely depend upon the dietary sources for all nutrients (essential AAs., vit.B groups & vit.K).
- 5-Include agro-industrial by-products to minimize cost of the ration,
- 6-Optimum level of ingredient inclusion as many of ingredients have a deleterious effect at higher levels.
- 7-Optimum Ca:P ratio for different purposes.

Nutrient requirements of poultry

The requirement for any nutrient may be defined as the amount of that nutrient which must be supplied in the diet to meet the needs of the normal healthy animal, given an otherwise completely adequate diet in an environment compatible with good health. Such a level of nutrient must be capable of meeting the requirements for maintenance, optimum growth and reproductive potential of the animal. Nutrient requirement is the amount of a given nutrient required by the animal to maximize performance but not necessarily maximize profit. The nutrient levels or requirements are expressed in the amount of nutrient per kilogramme of air dry feed (i.e. feed as fed) or in terms of percentages on as fed basis (air dry basis).

Factors Affecting nutrients requirements of poultry:

1. Environmental Temperature: This has a marked effect on energy requirement and hence the feed intake. Animals tend to eat less in warm than in cold environments. Research has shown that for every 5 °C change in pen temperature, there is about 20 kcal change in the ME intake of birds. Pen temperatures of 18 to 24°C are within the normal comfort zone of poultry.
2. Energy Content of the Diet: Poultry generally tend to eat to meet their energy requirements if fed ad libitum (i.e. if fed free choice). To put it another way, over a wide range of metabolizable energy (ME) concentration per unit weight of a balanced diet, and if fed ad libitum, most poultry will likely adjust feed intake in order to provide fixed ME consumption. Thus ME consumption is more likely to be constant than total feed intake. Chickens fed low energy diets will eat more feed than those fed high energy diets. Therefore, the amount of required nutrients in poultry rations must be adjusted in relation to the energy level in the ration in order to ensure that the birds consume the right amount of needed nutrient.
3. Productive State of the Animal: The broiler chicken and turkey poult have high requirements for amino acids to meet the needs for rapid growth; the mature cockerel has a very low requirement than the laying hen, even though body size is actually greater and feed consumption is similar; high egg producing hens would require more nutrients than low egg producing hens.
3. Sex: Cockerels need more energy than pullets and chickens.
4. Age: Nutrient requirements change with the age of the animal.

5. Size of the Animal: Large animals (broiler finisher, matured turkey) need more feed and hence more nutrients than spent layers.
6. Effects of Diseases (Ill-Health and Infection): Diseases and the presence of internal parasites, coccidia, bacteria or external parasites may affect feed intake and the requirements for certain nutrients. Infection reduces feed intake. Poultry recovering from illness need more energy and nutrients than healthy birds.
7. Balance between Nutrients: This may affect the metabolic utilization of individual nutrients and hence their requirements, e.g. dietary protein level versus individual amino acids, vitamin D, calcium and phosphorus interrelationship.
8. The Presence of Toxic Factors in Feeding-Stuffs: Linamarin in cassava products increases the need for methionine, gossypol in cotton seed; trypsin inhibitor in soyabeans; progoitrin in canola seed; toxins from field fungi; aflatoxin in groundnut cake.
9. System of Management: This may affect recommended nutrient levels of poultry in terms of the floor or cage rearing; intensive or extensive system of management.

1-Energy requirement:

The largest single dietary need of an animal is for a source of energy. Energy is required for all processes of life. Without energy birds cannot move, eat, digest, grow, maintain body temperature and, in the case of layers produce eggs. The requirements for energy cannot be stated as precisely as the requirements for protein, amino acids, minerals and vitamins. This is because good growth and egg production can be achieved with a wide range of energy levels. Most chickens have the ability to adjust feed intake in order to obtain the necessary energy required for optimum performance. Poultry eat to satisfy their energy needs when fed free choice, thus must control the intake of all nutrients by including them in a definite proportion to available energy level.

High energy cereal grains are the principal energy sources. Fat may be added at levels of 3-8% to increase dietary energy concentrations. Chicks aged day-old to 4–6 weeks are however not able to adjust feed intake to diet energy variations and thus tend to consume slightly more energy as the energy level of the diet increases. Not all energy eaten by the chicks is used. The energy that is used is called metabolizable energy (ME) and is measured in terms of kilocalories or kilojoules. The energy levels recommended for broiler chickens

(3000 kcal/kg diet) are lower than those (3200, 2900 and 2900 kcal/kg diet respectively) recommended or assumed for temperate zones of America. At high temperatures, heat losses and basal metabolic rates are generally lower than those at lower temperatures. This means that at high temperatures, the energy is used more for reproductive and productive purpose and less on non-productive purposes.

Factors affecting feed intake:

1-Energy levels in the ration:

↑ energy level ⇒ ↓ feed intake

↓ energy level ⇒ ↑ feed intake

2-Environmental temperature:(SET, 16-24C)

↑ Temp. ⇒ ↓ feed intake

↓ Temp. ⇒ ↑ feed intake

3-Health of the bird

4-Genetics

5-Form of the feed

6-Nutritive balance of the diet

7-Stress

8-Body size

9-Rate of growth & egg production

2- Protein requirement:

The amount of protein required is proportional to the energy level in the ration. Poultry required the 14 essential AAs. Once the minimum amount of protein required supporting maximum growth rate or egg production is supplied, additional protein is oxidized for energy. The crude protein required in a layers diet has been reported to vary from 15 to 18 per cent which is lower than the requirement for pullet chicks (20%) and broilers (20-23%), since protein sources are expensive component of a ration, it is not economical to feed excess protein to animals.

- \uparrow Temp. \Rightarrow \downarrow feed intake \Rightarrow \uparrow protein req.
 \downarrow Temp. \Rightarrow \uparrow feed intake \Rightarrow \downarrow protein req.
- The amino acid levels are expressed as percentages of the diets and decrease as the recommended protein level decreases. Some AAs can be met by other AAs:
Cystine \Rightarrow methionine, Tyrosine \Rightarrow phenylalanine
Glycine \Rightarrow Serine
- Overheating or underheating during processing can affect the availability of some amino acids.

Essential AAs for laying hens:

- **Leucine, isoleucine, lysine, methionine, tryptophan and arginine.**
- **Methionine is first limiting AAs for egg production.**
- **Mash for laying hens should contain not less than 3-4% animal protein supplement.**
- **Feather are high in sulfur amino acids (required methionine).**

The recommended protein levels decrease as the chickens get older. Under normal circumstances, birds eat more as they grow older. The total protein consumed increases as the birds get older and presumably increases in weight.

Mineral Requirements of Poultry

Minerals are basic elements required for skeletal tissue development and maintenance. Special mention must be made of the recommended levels of calcium and phosphorus, particularly for “layers”, because of the roles these two minerals play in egg formation. The levels of calcium and total phosphorus recommended for commercial layers (for table egg production) and breeders (for hatching chicks) are respectively 3.5% and 0.85%. The requirements for these minerals appear to be higher for warm climates than the cold climates. As a general rule, a level of 4-4.5% calcium and 1-1.1% total phosphorus should be provided at all times for birds reared in the tropics. In practice, 0.30–0.50% common salt or sodium chloride would take care of the requirements for sodium and chloride by all classes of poultry. All other **macro – minerals** are provided in ample amounts by the usual

natural ingredients used in formulating poultry feeds. The **micro-elements** are often included in

most commercial premixes. The amount of a micro-element is sometimes expressed in parts per million (ppm) or milligrams per kilogram of diet. In practice, about double the amount of premixes added to chicken diets should be used in turkey diets.

Points to note :

Calcium & Phosphorus:

- **The recommended ratio P:Ca in diet of poultry is 1:1.2 (range 1:1 to 1:1.5)**
For laying hen 1:4 (Ca important for bone & shell formation)
- **↑ Ca in diet ⇒ ↓utilization of Mg, Mn & Zn.**
- **Inorganic P have a higher availability than organic P**
- **All P from animal origin & 40% from plant origin (wheat bran & rice bran) is available.**

Salt (NaCl):

- **The amount added depend upon the feed ingredients.**
- **The recommended level in the ration 0.25-0.5% of the ration.**
- **Adult poultry can tolerate much higher inclusion but the water consumption increased.**

D- Iodine:

- **Iodine included at rate of 0.5mg but when fish meal included at 5-10% no need iodine suppl.**
- **↑ Ca & P in diet ⇒ ↑ iodine requirement**

E- Magnesium:

- **No Mg Suppl. Needed for poultry ration.**
- **↑ Mg in diet ⇒laxation**

Vitamin Requirements

Vitamins are organic compounds required in extremely small quantities but essential for normal growth, health and productivity. Unlike protein, vitamins are usually supplied to poultry feeds in excess of their minimum requirements. However, if only minimum levels are provided, variations of expected feed consumption must be considered, and very high energy rations must be more liberally supplied with vitamins than low energy rations. Requirements are expressed in international units (I.U) which are the same as United States Pharmacopoeia units (U.S.P.). Most requirements for poultry are precisely known, particularly for those vitamins likely to be deficient in practical rations. Rations for young starting chicks and starting broilers are usually very liberally supplied with supplemental vitamins. Dietary **vitamins premix** inclusion is at the rate of 2.0–2.5 kg/tonne of feed. There are 13 vitamins listed as required by the chickens. The vitamins are classified as fat soluble vitamins (A, D, E and K) and water soluble vitamins (the B-complex vitamins and vitamins C).

Vitamin A:

- **Liberal supply of vit.A or carotene is needed for normal growth & health.**
- **Def. Symptoms: retardation of growth, emaciation, staggering gait & ruffled feathers, reduced immunity**
- **Sources: fish liver oils & other animal sources.**

Vitamin D:

- **Vit.D required for bone formation, egg production, reproduction & prevention of rickets.**
- **Def.symptoms:poor growth, lameness & rickets.**
- **Poultry do not exposure to sunlight, ration must suppl. With vit.D.**

C- Vitamin E:

- **Vit.E in vegetable is not readily available as in oil concentrates.**
- **Vit.E essential to prevent encyphalomalacia or crazy chick disease.**

D- Vitamin K:

- **Def. of vit.K ⇒ delay clotting time of the blood & produce serious hemorrhage**
- **All mixtures should be suppl. With vit.K**
- **Treatment by sulfonamide ⇒ ↑ vit.K req.**

Riboflavin:

- **Def. of vit.B2 ⇒ curled-toe paralysis, dwarfism & degeneration of nerve trunks.**
- **Requirement: Broilers & breeder 4.4mg/kg**
Layers 2.5 mg/kg ration

F- Thiamin:

- **Def. of thiamin ⇒ nerve deg., convulsion & heart abnormalities.**

G- Niacin:

- **Def. of niacin ⇒ inflammation of tongue & mouth cavity (black tongue).**
- **Young chick required niacin more than adult due to less bacterial action synthesis.**

Vit.B12:

- **Animal proteins are good sources of vit.B12.**
- **Def. of vit.B12 ⇒ irritability, poor feathering & poor hatchability.**

Water Requirements

The quantities of water required by one hundred layers is about or over 24 litres per day or about one – quarter of a litre per bird per day. Normally, poultry consumes about 2 -3 parts of water for every part of feed on a weight basis (i.e. 2 to 3 kg water per kg consumed feed).

Depending on the age, turkey should be provided with about two to five times the amount of water recommended for pullets. During hot weather, consumption of water may rise to about 4-5 times the intake of feed. This has been suggested as being responsible for inadequate feed intake in the tropics.

FEEDING OF BROILERS

Age / Nutrients	Protein (%)	ME (Kcal/kg)
Starter ration (0-3weeks)	22-24	2800
Grower ration (3-5 weeks)	20-22	3000
Finisher ration (5-7 weeks)	18-20	3200

FEEDING OF LAYING HENS

Nutrient requirements of laying hens:

1-Energy requirement:

- For maintenance (2kg wt.) = 220 Kcal
- For 70% production = 130 Kcal
- For 1 g gain/day = 3 Kcal
- The usual energy conc. Is 2.8 Mcal ME/kg diet

↓ Energy conc. Than 2.3 Mcal ⇒ ↓energy intake & egg production

2-Protein requirement:

- Laying hen receiving diet containing 3.1 Mcal ME/kg DM require 16.5% protein.
- To get maximum economic return from laying hen flock, a feed efficiency of 1.6-1.8 kg of feed per dozen of eggs produced is need.
- A laying ration should contain about 15% protein based on 2900 Kcal ME/kg of diet.

Effect of environmental temperature:

- Small light body weight hens consumes:
- In Summer ⇒90g feed (19% protein ⇒ 17g protein/ hen/ day).
- In Winter ⇒ 110g feed (15.5% protein ⇒ 17g protein / hen / day)

Essential AAs for laying hens:

- Leucine, isoleucine, lysine, methionine, tryptophan and arginine.
- Methionine is first limiting Aas for egg production.
- Mash for laying hens should contain not less than 3-4% animal protein supplement.
- Feathers are high in sulfur amino acids (required methionine).

Fat supplement:

- Fat addition \Rightarrow \uparrow egg yield in cold weather
- Fat addition \Rightarrow \downarrow amount of feed required / dozen eggs.

3-Mineral requirements:

A-Calcium:

- Laying birds need large amounts of Ca because egg shells composed entirely of CaCO_3
 - \downarrow Ca in laying ration \Rightarrow \downarrow egg production & egg shell weak.
- Bird stored Ca for about 10-14 days before the first egg was laid in the marrow of long bone.

B-Phosphorus:

- Protein supplement used in poultry rations (mat meal, tankage, fish meal & dairy by-products) usually be sufficient in phosphorus.
- Plant protein supplement (SBOM) should supplement with P & Ca.
- Inorganic P is more available than phytate P.

C-Manganese:

\downarrow Ca in laying ration \Rightarrow \downarrow egg production & egg shell weak & \downarrow hatchability.

D- Iodine:

\downarrow Iodine in laying ration \Rightarrow goiter

- Iodized salt must be used instead of common salt in the ration of poultry.

E- Selenium:

\downarrow Se in laying ration \Rightarrow Exudative diathesis

F- Zinc:

\downarrow Zn in laying ration \Rightarrow skeletal abnormalities, ataxia, necrotic dermatitis & thin shell & hyperkeratinization of epidermis.

G- Salt:

- 0.15-0.25% of the total ration salt

4-Vitamin requirements:

A-Vitamin A :

- Laying hens require higher content of vit.A in their feed in very hot weather than cold because they consume less feed.

- ↓ vit.A in laying ration ⇒ Nutritional roup (sticky materials from eye & nostrils)

B-Vitamin D :

- ↓ vit.D in laying ration ⇒ thin shell eggs, ↓ egg production & hatchability, breast bone become soft & bones of legs & wings become fragile.

C-Riboflavin & vit.E :

- ↓ Riboflavin & vit.E in laying ration ⇒ low hatchability

Phase-feeding of laying hens:

To adjust nutrient intake in accordance with the rate of egg production

A-Phase I (most critical period):

During 20 W period (22-42 W of age) pullet :

- 1- ↑ egg production from zero to peak (85-90% production).
- 2- ↑ body weight from 1300 to 1900g.
- 3- ↑ egg size from 40g/egg at 22W to over 56g/egg at 42W of age

B-Phase II :

- Period after 42W of age when the hens attained mature body weight
- The period ranged from 42-72W of age.

Effect of temp. on egg shell:

- Hot weather ⇒ ↑ respiration rate ⇒ ↑ Co₂ loss ⇒ ↓ blood bicarbonate level ⇒ ↓ egg shell formation

Stage of egg production:

- Egg production hen usually cover a period of 15 months
- Commences at 20-22W of age ⇒ peak at 28-30W of age ⇒ gradually decline to 65% after 15 months of lay.
- ↑ lighted period ⇒ ↑ feed intake & ↑ stimulation of pituitary gland ⇒ ↑ egg laid

Feeding systems:

- 1-Whole grain method
- 2-Grain & mash
- 3-All mash: fed at first 8W
- 4-Wet mash feeding (more palatable)

5-Pellets

- With grain fed must used insoluble grit

- Also fresh green feed is fed to poultry.

Nutrition and egg quality:

A-Egg size (egg weight):

Factors affecting egg size:

- 1-Level of protein in diet:
- 4-20% CP rations \Rightarrow balanced AAs \Rightarrow heavier eggs
- The choice of protein level in layer diet depend on accurate evaluation of extra-cost for the additional protein compare with the income from larger eggs obtained.

2-Energy intake

3-Mineral & vitamin levels:

- \uparrow Ca & \downarrow vit.D \Rightarrow \downarrow egg weight
- 4-Level of linoleic acid:
 - Linoleic acid \Rightarrow formation lipoprotein in liver \Rightarrow ovary uptake by ova \Rightarrow higher egg weight

5-Strain

B-Shell quality:

- The quality of egg shells depend on the presence of adequate levels of vit.D₃ & certain minerals including Ca, P & Zn.
- Def. or imbalance of vit,D₃, Ca & P \Rightarrow \downarrow shell thickness & misshapen eggs \Rightarrow \downarrow egg production
- \downarrow Mn \Rightarrow thin & brittle-shelled eggs
- The blood carbonate is the source of carbonate in the shell formation
- Very hot weather \Rightarrow poor quality egg shells
- End of laying period \Rightarrow falls egg shell quality due to failure in Ca metabolism & \downarrow Ca of ration
- Sulphonamide drugs \Rightarrow thin shelled eggs
- Insecticides & fungicides in grains \Rightarrow malformed eggs
- Rancid cod liver oil in diet \Rightarrow rough shells
- Diseases \Rightarrow poor shell quality

C-Internal egg quality:

- The nutritive content of the egg depends upon the level of these nutrients in the diet of laying hen
- Suitable iodine in diet \Rightarrow \uparrow content of eggs

- Def. of vit.B2 ⇒ slight yellowish-green tinge in albumin

D-Yolk colour:

- The colour of egg yolk depend upon the presence of carotenoid pigment (xanthophylls) in the ration
- (fresh & good dried green feeds & feed additives)
- When 30% yellow maize or 5% good quality alfalfa or up to 22mg xanthophyll/kg ⇒ deep-yellow yolks
- Highly pigmented plants ⇒ undesirable coloured yolks
- Large amount of untreated CSM ⇒ brown mottled yolk & pinkish tint of albumin
- Pimento pepper in diet ⇒ orange-red yolks

FEEDING OF TURKEYS

The general principles of feeding turkeys are similar to those for feeding broilers. Major differences are in the protein levels required and the importance of the vitamins biotin & pyridoxine in turkey diets

- Poults must be fed & watered as soon as possible after hatching & if feeding delayed beyond 36h after hatching ⇒ difficulty learning to eat & drink.
- Vits. & minerals suppl. of the diet essential for good hatchability of turkey eggs.
- At 10-12W of age separate hens from toms

Period	Protein (%)	ME (Kcal/kg)
First 3 weeks	30-33	2930-3000
0-4 W	28	2930-3000
4-8W	26	2900
8-12W	20-22	3100
13-16W	19	3200
17-20 W	16	3275
21 W-market	13-14	3350
Laying hen	15-18	2925
Peak production	19	2755

Nutritional disorders of turkey:

1-Leg weakness disorders:

Cause: def. of Ca, P, vit.D, choline, biotine, folic acid, Mn & zinc.

2-Enlargment of hock joint:

Cause: def. Of niacin, biotin, vit.E & zinc.

3-Footpad dermatitis:

Cause: biotin deficiency

Symptoms: sticky droppings adhere to the feet & cause dermatitis

4-Pendulous crop:

Cause: yeast proliferation in crop

Symptoms: gas production from fermentation of carbohydrate \Rightarrow interfere with passage of ingesta from crops to proventriculus \Rightarrow pendulous crop

Treatment: fungal inhibiting antibiotics

5-Ascitis:

Cause: high salt intake \Rightarrow fluid accumulation in body cavities

6-Exudative diathesis:

Cause: Selenium deficiency

7-Aflatoxicosis:

- Aflatoxin affect the immune system \Rightarrow increase susceptibility to disease
- Mycotoxin \Rightarrow hemorrhage may bluish the carcass

FEEDING OF DUCKS & GEESE

- Commercial feeds in mash, pelleted or crumbles form available for ducks & geese
- If a commercial feed for ducks & geese is not available, chicken feed may be used (not contain coccidiostat)
- Geese will start to eat pasture when they are only few days old & feed additional grain if pasture is not of good quality.

Period	Protein (%)	ME (Kcal/Kg diet)
0-4 W (starter)	20	2900
After 4 W (grower)	15	3000
Breeding	15	2900

FEEDING OF DUCKS

Period	Protein (%)	ME (Kcal/Kg diet)
0-2 W (starter)	22	2900
2-7 W (grower)	16	3000
Breeding	15-18	2900