Poultry: Chicken

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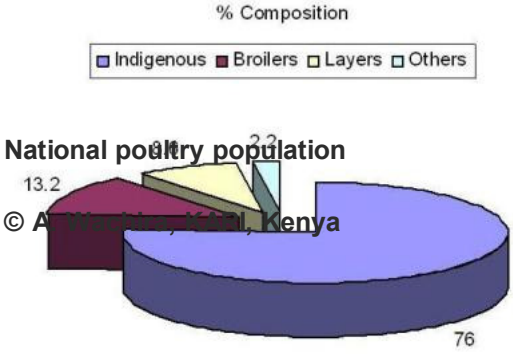
Introduction

The term poultry refers to domesticated birds kept for meat, eggs and feather production. Domestication of poultry is thought to have started in South Asia, at least 2000 years ago. The Asian Red Jungle Fowl is generally assumed to be the ancestor of the modern poultry breeds, although new evidence suggests that the first domestication

of the fowl took place much earlier in China. Following this domestication various breeds have originated from isolated groups of poultry, partly by adaptation to the various environments or cultivation by man. Today's poultry breeds are all different based on appearance and performance.

Poultry production is undertaken in a multitude of ways, utilizing different sets of resources, in a wide spectrum of social cultural and economic conditions. Major poultry species kept include chicken, ducks, guinea fowls, turkeys, pigeons, quails, and ostrich of which chicken dominate the industry. Chicken have the widest distribution, are most abundant world wide and are a source of high value protein in human nutrition.

Kenya has an estimated poultry population of 29 million birds, with chicken forming the largest proportion. Of these 75% consist of indigenous chicken, layers 8 %, breeding stock 1 % and 14% broilers. Other poultry species like ducks, geese, turkeys, pigeons, ostriches, guinea fowls, and quails make up 2 % of the poultry population. Poultry is one of the most important livestock enterprises in rural households where over 70% (24 million) of the country's population live and derive their livelihood. Indigenous chicken are kept by 90% of rural households while broilers and layers are



mainly reared by urban and peri urban farmers who target the ready market. Other poultry are kept by farmers with special interests.

Indigenous chicken

br]Village chicken production systems are mostly based on the local scavenging domestic fowl (*Gallus domesticus*), which predominates in African villages. Sometimes the productivity of these birds is very low, but with proper management practices indigenous chicken can become very productive and has a very good potential for improving the income of the owners.

Village chicken systems in rural Africa are characteristically:

- **an indigenous and integral part of the farming systems, with short life cycles and quick turnovers**
- **low input production systems**
- **a means of converting low-quality feed into high quality protein**

Hybrid layers

Hybrid layers are mostly kept near potential markets for eggs (such as cities and towns) where space is limited but ready made commercial feed are easily available. Layers may be kept in individual battery cages, but more often in Kenya they are reared in deep litter houses where there is free movement and perches are provided.

Broilers

Broilers are heavy breeds and usually reared on deep litter floor systems. Slatted floors dispose broilers to breast blister and leg problems just as cages, leading to lower quality.
The young chicks are bought from commercial hatcheries as day old chicks, and reared in the

facilities set aside.

Broilers kept for meat production, are also hybrid birds and the chicks need to be bought commercially, as farmers do not have access to the parent breeding stock. The same commercial hatcheries listed under 'Layers' usually also have broiler chicks for sale.

Broiler hybrids are very fast growing birds and need specially manufactured feeds. It will not work to try and rear broilers on any other feed than the specially made one from reputable companies.

Broilers can be kept in similar confinements as layers, but do not need the laying boxes. Because they grow heavy enough for slaughter in 6-8 weeks, their bones are sometimes weak. To keep them healthy and bones as strong as possible, it is good to provide exercise areas, even outside.

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Points to consider before investing

Market analysis

Before starting up a poultry enterprise, it is important to know the market requirements for the targeted market, the investment costs, running costs, and expected revenue for the different products. In Kenya markets for poultry products maybe categorized as follows

- **Famer to domestic trader where products are sold at the local market or farm gate.**
- **Farmer to retailer where poultry products are sold to supermarkets and restaurants. chains**
- **Farmer to leading farmer where poultry products are sold to a leading farmer who can access markets that demand large volumes**
- **Farmer to co-operatives or processor or exporter where farmers can bulk poultry products**

and sell to processors/packers.

- **Contract farming - direct farmer/producer group market access, where market for products is assured.**

Market Trends

Market trends in Kenya presently (Sept 2009) see consumers shifting interest from the previously dominant hybrid layer eggs and broiler meat towards what is conceived as a healthier diet of free range or indigenous eggs/chicken. Also organic eggs and chicken find very good and well paying market especially in the major urban centres in Kenya.

Major production systems The major production systems as per national pie chart are as follows: 1. Indigenous chicken (76% of Kenya chicken) 2. Broilers 6-8 weeks to maturity (13.2% 3. Hybrid layers 1-2 years production systems (8.6%) 4. Specialized production (hybrid cockerels, chicken breeds, organic chicken etc) (2.2%)

Each of these systems has its own risks and return pattern, and it is advisable to fully investigate what a production system will mean to you, before starting the production. Generally and if well managed, the return to investment in a poultry enterprise is rapid as compared to other livestock enterprises.

Broilers and layers are mainly commercially reared by urban and peri urban farmers who target the ready market. Commercial production mainly utilizes specialized hybrids of broilers and layers. Availability of chicken feed is a major challenge coupled with low quality of feeds and uncontrolled prices

.

Indigenous chicken can be reared in small plots with very little investment, whereas the broilers and hybrid layers require fairly heavy investment

Economic analysis and simple risk assessment

Before starting any poultry production enterprise, calculate if it is economically feasible thereby making the right decisions regarding the production system and the necessary interventions

Revenue or income

Revenue or income is all the money earned in relation to the poultry enterprise such as:

- **Income from sale of live birds, e.g. growers or spent hens;**
- **Income from sale of eggs;**
- **Value of eggs or poultry eaten or given away. (Side revenues - manure, empty gunny bags etc)**

Also value the standing stock, e.g. the production flock which is the foundation of future income. Poultry manure also represents a value when use on the farm or sold for other activities. As manure poultry waste reduces the cost of buying fertilizer and improves crop production.

Expenditure or costs and Risks

These are costs involved in relation to the poultry enterprise:

- **Poultry houses;**
- **Day old chicks;**
- **Supplementary feed, vitamins or minerals;**
- **Vaccines and other medication;**
- **Labour and technical advice**
- **Mortality (outbreak of diseases can wipe out the whole flock if not properly handled**

Points to consider before investing in a commercial poultry enterprise

1) Distance to the market for the finished products (eggs and broiler meat/live birds). This is

important because transport costs money. Broiler meat requires specialized (refrigeration) transport since it is highly perishable.

2) Availability of quality feeds. Feeds alone account for 70% of the production cost in a poultry enterprise hence the need to ensure quality at an affordable price.

3) Availability of information on basic management practices and animal health services especially for vaccines and drugs.

4) Seasonal fluctuation in demands for poultry and poultry products. Demand is generally high in the month of April and December. This is associated with the peak tourist season and the festive seasons over Easter and Christmas holidays.

5.) Optimum flock sizes so that the farmer can break even. Over 75% of all commercial poultry enterprises have flock sizes of below 300 birds. This is inefficient due to the high production cost. To break even flock sizes for broilers should be over 500 and hybrid layers 1,000.

In order to profit from any livestock enterprise, it must be remembered that we deal with fellow living creatures. There will be no profit or good returns unless we treat the animals well. The following five freedoms are seen as minimum requirements for any productive livestock enterprise. Provide your animals with:

FIVE FREEDOMS FOR POULTRY WEALTH - IMPORTANT

The welfare of an poultry includes its physical and mental state. Good poultry welfare implies both fitness and a sense of well-being for the animal. Any poultry kept by man, must at least be protected from unnecessary suffering.

An animal's welfare, whether on farm, in transit, at market or at a place of slaughter should be considered in terms of 'five freedoms'. These freedoms define ideal states rather than standards for acceptable welfare. They form a logical and comprehensive framework for analysis of welfare within any system together with the steps and compromises necessary to safeguard and improve welfare within the proper constraints of an effective livestock industry.

1) Freedom from Hunger and Thirst - by ready access to fresh water and a diet to maintain full health and vigor.

2) Freedom from Discomfort - by providing an appropriate environment including shelter and a comfortable resting area.

3) Freedom from Pain, Injury or Disease - by prevention or rapid diagnosis and treatment.

4) Freedom to Express Normal Behaviour - by providing sufficient space, proper facilities and company of the animal's own kind.

5) Freedom from Fear and Distress - by ensuring conditions and treatment which avoid mental suffering.

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Breeds and Breeding

Kenya currently has limited chicken breeds namely the hybrid layers, broilers and indigenous chicken.

Layer breeds

These are chicken breeds selected for laying eggs and maybe divided into several categories:

Light breeds

Light laying breeds include the White Leghorn, Brown Leghorn and Black Minorca. The maximum adult bodyweight of light races is about 2 kg for females and 2.5 kg for cocks. The white leghorn is known to lay a large number of white eggs. It requires less feed due to its small size and is an efficient feed converter. Its low body weight allows it to withstand high temperatures better than other breeds. However, White leghorns are generally nervous and at the end of the laying period give relatively less meat than heavier breeds. For this reason the use of lighter breeds has generally changed in favour of crosses.

White Leghorn

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Medium breeds

These are the Rhode Island Red (RIR), New Hampshire (NH) and light Sussex (LS). The RIR has dark brown feathers, lays brown eggs and is heavier but more susceptible to high temperatures than the White Leghorn. In poor conditions RIR is more viable than the light breed and has a higher carcass value. The NH has light brown feathers with similar characteristic to RIR. The LS is a white bird with black striped neck feathers and black tail.

RIR

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New Hampshire

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New Hampshire

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Light Sussex

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Australorp

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Heavy breeds

Heavy breeds include Barred and white Plymouth Rock, Buff Orpington as well as White Jersey Giant and Arbor Acres Hubbard Vantress. These breeds are used for crossing to obtain the fast growing broiler strains available from hatcheries. These are mainly the meat birds commonly referred to as broilers. Breeder stocks consist of the White Cornish (WS) and White Plymouth Rock (WPR). The White Cornish is a heavy, white feathered breed that lays brown shelled eggs. It has been developed for quality and quantity of meat. White Plymouth Rock is similar to the WS but lays more eggs.

Broilers

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Plymouth hen

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Buff Orpington

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Hybrids

These are crossbreds originating from breed crossing. Their performance and viability (hybrid vigour) is better than the pure breeds. Breed crossing is practised in most developing countries including Kenya. Large scale poultry enterprises always use hybrids originating from line crossing due to their superior performance.

Commercial Pure and hybrid birds are produced and sold by a limited number of breeding companies to poultry farms in almost every country of the world.

Hybrid layer

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Day old hybrid chicks

© A. Wachira, KARI, Kenya

Indigenous chicken breeds

Local chicken breeds are the most abundant livestock species in Kenya with an estimated population of 23 million birds. Indigenous chicken are mostly kept under a free range system in small flocks of less than 30 birds. They are more adapted to local conditions than the hybrids but have a lower productivity.

Below some normal features in indigenous chicken. As can be seen many of the above pure breeds features can be found among indigenous chicken, indicating a great amount of mixed genes. Breeding indigenous chicken for improvement of the breed is very feasible for the specialist.

Indigenous cocks
© A. Wachira, KARI, Kenya

Frizzled feathered chicken
© A. Wachira, KARI, Kenya

Feathered shank hen
© A. Wachira, KARI, Kenya

Kuchi game bird
© A. Wachira, KARI, Kenya

Normal feathered indigneous chicken
© A. Wachira, KARI, Kenya

Commercial sources of breeding stock in Kenya
Buy day-old chicks from hatcheries such as:

- **Kenchick**

- **Muguku**
- **Kenbrid**
- **Sigma suppliers**
- **Western hatcheries**
- **Bixa north coast**

Breeding

Introduce one new cock for every 10 hens every two years, in order to avoid inbreeding. Improved indigenous chickens for improving the local breeds can be bought from Naivasha research station in Kenya as well as from private breeders.

In the village setting care must be taken to protect brooding hens from predators, rodents and other forms of stress. If a brooder hen is well protected and comfortable she can easily hatch 15 eggs per sitting. A brooding cycle takes minimum 18 days after which the first eggs should start hatching. The mother will normally keep the chicks with her for a day or two before taking them to food and water. Any eggs not hatched after this will go cold and most likely not hatch. It is highly advisable to keep food and clean water available near the brooding hen during this whole period for her to hatch the maximum amount of chicks.

Selection of eggs for setting

A improved nutrition can raise the average quantity of eggs laid per clutch by 100%. For a successfull hatching, the eggs must be handled carefully from laying till setting. Eggs should be stored with the broad end facing upwards, as at this end there is an air sack, through which the egg breathes. Eggs should be stored in a clean and dried place to prevent rotting. Since fertile eggs grow slowly, eggs older than 14 days should not be used for hatching.

The reproductive cycle

By shortening the reproductive cycle, hens lay eggs earlier and double the number of clutches per hen per year. Improved management increase the survival rates of the chicks. Shortening of the reproductive cycle can be achieved by better feeding, protection form predators and rodents, timely vaccinations and deworming, control of external parasites, and culling of aggressive and unproductive birds.

Serial hatching
Introduce one new cock for every 10 hens every two years, in order to avoid inbreeding. Improved indigenous chickens for improving the local breeds can be bought from Naivasha research station in Kenya as well as from private breeders.

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Synchronised hatching

When hens that started laying within the same week get brooding, the first hen to reach this stage can be delayed by being given one egg to sit on. This will be repeated for the second and third hens, so that all the hens are set on one day. By the time of setting, all 'dummy' eggs should be destroyed. The time between the first hen and the last should not be more than one week. Chicks hatching on the same day fit in well with feeding and vaccination programs.

Synchronised ducks sitting on eggs

© Henry Ondwasy, KARI

Brooding

Before buying the young hybrid chicks, an appropriate brooding area needs to be prepared: Day old chicks need to be kept warm at all times. As they grow and the feathers start to develop

they tolerate cold better. At the same time they need to access feed and clean water at all times as they feed with short intervals.

Brooder Preparation

- **Use hard boards to make a brooding ring of 60 cm height**
- **Put at least 5 cm of clean dried grass/leaves (litter) on the floor inside the brooding ring**
- **Start with a density of 50 chicks per metre square**
- **A hover/cover should be provided about the brooder, to reduce heat wastage**
- **Make space for feed and water feeding equipment inside the brooder ring**

Brooding of the broiler chicks is similar to that recommended for layer chicks, but the feed is different. Make sure feeds are bought as recommended.

Heat Sources	Temperatures
• Charcoal Jiko - one is enough for 500 chicks • Kerosene lamps - one lamp for 50 chicks • Electricity - one infra red lamp for 250 chicks	• Temperature above the floor should be kept at 32° C for the first week, and then lowered by 4° C for each week up to the 4th week. • Observe the reaction of chicks to the heat: • At correct brooding temperatures, chicks are evenly spread within the brooder ringat • At low temperature they crowd around the heat source • At high temperature the chicks will move away from the heat source

Kerosene brooder

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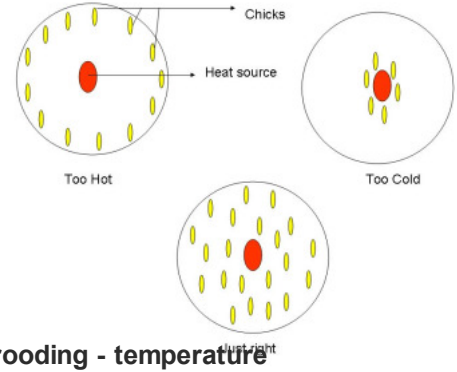

Brooding - temperature

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Other Conditions

- **Fresh air and light should be allowed in the brooder but no drift.**
- **The litter in the brooder should always be dry.**
- **Cleaned and disinfect brooder areas 1 to 2 weeks before bringing in new chicks.**
- **Beware of brooder fires. Take precautions when using charcoal Jikos**

As soon as the day old chicks arrive on the farm it is a good idea to make sure each individual bird gets to drink fresh clean water. Travelling can dehydrate these little birds quite badly. Then release them into the warm brooder ring. Show a few of the chicks where the feed is and the others will learn by example.

Molting

Normally layer hens are economical to keep for about 2 years. However after about 12 months of laying, we can expect a period of resting or molting. In the natural life cycle of chickens this is the breeding period, which artificial breeding systems have not been able to remove from the lifecycle of layer hens.
Molting involves "shedding" of feathers from an otherwise healthy chicken. A molting chicken will appear more ragged than bald, as if the feathers are thinned out. Feathers will lack the normal shining appearance and appear spotty. Good producers molt fast, and normal molting times of layers should not greatly exceed 10 weeks. After this the layers can with good management come back to good production for a second year.

Culled Birds

Dispose all birds when proved uneconomical to keep i.e. laying below 60 % of the hen housed. Cull all sick birds and the non productive ones.

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Housing

Why should poultry be housed?

Housing is necessary to protect chicken against predators, thieves, adverse weather (rain, sun, cold winds, low night temperatures) and to provide shelter for egg laying and broody hens. Suitable poultry houses are important for efficient production and management. Poultry houses and shelters vary depending on availability of materials, weather and tradition. Choice of chicken housing should be based on cost, durability and usage.

Points to consider when selecting sites for poultry housing:

- **A shady, dry flat ground. Alternatively the house can be elevated from the ground.**
- **Trees and bushes close to the houses provide shade, windbreaks and protect birds from flying predators.**
- **Secure premises near the family house. It is important to hear if the chickens get disturbed at night by predators or thieves.**
- **Select a site on which the poultry house faces South or East in wet regions. In a rectangular house the end walls should face East and West to ensure that only the end walls face the hot afternoon sun.**

Materials for building a poultry house

- **Always use cheap locally available material like bamboo, wood, reeds, thatch grass or clay bricks.**
- **Remove the bark from the wood to reduce the parasites load. Parasite often hide beneath the bark**
- **Poultry houses should have windows on either side for ventilation. In addition a hole or ridge on the roof will ensure proper ventilation and give light making it easier to work in the house. Make sure winds ventilate the house without making chicken cold.**
- **Heat, humidity, and harmful gasses may be considerably reduced through good ventilation. High temperatures may cause deaths, a drop in egg production, low shells quality and reduced weight gain. A combination of high temperatures and high humidity may cause death in young chicks.**
- **Placing perches and nests inside the house to safeguard chickens against various predators. Perches and nests will also help to keep chickens and eggs clean.**

- **Laying nests should be place in a quiet place in the house**
- **To protect against diseases and parasites the house must be easy to clean. It should be big**

- **Make the nests and perches easy to remove when cleaning**

- **Houses or shelters should be sprayed with a vermicide or lime washed after cleaning to disinfect and kill parasite eggs from the walls and cracks. Place ashes on the floor and in the nests to discourage parasites.**
- **Clear grass and bushes for about 3 meters on all sides of the house to keep snakes and rats away**
- **In wooden houses, use slatted, raised floors to remove droppings and avoid predators.**
- **Use wire (chicken and mesh wire) on windows to avoid predators and wild birds.**
- **Night houses/shelters should be built on poles, well above the ground to protect the chicken from predators such as dogs, rats and snakes.**
- **Build your poultry house to prevent possible injury to the birds. Remove any sharp edged objects from the house.**
- **For a round or square house give 1.5-2.0 m² for every 10-12 adult birds.**

Slatted floor of a poultry house

Perches

Perches are important for chickens to rest on at night. Diseases and parasites may attack poultry resting on the floor (in contact with litter). Each one-meter perch may roost five adult birds. Perches are best made of bamboo or rounded sticks and not too big or too small. Treat perches with used engine oil or kerosene to keep away parasites.

Nests

When laying nests are not provided, hens lay eggs on the ground, in tall grass or in natural shelters where they may be difficult locate. Avoid building nests on the ground or outside chicken houses. Nests outside the house expose eggs to predators and thieves.

Laying nests ease egg collection and avoids eggs that are dirty and cracked. Eggs should be collected twice a daily at the same time each day (mid-morning and the evening). Removing eggs continuously is important to stop hens from going broody since broody hens stop laying.
Nests should be placed inside the chicken house and preferably above the ground.

Provide one laying nest for every 5 hens. Brooding nests are individual nests and should be placed in quiet and dark places where eggs are easily removed. Once the hen is broody it maybe necessary to remove her to an isolated place to avoid other hens disturbing her or going broody as well.

Brooding hen

© A. Wachira, KARI, Kenya

Simple nests can be made out of clay, calabashes or baskets made of local fibres, cardboard or wooden boxes. Nests should have the correct measurement for the hen to feel comfortable. An individual nest box measures 30 x 30 x 30 cm. A calabash/nest basket or nests made out of clay measure 40 x 20 x 25 cm (upper diameter x height x lower diameter).

Three steps when preparing an individual nest

1) Ensure the pot or basket is clean and dry
2) Fill the pot or basket with sand mixed with ashes up to 1/3 full
3) Place clean, soft nesting litter material (hay or straw or woodshaving) on top up to 2/3 full.

Nesting material should be changed at least once a week. Ensure that the nest is 1/3 full with litter material to make the hen feel secure. When necessary place ?dummy eggs? (e.g. stone eggs) in the nests to train/attract the hens into using the nests.

Mix ashes, tobacco leaves or other anti-parasitic substances with the nesting material. This will keep out most external parasites. External parasites reduce hatchability, since brooding hens spend too much time and energy leaving the nest, cleaning and scratching her body hence leaving the eggs cold.

Shelters for mother hen and chicks

Upon hatching, it is important to keep the hen and chicks close together in a shelter. Shelter should protect chicks from adult poultry; feed competition with other poultry and protect against predators. Shelters should provide a stable environment for the chicks and shelter from

bad weather.

Place the shelter on a mat to protect against the cold. A shelter of basketwork with a top hole (diameter 20 cm) is useful, as feed and water may be changed without disturbing the chicks. It also gives the necessary ventilation. A woven mat on the floor may provide additional protection during cold weather. The mat should be cleaned daily to remove droppings and spilled/contaminated feed. Droppings may be recycled as farm manure

Chicken runs

Chicken runs are a fenced open air space of 25 m² or more where poultry are kept and protected against predators and thieves. Runs are also used for feeding, watering, for daily flock observation and collection of eggs. The walls are 2 meters high and can be made of clay or woven mat or chicken wire. A chicken run is relatively costly but provides security to the poultry. Allow adult birds to scavenge outside the run during daytime to reduce feeding costs.

Guide to good housing for chicken

1) **Use baskets for night shelter and day shelter for small chicks to reduce costs and labour**
2) **involved in constructing permanent houses;**
3) **Always use locally available materials to reduce costs;**
4) **In permanent or semi-permanent poultry houses use slatted, raised floors to remove**
5) **droppings and keep out predators;**
6) **Always use wire netting (chicken or mesh wire) for the windows to keep out predators;**
7) **Provide perches and nests inside the house and make them removable to facilitate cleaning;**
8) **Ensure adequate ventilation in poultry houses without making the poultry cold;**
9) **Provide adequate drainage incase of flooding and protect birds from the hot midday sun.**
10) **Provide nests with clean litter which are easy to access and clean**
11) **Always house young chicks with their mother away from adult poultry.**

Make sure that houses are easy to access and clean.
A good housing should be spacious, well illuminated, dry and airy, easy to clean and have perches for chicken.

Housing for Hybrid layers

The main types of housing systems for hybrid layers (Egg production), differ mainly in the floor types and are the following:

- **Deep litter system:**
  Birds are reared on a floor preferably concrete to allow easy disinfection and some litter material placed 15 cm deep. Litter materials may include wood shavings, rice husks, hay, chopped up straw, crushed maize cobs and shredded paper. Allow 3 to 4 laying hens and 12-15 broilers per square metre on deep litter floor systems

- **Full Slatted Floor system:**
  Birds are reared on a raised floor made of either wooden slats or wire mesh. Slats with s width of 1.5 cm and a height of 4 cm laid 2.5 cm apart are recommended. Wire mesh usually has netting of 2.5 cm by 7.5 cm with 3 mm thickness. Allow 10 to 12 laying birds per square

Housing for Broilers

Broilers can be kept in similar confinements as layers, but do not need the laying boxes. Because they grow heavy enough for slaughter in 6-8 weeks, their bones are sometimes weak. To keep them healthy and bones as strong as possible, it is good to provide exercise areas, even outside. Also broilers like some sunshine, which reduces stress in the flock and helps keep the birds healthy.

Part free range (required for organic/ecological markets)

Both hybrid layers and broiler products improve if the chicken have access to outside exercise area, greens in the diet, sunshine and areas where they can take dust baths. Eggs from layers fed with enough greens have a deep yellow yolk, which is much preferred by the market and fetches premium prices compared to the light yellow to almost white yolks of eggs from battery hens. Broilers produce better quality meat (better texture and taste) if they have access to outdoor facilities such as sunshine, exercise, dust bath areas and green feed. They also have stronger bones and less tendency to break legs during processing.

Housing for Indigenous chicken

Poultry are often allowed to scavenge for food in the local environment during day time, getting housed in the evenings. In some cases they roost in the branches of trees or in enclosed baskets in the house to protect from predators and theft. In other cases, keepers build wooden, stone or brick accommodation attached to the family dwelling house. As brick houses tend to be difficult to keep clean. They present a potential threat due to the build-up of pathogens.

In Kenya, there are several housing structures, which include:

- **The dome-shaped stick basket, known in western Kenya as Lisera, Liuli or Osero, ideal for daytime housing**
- **The stick-built Kiduli and other standard poultry houses**

Hygiene

It is important to reduce chances of infection to a minimum. Measures for preventing disease include the following;

- **Keep the chicken house clean and dry at all times**
- **Disinfect all litter material before use**

- **Locate the chicken farm at least 100m away from other chicken farms**
- **Keep away visitors from the chicken houses.**
- **Control rodents and mice**
- **Clean drinkers and feeders regularly**
- **Clean the chicken houses thoroughly and disinfect after disposing all birds**
- **Remove dead birds immediately**

Lighting

There should be adequate light in the poultry unit. The light should be enough for a person to read a newspaper at the centre of the building. Transparent roofing sheets should be fitted to improve lighting. Light in laying birds stimulates increased egg production.

Ventilation

- **Poultry unit should have free flow of fresh air.**
- **A chimney aids the flow of air from the back to the front.**
- **Place 0.6 m wire-mesh opening at the back, and 1.0 m opening in front of the building. In hot areas front ventilation should be made as big as 2 metres from the top. During the cold weather cover the ventilation with curtains.**

Sunshine/Shade

All creatures need some sunshine. The sun helps the birds manufacture Vitamin E. As far as possible try to provide an outdoor exercise area for the chicks to sun themselves and take dust bath during the day. This helps keep down external parasites, reduces stress and keeps the birds more resistant to diseases.

Space

- **Too many birds kept together may cannibalise/wound or even kill each other, as the stronger ones peck the weaker.**
- **Do not keep local breeds in confinement without free access to outdoor areas. Also hybrid chicken do better with acces to outside runs.**
- **Provide a space of 5 square meters per adult bird in a run system.**
- **When space is limited, diseases are passed more easily from one bird to another.**

Bio Security

- **Do not allow visitors or vehicles into the poultry farm unless thoroughly disinfected**
- **Use foot baths with disinfectant outside each poultry house**
- **Wear protective clothing for each house**
- **Do not allow wild birds and other fowls into the poultry house or farm**
- **Burn and bury dead birds**
- **Do not mix birds of various ages**

Farmers who regularly add EM (effective microorganisms) or BM to the drinking water of chicken are reported to have very few cases of coccidiosis and other diarrhea causing pathogens.. Also vinegar can be used as a water additive if signs of diarrhea appear in the flock.

Give clean and fresh waer in a specific place
© Henry Ondwasy, KARI

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Feeds and Feeding Chicken

- **Supplementary feeding in particular for small chicks, is one of the most important means of preventing diseases.**
- **Store Feeds in a dry and clean place always to avoid contamination and spread of diseases.**
- **Provide your poultry with clean water daily to avoid the spread of waterborne diseases, such as Fowl Cholera. Daily addition of EM to drinking water has been shown to help prevent diseases.**

Why feed indigenous chicken?

Feeding is important so as to increase the production of meat and eggs from indigenous chicken. A lack of feed or water will reduce resistance to diseases and parasites, and subsequently increase flock mortality. It is important to note that even small flocks of indigenous chicken will starve during certain periods of the year (e.g drought, planting season when birds are confined, floods etc) when left to scavenge without supplementary feeding.

Egg production and growth are limited by access to feed and genetic potential. Local birds are the best converters of feed to eggs under fluctuating environmental conditions, although their production potential is much lower than genetically improved breeds.You may easily increase

egg production and growth of local birds by giving supplementary feeds. Improved breeds also perform well under village conditions when given a steady supply of feeds. It is important to always start by making calculations of the cost-benefit and judge the risks involved before choosing the quantity and type of feed.

Feeds and feeding will vary between free range, semi-intensive and intensive systems of poultry production basically due to profitability. In the following we will focus on semi-intensive systems and discuss the importance of feed requirements, feed types, feed mixing, feeding equipment, feed storage, feeding and watering.

What to feed?

The composition and availability of feeds will vary, depending on the season, locality and production system. In general poultry, as other animals need feed containing energy and protein, as well as vitamins, minerals and water. The need for feed will change, depending on the age and status (chicken, grower, egg layer, broody hen) of the bird. The cheapest - and also often the best - way to supplement the diet of your poultry, is to use local resources. However, many vitamins and nutrients are destroyed if stored too long or under sub-optimal conditions, e.g. high humidity and heat. Knowledge of feed quality and sources of different feed types is important for feed safety.

If your production is based on improved breeds or hybrids for egg production, different types of commercial diets may be offered. These are divided into three distinct categories, with decreasing amount of protein as follows;

- **A starter diet or (chick mash): high in protein; offered from day old up to 8 weeks; Each chick will consume 2 kg during this period**
- **A growers' diet/mash: medium in protein; offered from 9 weeks up to 18 weeks; Each grower will consume about 8 kg during this period**
- **A layer diet/mash: lower in protein; offered to hens from 19 to 75 weeks. Allow 120 g of feed per bird per day. Hens consume about 45 kg of feed annually**

Note: The above quantities are a guide and will vary depending on feed quality and level of feed wastage.

Maize for energy
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Sorghum for energy
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Fish meal for protein
© A. Wachira, KARI, Kenya

Leucaena and vitam
© A. Wac

Sim sim for protein

© A. Wachira, KARI, Kenya

Green grams for protein

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When buying commercial feeds, calculate whether it is profitable based on the market price for eggs or meat/live birds. If the product price is lower than the price of feed consumed by the birds it is not economical to offer commercial feeds. Indigenous chicks may be offered commercial diets profitably from day old to six weeks of age.

Scavenging

In a free-range or semi-intensive poultry rearing system, adult hens and cocks ought to be given enough time and space for scavenging in the surroundings daily. The best time for scavenging is early morning and late afternoon when there are plenty of insects and less heat. Chicks below six weeks of age should be confined. Supplementary feeds should be offered in the morning and evening when the birds come back for the night. *Ad libitum* clean water should be provided in shady areas during the day to avoid heat stress.

Note; Always give free access to water.

Types of feeds

Energy feeds

As a rule 75% of a quality poultry diet is made up of energy feeds. Energy feeds are the most important feeds for maintenance requirements (e.g. body temperature, vital functions, exercise). Cereal grains, roots and tubers are the most important energy feeds. Examples of energy feeds are cereals like maize and its by-products (bran), sorghum, wheat and its by-products (bran), rice and its byproducts (bran, polishing), cassava root meal, yams and sweet potatoes.

Roots and tubers should be soaked in water for 60 minutes or cooked before drying to remove

harmful substances and the proportion in the diet in general kept below 10%. Fat is also a good source of energy in particular in hot climates, as the heat produced during metabolism is less than from traditional energy feeds, e.g. cereals. Sources of fat are e.g.: tallow, lard, oil cake meals, hotel used oils and fat. Such oils and fats should only be given in small amounts, i.e. less than 10% of the total diet.

Protein

Protein is needed for growth and optimal health status. Normally no more than 20% of a poultry diet is made up of protein-rich feeds mainly due to high cost. Protein sources may originate from animals or plants. Examples of protein-rich local feeds are: Maggots, termite eggs, insects, worms, meat scraps, fish scraps, fish meal, meat meal, bone meal, blood meal, feather meal, peas, beans, and oil cakes from e.g. ground nuts, cotton seeds, palm kernels, and coconuts. Some harmful substances (anti-nutrients) are present in some protein-rich plants e.g. beans. As such their proportion in the diet should be low based on type and processing prior to feeding.

Minerals

Minerals are important for bone formation, eggshell formation and for optimal health status. The most important minerals are calcium and phosphorous. To produce strong egg shells, laying hens need free access to calcium (limestone or crushed shells). Mature birds are usually able to balance their mineral intake according to their requirements. When phosphorous rich feeds are added to the diet, they should be balanced with calcium rich feeds, since high levels of one mineral will cause deficiency of the other. Examples of sources for minerals are: bone meal, limestone and burned eggshells. The use of bone meal or eggshells is a good way of balancing calcium and phosphorus levels in the diet. Eggshells should always be scorched or cooked before re-use in diets to remove contaminants.

Vitamins

Scavenging birds get vitamins from eating green grass, vegetables, fresh cow dung and

through sunlight. Vitamins A, B2, and D3 are important because many problems arise when birds are deficeint. Sunlight and green grass or green fodder normally provide Vitamin A and D, whereas Vitamin B may come from fresh cow dung. Vitamin B may also be added by giving multivitamins. Additional vitamins are given in very small quantities and purchased from agrovet stores or feed stockists. Supplementary vitamins are usually not required when birds are left to scavenge. Confined or intensively management birds always need additional vitamins added into their feeds.

Simple feed mixing

It is advisable to make a semi-balanced diet for the small chicks from 0-6 weeks of age. Locally available ingredients should be dried in the shade (the sun may destroy important vitamins) and grounded in a mortar before mixing. Locally available containers such as plastic tins or matchboxes may be used for easy quantification of the different ingredients. Grams or percentages should be transferred into local quantities for field practice. Large ready-mixed quantities should only be stored, if adequate storage capacities are assured (see under "Twelve simple rules"). In general mixed feeds should not be stored for more than a few weeks to avoid contamination from mould, bacteria or rodents. Above 8 weeks of age, poultry may be fed in a cafeteria system saving time and energy on mixing feeds. The cafeteria system is described below.

Table of Simple ration for supplementing local chicks from day-old to 8 weeks (total 930 g)

Ingredient	Quantity
1) Crushed maize/sorghum or millet	1 kg tin
2) Wheat/sorghum or millet bran	1 kg tin
3) Sunflower/sesame/groundnut cake	2 match boxes
4) Bonemeal/salt mix	1 match boxes

5) Blood or fish meal	**2 match boxes**
6) Sesbania/leucaena leaves	**2 match boxes**

Termites or maggots may also be added during the first 8 weeks. Depending on the types of crops grown in the locality cereals, oil cakes etc maybe substituted. Alternatively a commercial chick starter ration can be used from day old to 8 weeks of age. In this way you will ensure that the chicks have the daily requirements during the most vulnerable weeks.

Simple techniques for growing maggots and termites

Maggots and termites are a cheap source of protein in semi-intensive poultry production systems. However, they are a supplement to other feeds. Maggots or termites should be offered to young chicks since they require quality protein sources for optimal growth

Maggots may be grown by a simple technique and used to supplement the diet of the young chicks. Blood, offal and cow dung are mixed in a large open pot. The pot is filled with 1/3 water. Flies will lay their eggs in the mixture and maggots hatch and feed on the mixture. Leave the pot open during daytime and closed during the night. After 5 - 10 days (depending on temperature) the maggots will be ready to pupate. Collect the maggots by gently pouring water into the pot. The maggots will float and you can then wash them and feed them directly to the birds. Remember to place the pot away from public places, as the smell at times may be offensive.

Growing termites

Take a pot with a short neck and a capacity of at least 10 litres. Fill it up with cow dung and straw and sprinkle a little water on content. Set the pot upside down with the opening on sandy soil. After one day and one night, the pot will be full of termites and you may empty the living contents in front of the hen house in the morning.

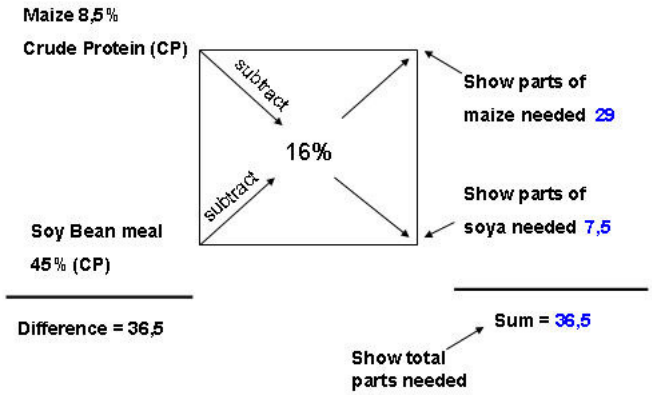
Formulating feeds using Pearson square (Box method)

It is possible to formulate poultry diets to balance for both energy and protein according to the requirement of specific diets i.e. Chick diets, Hens consume about 45 kg of feed annually

One of the simple tools to apply is the Pearson square. It involves making corrections for basically two ingredients and not more. However, one should be conversant with the nutrient composition of the specific ingredients before applying this method.

A worked example on the application of the method is indicated below

Example:
Soya bean meal with 45% crude protein, mixed with maize (8.5% Crude protein), to obtain a 16% crude protein ration. In these calculations, the parts are by weight.



The Box Method

Desired protein level in feed
To find the right combinations, work

diagonally, subtracting the smaller numbers from the bigger number:

Step 1
16 - 8.5 = 7.5 Parts Soya bean meal
45 - 16 = 29 Parts of maize
36.5

To find the percentage of each in the feed, divide each number of parts by the total parts as shown below:

Step 2
7.5 x 100 = 20.5 % Soya bean meal
36.5

29 x 100 = 79.4 % Maize
36.5

Examples of home made rations

Chick ration	
Ingredient	**% composition**
Maize	30
Wheat	20
Wheat bran	10
Rice bran	10

Layer ration	
Ingredient	**% composition**
Maize	35
Rice bran	35
Soya cake	10
Fish meal	15
Limestone	2
Ground dried Legume leaves	3.5
Salt	0.5
Mineral premix	1
	100

Grower rations	
Ingredient	**% composition**
Maize	25
Wheat	25
Wheat bran	15
Rice bran	10
Sunflower cake	5
Cotton seed cake	11
Fish meal	2
Beans	5
Bone meal	1
Limestone	0.5
Salt	0.5
Mineral premix	1

How much to feed?

A major economic advantage of the free-range or semi-intensive production systems over the intensive systems is the ability of poultry to scavenge for in the surroundings. This so-called scavenging feed resource base (SFRB) will change over the seasons based on climate, geography and production system in the area on which the poultry scavenge for feeds. Depending on the season, the chicken may find nearly all they need in the surroundings (e.g. during harvest) or nothing (during lean season).

Table: Amount of feed at different ages of local poultry

Age (wks)	Intake/bird/day (g dry weight)
1 week	**12 - 15**

~~2weeks~~	~~15 - 21~~
3 weeks	21 - 35
4 - 6 weeks	35 - 50
7 - 8 weeks	55 - 60
16 - 27 weeks	68 - 80
28 weeks	100

Limit the quantity of feed offered to the birds daily to at least 30% - 50% of their full daily intake. Allow a maximum of 30 - 40 g/bird/day from week 4 - 6 and gradually reducing the supplementary feeding. At day old to 4 weeks young chicks will receive feed according to their needs. As the birds grow, they will gradually get a smaller portion of what they need, until they only get between 1/3 and half of their needs as adults. Economic benefits are calculating the break-even point from the sale of eggs and live birds relative to the cost of disease control, housing, labour and feeds.

To ensure sustained egg and meat production, offer feeds on a continuous basis rather than large quantities during the harvest season and none during the lean season. Reduce the flock size when feed costs are high rather than reducing the amount of feed given to each bird.

How to feed?

It is important to use simple local measures to administer feeds. By using a table, you can calculate how much feed to use. Fig. shows calculated daily feed requirements based on a flock of 1 cock, 4 hens and 15 three week old chicks.

Table: Simple calculation for daily feed requirements

1 cock: 35 g. = 35

4 hens:	**4 x 35 g. = 140**
15 chicks:	**15 x 25 g. = 375**
Total	**= at least 550 g per day**

When using 1 kg containers (or a cup) measure the amount of feed the container holds, and then calculate the number of containers of feed needed daily. If the container holds 750 g of feed you will need to fill the container ¾ full. To keep the birds hungry for scavenging, offer half the feed in the morning, which will be equal to a half full container. To avoid competition, feed give the young chicks a little more than half in a separate shelter. Feed the hens next and finally before the feeder is empty feed the cock. When cocks are offered feed before the other birds, they over eat and leave less feed for the rest of the flock. Cocks are better at scavenging within the surrounding than the rest of the birds. Young chicks will need relatively more protein in their diet than adult birds hence the need to mix two different rations for young and adult birds, respectively. If you do not want to mix two different rations, you can alternatively give a little extra supplement of a good protein source to the young chickens, e.g. maggots and termites.

Cafeteria system

Adult birds are able to mix their own feed according to their needs. The best way to feed semi-intensively managed birds above 8 weeks of age is a cafeteria system, whereby various types of feeds are offered separately.

Feeders are divided into three compartments, enabling the poultry to choose the feed ingredient according to their needs.

In the cafeteria system, there should be at least one feeding compartment for:
A. Energy rich feeds, e.g. maize, millet, sorghum.
B. Protein rich feeds, e.g. beans, peas, oil cakes, fish, meat, bone meal, maggots, termites.
C. Mineral rich feeds, e.g. bone meal, burned eggshells.

An additional compartment for oil rich feeds may be added, e.g. tallow, oil cake meals, fish oil. By giving adult birds feeds in compartments, observe their feeding behaviour and avoid feeding unnecessary amounts and types of feed. For example, during harvest seasons you may find that they birds feed less on energy feeds in the evenings because there is plenty of cereal in the environment. You may also try out alternative feeds that the birds do not find tasteful. The cafeteria system is a good way of learning about your birds´ behaviour and taste.

Feed mixing

Mixing and formulation of poultry feeds may be based on simple assumptions about the nutritional requirements of the birds and the content of the feedstuffs, or it may be calculated by use of computers and of so-called Least Cost Formulation Programmes (see reference list).

If possible, it often pays to have samples of feed ingredients analyzed at a national nutrition laboratory once or twice a year, depending on season and geographical area. National tables on nutritional content of feed ingredients can also be used.

It is important to realise that the nutritional requirements of the birds may be met in many ways by offering a large variety of feed ingredients. Feed ingredients to be included in the ration in each seasons, will be based on availability, quality and price.

Feedstuff Problems

- **Fish meal can give a fishy taste to meat and eggs. Can contain excessive amounts of salt.**
- **Cassava tubers contain cyanide, which is toxic, and the tubers must be sliced and dried in the sun before feeding.**
- **Oil seed cakes can contain excessive amounts of oil and fibre, which lower digestibility of the feed.**
- **Beans and peas contain a number of anti-nutritional components and should be dried in the sun or cooked for a short period (chick pea and pigeon pea are exceptions and can be fed raw**

after crushing)

Feeders and drinkers

Feeders and drinkers are similar across the production systems. Feeders and drinkers should always be kept clean to prevent the spread of diseases. They should be big enough for all birds of the same age to feed at the same time. One metre trough or a 35 cm (diameter) tube feeder is big enough for 20 adult birds to eat and for 40 to drink. Feeders and drinkers may easily be produced out of local materials. An empty tin placed upside down on a plate forms a drinker. By keeping the tin upside down the water is not contaminated with dirt. Make two small holes near the rim diagonal to each other. Pour clean water in the can. Put a flat plate with a small rim on top and turn the can and plate upside down, while pressing them against each other. Gently place the drinker on the ground. The rim of the plate should be low enough for young chicks to drink, but also high enough for adult birds to dip their wattles to keep them cool during the hot weather. Usually several waterers in different sizes should be used. Ensure that feeders minimize feed wastage. Feed wastage can be minimized when feeders are not filled to the top. Fill the feeders half full and check them regularly for refills.

Automatic drinker

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Chick drinker

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Home made poultry drinker

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Commercial feeders and drinkers may also be bought at the market, either in metal or plastic. However they are often expensive and normally not any better than locally produced feeders or drinkers.

Guide to feed management

Before buying, mixing, and storing feeds, it is important to understand some underlying principles of good feed management.

It is crucial to:

1) Use local feed ingredients for local birds;
2) Know the quality or feed value and prices of each feed ingredient;
3) Buy missing feed ingredients, such as vitamins or protein sources locally from a stockist;
4) Change the feed formulation depending on availability, quality or feed value and price;
5) Reduce the flock size under free-range production system during lean seasons and when feed cost increases;
6) When changing feeds always do it slowly and gradually;
7) Mix feed ingredients uniformly in relatively small quantities to avoid long storage periods;
8) Use locally available materials such as tins or matchboxes for quantifying the different ingredients to be mixed. Grams or percentages do not work in practice;
9) Store mixed feed or feed ingredients separately on a platform approx. 30 cm above the floor;
10) Stop the entry of rats, pigeons, or other type of birds into the feed store;
11) Make sufficient ventilation to ensure that feed ingredients are not wet due to humidity;
12) Caution; Do not use feed ingredients that are mouldy, discoloured or infested with pests.

Water

Scavenging poultry can get diseases by drinking waterfrom small ponds or puddles, as these can transfer water borne diseases and parasites. Poultry should get clean and fresh water all the time at the same place. This makes it is easy to medicate them.
Clean water should be given at least early in the morning and again in the evening when the birds are returning to the house for the night. It is important that all feeders and drinkers are kept clean to avoid disease infection through dirty feed and water.

Age (weeks)	Daily consumption (litres)	Water space (m)
0 – 1	3	0.7
2 – 4	10	1.0
4 – 9	20	1.5
9 or more	25	2.0
Layer	50	2.5

Other feedstuffs

Algae and water plants material have been considered appropriate for feeding poultry since they provide carotenoids and other fat-soluble vitamins.The carotenoids improve the colour of the egg yolks and together with vitamin E enhance the egg quality and the viability of the hatchlings. The deeper the egg yolk colour and pigmentation, the greater is the supply with vitamin A to the consumer.

Where available, the mixing of dried molasses with protein feeds have been shown to improve nutritional status of chicken.

Dung heaps from the waste of cattle, goats and sheep are excellent sources of insect protein but also may act s sources of parasites (e.g. coccidia) and other diseases.

Feeding Hybrid layers

Hybrid layers have quite easy feeding regimes, as the feed they need is manufactured and can be ready bought. However if you want to have nice yellow eggs also greens need to be provided. This can be any kind of edible green plants such as vegetable waste, grass, legumes etc. Preferably the greens should be hung up in a string so the birds have to jump a bit to reach them. This gives both good exercise and avoids too much mess to clean up later. Without greens the yolks of the eggs will not have as much colour.

Feed intake of laying hens depends on the quality of the feed, the body weight, its performance and environment. The following standards maybe used as a guide when feeding birds on a layers mash (2800 kcal ME);

1) 2 kg body weight (for maintenance) 65g
2) For each 100g difference in body weight 2.5g
3) For each gram of egg weight 1g
4) For each degree deviating from 20 degree Celsius 1.5g

Thus, if the average weight of the layer bird is 1.8 Kg, with a daily egg weight of 56 g and temperatures of 24 degree Celsius (normal room temperature), the feed required will be as follows;

1. 1.8 kg hen	**65 - (2 x 2.5 g) = +60 g**
2. 56 g egg weight	**= +56 g**
3. 24 degree Celsius	**110 g**

Type of feed	Chick mash 0-8 weeks	Growers Mash 9-18 weeks	Layers Mash 19-75 weeks
Protein %	18	14	16
Energy Kcal ME/kg	2800	2750	2700

Hybrid layers have quite easy feeding regimes, as the feed they need is commercial available. Where the market demands a golden yellow egg yolk, the birds need to be provided with a scavenging area in a free range environment or provided with green leaves or vegetables wastes such as grass, Lucerne or kales. Yolk colour maybe influenced by the genotype and the rate of egg production but feed composition is the major influencing factor. Both natural and synthetic sources of pigmenting egg yolks are in use commercially. Feeds stabilized with antioxidants such as vitamin E and A improve yolk colour pigmentation.

Feeding broilers

Along with their recommended broiler feed, the birds also highly appreciate additions of greens for pecking and absorption of higher amounts of vitamins. AIM: Production of big broiler capons of 2 kg live weight (1.5 kg dressed weight at 6 - 8 weeks) In order to reach this aim a feed needs to contain the following:

Feed for the first 4 weeks (broiler starter):

- **Crude protein content greater than 22%**
- **Crude fiber less than 6%**
- **High energy content as close to 3000 kcal/kg as possible**

Each broiler chick takes 1.2 kg of this starter mix during this

Feed for week 4-8 (Broiler finisher):

- **Crude protein content greater than 18%**
- **Crude fiber less than 7%**

- **Energy content as close to 3000 kcal/kg as possible**

Each broiler chick consumes about 3.5 kg of this mixture during this phase.

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Chicken diseases

Chicken diseases - What causes diseases?

- **Microorganisms**
- **Parasites (Internal and external)**
- **Malnutrition**
- **Injuries**
- **Chemical (eg. Sodium chloride poisoning).**

Disease outbreak and death of the animals depend on their age, nutrional status and hygiene of their housing.

Characteristics of healthy birds:

- **Alert and on guard.**
- **Bright eyes and comb.**
- **Walk, run, stand and scratch.**
- **Continuously eat and drink.**
- **Normally lay eggs.**
- **Normally smooth and neat feathers.**
- **Soft compact droppings breathe quietly.**

Characteristics of unhealthy birds/sick birds

- **Tired and lifeless**
- **Dull eyes and comb**
- **Sit or lie down**
- **Eat and drink less**
- **Lay less or stop laying eggs**
- **Ruffled and loose feathers**
- **Wet droppings with blood or worms, diarrhea**
- **Cough, sneeze and breathe noisily.**

Health and disease management

- **Starts at the hatchery and continue to maturity.**
- **Poultry well fed and managed and effectively vaccinated against known diseases usually remain healthy.**
- **In case of disease outbreak, sick birds should be isolated and dead birds removed burnt or buried**
  - **Apply strict sanitary measures in all houses.**
  - **Notify veterinarian as soon as possible.**

Rules for disease prevention

- **Vaccinate the chicken as recommended by the vet**
- **Give access to the right feed and clean water, in particular for small chicks**
- **Build shelters against wind and rain and predators**
- **Clean houses regularly and apply lime wash/disinfect the floor and walls**
- **Provide dry litter regularly where applicable**
- **Do not put too many birds together**
- **Different species of poultry for example hens, turkeys, pigeons, ducks and guinea fowls should be kept separate**

- **Separate chicks from adult birds except from the mother hen**
- **Vaccinate chicks against the most important diseases and revaccinate if necessary**
- **Isolate and treat sick birds. If medication is not available then kill the sick birds**
- **Burn or burry killed birds (do not try to eat sick birds that have been killed - diseases can sometimes transfer to human beings never mind how well they are cooked).**

Vaccination regime recommended for commercial chicks, but also applicable to improved management of indigenous chicken (Sigma feeds chicken recommendations):

Age	Vaccinate against	Application
1st week	Marek and Newcastle disease	Subcut (neck)
2nd week	Gumboro	In drinking water
3rd week	Lasota + IB (Newcastle)	In drinking water or eye/nostril drop
4th week	Deworming, IBD forte	In drinking water
5th week	Lasota + IB	In drinking water
6 - 8th week	Typhoid	Injection
9th week	Deworming (every 2-4 weeks)	In drinking water
8 - 10th week	Fowl pox	Wing stab
12 - 14th week	Typhoid	Injection
16 - 18th week	Renewed Newcastle (where disease is prevalent)	Optional

Importance of a disease is judged by mortality rates and effect on production. Diseases in poultry are divided into three categories:

- **High importance**
  - **high mortality (more than 30% of the flock)**
  - **highly contagious and difficult treatment.**
- **Medium importance**
  - **medium mortality (10-30%) of the flock and/or difficult treatment.**
- **Less importance, signifies not common**
  - **lower mortality and/or easy treatment**

Diseases with high mortality (more than 30% of the flock), highly contagious and difficult treatment

- **Newcastle Disease**
- **Avian Influenza (AI)**
- **Fowl pox**
- **Fowl cholera (*pasteurellosis*)**
- ***Coccidiosis* (internal parasites)**

Disease with medium mortality (10-30%) of the flock and/or difficult treatment

- ***Pullorum* disease (Baciillary white diarrhea)**
- **Fowl typhoid**
- **Gumboro (Infectious Bursal Disease, IBD)**
- **Infectious coryza**
- **Chronic respiratory disease (Mycoplasmosis)**
- **Roundworms and tapeworms (Internal parasites)**
- **Mycotoxicosis (fungal poisoning)**
- **External Parasites**

Not common, with lower mortality and/or easy to treatment

- **Marek's disease**
- **E. coli infection**
- **Scaly legs**
- **Nutritional diseases**

Nutritional diseases

Symptoms: Bone deformation and feather loss. The birds walk with difficulty; they limp. Legs are deformed. Some deficiencies may cause feather loss. Treatment, if detected in time: Supplementary vitamins and calcium, fresh grass, and cow dung. Nutritional diseases may be avoided when the birds have access to normal vegetation and are therefore rare in scavenging chickens.

1) Protozoan diseases

Protozoa such as *Emiria tenella* (coccidia) are larger than bacteria and can be easily seen under the microscope. Protozoan diseases are caused by poor hygiene and sanitation. Symptoms: Sick looking birds with head down, ruffled feathers and bloody diarrhea, death of young chicks.

Prevention and control:

- **Avoid keeping different age groups of birds in the same house as disease may spread from adults to young chicks**

- **Use of EM or BM in drinking water for prevention**
- **Clean up chicken house and disinfect the area with lime (dusting with whitewash or agricultural lime)**
- **During outbreaks use coccidiostat mixture in drinking water**

2) Bacterial diseases

Bacteria are minute germs that can only be seen under microscopes. Bacterial diseases can be prevented through good hygiene and sanitation. Very common are diseases caused by *Salmonella* bacteria, namely:

- **Pullorum disease. It is caused by sub-species *S. pullorum* and it is severe by chicks. It is transmitted from hen to chicks during egg formation, contamination of eggs during laying or the chicksget infected form faeces.**
  Symptoms: dead embryo in eggs that do not hatch; chicks develop wet tails within the first week; whitish diarrhoea, chicks walk with difficulty, show big bellies and drag their wings, huddling anddifficulty in breathing. Mortality can reach 100% in the first two weeks.

- **Fowl typhoid. It is caused by the species *S. gallinarum* and it affects growers and adult chickens. It is spread through contamination of feed and water by faeces of infected birds.**
  Symptoms: Usually seen in older birds, high body temperature, tiredness, blue comb, decrease in egg production, egg fertility and hatchability; anorexia and dullness followed by sudden death.

- ***Salmonellosis*. It is caused by another *Salmonella* species. It affects chicks and adults.It is spread by contamination of eggs at laying or through contaminated feed and water and faeces.**
  Symptoms: Decline in egg production, egg fertility and hatchability; anorexia and dullness

followed by sudden death.

- ***Collibacillosis.*** **It is acute in chicks and chronic in adult chicken. Common in newly hatched chicks. Chicks get contaminated through eggs and contaminated faeces, while feed and water transmit the disease to both chicks and adults. It can be prevented by keeping good egg and nest sanitation.**
  Symptoms: Respiratory distress, diarrhoea, high mortality of chicks and dead embryos in spoiled eggs.

- **Infectious Coryza. This disease can be acute, mild or chronic. Contamination occurs by faecal matter, aerosols or through feed and water. It can be prevented by vaccination with bacterin in water at 10 to 12 weeks and 16 to 18 weeks.**
  Symptoms: Swollen watery eyes, closed eyes, nasal discharge (runny nose), laboured breathing and decrease in egg production. All clinically ill chicken should be destroyed.

- **Fowl Cholera (Pasteurellosis). This may occur at all ages of chicken, causing infection of the stomach region.**
  Symptoms: severe diarrhea, breathing problems, loss of appetite, blue combs and wattles. May occur as a cronic disease or as sudden death. Infection is mainly through contaminated feed and drinking water. There is no treatment. Best prevention is strict hygiene and vaccination. Destroy through killing and burn affected birds.

Prevention and control

Salmonella and other pathogenic bacteria are present in the air and feaces of most animals, and can even be present in some of the food items bought in the shops. Bacterial diseases can be prevented through good hygiene and sanitation. Which means regular cleaning of chicken houses and runs, regular disinfections with lime, etc. Some diseases such as fowl typhoid can be prevented by vaccinating the birds.

Note: Do not vaccinate sick birds.

3) Parasitic diseases

Parasites are organisms that live in or on a host (animal or plant); the parasite obtains nourishment from the host without benefiting or killing the host. Chicken parasites include lice and fleas, and worms living in the opening of organs. They may cause diseases and weaken the immune-system, making the chicken susceptible to other diseases.

Worms

Worms inhabit the alimentary canal and other internal organs such as lungs, trachea, etc. There are two groups of worms: round worms and flat worms.

Round worms

- ***Ascridia galli*. They infect both chicks and adult chicken. Infection occurs through eggs that are laid by female worms in birds' entestines and are passed out in droppings. They mature in one week or longer, and are swallowed up by chicken, hatch and cause new infection. Prevention is difficult due to feeding habits, especially by scavenging chicken.**
  Symptoms: Slow growth and stunted, culled feathers and drooping head, thirst, low egg production and death due to intestinal obstruction in young birds.
- **Gape worms (*Syngamus treachea*). They infect the trachea (windpipe) of chicken. Adult worms live and lay eggs in the birds trachea; the eggs get coughed out or get swallowed into the oesophagus and discarded via faeces. The eggs hatch to larvae which infect chicken or enter intermediate hosts such as beetles and earthworms.**
  Symptoms: Difficulty in breathing and gasping for air (thus the term gapeworm), huddling, and death fue to suffocation.

Flat worms

- **Tape worm (*Raillietina tetragona*) infests scavenging chicken. The worms release the eggs free or retained in a segment. Beetles and snails ingest the eggs. The eggs develop in these intermediate hosts infecting chicken that feed on them. Prevention occurs by using clean containers.**
  Symptoms: Stunting, Thirst, poor health, low egg production and death of young birds on poor diets.

Prevention and cure
Intestinal worms in chicken are controlled by regular deworming with recommended deworming medicine usually mixed with drinking water.

External parasites

The most common external parasites include lice, mites, fleas and ticks. They infest poultry houses and breed in cracks of the buildings. Infestation occurs through infected birds and pets, and affect all ages of birds but are severe in chicks.

Prevention can be done by maintaining cleaniliness of the poultry nests and houses and sealing cracks in the walls and on the floors.
Lice can be seen around eyes and nose. They lay eggs on the feathers and suck blood from chicken, causing discomfort.

Mites live in cracks in the poultry houses, not on the host. They suck blood from the birds at night and remain in the cracks during the day. In severe infections, birds become anaemic.
Fleas can be seen on the belly. They suck blood from birds after which they drop and lay eggs in the litter. The eggs mature to adult fleas, which can survive for up to a month without feeding. Attacks all ages any time, but occurs more frequently in humid chicken houses with bad hygiene. Adult birds are clearly disturbed and spend a lot of time pecking and polishing

feathers. Young chicks may die from anemia. If not treated, mites, lice, fleas, ticks will cause weight loss and possibly loss of feathers due to the parasites sucking blood and to skin irritation

Treatment: Spray or dust with pesticides, ashes, and oil. Ashes and sulphur powder may be used where the hens do dust bathing. Nests may be protected by putting a few tobacco leaves mixed with ashes in the nests.

External parasites (behaviour and parasites) Scaly legs

Scaly leg is caused by an external parasite irritating the skin on the birds' legs. Symptoms: Legs clearly have scales and wounds and may become crippled in their appearance. Treatment: Dip the legs daily in kerosene, oil or in an insecticide until the scales disappear.

4) Viral diseases

Viruses can be prevented by vaccination. They are the smallest germs and can cause incurable diseases. There is no treatment for virus diseases.

Newcastle disease

Newcaste is the most economically important and the only notifiable disease in chicken. Often 30-80% of the flock dies. It is spread by dogs, birds, wild birds and man. Prevention occurs only by early vaccination.
Symptoms: Respiratory stress, lack of appetite, green diarrhoea, nervous symptoms and high mortality. Death can also be sudden without symptoms.

A hen with Fowl Pox pimples on the comb.
© Henry Ondwasy, KARI

Fowl Pox

Fowl pox is a chronic disease in adult birds and deadly among chicks and growers. It is caused by Pox virus and is transmitted by mosquito bites and mechanically through broken skin. Prevention occurs by clearing bushes.
Symptoms: Pimples or scabs on the birds combs, wattle and eyelids, high body temperature a watery discharge from eyes, difficulty in breathing indicated by whizzing sound and loss of appetite, tiredness followed by sudden death.

Infectious bronchitis

This is a contagious disease, acute in chicks and chronic in adult birds. Transmission occurs through faeces from sick birds, contamination of litter and by air.
Symptoms: Sneezing, watery eyes, nasal discharge, wet droppings, poor egg shell with no death unless from secondary infection. Chicks gasp and cough, breath noisily, have watery eyes and nostrils, become depressed and huddle. Mortality can be as high as 25%.

Avian Influenza (Fowl plague)

This is an acute disease in chicken, turkeys, ducks and wild birds. The disease is found naturally in ducks and other waterfowl, and may spread as a highly contagious and potentially dangerous form to chickens. Infects through contaminated feed and drinking water from ponds. Transmission occurs through contaminated faeces, water and air.
Symptoms: Respiratory distress, sneezing, swollen head and face, emaciation and nervous disorder. High flock mortality, blue and swollen comb and wattles, Infected birds must be destroyed and location of infection quarantined. Always call a veterinarian if you suspect AI. Do not eat infected birds.

Infectious Bursa Disease (Gumboro)

This disease is common in hatcheries. It affects young chicken 2 to 6 weeks old and it is rare in indigenous birds. Transmission occurs through feed, water and faeces.
Symptoms: Diarrhoea, sleepiness and depression, ruffled feathers and trembling of the head. Mortality is between 50% and 80%. The disease weakens the immun-system, making the birds more susceptible to other infections. It can be controlled by vaccinating the chicken when they are 2 to 6 weeks old though drinking water.

Death caused by Infectious bursa disease.

© Henry Ondwasy, KARI

Marek's disease

Seen only in birds older than 16 weeks. Initially the birds may show paralysis of one or both wings. Or one or both legs might be paralysed. The disease is a virus, so there is no treatment, but commercial vaccines are available.

Mycotoxicosis (fungal poisoning)

Symptoms: Weakness, pale combs. Treatment: Supplementary vitamins. Prevention: Proper storage of feed to prevent growth of the fungi producing mycotoxins, the cause of the disease.

Vaccination methods

There are four fundamental ways of vaccinating birds:
1) Eye drops
2) Injections
3) Skin piercing.
4) Orally (in feed or water)

For scavenging poultry, you should avoid mixing vaccines with drinking water or feed, as it is difficult to give the right dose. Research has shown that protection against e.g. Newcastle disease is highly variable if vaccine is given through water or feed. Giving the right dose is essential for the vaccine to work properly. A too high dose of a live vaccine may kill a young chick, whereas a too low dose will not give adequate protection. Thus, it is important to consult a veterinarian or auxiliary veterinarians (barefoot vets, village vaccinators) for further advice before carrying out a vaccination.

Tools for application normally include a clean apron (green or other dark colour if possible)

vaccine vial (B) stored in a cool box (C), soap to clean hands (D), clean needles (E), clean syringe (G) and a clean box for needles and syringe (F). Needles and syringe should be boiled in water for 5 minutes and cooled before re-use

It is important to treat the clean syringe and needle carefully. Do no touch the end of the needle after cleaning. Put the needle gently on the syringe holding the needle with the sharp end upwards . Put the vaccine vial upside-down and press the needle gently through the plastic seal of the vial cap. Pull the syringe handle gently down, while sucking the vaccine out of the vial until the syringe is full. Press the syringe handle back until you reach the right volume.

Ensure that there are no air bubbles trapped in the syringe or the needle. Air bubbles will give the wrong dose to the chickens. Normally a full 1 ml syringe will match 10 doses, one for each of ten adult birds. This however depends on the weight of the bird and the type of vaccine, and the application method.

The most common methods for vaccinating adult poultry are eye drops (A), injections in the breast or thigh muscles (B) or by piercing the skin of the wing (C). The most common methods for young chicks are eye drops and skin piercing. When the birds grow older, injections are given in the breast or thigh muscles. Depending on the vaccine type, eye drops may also be used for adult birds. Please consult the local veterinarian for clarification and technical information

Vaccines should be given either early morning, before letting the birds out of the chicken house or when the local birds are easy to catch resting in the trees. When vaccinating adult poultry for the first time, you should preferably be two persons, one holding the bird, the other one vaccinating.

General precautions for vaccination with live vaccines:

- **All vaccines should be stored in a refrigerator before use.**

- **Some vaccines are heat stable, which means that the vaccine will tolerate high temperatures. However, heat stable vaccines should also be stored in a cold place to keep them viable. You should always keep vaccines out of direct sunlight.**

- **When using vaccines in the field, you should as far as possible transport them in a cool box with ice.**

- **The syringe, needle and other equipment to be used for vaccination should not be cleaned by any chemical disinfectants, as these may destroy the vaccine. They should instead be disinfected in boiling water and be used after cooling.**

- **The vaccines must be mixed or diluted in cold distilled water, and care must be taken to ensure that the vaccines do not come in contact with direct sunlight.**

- **It is best to vaccinate birds during the cool hours of the day, either in the morning or evening.**

- **Some mixed vaccines should be used within 30 minutes. Otherwise they will be useless and should be thrown away.**

- **Always consult a veterinarian or an auxiliary veterinarian before conducting a vaccination campaign.**

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Chicken Products and Marketing

Poultry play an important role improving the income of local population and providing high-quality protein (meat and eggs). It is important to know the market requirements, the investment costs, running costs, and expected revenue for the different products before starting any production activity.

Hence the need to carry out a detailed market study including a cost and benefit analysis, before choosing the system of production. Start with a production based on local breeds, local feeds and local demands before proceeding into a more sophisticated production system with improved breeds whose products require a stable market. In general the economic outcome as well as the necessary investments and risk involved in the production, will vary from one system to the other e.g A free range production system will have relatively low risks compare to an intensively managed systems (higher risk).

Commercialization

Live birds and fertile eggs are sold in village markets while hybrid table eggs are more often found in peri-urban and urban areas or along traffic corridors, where confined production systems can be managed. At village markets live birds are sold at highly variable prices depending on factors such as demand (high during festivals), size and weight, plumage and colour. Cocks are usually highly priced at most markets compared to hens. In certain regions e.g western Kenya indigenous chicken are also highly priced compared to exotic breeds irrespective of size. Likewise eggs from indigenous chicken are often more valued than table eggs from exotic hens, despite their smaller size. The taste and texture of meat and eggs from indigenous chicken are a major reason for the higher prices

Marketing

Birds for sale

Cockerels in a flock should be sold as soon as they attain the correct weight for the market. At

the age of 6 months and a weight of approximately 1.5 kg, cocks are usually big enough for sale in prime markets. Retain a breeding cock for every 10 - 15 hens in the flock. Breeding cocks should be sold when mating is inefficient (low fertility/hatchability). Care should be taken not to return live birds from the market back to the farm due to disease. Old hens which are out of laying should also be sold. Restrain birds for sale in the night or attract them with feed then hold them using a piece of metal wire bent at the end.

Production and sale of eggs

Egg production starts at 20 - 24 weeks of age depending on genetic and environmental factor such as light and nutrition. After the onset of lay, peak production is attained within 6 to 10 weeks. During this stage the rate of lay will be greater than 80 to 90 % (hens laying an egg daily). This level of egg production will continue and then gradually decline until it is uneconomical to keep the hens.

Hens will lay eggs is sequences (clutches) of 1 - 30+ eggs each separated by a single or more pause days. The first egg of a clutch is laid early in the morning and the following eggs laid later on successive days because the time interval between successive eggs is longer than 24 hours with an average of 25 hours. A hybrid layer will produce 250 - 300 eggs per laying cycle.

Handling Eggs

- **Collect eggs 2 to 3 times a day.**
- **Separate broken and dirty eggs from whole eggs.**
- **Place eggs with the broad end up in the egg tray.**
- **Store eggs in a cool dry place and Do not stack more than six trays.**

Eggs should be collected and sold while fresh, particularly when cooling is not practiced. Collect eggs from the laying boxes at least once, but rather two times a day, and store them in a dark, cool place. Eggs should normally not be cleaned. When the eggs are dirty, clean them with

a dry sponge or cloth and sell them immediately. Cleaning eggs with water often destroys the shells natural protection against infection.

Pack eggs in boxes, egg trays or other suitable containers to avoid breakage. Sell eggs in the market two to three times a week so as to create a name for selling fresh eggs. If profitable, grade your eggs according to size. Always keep records of your production and sale as explained under Record Keeping (verlinken mit Datasheet Record Keeping).

Manure

Litter in the poultry house should be kept dry and removed regularly to reduce the load of parasite. Chicken manure contains the highest amount of Nitrogen of any livestock manure. It is therefore very valuable as fertilizer, but if applied fresh to crops can also burn these crops. The best way of utilizing chicken manure is to compost it along with any plant material found around the farm.

Poultry manure

Uses of litter

- **As manure for crop production**
- **Compost improvement**
- **Feed in fish ponds**
- **Biogas production**

Average composition of Chicken manure

	Fresh Manure	Litter manure
Dry matter %	**20 - 22**	**50**

Nitrogen	**1 - 1.5**	**1 - 2**
Phosphorus	**1 - 2**	**1**
Potassium	**0.7**	**1**
Calcium	**2.2**	**3**

Quantify manure yield

Chicken manure can be used in fish ponds. The manure is partly eaten by the fish while the rest is used by plants to grow and then eaten by fish. Dried poultry manure maybe used to feed ruminants (cattle and goats) in combination with grains and molasses. A biogas digester can be used to make gas from the manure. The slurry left over may also be used as fertilizer for use in crops or fish ponds.
100 layers will produce about 3 tons of manure during a 448 day period (from chicks to end of first laying period.
1000 broilers will produce about 1.1 tons of manure in 42 days.

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Rabbits
status: under construction

more Images

Introduction

Feeding

Introduction

If every rural family in East Africa kept a pair of rabbits their children would eat meat every day. However, rabbit production in many parts of East Africa is still confined to the youth, mainly 4-K club members and some young farmers. More recently, however, a few farmers are showing some interest in rabbit keeping mainly due to an emerging market.

Rabbits are quick growing and prolific breeders. Their meat is of high quality and tastes similar to the meat of chicken. Second only to ostrich, rabbit meat is the highest protein meat available. It is fat and cholesterol free, so is not only highly nutritious but also very easily digested. It is, therefore, much better value than chicken. The potential for rabbit production is high considering that other sources of meat are often scarce and out of the financial reach of most families.

The Benefits and Pit Falls of Rabbit Farming

As more small holders are becoming aware of the potential of the market for rabbit meat in East Africa, there has been a huge interest in the past couple of years. However, it is apparent that some of these enthusiasts think that they can make quick money from rabbit farming. Nothing could be further from the truth. Keeping rabbits properly is a labour intensive venture, and comes at a reasonably high financial cost. A commercial unit requires dedicated staff, high feed costs and, if done properly, a well constructed unit.

Exotic breeding stock are not readily available, although for the small farmer, there is nothing wrong with local stock. Marketing is still a big hurdle for the small farmer and, before venturing into the business, prospective farmers should research the market before they start. As the market grows better stock will, inevitably become available. There is a shortage of facilities that

will accept pelts for tanning in East Africa which is a shame, as the pelts are a much sought after commodity in the fashion and fabric industries around the world.

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Breeds and Breeding

It is interesting to note that East Africa does not have wild rabbits. The brown creatures that are seen, mostly at night, on the plains are hares, not rabbits.

- **New Zealand White**
- **Californian White**
- **Chinchilla: The Chinchilla is kept almost exclusively for its fur.**
- **French Ear-lopped (sometimes referred to as Belgian Flop): The Lop family shares the distinction of being one of the oldest fancy breeds. The ear length, shape and size of the rabbit are a major attraction with farmers. It is favoured for meat production because of its body weight.**
- **Kenya White and crosses from them**


Lop eared rabbit buck © Valerie Corr, Naivasha, Kenya


Large Kenya white crossed with Lop - note good size

© Valerie Corr, Naivasha, Kenya


Kenyan x lop © Valerie Corr, Naivasha, Kenya

Breeding

Like goats, rabbits are referred to as 'Bucks' and 'Does' and their young are referred to as 'Kits'. It is important that you plan your breeding, otherwise you could end up with more weanlings than you can cope with. It is very easy to get over crowded very quickly as rabbits are very prolific breeders. It is advisable to keep a breeding sheet on the door of each doe pen. You should record date of birth, date of service, the buck used, number of kits reared, any deaths, as well as dates of deworming (You could include a column for 'comments' on the far right of the sheet - i.e., whether the doe adopted another's young or, indeed, had so many kits that she had to foster some of them).

Example of headings on breeding sheet: It is suggested that these should be posted on the door of every breeding doe, protected by a plastic bag and stapled where the rabbit cannot destroy it. Every breeding doe and buck should have a number, which would be at the top of the sheet.

Buck....	Date of Covering (mating)....	Date of Kindling (giving birth)....	Numbers Born....	Weaning Date	Notes...

If these sheets are kept up to date it is very easy to keep track of your breeding programme and to see which does should be culled at the end of a season.

Rabbits are very adaptable animals and are able to deal with changes in temperature because

they have an inbuilt mechanism for controlling temperature fluctuations. In cold climates the rabbits will curl up to keep warm and, in hot weather, they will stretch out (with the back legs stretched out behind them) so that they can lose as much heat as possible by radiation and convection.
At the same time their ear temperature will increase, it functions, like a car radiator, for cooling the blood. The ideal temperature is from 10°C - 26°C. They are able to survive in temperatures as low as 0°C and as high as 33°C but their efficiency will be compromised at these temperatures. Heat regulation of newborn rabbits is, however, different.They are born blind, naked and helpless; and it is interesting to note that they are born with teeth. To keep warm they huddle together in a nest made by the mother. This will be lined with fur from her chest and, after birth, she will pull out more hair and cover the nest.To limit heat loss the kits huddle together. If the temperature rises, they will move apart. A sudden drop in temperature can disable their temperature control before they can huddle together again, and a kit can die of cold 10 cm away from the group. The breeder must be watchful for such instances.
Rabbits are sensitive to humidity below 55%. They feel comfortable if the humidity level ranges from 60 - 70%. The problem arises during the rainy season when temperatures and humity fluctuate. Air which is too hot and dry is even more dangerous. This is why it is so important to have sufficient ventilation without draughts.

Rabbits are coprophagous animals which means that they form two kinds of faecal pellets. One type is what the farmer will see on the floor of the hutch or below the cage. The other is the one that the rabbit swallows whole directly from the anus. Coprophagy is a peculiar physiological and natural habbit which increases the digestive efficiency as it contains three and half times as much crude protein as the normal pellets which is probably why they instinctively eat these pellets.

Gestation Period: On the average 30 - 32 days and the rabbits born on any day between the 28th and 34th day after mating, usually survive. The duration of gestation is also affected by various factors which include the time of year, the size of the doe and, above all, the size of the

litter.

Pseudo Pregnancy: A doe may exhibit pseudopregnancy (behaves as if pregnant when it is not) but the symptoms do not usually last beyond the 18th day. The best way to confirm pregnancy is to palpate the abdomen gently on the 10th - 14th day.

Mating: When a doe is ready to be mated she may become restless and nervous and may have a red and swollen vulva and will be happy to join the bucks. Rabbits are spontaneous ovulators, so can be put in with the buck and covering will take place within minutes. A receptive doe raises her tail and allows mating. The buck will make a growling noise and fall to one side when mating has taken place. The doe should be removed immediately. If mating has not taken place in 15 minutes the doe should be removed and returned later. If left with the buck they will both become bored and the buck will lose interest.

Caring for the Doe: A pregnant doe deserves special care and management if the farmer is to achieve the best results. Although the general care of the doe is the same as that for the entire flock, it involves a slightly different management strategy. Special care should be taken in respect of: feeding; environment; kindling and housing as well as the diet.

Feeding a Pregnant Doe: Whilst she requires a minimum of 200 - 250 g of concentrated feed, this should not be restricted; rather it should be available all the time.
A balanced nutritive feed should have the following levels of nutrients:

Crude Protein:	**17%**
Crude fat:	**2%**
Crude fibre:	**14 - 17%**
Lysine:	**0.5%**
Vitamins:	**Adequate amounts of A, D, E, K, B complex**

Minerals:	**1.5%**
Total Dietary Needs (wt):	**600 g**

A balanced diet will ensure better fertilization, reduce the risk of embryonic deaths and ensure better foetal growth.

Miracle births
Cases of "miracle births" have been observed. This takes place when a doe produces young when it is absolutely certain that she has not been to the buck. Some does who will not accept the buck may already be pregnant even though they have not been with a buck. It has also been recorded that a doe that is in kit is sometimes able to retain sperm from a different covering, to produce another litter later.

The birth of young rabbits is known as 'kindling'. This usually takes time at night and the doe should not be disturbed by noise or frightened by animals. This can cause her to eat or abandon her litter. After birth, the mother will lick her young and let them suckle. The earlier this happens the better their chance of survival. Most does are good mothers and are very protective and careful of their litter.
Occasionally a doe will eat her young. There are factors that can be attributed to this, such as shortage of water before kindling, or noise and fear. If, however, she repeats this behaviour with subsequent litters she should be culled because this trait can be passed on to future generations.

Fostering: This means taking kits to another doe. This could be an option if a mother dies or abandons her litter or does not allow them to suckle. The other reason is if the litter is bigger than 8 kits, when it is advisable to foster the excess to mothers with less than 8.

Litter size and frequency: Under good management, a doe should produce 4 to 5 litters per year

with 7 to 10 kids per litter. Usually smaller litters thrive better than larger ones, but larger litters can be sustained with improved feeding. It is essential, therefore, to ensure that your does receive adequate concentrate feed, plenty of green fodder, supplements and plenty of clean drinking water. It should be remembered that a doe has 8 teats. If she produces more than 8 kits the smaller kits may not receive sufficient food. It is very easy to put the weaker kits with a doe who has fewer babies of the same age. They are very accepting of 'outsiders'.

With good feeding practices the doe should be ready to breed at 5 months of age. With poor feeding practices this may not happen till 7 to 8 months of age. Some first time mothers will eat their first litter, or abandon them. The dead kits should be removed immediately and disposed of. The doe should be rested for at least a week before being returned to the buck. If a doe has three unsuccessful breedings, she should be culled.

If one month is gestation and one month is for rearing young, the doe could not be taken to the buck more than once in two months. But this way you could have a continuous supply of meat. Depending on how many does you keep, you can work this out:

- **Gestation is one month**
- **One month is with the mother**
- **3 - 4 months to slaughter**
- **At weaning (one month) the kits must be sexed and kept separate as they are able to breed from a very young age. If you allow your rabbits to breed too young the result will be small and weak off-spring. They could even be born with birth defects and a young mother may not be able to look after her off spring properly, or she may even eat them all at birth or she herself my die.**

Age of breeding: Do not serve young does before 5 months. You may choose to wait until 8 months if you feel that the doe is not mature or big enough . Mature does can be served one

week after they wean.

Production Period: Does and bucks should be kept for 4-5 years after which time their production should be assessed. If the doe is still producing decent sized litters with healthy kits, it is possible to keep her for a further year. The same applies to the buck. It has been noted that older bucks may start to produce small or weak kits, in which case they should be culled.

Care of the young

A couple of days before giving birth the doe will start collecting hay in her mouth to make a nest. She will then pull hair from her chest and under her neck to line the nest. She will pull out more hair after the birth and cover the babies. This is the time that the young have to be watched carefully:

- **Kits are born blind and naked. The first 35 days of their life are crucial. They are usually confined to the nest for at least two weeks, sometimes longer. They should not be separated from their mother before 4 weeks of age. If they are weaned early they may die of separation shock.**
- **For the first 20 days the only food for the kits is their mother's milk. The mother feeds her young only once in 24 hours and only for 3 - 5 minutes. The doe must, therefore, have access to plenty of good food and water to ensure that she has enough milk for the litter.**
- **It is essential that the kits are not allowed to get cold, especially in the first few days after birth. The nest needs to be checked to ensure that the babies are not carried out of the nest by the mother after feeding (check early mornings as feeding normally takes place during the night). It is quite safe to handle the young and return them to the nest.**
- **If they are found outside the nest and cold, (the kits will feel cold and the skin will be wrinkled and 'sticky' to the touch) it is essential to warm them up quickly or they will die.**
- **Once they are warm (the kits will become a healthy pink colour, warm to the touch) they can**

be returned to the nest. Warming them can be done by wrapping them lightly in a cloth and putting this on top of a hot water bottle in a box. Make sure that the kits are protected from the plastic cover. They should be turned a couple of times to make sure that they are properly warm.

- **They will start to squeak and wriggle once they are warm enough. Remember that every dead kit is income lost.**
- **The kits will start coming out of the nest after 15 - 16 days and will start trying to chew green matter and concentrate whilst still suckling. They will gradually eat more solid food and suckle less.**
- **At one month the kits should be weaned and the males separated from the females. Determining the sex of the kits is not easy, but practice makes a master: Lay the baby on its back in your hand and gently blow on the hair around the genital area and, with 2 fingers, gently separate the genitalia towards the tail. The males will show a small upwards protrusion while the females will show a small opening. This is easier done by two people. One holding the baby and one doing the sexing. Kits generally lie very still when laid on their backs. It is essential that they are treated gently to avoid injury.**
- **The males and females should be separated at this stage as they can start breeding at a very youngage.**
- **They should then be put in separate weaning houses. A double pen of 90 x 180 cm can comfortably house 6 young rabbit growers. Remember there are now more rabbits in each cage, so they must be fed more food accordingly and given more water if they are to grow well.**
- **At weaning it is advisable to routinely treat the weaners with coccidiostat (the same one used for chicken). 1 ml dawa/litre of water for 3 days will protect them from diarrhoea and stress after weaning.**
- **It is also advisable to deworm them a week later with 1/4 ml of Albendazole administered by mouth with a small syringe (without needle) is enough for each one month old rabbit. Be careful, not to put the syringe too far into the mouth or you may damage the throat. Death will almost certainly be the result of rough handling.**

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Management: Handling, Slaughter

Handling

There are many ways of handling rabbits but they always should be handled gently but firmly. If the rabbit feels insecure or afraid it will damage itself and, in all probablility, the handler.

NEVER lift a rabbit by the ears. The most common and safest method is to grasp the ears close to the head with one hand, while the other hand takes the full weight of the rabbit. The hand holding the ears restrains the rabbit and prevents it from struggling, without damaging the joints where the ears meet the head.

When handling kits, they should be picked up by placing the whole hand, gently, over the kit and curling the fingers around it. Care should be taken not to squeeze the kit as they are very fragile and it is very easy to damage them.

When handling rabbits, of any size, for whatever reason, the easiest and safest way is to wrap the rabbit in a cloth and pick it up. The cloth or sack will give the rabbit a sense of security and it won't struggle.

Viciousness in rabbits

It occasionally happens that a rabbit becomes vicious and attacks those who attempt to handle it. A doe may become very aggressive when she has young - this is a natural instinct and should be respected. Bucks can also become aggressive for no obvious reason. However, aggression is nearly always as a result of bad handling or teasing. It can also be the result of

lack of water - so make sure that water is always available.

There are instances where a rabbit may become aggressive for none of the above reasons. If this behaviour becomes habitual, culling should be considered. A rabbit has the ability to open its mouth very wide, their teeth are very sharp and their bites are deep and painful.

Slaughter

It is important that the rabbit is killed very quickly. The quickest and kindest way to do this is:

- **Hold the rabbit in your left hand by its back legs. With your right hand hold the rabbit's head between your index and middle fingers, under the chin and against the base of the skull. Lift your right hand to shoulder height, stretching the rabbit, and pull the head quickly and sharply. If you try to do this any other way it will not work.**
- **The rabbit should then be hung by one back leg. The head is removed. The feet are clipped off. A small slit should be made on the inside of the back leg that is not attached to the slaughter post. The skin is peeled off this leg. The skin is then gently loosened round the body and front legs. You will then be able to take the skin off the remaining back leg, and by pulling down, so that the skin is now inside out, you will be able to peel the skin off like a sock. The rabbit is then gutted and entrails removed.**

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Housing

The rabbit unit should be located in a peaceful environment, away from the noise and bustle of human and animal noise. The unit must fulfil the following function:
a) protection from extreme influences of weather and noise, which could interfere with the

performance of the rabbits

b) protection from predators including snakes, insects and rats. While planning a unit, the following should be taken into consideration:

Unfinished rabbit units

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- **The exterior should provide protection against heat but at the same time it should be properly ventilated**
- **Avoid draughts**
- **There should be separate units for the does and bucks. Breeding stock should be kept in one unit and the 'meat' unit should be separate.**
- **Three or 4 does to one buck would be more than sufficient to keep a household supplied with meat all year round. You would therefore need:**
- **A pen for the buck**
- **A pen for each doe**
- **At least 2 weaning pens - one for females and one for males**

To grow healthy, rabbits must be fed properly and kept clean. It is best to house them off the ground as follows:

- **The house should be 90 cm off the ground, should be 90 cm high and 90 cm wide. As roofing sheets come in 2.5 metre lengths it makes sense to build blocks of houses 1.8 m wide so one roofing sheet can be used to cover 2 houses.**
- **The floors should consist of chicken wire (with the smallest size holes) so that droppings and urine fall through to the ground. This can then be swept up daily and used to mix with compost.**
- **The house should have a layer of hay/dried grass or straw as bedding. This is a very important part of the rabbit's diet. They will eat a lot of this bedding during the night.**

Rabbits housing

© S. Fontana, BioVision

Rabbit house floor consisting of chicken wire

© S. Fontana, BioVision

Rabbit on hay on wire

© S. Fontana, BioVision

- **Rabbits do not tolerate windy conditions, so houses should be placed in sheltered areas and windbreaks provided where appropriate.**
- **Rabbit houses should be cleaned every day. Wet bedding should be removed and replaced with dry material. If rabbits are left with soiled bedding, it will encourage flies and diseases to multiply.**

- **Dirty or wet houses will result in a very strong 'rabbit' odour which will taint the meat. A soiled pen is stressful for the rabbit and it will also mean that the pelts become soiled and 'felted' which makes them unusable.**
- **Mud hutches and thatched houses can also be constructed but they should be off the ground and kept clean as described above. Dirty rabbits are unhealthy rabbits.**
- **NEVER be tempted to try and save space by constructing houses in 'tiers' (one on top of another). This will lead to all kinds of problems as the lower houses will become fouled by the droppings and urine from the upper level.**
- **Lighting: Exposure to light plays an important role in reproductive efficiency. Bucks exposed to light for 8/24 hours are, generally, more sexually active. It also improves the productivity of the doe. It is possible to make up this light requirement using artificial light, but this is an expensive way of solving the problem.**

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Feeding

Food is the life blood of any living being. If rabbits are not fed well they cannot give the best returns. Proper feed management is the most important aspect of rabbit keeping.
There is a saying : "*no rabbit so good that poor nutrition will not ruin it, nor any so bad that bad feeding will not improve it*". The importance of correct feeding management becomes evident when we realise that the builk of expenditure incurred in breeding, producing and keeping rabbits is on concentrated feeds.

Interestingly, when available, rabbits prefer green fodder which is low in crude protein and is easily digestible. If they are forced to eat less preferred plant parts the feed intake may decrease drastically. The large capacity of the rabbits digestive organs enables it to compensate for seasonally lower concentrates in feed during cold periods and, during the warmer weather by a correspondingly higher intake. It is for this reason, accompanied by

corpophagy, that the chances of survival during feed and water deficiencies are improved.

Rabbits can survive on a wide range of food, thus enabling the keeper to adopt a feeding programme to suit the prevailing circumstances. There are different types of foodstuffs that are used as rabbit feed but the most convenient, and useful, is the pelleted feed which is more balanced and which will cut down on wastage. However, pelleted feeds are not always readily available and are, generally, more expensive. Feeds can be grouped as:
a) roughages, including hay, green leaves and weeds
b) succulent foodstuffs, including green grass, carrots and other green food
c) concentrates, including all cereals
d) compounded feeds such as complete pelleted feed

The primary constituents of all feeds include water, carbohydrates, proteins, fats, minerals and vitamins. As a precaution, if wild herbs are to be offered, a knowledge of poisonous plants is necessary.

Rabbits require different quantities of food at different stages of growth. The average intake of an animal ranges from 120g to 150g per day. A lactating doe will need 350g - 380g per day. The concentrate feed should be supplemented with green food or hay. The roughage is best fed in the evening as rabbits are much more active at night.
Roughages and greens should be available all the time. Rabbits eat most vegetable matter such as potato and carrot peelings, vegetable scraps etc. They thrive on weeds (especially chick weed, amaranth and thistles).
Other examples of good rabbit feed include lucerne, chopped napier grass, sweet potato vines and fresh green grass if it is available.
After the rains there is usually an abundance of wild herbs and weeds that rabbits will enjoy but ensure at all times that your rabbits have a varied diet of roughage and greens.

Concentrates (rabbit pellets or rabbit mash) should be fed twice a day as follows:

- **0 - 16th week after weaning give 65 - 100 g/day**
- **Pregnant does give 225 g/day/doe**
- **Active Buck give 90 - 100 g/day**

It is recommended that a square piece of plastic or sacking is placed under the feed bowl to catch and reuse spilled feed. The most food and water efficient food bowls are made of clay with an inward lip. These are too heavy for the rabbits to turn over and the lip prevents spillage. The water bowls should be scrubbed at least once a week to prevent algi growing. This will foul the water.

NOTE: Do not feed rabbits with tomato or Irish potato tops or mint as they are poisonous.

Economic feeding of rabbits

The feed conversion ratio of rabbit is considered to be half as efficient as that of cattle, due to the rapid rate of passage of food. More so because microbial digestion of fibre takes place in the hindgut rather than in the rumen. The digestive tract of a rabbit is known to be adapted to fibrous feed, but the hindgut is selectively able to excrete large fibre particles in faeces, and retain the smaller particles.
A balanced diet made up of high quality feed ingredients, and hay, is recommended for use in large scale units. Mash feeding alone might lead to a low conversion ratio resulting in higher feed intake accruing less return.

Most rabbit farmers in East Africa are dependent on commercially made complete rations. Efforts should be made to supplement this with green roughage, depending on availability. This will go a long way to keeping the cost of feeding down, as this is a major expenditure for the small farmer and should be kept at the barest minimum without compromising the requirements

and welfare of the rabbits.

Water

Rabbits need plenty of fresh water. It is wrong to assume that rabbits obtain sufficient water from their green food. Rabbits consume a surprising amount of water and it is important that this is readily available. Place a small water bowl with a solid base to avoid being overturned in each cage, and fill the bowl with water twice a day. Alternatively, use drip feed water system. This is more expensive, but the rabbits learn very quickly how to use it.

Minerals

Minerals are essential for proper growth and should include calcium, phosphorus and sodium chloride. On average the diet should include 0.5% - 0.7% phosphorus and 0.7% - 1.0% calcium. Lactating does require a slightly higher amount of phosphorus or calcium. It is a good idea to put minerals in the feed (for instance Coopers Macklic powder).

Vitamins

Vitamins are an integral part of the feed. These are abundant in roughages. Concentrate feeds also contain vitamins.

Hay

This is an integral part of the diet and is essential for the digestive system and the well being of the rabbit. A good farmer will notice that the rabbit eats much of its bedding during the night and will replace it the following day when the pens are cleaned.

Feeding Time

Rabbits are very 'time conscious'! They expect food at the appointed time and you may find them waiting by their doors at that time. A haphazard feeding schedule will cause distress to their digestive system. It is best to feed them twice a day: morning and evening.

Cleanliness and Hygiene

Feed, bedding and water should all be fresh. If concentrates are fed they should be stored in weather/vermin proof containers (drums with lids and old deep freezes make excellent feed stores). Keeping the feeders and water bowls clean can yield dividends to a farmer. Failure to maintain hygienic conditions will result in frequent disease outbreaks.
Tip: A spray bottle of 50/50 white vinegar and water makes a gentle disinfectant for wiping off surfaces and reducing odour.

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Common Rabbits Diseases

Good health in the rabbitry comes from keeping the environment clean, dry and well-ventilated and avoiding overcrowding.

The problem of disease is two fold in domestic rabbits. The first and most important part is prevention, the second concerns elimination and treatment of disease when it occurs. A healthy rabbit should recover rapidly from minor ailments and the keeper must direct every effort to assist the recovery and also to enable the rabbit to resist disease. Hygiene and sanitation play a big part in good management.

- **Quarantine new rabbits**
- **Rabbits should be allowed direct access to sunlight as it also acts as a germicide besides having a beneficial effect**
- **Destroy the affected rabbits in any outbreak. These complications can only be overcome by the keeper's vigilance.**
- **Prevention of disease is not a subject to which one should turn only when disease appears, that is usually too late. It must form part of the rabbit keepers day to day management.**

Some diseases spread so quickly that action must be taken immediately. Complete isolation of sick rabbits is essential. Early treatment is the only effective method of dealing with disease. A decision has to be made as to whether the rabbit can be saved and, if it can, is it financially viable to do so. If the rabbit is to be destroyed, it should be done humanely, away from the rabbit unit, and the carcass should be incinerated without cutting it up as this could spread bacterial infections through the unit.
A farmer may well be able to diagnose the problem, but it is advisable to seek veterinary advice in the event of a disease outbreak. Prevention and treatment of common disease, along with hygienic measures are necessary to avoid outbreaks. One can often draw conclusions from the symptoms with regard to the location and type of disease, along with the chances of recovery.

Early recognition of disease is most important as there is more chance of recovery if the treatment is started early. It is quite useless to commence treatment when the disease has progressed to the stage that the rabbit is obviously dying. A watchful rabbit keeper will be quick to notice any change in appearance of any of his stock.

- **A fall in weight is one of the first signs that all is not well. The reason for slow weight gain, loss of weight or lack of appetite should be sought.**
- **A good keeper will notice any change in the faeces.**

- **The coat is a good indication of a healthy rabbit. A dry, dull, harsh or patchy coat indicates something is wrong. A sleek, glossy coat indicates good health.**
- **A healthy rabbit is alert. Any sudden noise or movement will awaken its immediate interest. The rabbit's movements should be free and easy and it should not sit huddled in a corner.**
- **It's breathing should be even. The respiration rate of an adult rabbit is 30 - 50 breaths per minute. Shallow (rapid) breathing is an indication that something is wrong.**
- **The eyes should be bright with no discharge from them or from the nostrils, mouth, vent, anus or teats.**
- **The rabbit should not feel 'bony' and the muscles along either side of the spine should be firm and full, with no swellings, which are indicative of cysts or abscesses.**
- **A healthy rabbit is full of vitality and the farmer should aim to keep his rabbits like this.**

Causes of diseases

Diseases may be caused by:

- **Bacteria: Diseases of the rabbit caused by this group though relatively rare, include pasteurellosis in various forms and tuberculosis.**
- **Viruses: Few diseases are caused by these organisms, the most common being myxomatosis which is not seen in East Africa**
- **Animal parasites: Includes single celled animals or protozoa which produce coccidiosis, flukes, flatworms and roundworms. In this group are also fleas, lice, ticks and mites which can produce disease such as ear canker or, alternatively, can carry disease.**
- **Nutritional deficiencies: A shortage of vitamins, minerals and other essential items of food which give rise to ailments such as rickets, reproductive failures and other problems.**

The spread of diseases

Diseases can be spread by physical contact, confinement of healthy animals with diseased stock, contamination of food and through the air.
Many potentially harmful organisms are present in the animal's body in such small numbers that symptoms of disease do not manifest themselves, provided the animal remains in good health. The disease will only appear if the rabbit is subjected to challenges such as bad feeding, cold or any other stress factor.

Common Rabbits Diseases

Some of the commonly occurring diseases in rabbit units are:

Coccidiosis

This is probably the most common disease in rabbit units. Once a farm is infected with coccidiosis, it is very difficult to eliminate it completely or permanently. It is difficult to cure hepatic coccidiosis.

Symptoms:

- **Anorexia (not eating)**
- **Pendulus and distended abdomen followed by progressive weakness, diarrhoea, constipation and jaundice**

Prevention:

- **It is best prevented in well constructed rabbit units, where the rabbits are not living in cramped, crowded or dirty conditions.**
- **Cages should be disinfected at regular intervals and cleaned daily. Nest boxes should be disinfected between kindlings.**
- **Water bowls and feeders must be cleaned and disinfected regularly.**

Treatment:

All the drugs used are prophylactic (preventing infection) and should be given when there is risk

of disease. There are many coccidiosis preventative drugs on the market in East Africa, most of them for poultry, but these are suitable and effective in rabbits.

Pasteurellosis (snuffles)

The bacterium *Pasteurella multocida* causes a variety of diseases in rabbits. These include: snuffles, pneumonia, otitis media, conjunctivitis and abcesses. Snuffles is not a fatal disease but the animal can develop pneumonia, pleurisy or acute pasteurellosis as secondary infections. The disease may migrate from the nasal cavity through eustachian tube to the middle ear, causing inflammation and may lead to torticolis, uncoordinated gait, inability to take food and water and loss of weight. This particular disease does not respond to treatment.

Symptoms:

- **In snuffles, the main symptom is a thick sticky, white discharge from the nose which the animal wipes away with its fore legs.**
- **There is also constant sneezing, which will encourage the spread of the disease.**

Prevention:

- **Avoid cold draughts in the house.**
- **Construct rabbit hutch according to the recommendations.**

Treatment: Snuffles and pneumonia can effectively be treated by a combination of penicillin and streptomycin administered intramuscularly by injection.

Pneumonia

It is caused by poor housing, overcrowding and poor ventilation especially in cold areas. Ensure that there is sufficient bedding to prevent draughts coming through the floor, and that the rabbits are not subjected to cold winds, especially at night. It is advisable to have the ends of the units protected with plastic or heavy duty shade netting. It is also advisable to have roll

down 'curtains' over the front of the unit, made of plastic or shade netting, that are let down at night to keep the whole unit warm.

Conjunctivitis

***P.multocida* goes from the nasal cavity to the eye through tear duct and causes reddening of the conjunctiva and a discharge from the eyes.**

Treatment:

- **It can be treated with antibitotic ophthalmic ointments and drops.**

Abcess

Subcutaneous and visceral abscesses are quite common in rabbits. Subcutaneous multiple abscesses may be found on the face, body and lower jaw containing thick cheesy pus. Visceral abscesses however, may be found on the liver, heart and lungs. They may cause sudden death

Prevention/ Treatment:

- **Drain the abscess of all pus.**
- **Irrigate with a solution of hydrogen peroxide and water, flush again with saline and then irrigate with iodine. If the abscess has been drained completely, one treatment may be sufficient. The hole will close spontaneously.**

Sore hock

Ulcerated sores will develop on the back leg joint (the hock).

Prevention/ Treatment:

- **Keep the cages clean. Dirty wet cages are the source of the infection.**
- **Open the ulcerated sores and clean thoroughly.**
- **Apply antiseptic dressing.**
- **Failure to treat will certainly be fatal.**

Heat prostration

If the temperature soars beyond 35 degrees centigrade, the rabbits will become restless. They will start panting and blood will ooze from the nostrils followed by death.
Prevention: The only way to prevent this is to transfer the animals to a cooler situation.

Hind quarter paralysis

Sudden disturbance, fear or excitement may leave rabbits paralysed. They become helpless creatures and their activity is restrained. There is no cure for this deadly disease. The breeder should avoid strangers entering the unit for curiosity and fun.

Hairball occlusion

Sometimes fur and wool are accumulated in the stomach, blocking normal passage of food. This may be cured with mineral oil or surgery.

Incurable diseases

The following diseases are incurable and culling is the only way out:

- **Infections arthritis (thickening of the knee, hip, shoulder)**

- **Kidney fibrosis**
- **Leucosis (enlargement of liver, spleen, lumph nodes, whitish tumour foci in liver)**
- **Uterus carcinoma (tumour in uterus and lungs)**
- **Rabbit pox**
- **Paralytic tremor**
- **Epilepsy**
- **Encephalitis**
- **Spinal column injuries**
- **Syringomyelia**

Parasites

Ecto-parasites

These include ear mange or canker, skin mange, mites, fleas, ticks etc.

Ear Canker and Mange

- **Ear Canker and Mange are caused by two types of mites - *Posroptes communis* var. *cuniculi* and *Chorioptes cuniculi*. The mites attack the inside of the ear and cause inflammation and severe irritation. The animal will be restless and will shake its head from side to side. It is possible that the ears will become damaged from banging against the side of the pen. This can lead to 'cauliflower' ear which look like bubbles under the skin on the inside of the ear. At the onset the ear will feel hot and will be painful to touch. With time, the blisters (which can be quite big)**

Example of ear canker
© Valerie Corr, Naivasha, Kenya

will become very hard.

Treatment/Prevention:

- **It is essential that the mites are dealt with as mites travel from one animal to another.**
- **Ears of the entire unit should be checked at regular intervals.**
- **Remove the crusts, scales with the help of cotton wool and then apply ear canker preparation (readily available in veterinary outlets). Alternatively, use ear drops.**
- **Until the mites are dealt with, the rabbit will continue to shake its head. You can easily test for them by gently inserting a cotton bud into the ear and wiping it round. If there are mites they will be stuck to the cotton bud with a brown substance. The mites look like tiny fleas. They cause a lot of distress to the rabbit and will spread if left unchecked.**
- **Alternatively, dust the rabbits with recommended chemicals or try diatomite powder if available. If you keep your houses clean and dry, the risk of infestation by the above is minimalised**

- **Body or Skin Mange**

This is not quite as common. It is caused by one of two species of mites: *Sarcoptes cuniculi* and *Notoedres cuniculi*. The mites burrow into the skin causing intensive irritation. Scratching will cause open sores. If the disease is not treated the animal is sure to die within a few weeks.

Prevention/Treatment:

- **Keep the environment clean. Dirty units will harbour and encourage the spread. Hygiene cannot be emphasised enough.**

Endo-parasites

These include Tapeworms,roundworms, etc.

Prevention:

- **Deworm rabbits regularly with recommended drugs which are readily available in EA. It is adviseable to do this every three months. This is a good time to check the teeth. Sometimes rabbit develop crooked front teeth. This greatly inhibits their eating. The crooked teeth should be clipped with nail clippers. Be careful not to cause injury to the jaw. The best clippers are those used by vets to clip dogs nails.**
- **It is also a good time to check the claws, which tend to grow very long and sharp because the rabbit is on wire. These should also be clipped if they are too long.**

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Products

Rabbit meat is becoming more popular in some of the more upmarket restaurants, especially where they are catering to European (French, German, Italian and Belgium) markets. However, it is still a relatively new market.

Meat

Rabbit meat makes an excellent roast meat (nyama choma) if cooked quickly. It is a tender meat and cooks very quickly. If the meat is being sold into butcheries or restaurants, it should be well presented and it is essential the carcases have been cleaned properly. This can be done in three ways:

1. Lie the rabbit on its side. Push the back legs into the empty cavity and under the breast bone. Fold the front legs down, and pack into plastic bags.

2. Lie the rabbit on its chest with its front legs together in front of it and the back legs folded underneath (as if it is crouching), and pack into plastic bags.

3. Debone the flesh and cut into neat pieces or mince. This is a fiddly job and mincing rabbit meat can be difficult as it is soft and tends to block the mincer.

Hides

These are more often referred to as pelts. Most tanneries in Kenya will not accept rabbit pelts for tanning as they are considered too delicate. They are probably one of the most difficult skins to tan, but are much sought after. Pelts for tanning should be left inside out, no more than 4 together, packed into strong plastic bags. The air should be squeezed out of the bag and it should be securely tied. The bags can then be frozen for delivery to the tannery.

- **The heads, spleens, kidneys and heart make excellent dog food. The liver is a delicious delicacy and highly nutritious**
- **NEVER feed rabbit bones to dogs. They are very brittle and will splinter, either becoming stuck in the throat or piercing the intestines. The bones do, however, make very good stock for soup. Make sure the bones are then disposed of safely.**

Manure/Compost

Rabbit manure is one of the most valuable manures of all livestock. Sweep all the droppings and soiled bedding into a pit or a neat, square heap every day. If possible sprinkle with water or, better still, with effective microorganisms (EM1). After two weeks turn it over and keep moist until you have a lovely dark compost. If you keep other livestock (cattle, sheep, goats, donkeys and chickens) their droppings can be added to this compost for an even better end product. This would give you an endless supply of good compost for your shamba or, alternatively, a by

product that you can sell.

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Information Source Links

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more Images

Beekeeping

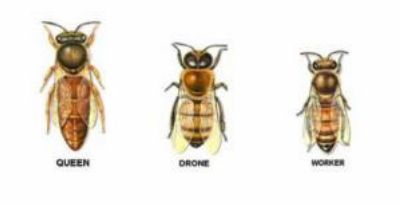
Introduction

Predators and pests and their control

Introduction

Beekeeping in Africa has been practised from time immemorial. The traditional beekeepers use simple hives often made from hollowed logs. The empty hives are placed high up on trees, become occupied by passing swarms and in due course are harvested by the beekeepers. This method of honey harvesting may destroy the colony and and result in a poor yield of low quality hive products. However hives have improved with time which allows harvesting without destroying the bees.

The bee colony



Honeybee castes (different kinds of bees) in a colony.

There are 3 different kinds of bees in every colony: a queen, drones (male bees) and workers.

Products

Illustration

Queen

Queen. The queen has a long and slender abdomen, with wings covering about ¼ of the entire abdomen and 2 large ovaries and the spermatheca (sac-like structure for sperm storage) housed in the abdomen.
Her function is to

- **Mate**
- **Lay eggs for the rest of her life, in peak times up to 2000 per day. This is more than the weight of the queen. The larvae hatching from these eggs develop into workers, queens or drones depending on specific conditions.**
- **To produce chemical substances called pheromones that keep the colony cohesive.**

Average life spans of queens ranges from 1-4 years serving as an egg laying machine capable of laying 2000 eggs a day during peak colony growth seasons.

Drone

Drones. Drones are the male honeybees and develop from unfertilised eggs. They are larger than workers with large eyes which cover practically the whole head and have a blunt abdomen covered with a tuft of small hairs. Drones fly with a loud buzzing sound and this coupled with their large size makes them very scary, however, they lack the sting. They do not collect pollen or nectar, and are unable to produce wax. Drones lack work related structures and their sole function is to fertilize the queens. During the dearth period when resources are scarce, drones are chased from the hive and usually die off as they can not fend for themselves. Drones also die minutes after mating the queen as they loose "vital parts" of the abdomen in the process.

Worker

Workers. Workers are the smallest in size and majority in the colony and develop from fertilized eggs. Here, the feeding of the larvae with royal jelly, a glandular secretion of the workers, is the decisive factor. Fertilised larvae up to three days old can be changed to queens by feeding royal jelly to them. Otherwise a worker bee will result. Workers can not mate or store semen. However in abnormal colony conditions they can lay unfertilized eggs which develop into drones (male bees). Laying workers is a sign that a colony has become queenless for a long period of time.

The worker bees make up about 95% of the colony and they do almost all the work: Older workers bring in nectar, pollen, water, and propolis (bee glue) back to the hive. Their hind legs are specially equipped for this task with the so called pollen baskets. Lastly the oldest bees guard the hive entrance. Their sting is a powerful weapon. If used against a human the bee usually looses the sting and dies. This will not happen if another bee is stung.

Younger bees tend to perform duties inside the hive. Very important is the feeding and cleaning of the queen. Other duties are: cleaning the hive, building wax combs, feeding the young and or controlling the temperature of the brood area. For this duty workers eat honey to produce heat in cold weather. Bringing water inside the hive and fanning with their wings will keep the hive cool in hot weather.

A honey bee nest consists of a series of parallel beeswax combs. Each comb consists of hexagonal cells, which function as containers for honey, pollen or developing bee larvae (brood). If enough nectar is available young worker bees will produce the needed wax with 8 glands situated on the abdomen (belly). The combs are evenly spaced and are attached to the ceiling and the walls of the nest. The space between the faces of the combs is known as 'bee space'. In natural nests it is usually 6-8 mm. This is critical and gives the bees enough space to walk and work on the surfaces of the combs. The bee space, the dimensions of the individual cells as well as the size of the nest vary with the race and species of the honey bee. The bee

space is a crucial factor in the use of bee equipment and honey bees cannot be managed efficiently using equipment of inappropriate size.

Bees need a supply of food and water to live, and during dry periods the beekeeper may have to supplement these natural resources. As a general rule, attempts to begin beekeeping should start with the area's existing bees, techniques and equipment, which will all have been adapted for the local circumstances.

Importance

Bee farming has many benefits. It has the following advantages over other farm enterprises.

- **Requires little land**
- **Cost is low compared to other farm enterprises**
- **Does not interfere with other agricultural enterprises in terms of resources**
- **Labour required is low**
- **Many products can be manufactured for supplementary income**
- **Encourages environmental conservation.**
- **Bees are essential pollinators of plants thus playing a big role in bio-diversity and improvement of crop yields**
- **Most hive products have a therapeutic value**

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African Bees: Honey Bees and Stingless Bees

Honey Bees in Kenya

There are many different species of bees in the world most of them solitary (living alone). A few species of bees are kept for pollination and honey production. In Kenya the most important

species is called the honeybee or *Apis mellifera*. This is the species of bee that is familiar to everyone. It is this species of bee that this book is about. Within this species there are a number of races of bees in Kenya which have their own particular characteristics. We have *Apis mellifera scutellata, Apis mellifera monticola, Apis mellifera yeminitica (nubica)* and *Apis mellifera littorea*.

1. *Apis mellifera yemenitica* (formally *A. m. nubica*)
This is the smallest race in Africa. It has the most slender abdomen and the largest yellow abdominal colour band of all African races. It commonly withstands and survives drought conditions by frequent migration. It is mostly found in the northern parts of Kenya.

2. *Apis mellifera scutellata*
Bees from the savannahs of central and equatorial East Africa. This is the species that was introduced to South America and became infamously known as the "killer bee". This is a small bee with a short tongue which is highly aggressive and swarms frequently and is able to nest in a broad range of sites from cavities to open places. It is found in plains and their high reproductive rate is attributed to massive flowering, which occurs in the plains just after the rains.

3. *Apis mellifera littorea*
This bee inhabits the low lands of the Kenya Coast. It does not migrate as much as scutellata. It has a tendency to rear brood throughout the year due to availability of forage along the coast.

4. *Apis mellifers monticola*
This bee is called the mountain bee and is found at high altitudes in Tanzania and Kenya - 1,500 - 3,100 meters. The bee inhabits places where the sun is frequently obscured by clouds and mist and ground frosts can occur at night. It is the largest bee in Africa. It has a tendency to reduce brood rearing at the first sign of forage decline and may not migrate. It is less productive and less vicious. It is found in Meru and Mt. Elgon. (Source National Beekeeping

Station, Nairobi).

2. Honeybees from other countries in Africa

Apis mellifera intermissa

This is a North African race of honeybee found north of the Sahara from Libya to Morocco. The bee is reputedly very aggressive and swarms frequently. During droughts over 80% of colonies may die but owing to intensive swarming colony numbers increase when conditions improve.

Apis mellifera lamarckii

Egyptian bees found in North East Africa primarily in Egypt and the Sudan along the Nile Valley. Like intermissa they rear numerous queens with one colony recorded as rearing 368 queen cells and producing one small swarm with 30 queens!

Apis mellifera adansonii

These bees are found in West Africa and are yellow in colour. They appear to be very similar to scutellata in many of their behaviours.

Apis mellifera capensis

These bees are found in South Africa and are unique among Apis mellifera in that they have a common occurance of female-producing laying workers.

Some of these races are highly aggressive if the nest is disturbed, but stay calm if there is no brood or stored honey to protect. The African bees are also more likely to abscond (abandon) their hives on slight disturbances, and in some areas the colonies migrate seasonally.

3. Stingless Honeybees

There are also species of stingless bees in Kenya. These bees also produce honey which is prized as a medicine. Stingless bees can be kept in small hives but are not kept commercially in Kenya at the moment. However there has been renewed interest in these bees recently with the discovery of new species in Kakamega by a scientist working for the National Museums of Kenya.

Note: This article on African races of bees and their behaviour will be developed over time to include more detailed information on specific African bee races. An understanding of the type of bees we have in Africa and their behaviour is fundamental to good beekeeping.

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Bee Hives

A hive is the box or some other container where bees live. In Kenya there are three types of hives:

- **Traditional Hives**
- **Kenya Top Bar Hives (KTBH)**
- **Frame hives**

Traditional Hives (Log Hives)

Log hives and other traditional hives contribute to about 80% of Kenya's honey production.

They are estimated to number almost 1.5 million countrywide, and provide a livelihood to many especially in arid and semi-arid lands. Log hives are cheap but difficult to harvest.
Traditional hives are largely considered as no more than man-made cavities in which bees live. They come in all forms as hollowed-out logs, discarded metal cans or drums, clay pots, wooden boxes, baskets of straw, bamboo and many others. Honeybees attach combs directly on the upper surfaces of the hive and usually to the sides.

Log hive from Tana River, Kenya

Advantages
- Materials for construction are readily available and are cheap in most cases free
- Beeswax and propolis production is relatively high
- Traditional hives and methods of working with them are established

Disadvantages
- It is impossible to remove or replace combs. This makes examination and harvesting difficult.
- Swarming is often common due to limited space.
- Brood is often lost during harvesting.
- Honey production is limited.
- Honey quality is usually low (mixed with pollen, brood and ashes).
- Many adult bees are usually killed during harvesting.
- There is usually a lot of colony disturbance during harvesting which in most cases causes absconding.

Kenya Top Bar Hives (KTBH)

Usually the bees attach their combs to the bars but not to the side of the hive, since the walls are slanted at an angle of at least 14°. This allows lifting out of the combs for examination. The bees attach their combs to the bars which can be lifted out of the hive for examination.

In Kenya, the Kenya Top Bar hive was designed and adopted in 1971. Other hives, such the modified African Long Hive and the Langstroth Hive, have since been introduced. However, the Kenya Top Bar Hive remains the most dominant and most widely used due to its simplicity, affordable price and advantages.

Kenya top bar hive
© P. Luethi, Biovision

Advantages

- Only one critical dimension in construction i.e the top bars. Other measurements are not too critical, thus hives can be made with simple tools from relatively cheap local materials, including concrete.

- Every comb is accessible without removing the others. This causes less disturbance to the colony and greatly reduces the number of bees flying around when the hive is open.

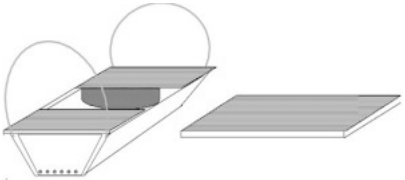
- The brood can be inspected easily, which gives the beekeeper real control over the management of the hive.

- The beekeeper can judge the exact time when combs are ready for honey harvesting without disturbing the brood.

- The honey is of higher quality as the combs can be selected to be free of pollen and brood.

- The top-bar hive makes it possible to gather good quality beeswax for which there is always a ready market.

- The better management techniques promoted by these hives help preserve and increase the bee population and leads to increased pollination and production of honey and wax.



Major disadvantage
- Combs are cut during harvesting, and bees have to make new combs after each harvest

Kenya Top Bar Hive (KTBH) with suspension wires

© Apiconsult

The Kenya top bar hive

The Kenya Top Bar Hive (KTBH) was developed in Kenya and is now used around the world.

© Thomas Carroll, Kenya (2006)

Working with bees in a KTBH

Notice one comb per top bar, which allows modern bee management by the ability to move combs without breaking them.

Frame Hives (FH): Example, Langstroth Hives

This hive is named after its inventor L.L. Langstroth. The hive consists of precision-made rectangular boxes which fit one on top of the other. It has at least two boxes (supers) with the lower chamber called the brood chamber.
Between the brood chamber and the super sometimes a queen excluder is placed. It limits egg laying activity of the queen to the brood chamber only. The wooden frames are "wired" and complemented with a sheet of wax foundation. Each box contains a set of framed combs.
During harvesting the frames are removed and put into a extracting machine, which removes the honey leaving the combs intact. The combs are then returned into the hive for reuse by the bees.
Besides the Langstroth hives there exists other standard hives, the Dadant being another well known type.

The race of the kept bees, financial means as well as available woodworking equipment are more important then the dimension of the hive box. However, bee space is critical. Bees require this space between the sides of each frame and the walls of the hive. The bees space for most African *Apis mellifera* is 6 mm (¼inch). Without attention to the proper bee space, beekeeping will be difficult, because the bees will be building burr combs.

Langstroth hives

© P. Luethi, Biovision

Advantages

- The wax comb is fixed within a frame facilitating and maximizing harvesting and the added strength means less chance of damage to combs during removal from the hive and extraction.of honey. - The frame/comb strength allows the hive to be transported even on rough roads, and so the beekeepers can cash in on the pollination market or move bees to another area when forage is short. - The whole honey supers can be harvested without disturbance of the brood box below. - Standardization of parts makes for much easier large-scale and commercial operation. - Honey can be extracted by means of a centrifugal extractor and empty combs returned to the hive where they will be reused and refilled. This maximizes the honey harvest.

Disadvantages

- There are few local craftsmen who have the skill, equipment and precision to consistently make parts that fit exactly and are compatible with each other time after time.

- The need to keep a supply of spare frames and supers for use at appropriate times is an expensive investment.

- In order to capitalise on the frames, a centrifugal extractor is essential. This is difficult to make and has to be purchased from a commercial supplier.

Langstroth hive with frame
© AIRC, Kenya

The Langstroth frame hive

The Langstroth hive: inspecting frames
© Thomas Carroll, Kenya (2006)

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Equipment

Most of the equipment needed for small-scale bee-keeping can be made at village level. It can be helpful to import basic equipment to serve as prototypes for local manufacturers. For practicing on a large scale, some specialized equipment will probably need to be bought such as honey gates, special filtering gauze, and gauges to determine honey quality.

Smoker

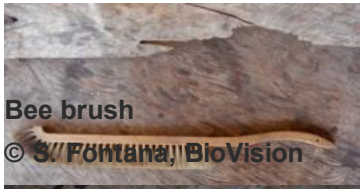
A beekeeper uses a smoker to produce cool smoke to calm the bees. The smoker consists of a fuel box containing smouldering fuel (for example dried cow dung, cardboard, dried bark or grass) with a bellows attached. The bee keeper puffs a little smoke near the entrance of the hive before it is opened, and gently smokes the bees to move them from one part of the hive to another.

Local smoker

Imported smoker (from the USA)

Bee brush

The bee brush is for brushing bees from combs when harvesting honey or when it is necessary to remove bees. Using a feather is also a good alternative.



Bee brush

Hive tools

The hive tool is a handy piece of metal which is used to pry open supers, scrape off odd bits of bees wax, separate frame-ends from their supports and so on. They can be made from pieces of flat steel, and screwdrivers are often used. It is possible to use an old knife for the job but knife blades tend to be too flexible and give too little leverage.

Hive tool

Protective clothing

Good protective clothing gives beginner beekeepers confidence, but more experienced beekeepers find that too much protective clothing makes it difficult to work sufficiently gently with bees, and it is very hot to wear. Always wear white

Protective clothing for beekeepers

© P. Luethi, BioVision

or light coloured clothing when working with bees - they are much more likely to sting dark coloured clothing. It is most important to protect the face, especially the eyes and mouth. A broad rimmed hat with some veiling will be good enough. Individual items of clothing must be impermeable to bee stings, and every joint between them must be bee tight. Rubber bands can prevent bees from crawling up trouser legs or shirt sleeves. Some people find that a good way to protect their hands is to put a plastic bag over each hand, secured at the wrist with a rubber band.

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How to set up and maintain a good apiary

A good way to begin beekeeping, especially in Africa, is to bait an empty hive to attract a swarm. Set up a hive and either rub it inside with some bees wax or lavender (plant leaves) to give it an attractive smell, or leave some attractive food for the bees. Granulated sugar or cassava powder will work. You could also put some honey on the top of the top bars. The bees will not be able to get at it and take it away to another hive, but the scent will remain and attract them. This will only be successful in areas where there are still plenty of honey bee colonies. Another option is to transfer a colony from the wild into the hive. The wild colony will already have a number of combs and these can be carefully tied on to the top bars of the hive, making sure that you include the brood combs and the queen. One of the best ways to get started in beekeeping is with the assistance of a experienced local bee keeper.

How to Set Up a Good Apiary

Quality honey starts with a good apiary. An apiary is a place where small groups of beehives are kept. The following steps are necessary in starting a good apiary:

Step 1: Site selection

- **Easy to access**
- **Away from human activity and noise and safe from thieves**
- **Near a place where bees can find water**
- **Near flowers, and trees that produce flowers**
- **Protected from strong sun and winds**
- **Usually a place that is not useful for other activities such as crop farming**

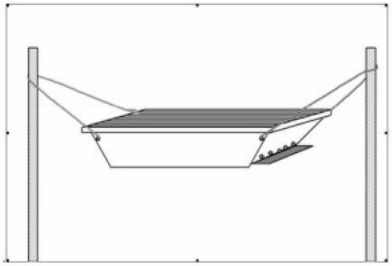
Step 2: Site Preparation

- **Clear obstacles and vegetation around hives to allow easy movement**
- **Protect against unwanted visitors such as thieves and large animals**
- **Plant nectar-producing plants to provide forage**

Step 3: Placing the hives: Things to observe

- **If you decide to use stands they should be at least 1 metre high. They must be made of strong, termite resistant wood, so they will last. Live stands will not rot and you can use types of wood that will grow easily into new plants when stuck in the ground. Otherwise, the legs of stands must be covered with grease or put in tins of oil so ants cannot climb into the hive.**
- **Use suspension wires if honey badgers are a danger. The wires need to be well greased to keep ants away. The suspension wires must allow the hive to swing easily to keep animals away.**
- **Hang hives at least 1 metre from the ground.**
- **Leave enough space (10-20 m for *scutellata* bees) between hives to make it easy to work without disturbing bees in other hives.**

- **Make sure the hive entrances face away from footpaths.**
- **Limit the number of hives.**



Hanging a KTBH posts 2 meters apart and the hive 1 metre from the ground

Step 4: Hive Preparation and Maintenance

The hives need to be clean and to contain a good bait to attract honeybee swarms to live there

- **Use plenty of bees wax around the inside of the hive and at the entrance. A top bar with a fresh bees wax starter strip is excellent for attracting bees. Bees are also attracted by a comb containing brood**
- **If possible use wax starter strip on each top bar. This will force the bees to build in the desired direction**
- **The bees like the odour of some leaves, which are always known locally and are sometimes used as extra baits**
- **Inspect hives regularly to check if bees have moved into them. If there are no bees check hives are clean and dry and that no pests, such as ants and spiders or snakes have moved in**
- **Add more wax bait if needed. The best time to colonise hives is when bees are swarming or migrating**

- **Discuss with experienced local beekeepers when the best colonising times will be**

Step 5: Hive Inspection (only for Langstroth and Top Bar - Hives)
Hive inspection should be done at least once a month in order to get acquainted with your bees. This will enable you to know:

- **When the colony needs a new queen**
- **The colonies with docile bees**
- **Productive colonies**
- **Colonies with less tendency of swarming**
- **Performance of the queen**
- **Presence of pests, predators and diseases**
- **Whether the honeybee colonies need supplementary feeding**
- **When to make a division to form a new colony**
- **When to harvest the honey**

This is normally done through keeping a work-plan

Step 6: Inspect inside the hives to see if:

- **The bees are building combs correctly (one comb on one top bar);**
- **The queen is laying enough eggs;**
- **The brood nest has a closed brood area without too many empty cells in between**
- **There are any leakages of water;**
- **There are intruders like ants, beetles or spiders;**
- **There are diseases harming the bees.**

Step 7: Harvesting the combs
Harvesting of the honey should be carried out in the evenings or early mornings. Gentleness is

the key to successful colony manipulation, so learn to carry out this process swiftly but calmly to avoid upsetting your bees.

- **Put on your full protective clothing**
- **Get your smoker, brush or quill, knife or hive tool and a rust-proof container in which to put the honey combs**
- **Load your smoker, and puff some smoke gently around the hive for a few minutes. Wait a few more minutes, then puff smoke around the entry holes.**
- **After puffing the smoke open the lid**
- **Use the knife or hive tool to remove the first bar from the end of the hive**
- **Puff smoke gently into the gap to drive the bees to the other side of the hive.**
- **Start removing the bars one by one, until you get the first comb which will be white and new. It may be empty or it may contain some unripened honey. Replace it and leave the comb for the bees to develop.**
- **Remove only the capped or partly capped combs, which will be quite heavy. Use a brush or feather to sweep any bees back into the hive.**
- **Cut off the comb, leaving about 2 cm for the bees to start building up again. Put the comb in your container and replace the top bar.**
- **Carry on harvesting until you come across a brood comb which will be dark in colour and contain pollen too. Leave this honey for the bees.**
- **Start the process at the other end of the hive.**
- **Close the hive carefully, replacing the lid**

Step 8: After harvesting

Feed the bees if necessary with sugar syrup to:

- **build/strengthen new colonies.**
- **sustain starving colonies during drought.**
- **stimulate brood rearing before honey flow.**

If bees have absconded:

- **Harvest all the combs to reclaim the wax.**
- **Clean dirt and debris out of the hives.**
- **Re-wax the top bars and replace them inside the clean hive.**

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Seasonal management

Some of the behavioural aspects of bees that affect their management are as follows:

1) Swarming

This is a natural way by which bee colonies multiply their numbers. About half of the colony leaves the hive together with the old queen. Overcrowding in the hive normally causes swarming.

Signs of swarming:

i. Increased number of bees at the hive entrance.
ii. Increased number of drones
iii. Presence of swarm cells along the edge of the combs.
iv. Increased defensiveness

Control:

i. Provide ample space in the hive by either dividing the colony or harvesting some of the combs.
ii. Decrease overheating by providing some shade.
iii. Destroy the queen cells so as to stop the emerging of new queens.

2) Absconding

This is an abrupt departure from the hive by the whole colony

Causes:
i. Physical disturbance of the hive e.g. poor harvesting methods, attacks by honey badgers, ants, termites etc
ii. Presence of pests e.g. insects, spiders, ants
iii. Bad odour
iv. Starvation
The colony does not take time to prepare, hence there are remnants of food, brood, eggs etc.
Control:
Proper management e.g. proper harvesting, handling of bees, proper hanging of hives, clearing the apiary and greasing the wires.

3) Migration

This is a natural phenomenon whereby a colony moves from one habitat to another mainly due to unfavourable weather conditions. Nothing is left behind in terms of brood or food reserves. Migrating bees seasonally follow well-established routes.
Control:
Feed bees in times of food shortage.

4) Supercedure

This is the replacement of a failing queen by the bees.
Signs:
i. Irregular egg laying pattern
ii. Weak colony
iii. Queen cells on the comb surface

5) Dangerous conditions

Period caused by:

- Prolonged dry spells, heavy rains cold weather
What to do:
- Provide shade, feed colonies, provide water

6) Production period during onset of flowering.
Build up period:
- Start of forage and egg laying
- Colony increases
What to do:
- Regular inspection
- Remove old black combs
- Unite queenless colonies

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Predators and pests and their control

During the last two decades there has been a tremendous increase in the spread of bee diseases around the world. This has been brought about by the movement of honey bee colonies and used beekeeping equipment by people. There are few remaining regions without introduced honey bee diseases, and as a rule used beekeeping equipment should not be imported.

Honey bee colonies, or even single queen bees, must never be moved from one area to another without expert consideration of the consequences.

There are numerous pests that will disrupt a beehive and prey on your bees. Wax moths are almost universal, ants are very common and persistent hazard, and honey badgers a serious

nuisance in Africa. It is best to talk to other local beekeepers about what the most common problems are and take their advice about appropriate defences.The major bee pests and predators that affect the performance and production of honey bee colonies are:

Pests	Control
Termites, ants	Greasing suspension wires
	Clearing the vegetation beneath and around the hives
Hive beetles	Use the right size of entrance holes
	Maintain a strong colony
	Inspection and physical removal
Wax moth	Strengthen colonies by feeding and destroying infested combs
Sugar ants	Greasing of suspension wires
	Cleaning the apiary
Predators	
Pirate wasp	Strong colonies
	Wasp trap
Honey badger	High hive hanging method

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Honey and beeswax harvesting and processing

Honey is harvested at the end of a flowering season. The beekeeper selects those combs which contain ripe honey, covered with a fine layer of white beeswax. These combs are usually the outer ones. Combs containing any pollen or brood should be left undisturbed. Honey will keep a

long time if it is clean and sealed in an airtight container, but will deteriorate rapidly and ferment if it has absorbed water. Preventing this from happening is crucial in honey harvesting.

The principal idea in harvesting honey is identifying the comb with ripe honey, free it of bees and take it away for processing. This entails shaking the bees off the combs, young bees normally cling on the comb therefore they are brushed off using a bee brush.

Reasons to increase honey quality through processing

- Processing eliminates all foreign particles and dirt from honey.
- Warming (not over 40°C) honey during processing destroys yeast which cause fermentation (but only if the honey contains juice from crushed bees or bee larvae). (Do not overheat the honey on the open fire)
- Warming honey delays crystallisation.
- Processing adds value and therefore honey fetches more money.

Honey extraction

The honey comb can be simply cut into pieces and sold as fresh cut comb honey. Alternatively, the honey and comb can be separated and sold as fresh honey and beeswax. It is important when processing honey to remember that it is hygroscopic i.e. will absorb moisture, so all honey processing equipment must be perfectly dry.

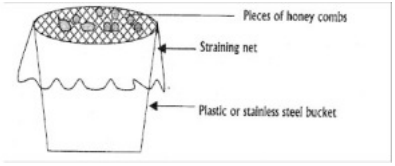
Squeezing the honey out by hand

The most common traditional methods of honey extraction are squeezing or melting the combs. Melting the honeycomb is wasteful and makes the quality of both the wax and the honey inferior; it should be avoided at all costs. If your quantity of honey or financial resources are small, then squeezing the honey out by hand is probably the most viable option. Honey combs should be scraped with a knife or fork on both sides to open the capping of the cells, then left

to drain through a fine dry sterilized muslin cloth into a clean container. Make sure there are no crushed bees or bee larvae among the honey combs, as this reduces the quality.

Framed comb

The honey extracted by this method will have to be strained through several increasingly finer meshes to remove any bits of wax or debris, ending with something likemuslin cloth. It is very important that this procedure be carried out hygienically, and that the honey is not left exposed to the air, where it will pick up moisture and deteriorate.



Honey combs cut from a KTBH or Log hive can be strained with a straining net as illustrated

With a Langstroth hive one can use the bee escape (clearer board). Fix the bee escape between the brood box and the super. After 24-48 hrs all the bees will be cleared off the honey supers. The supers can then be removed for honey extraction. Ensure the clearer board is removed and the supers replaced with empty ones.

Extractor

Another good way of extracting honey from top-bar or movable frame hives is to use a radial or tangential extractor after slicing of the wax that caps the cells. This is a cylindrical container with a centrally-mounted fitting to support combs or frames of uncapped honey, and a mechanism to rotate the fitting (and the combs) at speed. The honey is thrown out against the side of the container and runs down to the bottom, where it is collected and then drained off with a tap. Most manufactured extractors are made to hold frames and have to be adapted to take the cut comb pieces from top bar hives. This is usually done by making wire baskets to hold the comb. The baskets can either lie flat horizontally, or be attached to the vertical frames and sit tangentially within the container. Top-bar combs in tangential extractors have to be spun twice, once on each side, to extract all the honey.

Manual extractor (Centrifuge)

Manual extractor

© S. Fontana, BioVision

Honey storage

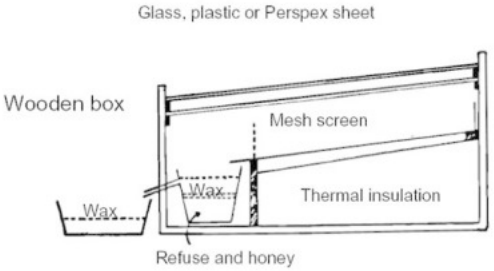
Store the honey in glass jars or plastics buckets with well-sealed lids or in a metal container which is coated with a layer of food grade varnish. In humid areas the honey must be stored in airtight containers to prevent water absorption and consequent fermentation within a few days after extraction. If you want to sell your honey you should add a label describing the source of the honey (for example sunflower, mixed blossom, tree honey), the country and district it was produced in, the net weight and your name and address.

Beeswax processing

The comb from which bees build their nest is made of beeswax. After the honey has been removed from the combs, the beeswax has to be extracted. This is to save it from destruction from the wax moth.

Put the wax into an open container which sits in a water bath. Bring the water to a boil and skim off any debris floating on top. Afterwards pour the liquid wax through a fine filter for a final clean.

Another option for processing the wax is a solar wax melter. This appliance is easy to make and consists of a wooden box with a galvanised metal shelf with a spout, a bowl or container that sits under the spout, and a glass or plastic cover. When placed in the sun the temperature inside the box will melt down a comb and the wax will flow into a container inside the box. Any honey that was left in the combs will sink to the bottom; it is usually used for cooking or beer making as its taste is spoiled somewhat by this process.



Solar wax melter

© Practical Action

Beeswax does not deteriorate with age and therefore beekeepers often save their scraps of beeswax until they have a sufficiently large amount to sell. Many beekeepers still discard beeswax, unaware of its value. Beeswax is a valuable commodity with many uses in traditional societies: it is used in the lost-wax method of brass casting, as a waterproofing agent for strengthening leather and cotton strings, in batik, in the manufacture of candles, for making polish, and in various hair and skin ointments. Beeswax is also in demand on the world market. Beeswax for export should be clean and have been re-heated as little as possible.

Before you can put the beeswax on the shelf for the purpose of selling it you must prepare it well having the following general requirements in mind.

- The colour of beeswax varies from whitish yellow to yellowish brown. This will depend on the type of combs one used when making the beeswax.
- Beeswax should be free from organic matters such as bees, brood, debris, sand or any other undesirable materials.
- It should not be adulterated by blending it with other types of wax such as paraffin wax, synthetic wax or any types of oil or fat (animal or vegetable).

Uses of wax

Once beeswax has been extracted from the combs, the beeswax cake maybe remoulded into desired shape. There is a high demand for beeswax for making candles.

Procedure:
Melt the piece of beeswax using a water-bath (indirectly), quickly pass the molten wax through a clean cotton cloth, the desired mould (smeared with detergent solution) should be ready to receive this wax. Let it cool for several hours. Remove and clean the beeswax cake with a soft damp cotton cloth.

Value addition for bee products

Honey is a major ingredient used in the preparation of various products that are of benefit to the human body. It is also used as a sweetener in various recipes.

Bee products and description of their use

Bee Product	composition	Use as	Added to	%	function	application
Beeswax 60°C	Complex	stabilizer weak emulsifier	oil	8-12%	increases water holding capacity of ointments and creams	non fat on skin in creams acids gives a saponification any cream/milk can be called as cleansing
Propolis	Complex	preservative	cream	1-5%	anti-bacterial anti-fungal	Anti-bacterial Anti-dandruff for shampoo Healing for acnes , after-shave Anti-irritant, anti-bacterial for mouth rinses and toothpastes Purifying for cleansing creams and milk Tissue regeneration Tissue rejuvenation
Royal jelly	Complex	additive	cream	0,05-1%	nourishing	Skin refreshing, regeneration, rejuvenation, Healing wounds
Honey	Complex	additive	cream	1-4%	Moistening and soothing effect	Creams, face pack, ointments
Pollen		additive	cream		Can cause allergic reaction	Very well dried and grounded

Table, bee products and description of their use

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Simple bee product recipes

The following recipes were popular on a bee product training course of Apiconsult conducted in Somalia. Ingredients are generally available in Kenya. Be innovative where something is missing and experiment with what is at hand. Many bee farmers in Kenya make additional income making and selling simple beeswax based creams which are reputed to have medicinal properties. Add value and make more money from your beekeeping!

1. Candles

There are many possibilities such as dipped, moulded, balloon shell, scented, engraved and herb candles

2. Leather Softner

When old leather such as belts, gloves and shoes become hard. This formula softens leather and makes it waterproof.

- **30g beeswax**
- **240g of petroleum jelly**

Melt the ingredients in a double pan. Brush the hot mixture onto the leather and allow it to penetrate. If possible place the item in the hot sun to allow the mixture to penetrate the leather. Polish the leather with a cloth to remove excess waterproofing.

3. Wood Dressing

This finish protects floors and outside timber which have not been painted and where paint is not desired.

- **60g of beeswax**

- **1 litre of linseed oil**

Melt the beeswax and stir in the oil. Apply the mixture with a brush.

4. Chapped Lip Balm

- **1 Tablespoon of Shredded Beeswax**
- **1 Tablespoon of Petroleum Jelly**
- **1 Teaspoon of Honey**
- **1 Tablespoon of Lanolin**
- **3 to 4 Drops of Essential Oil**

Melt the wax lanolin and petroleum jelly in a double pan. Add the honey and essential oil. Stir the mixture until it cools.

5. Honey Ointment

- **1 part honey**
- **2 parts petroleum jelly**

Combine the ingredients. Honey has well documented healing properties.

6. Saddle Soap/ Skin Cream

- **75g of beeswax**
- **120g of anhydrous lanolin**
- **2/3 cup of baby oil**
- **3/4 cup of water**
- **1 teaspoon of borax (sodium borate, C. P.)**
- **Fragrant essential oil (optional)**

Chemically pure borax is sold in a pharmacy. Lanolin can also be purchased there. In a double pan melt the oil beeswax and lanolin to about 70 degrees centigrade. Melt the borax and water in a separate container to the same temperature. Add the water mixture to the oil mixture while stirring briskly. When white cream forms stir slowly until the mixture cools to 38 degrees centigrade. Pour into small wide mouth jars.

7. Petrolium Jelly

Petrolium Jelly is easy to make and is an ingredient in many other products. Naturalists preferring not to use petrolium products may use a natural oil instead of the mineral oil such as coconut oil, olive oil, corn oil etc to give an "un-petrolium jelly"

- **30g of beeswax**
- **1/2 cup baby or mineral oil**

Melt the ingredients in a water bath. Remove the mixture from the heat and stir until it cools.

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- **Apiconsult, Box 3354 Nairobi Kenya, Phone +254-733-716948, Email: info@apiconsult.com www.apiconsult.com,**
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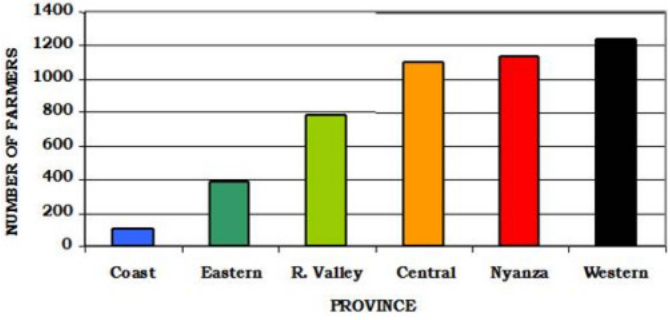
Fish farming

Introduction - What is aquaculture?

Aquaculture refers to the farming (propagation and rearing) of aquatic (water dwelling) organisms that include fin fish, molluscs, crustaceans and aquatic plants in controlled or semi controlled environments. The farming activities involve interventions such as stocking, feeding and protection from diseases and predators to enhance productivity.



However Aaquaculture is used interchangeably with other terms like fish farming, pisiculture, pond fisheries and

Conservation

pond culture.

Products

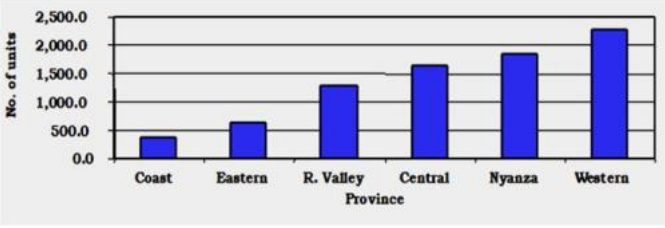
Mariculture refers to aquaculture done in marine (ocean) environments.

Some examples of aquaculture include:

- **Algaculture: Production of seaweeds and other algae**
- **Fish farming: Farming of Fin fishes (e.g. Tilapia), shrimps, shellfish, cultured pearls etc.**

Number of farmers by province.

© Mbugua Mwangi



Number of production units by province

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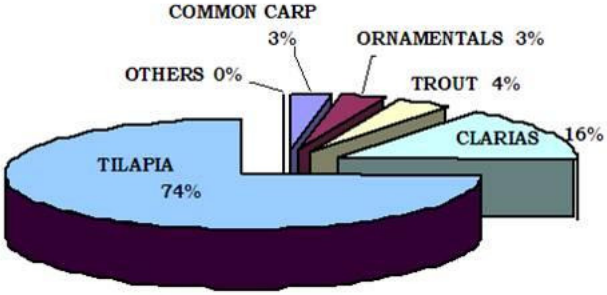
Aquaculture production is what is produced from aquaculture activities meant for harvest and human use. Although aquaculture is a fairly new concept in Kenya, it has a long history in Asia and Europe. It is believed to have started in China as early as 500 BC.

Compared to conventional livestock and crop farming, aquaculture is much more diverse. There are many different species cultured. The different species have different biology and therefore different ecological requirements. They will therefore have different feeding, breeding and water quality requirements. Coupled

with different management and intensification levels used, aquaculture production is very varied and diverse.

Aquaculture in Kenya

In Kenya, resources have been spent to promote aquaculture development through various aquaculture projects over the last few decades. The promotion started in the early 1920s as a means of supplementing protein sources in the rural areas. This was a non-commercial approach and it was promoted only as a family subsistence activity. This has however changed over the years and many investors have now invested in commercial aquaculture.



Percentage production by species.jpg

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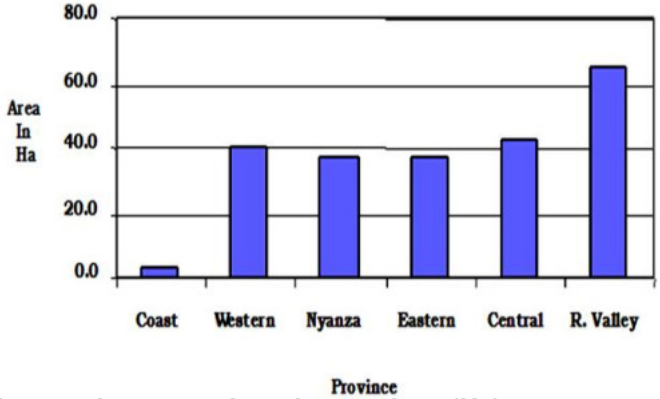
Majority of aquaculture activities in Kenya involves the production of various species of tilapia (mainly *Oreochromis niloticus*) and the African catfish (*Clarias gariepinus*) and Rainbow trout. The tilapines and catfish production is mainly done as mono or polyculture of the two under semi-intensive

systems using earthen ponds while the Rainbow trout production is done in intensive raceways and tank systems. The Tilapine species constitute about 90% of aquaculture production in Kenya. Although most of the production targets the food fish market, there has been an increasing demand for baitfish for the Nile Perch capture of Lake Victoria. Several entrepreneurs are producing the catfish juveniles for this market. Ornamental fish production is also gaining interest and several producers are engaged in the production of gold fish and koi carp among other ornamental species.

There are two broad aquaculture divisions in Kenya:

- **Marine aquaculture**
- **Fresh water culture**

With an Indian Ocean coastline of about 600 km, mariculture is yet to realise any sensible development and therefore fresh water culture dominates aquaculture activities.



Area under aquaculture by province (Ha)

© Mbugua Mwangi

Fresh water aquaculture can be divided into:

- **Cold water culture involving culture of Rainbow trout (*Oncorhynchus* mykiss) in highland areas**
- **Warm water culture involving the culture of Tilapine fishes, the African catfish, common carp and a variety of ornamental fishes in low land regions of the country**

The total area under aquaculture in Kenya stands at 722.4 ha which include culture-based fisheries. National average productivity stands at about 5.84 Mt/ha/year while the total production from this utilized area average 420,000 kg per year.

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Considerations before investing in aquaculture

Starting aquaculture as an economic enterprise, like any other economic enterprise, should be taken seriously. One needs to acknowledge that it involves making a significant investment decision and requires serious commitment. This is always true when deciding on the feasibility

of any economic investment.

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Thorough prior planning is therefore a must before any investment is made. Planning involves a detailed evaluation of the biological, economic, and socio-legal feasibility of production. Remember that economic considerations are as important as biological considerations in aquaculture. Socio-legal issues are potentially capable of limiting or even making it completely impossible to undertake aquaculture production.

It is essential to ascertain that the business concept is sound. Ask whether:

- **There are adequate and profitable markets for proposed product(s)**
- **You have a suitable site for the proposed production**
- **You have enough resources to meet the projected targets**
- **The financial projections are realistic, robust and consistent**
- **You have the expertise to produce**
- **There are adequate essential support services**
- **Your proposed undertaking meets all the environmental, social and legal requirements**

These should be answered in a well thought out BUSINESS PLAN and will provide you with a written document to serve as a blueprint for future reference for your operations.

Business planning

Business planning is important to both new and established aquaculture enterprises. It enhances the chances for success and helps avoid costly mistakes. This plan will be helpful when looking for financiers, because many financial institutes require a formal business plan. A business plan should be a working document that is reviewed and updated at least on yearly basis. Importance of business planning:

- **Many potential and existing fish farmers have difficulty obtaining financing**
- **Potential financiers may not be familiar with aquaculture as a viable investment**

- **Proper planning for the business will help avoid mistakes**
- **Proper planning for the business can also minimize risks associated with the market, production and financing**

A business plan is an analysis of the production, market and financial aspects of the proposed enterprise. It consists of:

- **Description of the proposed production site (see pond construction)**
- **A Marketing plan/strategy**
- **Description of production techniques/strategy**
- **Financial analysis of the proposed venture.**

Marketing plan

Where will I sell my fish? Surprisingly this question is asked very often by very many producers deep into their production cycle. Others ask this question after they have harvested their fish. Serious producers should ask and get answers to this question well before they go into production.

Marketing is normally overlooked by many entrepreneurs and yet aquaculture production, like any other serious investment, should target specific market(s). Indeed for any aquaculture enterprise to be successful, it must target a specified market or markets.

Any serious entrepreneur will produce goods which match the needs and wants of the customers they wish to serve. Therefore, one must make a decision on what to produce based on what the market wants.

Therefore, to avoid uncertainties and eminent failure, the first questions that an investor must ask and get answers to, are:

- **What products does the market demand?**

- **What quantities does the market demand?**
- **What production resources do I have?**
- **Can the resources meet the proposed production?**
- **Which products am I capable of producing?**
- **What quantities can I realistically supply?**
- **When does the market want them supplied?**
- **What quality does the market require?**
- **Can I meet these standards?**
- **Is it possible to get a bulk buyer?**
- **Does the demand in the market justify the intended production?**
- **What prices is the market ready to pay?**
- **Is it cost effective to produce at the offered prices?**
- **What competition exists in this field and how do I deal with it?**
- **Are the existing physical infrastructure (roads, power telecommunication etc) sufficient to meet the marketing needs for the produce?**

After answering these, the entrepreneur should be able to make a decision on whether to continue or abandon the proposed production. If the entrepreneur decides to go on, then, it is time to develop a marketing strategy.

Marketing strategy

A marketing strategy is a plan to achieve the financial goals of the entrepreneur. The strategy should address; the products, product prices, advertisement and where to sell as regards marketing. Ideally, the products must be sold for more than the production cost and quantities that allow the producer to make gains and remain in business.

Marketing strategy involves:
i. Analyzing the market situation

ii. Formulating marketing goals
iii. Evaluating and selecting suitable marketing alternatives

i. Analyzing market situation
To do this, the entrepreneur should have a good knowledge of:

- **Potential customer**
- **Modes of marketing (e.g. do you need to draw agreements, do you have to go through brokers etc)**
- **Product prices and their seasonality**
- **Product forms acceptable by the market**
- **Product quality requirements including regulation governing this**
- **Consumer preferences**
- **Quantity requirements**
- **Modes of payments and frequency**
- **All costs involved**
- **All competing products**
- **Alternative markets**
- **History regarding prices, demand, supply, product spoilage, product rejection etc**

ii. Marketing goals
The goals must be realistic and achievable; otherwise the producer will be groping in darkness without purpose. In formulating marketing goals, the producer must ask, and be able to answer, the following:

- **What is the targeted production?**
- **Is this achievable?**
- **What is the size of the target market in terms of geographical extent and consumer number?**
- **Is it possible to reach this market?**

iii. Marketing alternatives

It is important to consider marketing alternatives to avoid disappointment where a target markets collapse. For the marketing alternatives chosen or considered, product volumes and size preferences, costs associated with the marketing, and relevant legislations should be considered very carefully. Alternative markets for aquaculture products to consider include:

- **Hotels, restaurants, retail markets and fish (sea food) shops including supermarkets: This could be out of reach of most small scale producers because they might not meet the frequency and quantity requirement of such outlets. However they can easily over come this by forming marketing groups.**
- **Farm Gate Sales: Where local demand for fish is high, this offers a very good option. It removes the problems associated with taking the produce to distant markets. However it necessitates for proper storage facilities like deep freezers or cold rooms and some degree of processing and packaging.**
- **Sales to whole sellers, fish processors and large institutions: The advantage here is that large quantities can be disposed off at once and terms of supply and payment are normally stipulated in a legal contract. But this is only suitable for large scale producers.**

Production techniques

When planning for commercial aquaculture, the following aspects of production must be considered very critically:
i. Species to be produced
ii. Production site
iii. Production technology

I. Species to be produced
The choice of what to produce will be guided by:

a) Market preference
b) Ecological requirements of the species
c) Production technology of the species
d) Resources available to produce

The species to be produced must not only be marketable but also suited for the climate and be produced cost effectively. Different species require different climatic conditions to perform optimally. For example:

- **Nile tilapia and African catfish require warm water of more than 25°C.**
- **Growth of these fish is quite slow at elevations greater than 1600 meters because the water temperatures are very low**
- **For best performance, average water temperatures of about 28°C are best**
- **In Kenya, such regions are to be found in low land areas**
- **In areas where temperatures are lower than this, a larger pond surface area can compensate**
- **High sunlight intensity is also preferred for tilapia culture under semi-intensive production.**
- **Trout require cold water of less than 18°C for growing out and below 10°C for hatchery production. Such conditions in Kenya are to be found in high altitudes areas. The water must be adequate, clean and fast flowing.**

It is also important to know whether the species selected for production is adaptable to intended culture conditions and there is adequate knowledge of the reproductive biology, nutritional requirements, common diseases and parasites of the species. Also important is to ascertain that the species proposed for production is being profitably produced at commercial levels by other producers.
Other issues to consider, which are equally important are:

- **Is there a reliable supply of good quality juveniles at a reasonable price, for stocking?**
- **Are you capable of establishing your own seeds (juveniles or ova) production capacity?**
- **Is there quality feed for the species and are the prices cost effective?**
- **Do you have a reliable and affordable source for specialized production supplies and equipment?**

A good species should have the following characteristics:

- **Adaptable to culture conditions**
- **Fast growth rate, from egg to market size**
- **Simple and inexpensive dietary requirements**
- **Hardiness and resistance to diseases and parasites**
- **Producer can have full control over the life cycle processes in captivity**
- **Easy market acceptability**
- **Availability of advanced and proven production technology**

II. Production site

The proposed site should have the following characteristics:

- **Be located in a region suitable and allowed for aquaculture production**
- **Have a climate suitable for the species intended for production (preferably indigenous to the area)**
- **Be well drained and protected from floods**
- **The topography and the soils should be suitable for the construction of the proposed production system**
- **Have adequate and preferably free flowing good quality water supply. This is the life line of aquaculture and is a must.**
  - **Water is the key to a good site and not a matter of choice.**
  - **Water should be available throughout the year**
  - **Water must be free from pollution e.g. pesticides and other detrimental chemicals**

- **Accessible through out the whole production cycle and have easy access to services and technical assistance**
- **Have adequate space for intended function and possible future expansion**
- **Located on site acceptable under local and environmental management legislations**
- **Have good Infrastructure like:**
  - **Roads to bring supplies to the farm and take the products to the market?**
  - **Air or water transport where export markets are the targeted**
  - **Power where intensive production systems are proposed**
  - **Telephone service may be needed to run the enterprise efficiently**
- **Have good security**

III. Production technology

Aquaculture, compared to crop and animal farming, is much more diverse and varied. There are many different species that are cultured each with different ecological requirements. They will have different feeding and breeding requirements as well water quality. Aquaculture, like any other production is done at different management and intensification levels. Aquaculture production systems have therefore been developed to meet both the economic needs of the producer and the requirements of the species to be cultured.

The choice of the production level will depend on:

- **The species of choice**
- **Availability of the needed technology**
- **Potential prices of fish**
- **Available resources**
- **Available capital**
- **Availability of essential inputs for example feeds, power, skilled labour, professional expertise etc.**

Depending on the proposed targets and the resources available, the producer will make a

choice from the following:

Extensive systems

In these systems little or no input is used in the production. Fish are stocked in cages, still water earthen ponds and other water impoundments (for example reservoirs) and let to fend for themselves. Low stocking densities and thus low yields characterize the systems. The main cultured species are Tilapines (e.g. *Oreochromis niloticus*), *Clarias gariepinus* and *Cyprinus carpio*. These are low input-low out put production systems. Majority of the small scale, subsistence fish farmers in rural Kenya fall in this category. Production in these systems ranges between 500 and 1500 Kg/Ha/year.

Fish cultuture cages

Small Scale Fish Farm.

Semi-intensive systems

These systems form the bulk of aquaculture production in Kenya. In these systems still water earthen ponds and cages are used as holding units for fish culture. Still water pond culture uses the natural productivity of the water to sustain the species under culture. However to enhance productivity, the ponds are fertilized using both chemical and organic fertilizers at varying proportions to enhance natural productivity. Exogenous feeding using cereals bran and other locally available feeds is done to supplement pond productivity. Polyculture of *Oreochromis niloticus*, *Clarias gariepinus* and *Cyprinus carpio* is practiced with various combinations of species.

Commercial production in these systems ranges between 1 to 3 Kg/m2/year depending on the management levels individual farmers employ. There are Tilapia/Catfish producers in Western Kenya who have achieved productions between 6-10Kgs/m2/year.

A well fertilized pond in an ornamental fish farm in Kenya
© Mbugua Mwangi

Simple peletizing machine
© Mbugua Mwangi

Intensive systems

In these systems water flows in and out continuously (flow through). This allows higher stocking densities. The systems require good supply of good quality water. Less land is required to produce the same quantity of fish as compared to extensive and semi-intensive systems. The systems employ mainly raceways, various types of tanks and floating cages as holding units. In these systems, more fish are produced per unit area by complementing or substituting the natural productivity in the culture units by feeding from outside using complete feeds (the feeds are specifically manufactured for the species under culture) and water aeration. Such operations require high initial capital investment and high operational cost. They are mainly suited for high value fish. There are very few such operations in Kenya and most of them produce Rainbow trout. Production in these systems range from 10 to 50 kg/m2/year. This depends on the management levels employed by individual producers. This production can go higher with better management and quality feeds.

simple floating cage

© Mbugua Mwangi

A paddle wheel aerator in action in an intensive fish farm i

© Mbugua Mwangi

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Economic analysis for proposed aquaculture venture (advanced)

One useful tool for planning the use of money in an aquaculture enterprise is a cash flow budget. A cash flow budget is an estimate of all cash receipts and all cash expenditures during a certain time period. Estimates are made monthly, bimonthly, quarterly or annually. Estimates can include non-farm income and expenditures as well as farm items. Cash flow budgeting looks only at money movement, not at profitability. Non-cash revenue or non-cash expenses, for example depreciation, are not considered.p]

A cash flow budget is a useful management tool because it:

- **Makes you to think through your production and marketing plans for the year.**

- **Tests farming plans: will it be possible to produce enough income to meet all cash needs?**
- **Projects need for operating credit and ability to repay borrowed funds.**
- **Projects when to borrow money and when to repay.**
- **Helps in control of finances. By comparing the budget to actual cash flow, one can spot developing problems due to an unexpected drop in income or unplanned expenses, and opportunities to save or invest funds if net cash flow is higher than expected.**
- **Helps communicate farming plans and credit needs to lenders.**

Items to be included in a cash flow budget include:

- **Receipts from sales**
- **Operating cash expenses**
- **Living expenses**
- **Other expenses e.g. Personal withdrawals**
- **Debt interests and payments**
- **Capital sales**
- **Capital purchases**
- **Income tax payments**

Each type of revenue is charged during the specific period when it is occurred.

Cash flows differ depending on the purpose for which the analysis is being developed. You could have:

- **Monthly cash flow budgets - for detailed financial planning**
- **Quarterly budgets - to develop estimates of cash needs over a several year period**
- **Annual budgets - used in investment analysis to determine cash flow over the life of the investment**

Components (items) of a cash flow budget

- **Beginning cash balance (BCB) - this is the amount of cash at hand at beginning of the production period.**
- **Receipts - cash revenue generated by sales of the crop or capital assets.**
- **Note: cash revenue items (receipts) + BCB are summed up to obtain Total cash inflow for the time period**
- **Operating cash expenses - expenses related directly to the quantity of fish produced. e.g. fingerlings, feeds, field labour, security personnel, repairs etc.**

Also expenses associated with the purchase of capital assets or breeding stock are included.

- **Living expenses - this Includes what the owner of the enterprise spends on the self which can be referred to as nonfarm investments**
- **Other expenses - not related to actual production**
- **Scheduled debt payments - includes principal and interest payments for each separate loan.**

Note: All expenses are summed to obtain total cash outflow.

- **Cash available - this is the difference between Total cash inflow and total cash outflow**
- **New borrowing - if the cash available is negative, this means that there is insufficient cash generated during the period to meet all cash obligations and additional borrowing is needed for that time period.**
- **Cash balance - obtained by adding cash available to new borrowing . It becomes the beginning cash balance at the start of next time period. This must always be positive**
- **Debt outstanding - an accounting of the debt outstanding for each loan is kept at the bottom of the cash flow budget. Therefore, principal payments in a time can be subtracted out of the balance owed.**

Table 2: An annual Cash Flow budget for a hypothetical fully operational tilapia /catfish farm

- **Farm size: 0.5 Ha**
- **Productivity: 3kg/m2/year**
- **Av price of fish in KES/Kg: 250**

Item	Yr 0	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6
Beginning cash Balance		100,000	732,000	1,364,000	1,996,000	2,628,000	3,260,000
Tilapia		2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000
Catfish		900,000	900,000	900,000	900,000	900,000	900,000
Total Cash inflow		3,400,000	4,032,000	4,664,000	5,296,000	5,928,000	6,560,000
Operating cash expenses							
Tilapia fingerlings		50,000	50,000	50,000	50,000	50,000	50,000
Catfish fingerlings		900,000	900,000	900,000	900,000	900,000	900,000
Wheat bran		1,050,000	1,050,000	1,050,000	1,050,000	1,050,000	1,050,000
Fertilisers		6,500	6,500	6,500	6,500	6,500	6,500
		13,500	13,500	13,500	13,500	13,500	13,500
Lime		26,000	26,000	26,000	26,000	26,000	26,000
Interest on operation loan		60,000	60,000	60,000	60,000	60,000	60,000
Total Operating cash expenses		2,406,000	2,406,000	2,406,000	2,406,000	2,406,000	2,406,000
Living expenses		100,000	100,000	100,000	100,000	100,000	100,000
Other expenses		50,000	50,000	50,000	50,000	50,000	50,000

~~Scheduled debt repayments~~							
Interest on Investment loan	12%		150,000	120,000	90,000	60,000	30,000
Repayment	5 yrs		250,000	250,000	250,000	250,000	250,000
Operating principle		100,000	100,000	100,000	100,000	100,000	100,000
Interest on operation loan	12%	12,000	12,000	12,000	12,000	12,000	12,000
Total Cash Outflow		2,668,000	2,668,000	2,668,000	2,668,000	2,668,000	2,668,000
Cash available		732,000	1,364,000	1,996,000	2,628,000	3,260,000	3,892,000
New Borrowing							
Cash Balance		732,000	1,364,000	1,996,000	2,628,000	3,260,000	3,892,000
Outstanding debts							
Investment		1,250,000	1,000,000	750,000	500,000	250,000	0.0

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Commercial aquaculture species in Kenya

The following are the important commercial aquaculture species cultured in Kenya:

Nile tilapia (*Oreochromis niloticus*)

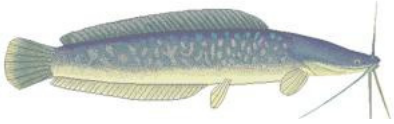
- **Tilapia are indigenous to Africa, but have been introduced in many parts around the world.**

Nile tilapia; max. length: 60 cm

© Mbugua Mwangi, Kenya

- They are disease-resistant
- They are prolific breeders and reproduce easily under culture conditions
- Feed on a wide variety of foods and tolerate poor water quality with low dissolved oxygen levels.
- Can grow in brackish water and some will adapt to sea water
- Mainly grow under semi-intensive systems as monoculture, males only monoculture or polyculture with African catfish
- Optimum temperature range 27 - 30°C
- Very popular in Kenya and have a good market in world
- Fillets yield is from 30% to 37%, depending on fillet size and final trim

African catfish (*Clarias gariepinus*)



African catfish; average lenght: 1 - 1.5 m

© Courtesy of Sagana Aquaculture Centre Kenya

- Indigenous to Africa.
- Can be described as omnivorous eating vegetable matter, zooplankton, insects, snails, tadpoles, leeches, small fish etc.
- Very hardy and can survive in low oxygen waters
- Can grow in brackish water in salinities of 10ppm
- Has ability to breath atmospheric oxygen
- Do not breed in captivity and artificial spawning is used
- Grows very quickly if adequate high protein feed is available.
- Few bones; has higher fillet percentage than tilapia
- Mainly grown in semi-intensive polyculture systems with tilapia
- Optimum temperature range 25 - 27°C

A good candidate for rural aquaculture in developing countries

Rainbow trout (*Oncorhyncus mykiss)*

Rainbow trout; average length: 51 - 76 cm

© Mbugua Mwangi

- **Native of North America but has been introduced and farmed all over the world**
- **A carnivorous fish which in natural waters consumes insects, crustacean and other small animals**
- **Grows well in cool fast flowing waters, 10 - 18°C, with high oxygen content**
- **Under culture conditions, require a water flow rate of 1 l/min/kg without aeration**
- **Trout will not spawn naturally in aquaculture systems and artificial spawning is used**
- **Produced in intensive systems in tanks and raceways**
- **Restricted to highland areas in tropical regions where favourable conditions allow**
- **Requires high quality feed, >40% protein.**
- **High market price, especially when fresh**
- **Fine bones; high fillet percentage and excellent when smoked.**

Common carp (*Cyprinus carpio*)

Common carp; max length: 1.5 m

© Courtesy of Sagana

- **An exotic species that has established itself in natural water bodies in Kenya**
- **An omnivore feeding onorganisms in mud at pond bottom, makes the pond water muddy.**
- **Eats a variety of supplementary foods including bran.**
- **Very limited aquaculture production in Kenya where they are grown under semi-intensive systems**
- **Attains a large size and does not usually overpopulate a pond.**
- **Optimum temperature range, 23 - 26°C**

Aquaculture Centre Kenya

- **Poor market in Kenya due to intramuscular bones but popular in Asia.**

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Pond design and construction for semi-intensive aquaculture

The importance of proper designs, construction and the need for involvement of experts during the process of setting up aquaculture production units is paramount. Ideally, production units should be designed in such a way to allow total control of:

Ideally, production units should be designed in such a way to allow total control of:

- **What gets in or out**
- **When its gets in or out**
- **How it does this**
- **How much gets in or out**
- **Rate of getting in or out**

The production site is of great importance. It does not only dictate the fish species to be produced but also important, the cost of construction is directly related to the nature and location of the site. A good site should therefore meet the following criteria:

- **Have water in quantity and quality needed for the proposed production**
- **Suitable topography to allow cost effective setting up the proposed production facility**
- **Have soil suitable for pond construction (if ponds are planned).**

A simple test of the suitability of a soil for pond construction:

- **Dampen a handful of soil with water. Use only enough water to dampen the sample (do not**

saturate it).

- **Squeeze the sample tightly in your hand.**
- **Open your hand:**
  - **If the sample keeps its shape, it is probably good enough for building a pond (sufficient clay present).**
  - **If the sample collapses and does not keep its shape, it is probably not good enough for building a pond (too much sand present)**

- **The site be in a region or area that is suitable and allowed for aquaculture production**
- **Well drained and away from flood-prone areas or at least having potential for flood control**
- **Allow for acceptable effluent disposal as required by environmental management authorities**
- **Have a climate suitable for production of the intended species**
- **Have accessibility to a good and all-weather market**
- **Have easy access to services and technical assistance**
- **Have adequate room for intended investment and possible future expansion**
- **Not in a pollution prone area**

The final size of a fish farm is determined by:

- **Amount of water available for fish culture**
- **The technology to be employed; Intensive systems require less land compared to semi-intensive systems, to produce the same quantity of fish**
- **The target production**
- **Capital available for investment**

The number, size and the shape of ponds will be determined by:

- **Land size**
- **Topography of the land**
- **Intended use of the pond**
- **The species to be produced**

- **Frequency of harvest**
- **Target quantity per harvest**
- **Whether juvenile production is intended etc.**

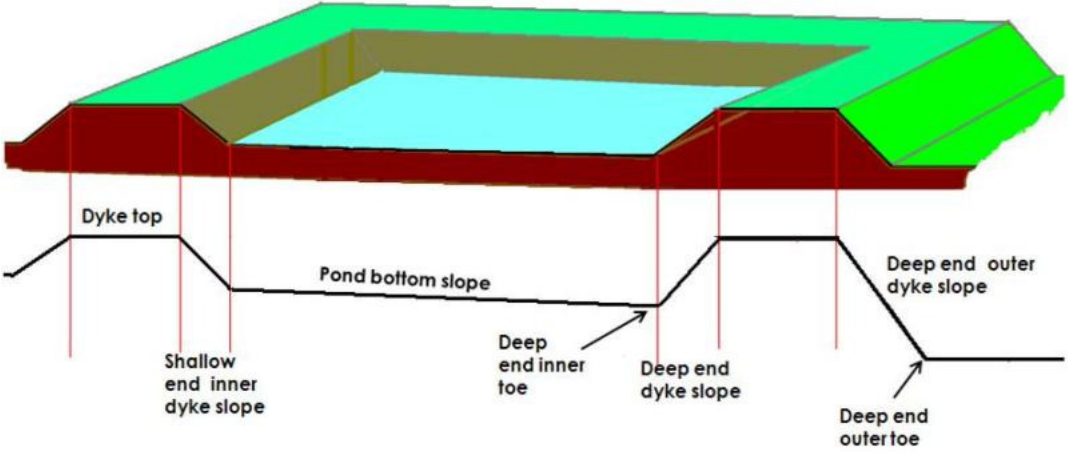
For these reasons it is not always possible to give general recommendations on the sizes and shapes of earthen ponds. However, rectangular ponds are easier to manage. Fingerling ponds should be smaller than fattening ponds.

Pond design

Once the site has been identified, surveyed and the producer has made decision on the number and sizes of ponds that will be needed when the farm is fully operational, it is time to make a decision on the design of the ponds.

. During the process of designing ponds, decisions on the following should be made:

- **Total area of the pond water surface (this is the actual pond size)**
- **The length and the width of the pond water surface**
- **The water depth and the total pond depth at the deep end**
- **The slope of the dykes and the pond bottom**
- **The size of the free board (height of dyke above water level)**
- **The width of dykes**



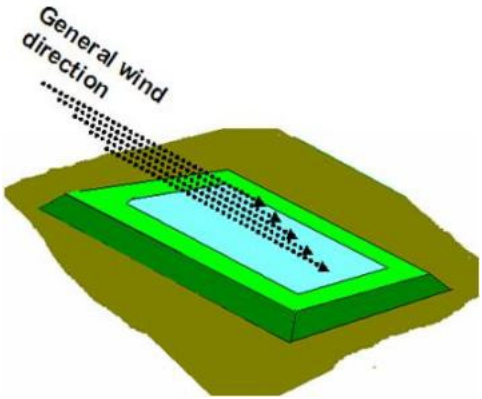
A cross section on an earthen fish pond showing the slopes and the dykes

Once this is done, all other pond dimensions can be calculated. The diagram below gives the relationships between various pond dimensions.

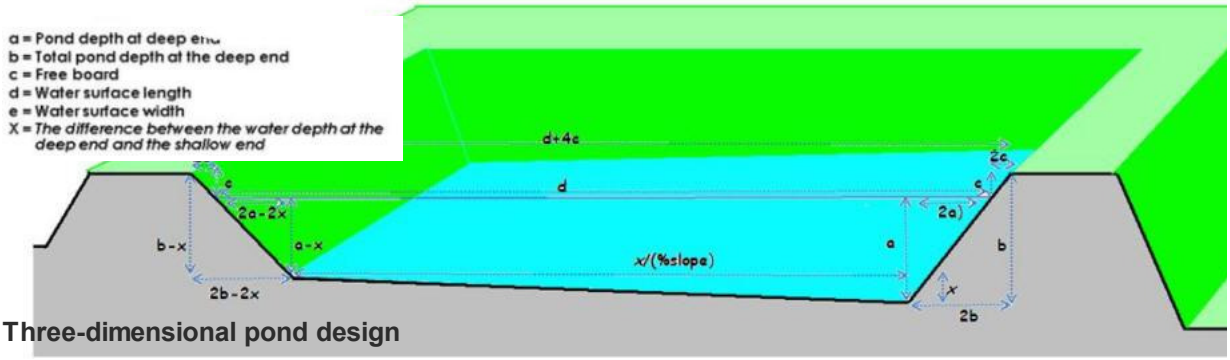
Calculations for the following design are based on the assumptions that:
- Dyke slope: 50% (0.5)
- Bottom slope: 1% (0.01)

Based on the above, the following apply:

Total pond length	**d+4c**
Total pond width	**e+4c**
Shallow end water depth	**a-x**
Shallow end total depth	**b-x**
Shallow end bottom width	**e-4a-4x**
Deep end bottom width	**e-4a**
Dyke top-Inner toe horizontal distance at deep end	**2b**
Dyke top-Inner toe horizontal distance at shallow end	**2b-2x**

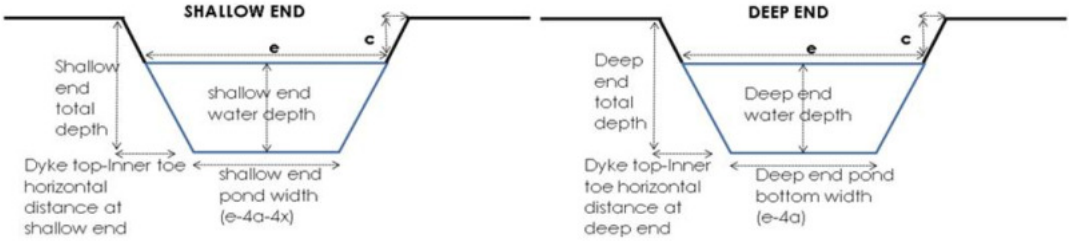


Pond designed to take maximum advantage of the winds



Three-dimensional pond design

© Mbugua Mwangi



Steps in the construction

Step 1. Mark out the area that the pond will occupy using wooden pegs and strings and then remove all the vegetation.

Clearing vegetation from the pond site

© Mbugua Mwangi, Kenya

Step 2. Remove the top soil and keep it in a good location close to the site. It will be used to cover the pond bottom and the dyke tops to enhance fertility. Remember that if the soil is kept far away, this will increase the cost of pond construction since the soil will need to be brought back.

Step 3. Clear the area within the pond limit of all vegetation including the area within 10 m of dykes and pond structures and any access, water supply or drainage area.

Step 4.Establish a Temporary Bench Mark (TBM). A bench mark is a mark on the ground that establishes the elevation of a place and is used as a reference point for all other elevation. This will allow you to determine and check by use of levelling equipment (e.g. spirit level) the elevations of the dykes, canals and other structures. The TBM should be set and permanently fixed in a protected location during the whole construction period.

Step 5. Using spirit level, measuring tape, pegs and strings, mark out:

- **The dykes**
- **Dyke slopes**
- **Inner and outer toes**
- **The pond bottom**

A site pegged ready for digging and filling

© Mbugua Mwangi, Kenya

Step 6. Using the determined pond depths and the actual elevations of the site, determine which areas need digging and which need filling. This is very important because it eliminates unnecessary movements of soil and thus keeps the construction cost at a minimum.

Step 7. Dig out the soil at the 'dig' areas and place it on the 'fill' areas. Most of the fill areas will be on the dyke position.

Dig the soil from the dig areas and move it to the fill areas

© Mbugua Mwangi, Kenya

Make sure to remove boulders and tree stumps from the pond

area.

Remove boulders and tree stumps from the pond area.

© Mbugua Mwangi, Kenya

Step 8. Once the soil is placed on the fill area, make sure that this soil is properly compacted. To achieve good compaction, place soil in layers not exceeding 15 cm in height and compact back to at least 10 cm. When constructing dykes, soil layers are place 20 cm inside on top of each other to reduce amount of work during dyke cutting.

Good dykes should:

- **Be able to resist water pressure resulting from the pond water depth**
- **Be impervious**
- **Be high enough to keep the pond water from overflowing**

Compact the soil properly

© Mbugua Mwangi, Kenya

To determine the height of the dyke to be built, take into account:

- **The water depth you want in the pond**
- **The freeboard (upper part of a dyke that is never under water). It varies from 0.25 m for very small ponds to 1 m for very large ponds**
- **Dyke height that will be lost during soil settlement. This varies from 5 to 20 percent of the construction height of the dyke**
- **Dyke width depending on the water depth and the role the dyke will play for example transportation in the farm**
  - **It should be at least equal to the water depth, but not less than 0.60 m in clay soil or 1 m in somewhat sandy soil**
  - **It should be wider as the amount of sand in the soil increases**

Shape the dike slope and the pond bottom

© Mbugua Mwangi, Kenya

Dyke slopes should be determined bearing in mind that:

- **Steeper slopes erode easily**
- **The more the soil becomes sandy, its strength decreases, and slopes should be more gentle**
- **The bigger the pond size, the stronger is the erosive power of the water waves**

Getting the desired slope and uniformity

© Mbugua Mwangi, Kenya

- **As the slope ratio increases, the volume of earthwork increases, and the overall construction cost and the land area required for the ponds increases**

Note that the more gentle the slope, the more solid the pond, but very gentle slopes make ponds more expensive and make rooted weeds control difficult. A slope of 50% is the minimum recommended

.

Fill the trench with moist clay and compact thoroughly

© Courtesy of Ngugi C. N., Kenya

The ability of the dykes to hold water can be enhanced by:

- **Using good soil that contains enough clay (about 25% clay is best)**
- **Building a core trench (clayey core) within the dyke where the soil is pervious**
- **Building a cut-off trench when the foundation is permeable**
- **Proper compacting of the soil**
- **Ensuring that the thickness of the dyke is appropriate**

Newly built dykes should be protected against erosion by planting a grass cover on the crest of the dykes, on outer slope and on the free board. The pond bottom should be constructed such that water drains towards a harvesting sump at the deepest part of the pond, in front of the outlet, where all the fish can be concentrated during complete draining of the pond.

Water intakes

Main water intakes are used for the overall regulation and

Water intake weir for a trout farm

© Mbugu Mwangi, Kenya

transportation of water to the fish farm. They ensure constant supply of water and allow regulation of the amount of water to the farm allowing for diversion of what is not needed.

When setting up main the intake, consider:

- **The levels of the water source (river, stream, etc.) in relation to the elevations of the water supply structure and the ponds themselves and where the water will eventually leave the farm.**
- **The depth from which you want to take the water (surface, lower levels or the complete depth of the water supply source) at the intake**

An open water supply canal lined with concrete slabs.

© Courtesy of Ngugi C. N., Kenya

There are several types of canals depending on their use:

- **Feeder canals to supply water from the main water intake to the fish ponds**
- **Drainage canals to take away water from the fish ponds**
- **Diversion canals to divert excess water away from ponds**
- **Protection canals to divert water runoff/floods away from the fish farm**

All canals should be well designed to have the required water carrying capacity at the required rate. If the water quantity is low and the rate of delivery is slow, pond will take too long to fill.

Pond inlets

Water inlet for a trout raceway

© Mbugua Mwangi, Kenya

There are two common types of inlet structures used in Kenya:

- **Pipe inlets**
- **Open inlets**

When designing and constructing an inlet:
a) Place the inlet at the shallow end of the pond
b) Make sure that the bottom level of the inlet is at the same level as the bottom of the water feeder canal and at least 10 cm above the maximum level of the water in the pond
c) Design the inlet structure to be horizontal, without a slope.
d) Make it wide enough to fill the pond completely in reasonable time
e) Make it such that water splashes and mixes as much as possible when entering the pond.
f) Provide a screen to keep unwanted fish and other organisms out
g) Control mechanism e.g. gate valves

Pond Outlets

Pond outlets are built to:

- **Keep the water in the pond at its optimum level, which should be the maximum water level**

designed for the pond

- **Allow for the complete draining of the pond and harvesting of the fish when necessary**

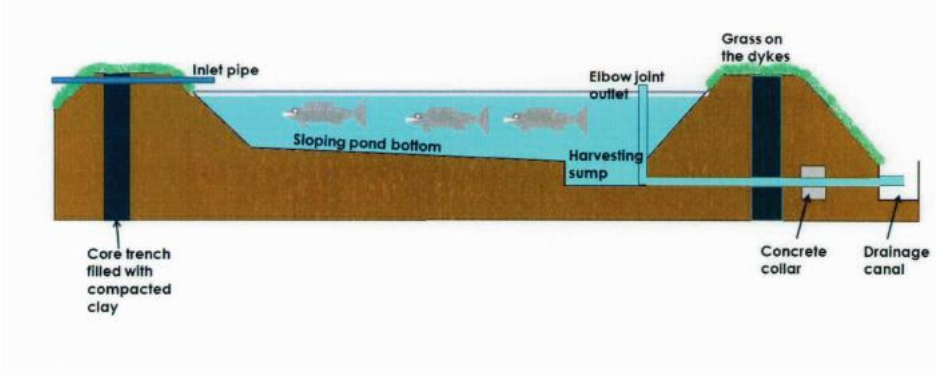
A good outlet should ensure that:

- **The time needed to drain the pond completely is reasonable**
- **The flow of the draining water is as uniform as possible to avoid disturbing the fish excessively**
- **Fish are not lost even during the draining period**
- **Water can be drained from any pond levels**
- **Allow for overflow of excess water**
- **Can be cleaned and serviced easily**
- **Construction and maintenance costs are kept at a minimum**

In most cases, outlets have three main elements:

- **Water control plugs, valves, control boards, screens or gates**
- **A collecting sump inside the pond, from which the water drains and into which the fish is harvested**
- **A conduit through the dyke through which the water flows out without damaging the dykes or the drainage canal**

For small rural ponds, investing in elaborate outlets may not be necessary. Complete drainage of the pond can be done by cutting the dyke open at one of the deepest point of the pond. Repairing the dyke should not take more than two hours.
Materials that can be used to construct pond outlets and inlets include bamboo poles, PVC pipes, wood, bricks, cement blocks or concrete.



A cross section of a completed pond showing the position of various structures.

Pond construction costs

Through experience in Kenya, one pond of 100 m2 will take 15 people about 8 days to complete, working 8 hours a day.

This will cost 15 x 8 x KShs X
X = wages per day

Note that the construction cost will vary with soil types and the weather. Rocky soils are hard to work on and construction will be more expensive. Black cotton soils are very difficult to work on during rainy weather and this too will increase construction cost.

Inlet canal and outlet canal: Include the cost of cement, sand, pipes, valves etc. Consider other incidentals costs especially due to the nature of the site and the prevailing weather.
Available pond construction experts in Kenya charge bout KShs 150 to 500 per square meter of

pond depending on the soil type and weather (2009 rates).
This should give the total cost of constructing one pond but not setting up the fish farm.

Remember that many but small ponds are more expensive to construct as compared to a few but larger ponds. Small ponds also waste a lot of space in comparison. However, very large ponds take long to fill and drain and are also difficult to manage.

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Farming Tilapia

Biological characteristics of tilapia

Tilapia is the generic name of a group of cichlids endemic to Africa. The important aquaculture genera in Kenya are *Oreochromis*, and *Tilapia*. All tilapia species are nest builders; fertilized eggs are guarded in the nest by a brood parent. *Sarotherodon* and *Oreochromis* are mouth brooders; eggs are fertilized in the nest but parents incubate them in their mouths including several days after hatching. For the *Oreochromis*, only females practice mouth brooding, while in *Sarotherodon*, either the male or both male and female mouth brood.

Tilapias are natives of Africa but have been introduced and produced widely around the world. They are primarily freshwater fishes. They are very tolerant of low water quality and can survive with low dissolved oxygen and even live and breed in saline water. They are hardy, grow well under crowded condition, resist diseases, have a higher fecundity than most fishes and reproduce freely in ponds. They grow well in culture systems, have well established markets around the world and are popular in various product forms.

Nile tilapia
© Mbugua Mwangi, Kenya

Tilapia farming involves the culture of following species:

i. *Oreochromis niloticus*
ii. *Oreochromis mossambicus*
iii. *Oreochromis aureus*
iv. *Oreochromis spilurus*
v. *Oreochromis andersonii*
vi. *Tilapia zillii.*
vii. *Tilapia rendalli*

Feeding Habits

Tilapias are heterogeneous in their feeding. They are hardy, have rapid growth, and have ability to consume and efficiently assimilate a wide variety of foods. Various species are omnivorous; others are phytoplanktonous while others are macrophyte feeders.

- **Omnivorous are: *O. mossambicus*, *O. niloticus*, *O. spilurus*, *O.andersonii* and *O. aureus*.**
- **Phytoplankton feeders: *O. leucostictus*, *O. macrochir*, *O. esculentus*, *O. alcalicus grahami,* and *S. galilaeus***
- **Macrophytes (feed on larger plants) feeders: *T. rendallii* and *T. zillii*.**

Maturation

In natural water bodies, tilapias mature in about two to three years. Under culture they tend to mature early. Sexual features distinguishing males from females are clear when fish mature (about 15 cm in *Tilapia zillii* and 10 cm in *Oreochromis niloticus*). Males have two orifices situated near the ventral (anal) fin, one is the urinogenital aperture and the other is the anus. The females have three orifices, the genital opening the anus and a urinary orifice (but difficult to visualize with the naked eyes). Separation of males and females can be made easier by applying dye (India ink, indigo, etc.) to the papilla with a cotton swab to outline the male and

female openings.

Fecundity

Fecundity refers to the number of eggs produced by a fish in a spawn. This applies well for monocyclic species, that is, once a year breeders. Tilapias are polycyclic (many times breeders) and their ovary may contain eggs at different stages of maturity.
In substrate brooding (nest building) tilapias, fecundity is much higher than mouth brooders. Other characteristics that differentiate substrate brooders (Tilapia) and mouth brooders (*Oreochromis*) are:

Characters	*Tilapia*	*Oreochromis*
Fecundity	high	low
Egg diameter (mm)	1-1.5	up to 5.0
Yolk percentage	less than 25%	up to 45%
Yolk colour	pale yellow	orange
Size of fry at feeding	5-6 mm	9-10 mm
Courtship	prolonged (monogamous)	brief (polygamous)
Juvenile mortality	high	low
Longevity	up to 7 years	over 9 years

Environmental requirements

Optimal Temperature
Temperature affects fish distribution, survival and growth, rate of development, reproduction and even susceptibility to diseases. Various species and strains of tilapia differ in tolerance to

low temperatures, but growth is generally limited at water temperatures below 16°C and most become severely stressed at 13°C. Death occurs from 12°C with few surviving temperatures below 10°C. Most will not feed or grow at water temperatures below 15°C and will not spawn below 20°C. The normal water temperature should be between 20 to 30°C. Metabolic rate rises at higher temperatures which lead to death.

Optimal Dissolved Oxygen (DO)
Tilapias are able to tolerate low levels of ambient oxygen. Usually, well fertilized ponds will have low levels of oxygen early in the morning. Night activities are dominated by respiration and decomposition which reduce DO. Larger fish are less tolerant than juveniles. This could be due to the difference in their metabolic demand. The optimal DO for tilapia culture is 4 mg/litre (50%) and should not go below 2.3 mg\litre.

Salinity
All tilapia are tolerant to brackish water. The Nile tilapia is the least saline tolerant of the commercially important species, but grows well at salinities up to 15 ppt. The Blue tilapia grows well in brackish water up to 20 ppt salinity, and the Mozambique tilapia grows well at salinities near or at full strength seawater

pH
Tilapia can survive in pH ranging from 5 to 10 but do best in a pH range of 6 to 9.

Ammonia
Massive tilapia mortality will occur within a few days when the fish are suddenly exposed to water with unionized ammonia concentrations greater than 2 mg/l Prolonged exposure (several weeks) to un-ionized ammonia concentration greater than 1 mg/l causes deaths, especially among fry and juveniles in water with low DO concentration.

Nitrite Nitrite is toxic to many fish and chloride ions reduce the toxicity. Tilapia are more tolerant to nitrite than many cultured freshwater fish. In general, for freshwater culture the nitrite concentration should be kept below 27 mg/l.

TILAPIA FARMING

Pond culture is the most popular method of growing tilapia in the world. They are grown in fertilized ponds where the fish utilize natural foods from ponds. Management practices of the systems ranges from extensive; using only organic or inorganic fertilizers, to intensive systems, using high-protein feed, aeration and water exchange. The major problem to overcome in this system is the prolific breeding of the fish that occur in ponds under mixed sex culture. This breeding if not controlled results to overcrowding in the ponds. The end result is stunted growth yielding small size fish (less than 100 g) which may not be of market value. In mixed-sex populations, the biomass of juveniles can make up to 70 percent of the total harvest weight. Therefore strategies for producing tilapia in ponds should aim at controlling spawning and recruitment.

For easy management and economical operation in Kenya, grow out ponds should be about 1 to 2 metres deep and at least 300 sq metres for semi-intensive production of tilapia. A harvesting sump in the pond behind the drainage outlet is needed to concentrate the fish in the final stage of drainage. The pond should be drained completely and be allowed to dry to eradicate any fry or fingerlings that may interfere with the next production cycle. This will also kill some parasites, frogs' egg and other unwanted organisms that may be in the ponds.

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Mixed-sex culture

Under mixed-sex culture of tilapia, both males and female are cultured together but harvested before or soon after they reach sexual maturity. This minimizes chances of recruitment and overcrowding. The disadvantage in this is that fish are harvested at a smaller size due to the limited growth period. In this culture practice, fish are usually stocked at low rates to reduce competition for food and promote rapid growth. One month-old, 1-gram fry are stocked at 1 to 2 per square meter and grown for about 4 to 5 months. In cold areas where the water temperatures are low and therefore growth is slow, tilapia might not reach marketable sizes in that period.

Newly-hatched fry should be used all the time because older ones will reach sexual maturity at a smaller, unmarketable size. They could also be mature fish but stunted. Supplemental feeds with 25 to 32 percent protein are generally used. The average harvest weight is about 250 g and total production about 0.25 kg/sq m for a stocking rate of 1 fish/m2. Higher stocking densities can be employed to achieve higher production but must be combined with very good management. Expected survival is about 80 percent.

Species such as *Tilapia zilli*, *T. hornorum*, or *T. mossambica* are not suitable for mixed-sex culture because they reach reproductive maturity at 2 to 3 months at an unmarketable size of about 30 grams. Those that are suitable for this culture are *O. nilotica* and *O. aurea* which reach reproductive maturity at 5 to 6 months. Two to three crops of fish can be produced annually in Kenya depending on the water temperatures.

Mono sex culture

To overcome the problem resulting from prolific breeding of tilapia, ponds are stocked with males only because the males grow almost twice as fast as females. Male fingerlings can be obtained by three methods:

- **Hybridization**
- **Sex-reversal and**
- **Manual sexing.**

None of these methods is 100 percent effective, and a combination of methods is recommended. Hybridization can be used to produce better results of males only. The hybrids can then be subjected to hand sexing and/or sex-reversal treatment. Sex-reversal requires obtaining recently hatched fry and rearing them in tanks or hapas where they are subjected to hormone laced feed for about three weeks. (For details see chapter Hatchery Management and Tilapia Fingerling Production).

Manual sexing (hand sexing) involves separating males from females by visual inspection of the external urinogenital openings. Reliability of manual sexing depends on the skill of the workers, the species to be sorted and fish sizes. Experienced workers can easily sex 20-gram fingerling *T. hornorum* and *T. mossambica*, 30-gram *T. nilotica*, and 50-gram *T. aurea*. Tilapia males are preferred for culture because they grow faster than females. Females use considerable energy in reproduction and do not eat when they are incubating eggs. All-male culture permits the use of longer culture periods, higher stocking rates and fingerlings of any age. High stocking densities reduce individual growth rates, but yields per unit area are greater. If the growing season can be extended, it should be possible to produce fish of up to 500 grams. Expected survival for all-male culture is 90 percent or greater.
Females included in a population of mostly male tilapia affects the maximum attainable size of the original stock in grow-out. A stocking rate of 2/m2 is commonly used in Kenya to achieve yields of 1kg/ m2. At this stocking rate the daily weight gain will range from 1.5 to 2.0 grams. Culture periods of 6 months or more are needed to produce fish that weigh close to 500 grams. There are cases in Kenya where stocking densities of 6 juveniles/ m2 is practiced with a production of up to 3kg/m2. Higher stocking densities will require water aeration and sub-optimal feeding rates may have to be used to maintain suitable water quality.

Polyculture
In Kenya tilapia are frequently cultured with other species, mainly catfish (*Clarias gariepinus*) to take advantage of many natural foods available in ponds and to produce a secondary crop, or to control tilapia breeding. Polyculture uses a combination of species that have different feeding niches to increase overall production without a corresponding increase in the quantity of supplemental feed. Polyculture can improve water quality by creating a better balance among the microbial communities of the pond, resulting in enhanced production.

Other possible polyculture combinations that can be done in Kenya include:

- **Tilapia and prawns (*Macrobrachium rosenbergii*): In this case, survival and growth of tilapia**

and prawns are independent. Feed is given to meet the requirements of the fish. Prawns, which are unable to compete for the feed, utilize wasted feed and natural foods that result from the breakdown of fish waste.

- **Tilapia and large mouth bass (*Micropterus salmoides*): The bass which is carnivorous, control the breeding of tilapia in mixed sex culture. This allows the original stock to attain a larger market size. Predators must be stocked at a small size and percentage to prevent them from depleting the tilapia stock.**

Fertilization and manuring

Where the natural pond productivity is enhanced through water fertilization, reasonable production can be achieved without exogenous feeding. Although yields will be lower than those obtained with exogenous feeding, fertilization will reduce the quantity and expense of feeding. Application of an inorganic fertilizer high in phosphorus should be done prior to stocking fish to create an algal bloom. Tilapia productivity is stimulated mainly by an increase in phosphorus and to a lesser extent by an increase in nitrogen. The inorganic fertilizers used in Kenya are DAP (Diammonium phosphate) and CAN (Calcium ammonium nitrate).

Animal manure is widely used in Kenya in fish production in earthen ponds. The quality of manure as a fertilizer varies depending on the source animal and the quality of feed fed to the animal. Pig, chicken and duck manures increase fish production more than cow and sheep manure. Animals fed high quality feeds (grains) produce manure that is better as a fertilizer than those fed diets high in crude fibre. Fine manures provide more surface area for the growth of microorganisms and produce better results than large clumps of manure.
Manure should be distributed evenly over the pond surface area. Accumulations of manure on the pond bottom produce low oxygen conditions (during decomposition) in the sediment resulting to reduced microbial activity and sometimes result in the sudden release of toxic chemicals into the water.

Manure crib

© Mbugua Mwangi, Kenya

Methods of applying manure

- **Crib method: A compost crib constructed using wooden sticks at one or more sides of the pond. It helps fertilize the water gradually. The manure in the crib requires frequent turning to facilitate the release of nutrients.**
- **Bag method: A bag is filled with manure and tied to the corner of the pond. The bag is shaken weekly or daily to release nutrients.**

Manure application rates for ponds

Manure application rates depend on the size of the pond, which is expressed as surface area of the water in the pond. The recommended rate is 50g of dry matter per m2 per week i.e. 5kg/100m2/week.

The maximum rate depends on the quality of the manure, the oxygen supply in the pond and

water temperature. If early morning DO is less than 2 ppm, manuring should be reduced or stopped until DO increases. When water temperatures are less than 18° C, manure application should be discontinued. At low temperatures the rate of decomposition decreases and manure may accumulate on the pond bottom. A subsequent increase in temperature could then result in oxygen depletion.

Agricultural Lime

- **Used to improve soil quality, which helps the organic and chemical fertilizers to work better. It also helps to clear up muddy water.**
- **In red soils; about 20kg per 100m2 can be applied. Black cotton soils may require a little more.**

Some characteristics of organic and chemical fertilizers

Organic (farm manure)	Chemical: DAP, Urea, MAP, TSP
Contains trace minerals and vitamins.	Contains only what the label says
Uses oxygen to decompose.	Does not use oxygen when dissolving
Is highly variable in composition depending on feeds given to the animals and bedding used	Varies little in composition from what is indicated on the label.
Can help reduce turbidity due to clay silt in the ponds	Does not reduce turbidity
Can help reduce seepage in ponds	Does not act on seepage
Some of the ingredients can be consumed directly by the fish	Not directly consumed by the fish

Integrated systems

Manure application can be made easy by placing animal production units adjacent to or over the

fish ponds so that fresh manure can easily be delivered to the pond on a continuous basis. This also allows the feed wasted by the animals to fall into the fish pond and utilised by the fish. Effective and safe manure loading rates are maintained by having the correct number of animals per pond surface area.

Tilapia and Catfish farming integrated with poultry

© Mbugua Mwangi, Kenya

Chicken/fish farming

Maximum tilapia yields are obtained from the manure output of 5,000 to 5,500 chickens/ha, which deliver 100 to 113 kg (dry weight) of manure/ ha/day. Several crops of chickens can be produced in one fish production cycle.

Duck/fish farming

Ducks are grown on ponds at a density of 750 to 1500/ha. The ducks are raised in confinement, fed intensively, and allowed a small portion of the pond where they forage for natural foods and deposit their manure. Ducks reach marketable size in 10 to 11 weeks and therefore staggering production cycles is needed to stabilize manure output.

Pig house with fish pond

© Stephen Gikonyo, Kenya

Pig/fish farming

Approximately 60 to 70 pigs/ha are required to produce a suitable quantity of manure (90 to 100 pounds of dry matter/acre/day) for tilapia production. The pigs are usually grown from 44 to 220 pounds over a 6-month period. In certain cultures and religion, where pigs are considered unclean, used of pig manure might reduce the marketability of the fish.

Further information on how to integrate animal production with fish culture under www.agromisa.org

Harvesting

Pond harvesting using a sein net

© Mbugua Mwangi, Kenya

Fish produced for consumption should be harvested when they reach market size. In Kenya, tilapia are ready for harvesting within six to nine months depending on the size at stocking, target harvest size, water temperature and level of management employed. The time of harvesting is determined through regular sampling which should be done monthly. A day or two before harvesting, feeding and fertilizer application should be stopped. During harvesting:

- **Fish should be checked for off flavours**
- **Fish should be harvested during cool weather**
- **Harvesting and transportation equipment should be set up well in advance to ensure reduced stress and minimal fish mortality.**

Tilapias are best harvested by seining for partial harvesting and complete drainage for complete harvesting. Once harvested, fish should be handled with care and transported to the market while still fresh.

Growth and yields

Under proper management and optimal conditions, 1-gram fish are cultured in nursery ponds to 20 to 40 grams in 5 to 8 weeks and then stocked into grow-out ponds. In mono-sex, males can reach 200+ grams in 4 to 5 months, 400 + grams in 5 to 6 months, and 500+ grams in 8 to 9 months. Dress-out percentage on tilapia is low compared to species such as trout and catfish. Tilapias have a dress-out of 51 to 53 percent of live weight for whole-dressed fish (head-off) and 32 to 35 percent for fillets.

Diseases

Tilapias are more resistant to viral, bacterial and parasitic diseases than other commonly cultured fishes. Few diseases and mortalities have been reported in semi intensive tilapia farms in Kenya. This could due to low stocking densities in these systems. Lymphocystis, columnaris, whirling disease, and hemorrhagic septicemia may cause high mortality, but these problems occur most frequently at water temperatures below 11°C. The most important cause of mortalities is anoxia resulting from blooms of algae. Sudden lowering of temperatures to below the tolerance levels, which can happen during the rainy seasons, can lead to problems including mortalities.

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Hatchery Management and Tilapia Fingerling Production

Although tilapia breed freely in ponds, it is important for farmers (producers) to consider using properly produced fingerlings. They need to invest in hatcheries for fry and fingerling production. Quality fingerlings in tilapia aquaculture are very important. For this reason it is advisable for farmers to generate their own fingerlings if they can not ascertain the quality of those from other sources. Poor fingerlings result in poor harvests.

Developing a hatchery will allow the farmer to have ready fingerlings whenever he needs them. As long as the demand for fingerlings exists, a well-managed hatchery can turn out to be a good business.

Three methods of tilapia fingerlings production are commonly practiced in Kenya. These are:

- **Open ponds (the most commonly used)**
- **Tanks**
- **Hapas (net enclosures) placed in ponds**

For these methods, fry are collected from the spawning units and stocked into fertilized ponds for rearing to the fingerling stage before they are stocked into grow out ponds.

Open pond method

Earthen fish ponds at a fish farm in Kenya

© Mbugua Mwangi, Kenya

This is the simplest and most common method of tilapia fingerling production in Kenya. A properly constructed and well fertilised pond serves both for breeding and rearing fry. Brooders are stocked into the ponds and allowed to spawn naturally. The brood fish are stocked at the rate of 100 to 200 kg/ha at a sex ratio of 1:3 or 1:4 (males to females). A female brood fish of 90-300 g produces as much as 500 eggs per spawning. They should produce 6 - 15 fry/m2/month. To increase seed production, use larger brooders. Brooders of 1 - 1.5 kg can produce 45 fry/ m2/month. For this case, you need to harvest every 17-19 days.

Harvesting fry from the ponds is done every 15 - 21 days (More frequently where average water temperatures are above 25°C). The brooders can be used for 3 - 5 years. Fry harvesting should be done by hand scoop nets along the edges of the pond to minimise pond disturbance and fry mortality.

Poorly constructed earthen ponds

© Mbugua Mwangi, Kenya

The tank method

Tank-based hatcheries are relatively expensive to set up. The tanks should be circular in shape and can be made of concrete, plastic, fibreglass or even metallic..

When using this method:

- **The tanks should be 1-6 m diameter and a water depth of 0.5-1 m.**
- **Stock 100-200 g brooders at a density of 3-5/m2 at a sex ratio of 1 male to 2-7 females.**
- **Feed using a 30-40% crude protein diet at a rate of 1-2% body weight/day.**
- **Collect fry every 10-14 days**

Yields of up to 400-3,000 fry/m2/month can be realised using this method.

An advantage of using the tank method is that they are easy to manage. On the other hand, tanks are often relatively expensive to set up compared to ponds and hapas.

Circular tanks for a trout hatchery

© Mbugua Mwangi, Kenya

The 'hapa' method

A hapa is a cage like, rectangular or square net impoundment placed in a pond for holding fish for various purposes. They are made of fine mesh netting material. The mesh size is such that the fry or fish inside can not escape.
Hapas sizes vary but the ideal size measures 3 m long, 3 m wide, and 1.5 m deep.

Breeding hapas in a fish pond

© Mbugua Mwangi, Kenya

When using hapas to generate fingerlings:

- **Stock brooders used should be weighing about 100 to 200 g at a ratio of about 1:5 to 1:7 males to females.**
- **Stock the brooders at a density of 4 - 5 brooders / m2.**
- **Hapas should be inspected for fry every day**
- **Remove the fry using a scoop net after two week and stock them into tanks, other hapas, or a rearing pond.**

Production in hapas range from 150 fry/m2/month to over 880 fry/ m2/month.

Inspecting tilapia breeding hapas

Feeding

- **Fry reared in a hapa should be fed 4 times/day on a daily basis until the fry reach the desired size (5 g).**
- **Use a diet in powder form at the rate of 5-10% of the total body weight per day.**

Advantages of using this method are

- **Fry and brooders are easily handled**
- **Production on a per unit area is high.**
- **Assurance of uniform fry of relatively the same age**
- **Minimised lose of fry**
- **Hapas can be set up in ponds stocked with fish**

Disadvantages of the hapa method

- **Management is more demanding compared to the other methods**
- **Mortalities may occur due to agressiveness during spawning**
- **Feeding is a must**
- **Hapas can be destroyed during stormy weather**
- **Hapa material will degrade in sunlight and need replacing**
- **Fish may easily escape if the hapa is damaged**
- **Localised poor water quality is likely due uneaten feed and fish waste**
- **Hapa mesh will get clogged limiting water circulation and need periodic scrubbing**

Production of all-male fingerlings

Males-only fingerlings can be obtained by three methods:

- **Hybridization. Hybridization can be used to produce better results of males only. The hybrids can then be subjected to hand sexing a sex-reversal treatment. Producing sufficient numbers of hybrid fry maybe difficult because of breeding incompatibilities between the**

parent species.

- **Sex-reversal. Sex-reversal is more complicated and requires obtaining recently hatched fry and rearing them in tanks or hapas where they are subjected to hormone laced feed for about three weeks.**

- **Manual sexing. Manual sexing (hand sexing) involves separating males from females by visual inspection of the external urogenital openings. Secondary sex characteristics may also be used to help distinguish sex. Reliability of sexing depends on the skill of the workers, the species to be sorted and its size.**
  Experienced workers can easily sex 20-gram fingerling *T.hornorum* and *T.mossambica,* 30-gram *T. nilotica*, and 50-gram *T. aurea*.

None of these methods is always 100 percent effective, and a combination of methods is recommended.

Hormonal sex reversal

- **To do this, you need a tank-based or hapa-based hatchery that will allow fry to be collected at the yolk sac or first feeding stages (no later than one week after they have been released from the female).**
- **Transferred healthy fry of uniform size to the tank or hapa where you will feed them with hormone-laced diet for 21-28 days**

The sex reversal feed is prepared as follows:

- **Mix 30 - 70 mg of hormone (methyl or ethynyl testosterone) in 700 ml of 95% neutral ethanol**
- **Add 700 ml of hormone solution to each kg of finely ground feed then mix thoroughly and dry. At this stage you may add any needed supplements**

- **This feed should be kept under refrigeration if it is not going to be used immediately**
- **Feed the fry at a rate of 10 - 30% of body weight per day, at least four times a day for 21 - 28 days.**
- **The fry must eat this feed to sex-reverse**

Tilapia males are preferred for culture because they grow faster than females. Females use considerable energy in reproduction and do not eat when they are incubating eggs.

Males only culture permits the use of longer culture periods, higher stocking rates and fingerlings of any age. High stocking densities reduce individual growth rates, but yields per unit area are greater. If the growing season can be extended, it should be possible to produce fish of up to 500 grams. Expected survival for all-male culture is 90 percent or greater. A disadvantage of male mono-sex culture is that female juveniles are discarded.

Females included in a population of mostly male tilapia affect the maximum attainable size of the original stock in grow-out. A stocking rate of 2/m2 is commonly used in Kenya to achieve yields of 1kg/m2. At this stocking rate the daily weight gain will range from 1.5 to 2.0 grams. Culture periods of 6 months or more are needed to produce fish that weigh close to 500 grams. There are cases in Kenya where stocking densities of 6 juveniles/m2 is practiced with a production of up to 3kg/m2. Higher stocking densities will require water aeration and sub-optimal feeding rates may have to be used to maintain suitable water quality.

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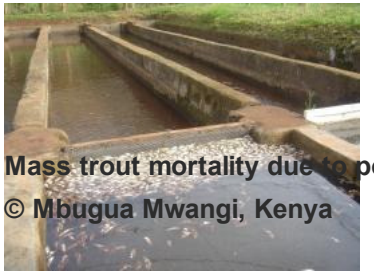
Water Quality Management

Water quality is the most important factor affecting fish health and performance in aquaculture production systems. Good water quality refers to what the fish wants and not what we think the fish wants. This means that we must understand the water quality requirements of the fish under culture very well. Fish live and are totally dependent on the water they live in for all their needs.

Different fish species have different and specific range of water quality aspects (temperature, pH, oxygen concentration, salinity, hardness, etc.) within which they can survive, grow and reproduce. Within these tolerance limits, each species has its own optimum range, that is, the range within which it performs best. It is therefore very important for fish producers to ensure that the physical and chemical conditions of the water remain, as much as possible, within the optimum range of the fish under culture all the time. Outside these optimum ranges, fish will exhibit poor growth, erratic behaviour, and disease symptoms or parasite infestations. Under extreme cases, or where the poor conditions remain for prolonged periods of time, fish mortality may occur. Pond water contains two major groups of substances:

- **Suspended particles made of non-living particles and very small plants and animals, the plankton.**
- **Dissolved substances made of gases, minerals and organic compounds.**

The composition of pond water changes continuously, depending on climatic and seasonal changes, and on how a pond is used. It is the aim of good management to control the composition to yield the best conditions for the fish. For producers to be able to maintain ideal pond water quality conditions, they must understand the physical and chemical components contributing to good or bad water quality.



Mass trout mortality due to poor water quality
© Mbugua Mwangi, Kenya

Physical Aspects of Water Quality

Temperature

Fish are "cold-blooded" and therefore assume the temperature of the water they live in. Water temperature is therefore the most important physical factor for fish survival and growth. Body temperature, and thus the water temperature, has an effect on level of activity, behaviour, feeding, growth, and reproduction of the fish. Each species has its tolerance limits and optimum range. When water temperatures are outside the optimum range, fish body temperature will either be too high or too low and fish growth will be affected or the fish will even die.

Tolerance limits and optimum temperature ranges for commonly cultured fish species of Kenya (Nile tilapia, African catfish, common carp and rainbow trout):

Fish species	Lethal water temperature (°C)	.	Optimum temperature range for adults (°C)	Temperature range for spawning (°C)
	Lower	Upper		
Oreochromis nilotica (Nile tilapia)	12	38	27-30	22-32

~~*Clarias gariepinus* (African catfish)~~	~~-~~	~~-~~	~~25-27~~	~~20-30~~
Micropterus salmoides (Largemouth bass)	2	35	23-30	17-20
Cyprinus carpio (Common carp)	2	36	23-26 (25)	Above 18
Oncorhynchus mykiss (Rainbow trout)	Close to 0	22	15-17 (16)	4-18

Turbidity

Fine solid particles suspended lead to a turbidity. Turbid Water can be said to be "cloudy". Turbidity can result from suspended solids (clay) or plankton. Clay turbidity in pond water (muddy water) can be harmful to fish and limit pond productivity. Clay turbidity in pond can be controlled by:

- **Treating affected ponds with animal manures at rates of 2.4 T/ha every three weeks or agricultural limestone, using recommended rates to improve soil pH and water alkalinity**
- **Avoiding stocking species that stir up pond bottom mud e.g. the common carp**
- **Designing water supply system such that muddy water can be diverted away from ponds**

Plankton are small often microscopic aquatic plants (phytoplankton) and animals (zooplankton) found suspended in the water column. Phytoplankton form the base of the food chain while zooplankton form the second link in the chain in aquatic systems such as ponds.

Plankton are small often microscopic aquatic plants (phytoplankton) and animals (zooplankton) found suspended in the water. Phytoplankton form the base of the food chain while zooplankton form the second link in the chain in aquatic systems such as ponds. [pln addition to their role as food for fish in ponds, phytoplankton produce large amounts of oxygen for the pond during the day by photosynthesis providing dissolved oxygen (DO) in ponds. Low phytoplankton density in ponds means less food and DO for the fish. On the other hand, too much (algal bloom) lead to minimised sunlight penetration causing algal deaths. Less phytoplankton and

decomposing plankton also lead to less food and DO for the fish. Good water quality, in relation to plankton therefore means water with just right bloom. Visibility in a pond with the right plankton density should be about 30 cm. [/p/]

How to measure turbidity:

A simple method of measuring turbidity it to stretch one arm, and immerse it vertically into the water until the hand disappears from sight. Note the water level along your arm:

- **If it is well below your elbow, plankton turbidity is very high**
- **If it reaches to about your elbow, plankton turbidity is high**
- **If it reaches well above your elbow, plankton turbidity is low.**

Suspended fish wastes are generally not a problem in semi-intensive aquaculture but in intensive systems, especially recirculation systems, they may be a major cause of poor water quality:

- **1 kg of fish waste per kg of fish produced**
- **up to 70% of the nitrogen load in the system**
- **build-up of ammonia and nitrite**
- **reduction of dissolved oxygen**

Chemical Aspects of Water Quality

- **pH**
- **Alkalinity**
- **Hardness**
- **Dissolved gases: oxygen, carbon dioxide, nitrogen, ammonia**
- **Salinity**
- **Essential nutrients: N, P, K**

Soil pH and Acidity

Pond water may be acidic, alkaline or neutral. Depending on this, water will react in different ways with substances dissolved in it. It will also affect in different ways the plants and animals living in the water. The measure of the alkalinity or acidity of water is expressed by its pH value. The pH value ranges from 0 to 14, with pH 7 indicating that the water is neutral. Values smaller than 7 indicate acidity and greater than 7, alkalinity.

Fish production can be greatly affected by excessively low or high pH. Extreme pH values can even kill your fish. The growth of natural food organisms may also be greatly reduced. The critical pH values vary according to the fish species, the size of individual fish and other environmental conditions. For example, fish are more susceptible to extreme pH during their reproductive seasons, and eggs and juveniles are more sensitive than adults. Waters ranging in pH from 6.5 to 8.5 (at sunrise) are generally the most suitable for pond fish production. Most cultured fish will die in waters with pH below 4.5 and 10 or above. Fish reproduction and general performance can be greatly affected at pH below 6.5 and above 8.5.

How to correct the pH of your pond water

Pond water with pH unfavourable for fish production can be corrected by:

- **If the pH is below 6.5 (at sunrise), use lime and alkaline fertilizers**
- **If the pH is above 8.5 at sunrise, you can use acid fertilizers**

Ensuring that soil pH and acidity are within acceptable limits is a necessary part of managing the alkalinity, hardness, and pH of the water, which were discussed above. The key is to keep soil pH at 6.5 or above, which will usually maintain water pH, hardness, and alkalinity at desirable levels.

How to keep soil pH at the right level

- **Drying the pond for at least two weeks after each harvest before refilling and restocking.**
- **Applying lime (preferably agricultural limestone) to the pond after each harvest. Normally lime should be applied to the pond bottom before it is refilled, but if necessary, it can be applied to the water surface after filling the pond. Only recommended liming materials and application rates should be used.**

Pond water pH varies over the course of a 24-hour day. This variation is related to the light intensity which is important in photosynthetic activity of phytoplankton.

- **pH is lowest at sunrise and as photosynthesis increases as the light intensity increases, more and more carbon dioxide is removed from the water by the plants causing the pH to increase**
- **A peak pH value is reached in late afternoon.**
- **As the light intensity starts decreasing, which reduces photosynthesis less and less carbon dioxide is removed from the water; as respiration adds more carbon dioxide to the water, pH starts to decrease.**
- **At sunset, photosynthesis stops, but respiration continues for the rest of the night. More and more carbon dioxide is produced, and pH keeps decreasing until sunrise, when it reaches its minimum.**

Dissolved oxygen in fish ponds
The most important gas dissolved in water is oxygen. Dissolved oxygen (DO) is essential for respiration and decomposition.
Dissolved oxygen in water comes from atmospheric oxygen and photosynthesis. The atmospheric oxygen diffuses and dissolves into the water. But the diffusion and its subsequent dissolves into water is a slow process. The major source of dissolved oxygen in ponds is photosynthesis. However this process depends on the amount of light available to the aquatic plants in water (Phytoplanktons). Therefore:

- **Oxygen production decreases during cloudy days**

- **It stops at night**
- **It decreases in increase in water depth the rate of the decrease depending on the water turbidity**

How to measure Dissolved Oxygen (DO)
DO can be measured by chemical or by electrical methods. Chemical methods rely on the use of kits which can be bought from shops dealing with laboratory equipment. They contain chemicals and equipment necessary to determine the DO content with sufficient accuracy for pond management purposes.

Electrical methods use an oxygen meter, this too can be bought from laboratory equipment shops but it is expensive. Using this equipment, DO can be measured directly from the pond at any depth. DO and water temperature should be measured at the same time so as to be able to relate the DO to the temperature. DO is expressed as mg of oxygen/litre of water (mg/l).

Dissolved oxygen (DO) requirements commonly farmed fishes in Kenya (in mg/l or percent saturation values)

Fish species	Ova and juveniles	Adults	
		Minimum DO level	Preferred DO level at least equal to
Trout	Close to 100%	5 mg/l (50%)	8 mg/l or 70%
Common carp	At least 70%	3 mg/l (30%)	5 mg/l or 50%
Tilapia	At least 70%	2 mg/l	4 mg/l or 50%
African catfish	At least 90%	1 mg/l or less (aerial respiration)	3 mg/l or 35%

Fluctuating oxygen levels
From sunrise to sunset

- **Photosynthesis increases the DO level**
- **DO production is higher on clear sky days than on cloudy days**
- **The higher the phytoplankton population, the higher the DO production.**

At night,

- **Photosynthesis does not take place**
- **Respiration and decomposition which are the main activities taking place, reduces the DO content until sunrise**
- **The higher the plankton population and dead matter, the faster the DO will fall**

There may be very little oxygen left by morning and fish may suffocate if corrective measures are not taken. In over fertilised ponds, where there is very high plankton density and high turbidity, the DO content of the bottom water may become anoxic (without oxygen) even during the day. The fish will concentrate at the surface of the pond to survive. This will be much worse at night.

Where DO test equipments are not available, signs indicating reduced DO in pond water include:

- **Fish not feeding well or even stopping feeding**
- **Fish coming to the water surface to breathe from the better oxygenated surface water (this is called piping).**

The DO content of pond water can be increased in several ways:

- **Through design and management**
- **Through structures that cause water to splash e.g. by use of cascades along the inlet canal**

and raised inlet pipes before the water gets into the ponds

- **By use of mechanical aerators for the emergency aeration of pond water**

A simple way to ensure a good supply of atmospheric oxygen to fish ponds is in the design of the pond. The ponds should be designed such that they take maximum advantage of the winds. The ponds should be designed so that the lengths are parallel to the direction of the prevailing winds.

Proper pond management can also improve the DO content of the water. The following measures can be taken before any emergency happens:

- **Flashing the pond by removing the less oxygenated bottom water and replacing it with better oxygenated water**
- **Use of water aerators e.g. mushroom blowers and paddle wheels**

Alkalinity and Hardness

It is desirable to maintain both alkalinity and hardness at 40 - 70 mg Calcium carbonate per litre. This can be done by:

- **Where water is 'soft' or acidic and soils are acid, apply lime (agricultural limestone) to the pond soil at recommended rates before to filling the pond**
- **Lime may also be added after filling by spreading it uniformly over the water surface.**
- **In areas where soils are alkaline and hardness and alkalinity are high, application of lime is not required.**
- **Note that proper management of hardness and alkalinity will usually eliminate the need to worry about pH.**

Ammonia

Un-ionized ammonia (NH3) concentrations in pond water should be kept below 0.5 mg/l

Concentrations of this form of ammonia, which is toxic to fish, are influenced by DO, pH, and alkalinity, therefore it is important to manage this by:

- **Maintain water alkalinity at 40 mg Calcium carbonate per litre or above**
- **Keeping pH near neutral, and at least below 9.0**
- **Keeping DO concentrations high**

Toxic Materials

Substances toxic to fish and other organisms (herbicides, insecticides, and other chemicals) should be kept out of the ponds. Ponds should be protected by:

- **Not using insecticides, herbicides, or other chemicals (except for recommended inorganic fertilizers) in or near your pond**
- **Keeping agricultural runoff from the ponds**
- **Avoiding spraying agricultural crops near ponds on windy days**

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Fish nutrition, fish feeding and feed formulation

Compared to terrestrial animals, fish have certain specific characteristics in terms of dietary requirements:

- **They have lower energy requirement**
- **Require less lipids in feed (except for cold water species such as trout)**
- **Can directly absorb certain mineral element from water medium**

There are three types of food used in aquaculture:

1. Natural food occurs naturally in fish ponds. This includes detritus, bacteria, plankton, worms, insects, snails, aquatic plants and fish. Their occurrence and abundance depends on the water

quality and in particular fertilization.

2. Supplementary feeds usually consist of cheap feed materials available locally such as terrestrial plants or agricultural by-products. Many kinds of feed materials may be used as supplementary feeds for your fish such as:

- **Terrestrial plants: grasses, legumes, leaves and seeds of leguminous shrubs and trees vegetables**
- **Aquatic plants: water hyacinth, water lettuce, duckweed**
- **Small terrestrial animals: earthworms, termites, snails**
- **Aquatic animals: trash fish**
- **Rice: broken, polishing, bran, hulls**
- **Wheat: middling, maize bran: gluten feed, gluten meal**
- **Oil/cakes after extraction of oil from seeds of mustard, coconut, groundnut, cotton, sunflower, soybean**
- **Cottonseeds**
- **Brewers wastes and yeast**
- **Slaughterhouse wastes: offal, blood, rumen contents**
- **Manure: chicken droppings, pig manure**

Supplementary feeds are available in two forms:

- **Dry feedstuffs such as cereals and cakes with about 10% moisture. These are easier to transport, store, and to distribute to the fish.**
- **Wet feedstuffs such as blood, rumen contents, molasses and brewery wastes with 30 to 50% moisture. Moist feeds do not keep well, and only small quantities should be prepared at a time. These feeds require special treatment, for example mixing with dry feedstuffs to absorb part of the moisture or drying to improve storage life before feeding.**

3. Complete feeds are made from a mixture of carefully selected ingredients to provide all the nutrients necessary for the fish to grow. They are made in a form which the fish find easy to eat and digest. These feeds are difficult to make on the farm and are usually expensive to buy.

Under intensive systems, feed provided to the fish must meet all their dietary requirements. The fish rely wholly on exogenous feeds. The feeds must be complete in terms of nutrients supply.

Fish dietary nutrient requirements

Protein

- **Important tissue building component**
- **Also important in repairing worn out tissues**
- **Important to juveniles for growth.**
- **Fish requires much more protein levels in feeds compared to most domestic animals**

In semi-intensive production, protein comes from the algae (resulting from proper pond water fertilization) and exogenous feeding with supplemental feed. However in intensive production of tilapia, the diets should have 28-32% protein.

Carbohydrates

Provides energy needed by the fish to carry out its physiological activities like respiration. Any excess is converted and stored as lipids.

Fats

They are utilized to supply energy like the carbohydrates. They also provide structural support and act as precursors to physiological chemical processes. Excess of fats reduce the marketability of fish. Diets for adult fish should not have high amounts of fats because it accumulates and reduces flesh quality. However, trout is able to utilize fats much more effectively and can ingest considerable amounts with their diet.
Deficiency in essential fatty acids result in reduced growth, de-pigmentation, erosion of fins, fatty liver and even shock.

Vitamins

Vitamins are required in very small quantities but play a major role in the chemical processes

within the fish body. Deficiency results in poor health and deformities.
In artificially produced feeds, a balanced mix of vitamins and minerals (premixes) can be obtained from specialized feed manufacturers. They should be used in proportions that meet the nutritional needs of the fish under culture.

Minerals
These are inorganic elements needed for various metabolic functions. Fish can obtain some of them through the gill surfaces into their bodies. Some important minerals include calcium, potassium, sodium and magnesium.

Other feed additives
Some feed additives that could be used in fish feeds includes attractants, binders, dyes and medicinal agents like vaccines.

FEED CONVERSION RATIO (FCR)

- **Feed Conversion (FCR) is the ratio of the quantity of food given to the fish (in kg) to the weight gain of fish (in kg), over a given period**
- **It can be used to estimate the quantity of feed needed in a production season for a given crop of fish**
- **For example, if the estimated FCR for a feed is 3:1, it means that a farmer needs 3kg of that feed to produce 1kg of fish.**

It is important to note that:
i). Small fish need more food than larger ones.
ii). Where there is plenty of natural food, less supplementary feed should be used
iii). Where low stocking densities are used, less supplementary feeds are used
iv). The better the quality of the feed (low FCR), the less the quantity needed to feed the fish
v). More food is required in warm water than in cooler water.

vi). It is therefore recommended for producers to constantly adjust the feeding throughout the production cycle for better results.
vii). FCR will be affected by overfeeding, poor feeds, poor pond fertilisation for semi-intensive production and poor fish health.

FISH FEEDING

It is normally not easy to estimate the amount of feed to provide to each pond. However, the following should be avoided:

- **Underfeeding, will lead to loss in fish production**
- **Overfeeding, uneconomical (higher production costs) and may also result in poor water quality**

A producer must at all times know approximately how many fish are in each pond to be able to estimate the amount of feed to apply. It therefore recommended that a producer conducts fish sampling in the ponds at least on monthly basis.

How to feed:

For most fish, feeding twice a day is sufficient - at about 10 am and 4 pm. Earlier than 10 am in the morning, the water is a bit cold and oxygen levels are low so this is not a good time to feed the fish.
If you feed at close to the same time and at the same place in the pond every day, the fish will learn to come for the feed.

Recommended feeding rates for tilapia or tilapia/clarias polyculture

Approx month after stocking	Assumed size of fish	Amount of wheat bran per day	Pelleted diet (26% protein)
1-2	5-20g	1 g/fish	1 g/fish
2-3	20-50g	1-3 g/fish	1-2 g/fish
3-5	50-100g	3 g/fish	2 g/fish
5-8	100-200g	4 g/fish	3 g/fish
8 or more	Over 200g	5 g/fish	3-4 g/fish

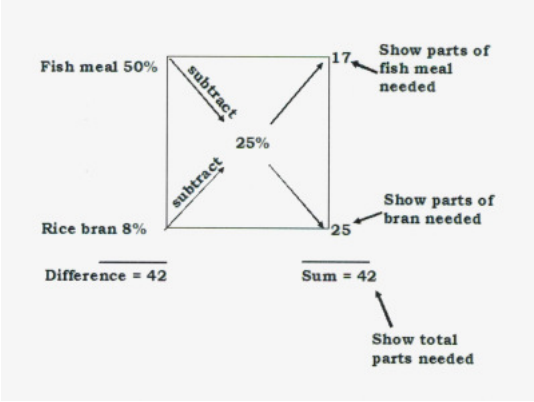
FEED FORMULATION

The purpose of feed formulation is to ensure that the aquaculture diets meet the nutritional needs of the fish under culture during it various stages of growth. Therefore, for one to be able to formulate a specific feed for a particular fish, they need to know the following nutritional needs as regards the fish:

- **Crude protein**
- **Crude fibre**
- **Energy**
- **Specific amino acids and**
- **Ash**

The square method - How to formulate fish feeds: The square method
The most common and simplest method of formulation fish feeds in Kenya is the square method. For example, if the desired feed should contain 25% protein, and there are two ingredients to use (fish meal with 50% protein and rice bran with 8%)

i). The desired protein level is inserted at the centre
ii).The two ingredients with their protein levels are



placed at each corner on the left hand side of the square
iii). The differences between the centre and each feed ingredient are placed at each corner on the right side diagonally opposite the ingredient (ignoring the plus or minus signs)
iv). The upper right hand corner in this example indicates the proportion of fish meal needed and the lower one that of rice bran
v). This can be expressed as

- **Ratio i.e. fish meal:rice bran 17:25**
- **Percentage 17/42 = 40.5% for fish meal and, 25/42 = 59.5% for rice bran.**

The square method

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Fish disease, parasites and predators management and control

Occurrence of disease and parasites in farmed fish is mainly as a result of poor husbandry. Disease causing organisms are always in the environment fish live in and they cause few

problems. The pathogens naturally exist in an unstable "equilibrium" with their hosts until this balance is disturbed through environmental changes and human activities. Fish are stressed through inadequate dietary or environmental conditions. The water quality parameters such as pH, temperature, dissolved oxygen may lead to outbreak of disease pathogens and parasites. Pathogens naturally exist in an unstable "equilibrium" with fish.

Prevention

It is better to try to prevent diseases than to wait to cure them once they start to cause problems. To cure a fish disease is much more difficult and may require the services of a specialist. By the time proper treatment can be sought, the disease may have caused a lot of damage. Most disease problems in aquaculture result from things that can be avoided. Some fish stressors that lead to diseases that need to be avoided are:

- **Poor handling of fish is a major cause of both bacterial and parasitic infections.**
- **Translocation of fingerlings/fry from one place to another without proper care can spread diseases and parasites.**
- **Increased nutrient levels due to intensive cage culture promote proliferation of parasites.**
- **Pollution due to high levels of ammonia predisposes fish to succumb to large numbers of parasites. Human faeces may be a source of gut parasites especially to common carp.**
- **Damages of fish by predators lead to secondary bacterial or fungi infections. The predators especially birds and mammals play an important role in life cycles of certain parasites.**

Disease, parasites or pathogens may enter fish through gills, penetration of egg membrane, ingestion and rupture of skin, wounds or through the digestive tract. Fish diseases may cause severe losses in fish farms through:

- **Reduced fish growth and production**
- **Increased feeding cost caused by lack of appetite and waste of uneaten feed**
- **Increased vulnerability to predation**
- **Increased susceptibility to low water quality**

- **Death of fish.**

Main causes of disease in farmed fish

Disease, parasites or pathogens may enter fish through gills, penetration of egg membrane, ingestion and rupture of skin, wounds or through the digestive tract. Fish diseases may cause severe losses in fish farms through:

- **Poor feeds and feeding; When fish are not provided with the right food in the right way, nutritional diseases occur.**
- **Exposure to extreme conditions or toxic environments**
  - **Unsuitable water quality**
  - **Extremes in pH towards acidic or basic conditions**
  - **Presence of toxic gases such as ammonia**
  - **Lack of dissolved oxygen**
  - **Overcrowding and/or behavioural stresses, for example in storage or transport**
  - **Improper and/or excessive handling**
  - **Toxins in food such as fungal toxins in stored feeds ,pesticide residues etc**
  - **Water pollution by agricultural or industrial effluents, sewage effluents, heavy silt loads.**

- **Actual attack by disease causing organisms; Fish like other living organisms, can be attacked by disease organisms, either externally (on the skin, gills or fins), or internally (in the blood, digestive tract, nervous system).**

Preventing diseases through proper management

Prevention is better than cure, so it is very important to:

1. Ensure good water quality: sufficient supply, with adequate dissolved oxygen and free of pollution

2. Maintain clean pond environment by controlling silting, plants and proper phytoplankton and zooplankton balance. Regular pond disinfection is recommended.

3.Keep the fish in stress free conditions by controlling stocking density, keeping different sizes separate to reduce fighting, providing proper food supply, handling the fish properly etc

4. Prevent the entry of disease organisms by:

- **Preventing entry of wild fish by using screens and eradicating them from canals and ponds**
- **Ensure that all fish got from outside to the farm are clean without parasites or diseases**
- **Always using good quality feeds**
- **Regular monitoring of the water entering the farm to ensure of its quality**

5. Prevent the spread of disease within the farm by:

- **Controlling predators, particularly birds and mammals**
- **Disinfect ponds regularly to kill both the disease organisms and their intermediate hosts**
- **Avoiding water sharing among ponds**
- **In case of disease outbreak, remove sick and bury diseased fish with quicklime away from the ponds; carefully treat infected ponds and disinfect all dead fish from the ponds immediately**
- **Always disinfect pond and fish handling equipment**

Common disease symptoms in fish

Behavioural signs:

- **Decreased feeding**
- **Weak, lazy or erratic swimming**
- **Floating on water belly up**
- **Roughing against hard surfaces**
- **Crowding/gathering at the inlet**

Physical signs

- **Gaping mouth**
- **Open sores, lesions, loss of scales, bloated belly**
- **Pale, eroded, swollen, bloody or brownish gills**
- **Abnormally folded or eroded fins**
- **Cloudy or distended eyes**
- **Presence of disease organisms on skin, gills, fins**

Fish diseases can either be:

(i) Bacterial - which causes diseases like fin rot and tail rot

(ii) Fungal infections - wooly or cottony patches on the surface of fish, and gill rot causing asphyxia.

(iii) Parasititic

- **Ectoparasites - causing Black spot, white spot, fish louse and nematode.**
- **Endoparasites - like the *Contraceacum*, and the *Ligula intestinalis*.**

(iv) Dietary - High carbohydrate levels in trout feeds, lack of proteins and lipids will result to liver tumour.

Some common fish diseases and their prevention

PATHOGEN	SYMPTOM	PREVENTION
Fungus	• Cottony grey-white or brown patches on the skin	• Proper fish handling • Avoid handling fish in cold water. • Low organic matter in water
Trematodes	• Black spots • Yellowish cysts on gills	• Control snails and control predators like birds • Remove infected fish.
Bacteria	• Loss of appetite.	• Improved water quality

	• Fin and tail rot. • Pale gills • Fluid in abdomen	
Nematode (Contracaecum)	• Round worm in spiral shape near gills	• Not really a problem for fish health but leads to consumer dissatisfaction
Parasitic protozoan	• Fish try to scrap their bodies on hard surfaces (flashing)	• Salt, potassium permanganate or formalin bath. • Keep water temperature near optimum range for that species of fish.

Nutritional Diseases

CAUSE	SYMPTOM	PREVENTION
1. Lack of proteins	• Poor growth. • Caudal fin erosion. • Loss of appetite.	• Feed protein rich food e.g. soya beans, slaughterhouse by-products, fish meal.
2. Lack of lipids	• Poor growth	• Feed with energy-rich foods

The following points should be followed in treatment of infected ponds.
Ponds with infections should be drained and badly infected fish culled.

- **Dry the pond under the sun for about seven days**
- **Dampen the pond bottom**
- **Spread Lime (Calcium carbonate) evenly over entire surface of pond bottom at the rate of 1500 kg/Ha**

- **Wait for 15 days then restock the pond with healthy stocks.**

Some common chemicals for use in fish farming
- Limes and agro-industrial by-products e.g. rice bran and molasses: Pests control in drained ponds.
- Organic poisons such as rotenone can control pests in filled ponds.
- Household bleach is a good disinfectant of non-metallic equipment and working areas.
- Chlorine bleach liquid and powder can be used as strong disinfectants for fish handling equipment.
- Common salt is cheap and easily available. Kills several disease organisms and have positive effects on the fish by stimulating appetite and increasing mucus secretion, improving resistance to handling.
- Formalin is toxic to fish particularly in soft water because it lowers dissolved oxygen levels, make sure treatment water is well oxygenated.

Some common fish predators and their control measures

Predator	Type of fish eaten	Control measure
Insects and insect larvae	Juvenile fish and eggs and fish just hatched.	i) Oil emulsion to prevent aerial breathing. ii) Use of fish that feed on insect larvae especially those that have gills and can remain in the bottom.
Frogs and toads	Juveniles of tilapia and catfish	i) Fence with frog proof wire mesh. ii) Clear bush around pond. Screen both in and outlets. iii) Use traps. Adult catfish and bass eat frogs.
Fish	all types of fish	i) Use screen in the inlets and outlets. ii) Do pond draining periodically
Snakes	Destroy larval and	Clear bush around the pond and fence properly, using

	juvenil fish	cacti (crown of thorns).
Crocodiles, alligators and large lizards.	All types of fish	Proper fencing and keeping dense bushes cut down.
Turtles	Prey on catfish	Fencing around pond with wire mesh, trapping.
Birds: Wading birds e.g., Herons and egrets Diving birds. Kingfisher, fish eagle cormorants, pelicans	All types of fish and at all stages especially in shallow waters. Cormorants feed on fish just after the fish are fed- when they are most concentrated.	i) Proper fencing all round and then above with netting material or manila ropes/strings on poles with bright colored cloth or metal crossed over the pond. ii) cover ponds with nets or wire mesh, use flash guns, windmills that revolves and flash brilliantly and bells to scare the birds a way. iii) The birds can also be actively discouraged by destroying their nest .
Otters	Prey on large fish at night killing more than they can eat. They burrow and live under the roots of trees near the water. Otters are very clever They can even open latches on gates.	i) Proper fencing around the ponds. ii) The otters can also be trapped using special otter traps set in their passages. iii) Guard by use of trained dogs. iv) Fence the pond half way across and thus provide hiding places for fish. v) In general, measures to combat monkeys are also effective on otters' meaning both are very difficult to control.
Man (theft)	All types of fish. This is also considered among	Extremely difficult to control and is most common in cage culture and other intensive fish farming. Can however be controlled by:

	the major predators through which fish are lost.	**i) Employing security personnel ii) Use of trained dogs iii) Hidden obstruction to prevent pond seining. iv) Fence farm and lock securely. v) Burglar alarms or electrified fence**

- **If the situation is bad, then trapping or shooting can be used as the last resort in cases of birds and otters but in consultation with the authorities**
- **Be careful when poisoning: predators, humans and non target animals can be affected**

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Animal nutrition and feed rations

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Introduction

Livestock production in all its ventures is a major source of incomes all over Kenya, from the most productive to nearly desert areas, And for all livestock owners livestock feeding and nutrition is a major concern. Inadequate nutrition is a major cause of low live-weight gains, infertility and low milk yields in dairy cattle. Also pig, chicken, dairygoat and many other livestock producers have expressed challenges in feeding their animals optimally. The following will explain the principles of animal nutrition and some examples of how to make home feed rations based on the types of feed available in major agroecological zone

The feed nutrients

Animal feed needs to contain various groups of nutrients, and the composition depends on which type of animal is being fed and the stage of production. Generally,

- **protein is the one element most necessary for body building and maintenance as well as milk production. Without protein there would be no body weight gain nor milk production**
- **carbohydrates provide energy and body fat,**
- **fats provide energy and the excess is converted to fat and stored in the body**
- **Minerals help in body building as well as in biological regulation of growth and reproduction. They are also a major source of nutrients in milk**
- **vitamins help regulate the biological processes in the body and become a source of nutrients in milk**
- **water helps all over in body building, heat regulation, biological processes as well as a large constituent of milk production as well as eggs.**

When calculating feed needs of different animals a system called Metabolisable Energy as a basis for formulating rations on the farm is used. Metabolisable energy basically means that part of the feed which the animal is able to utilize.

The unit of energy in the ME system is the Joule (J) of which one million units (1000 000 J) is referred as Megajoule (MJ). All foods contain energy, but not all of it is available to the animal. Parts of all feed is lost in the faeces, this part is described as indigestible. Other losses of energy occur in the production of methane, the urine of the animal and the loss of body heat. The energy remaining after all this is called the Metabolisable Energy or ME.

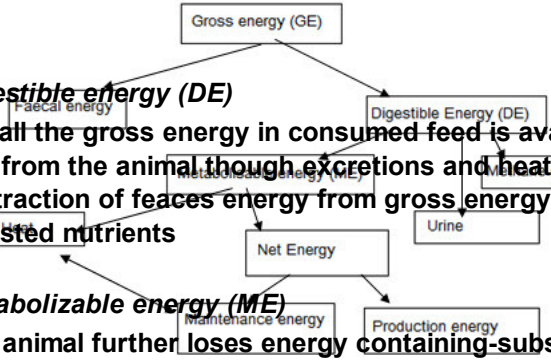
Basically, feed organic nutrients are required by the animals for three things: These are:
(i) use as materials for the construction of body tissues (growth and maintenance)
(ii) synthesis of products such as milk and eggs
(iii) use as sources of energy for work done. The work done include both metabolic (heat increment and maintenance) and physical e.g. walking and feeding.

Use of feed energy within the animal

Gross energy (GE)

The feed is comprised of chemical ingredients which are broadly classified as carbohydrates, proteins, lipids and vitamins. Heat is released when organic material such feed is burnt. For this reason, methods have been developed to measure the quantity of chemical energy present in a feed by determining the amount of heat generated from complete burning a known quantity. This is referred to as gross energy . Most of the

common feeds have energy content of about 18.5 MJ/kg DM.



Digestible energy (DE)

Not all the gross energy in consumed feed is available and useful to the animal. Some energy is lost from the animal though excretions and heat. The digestible energy is calculated by subtraction of feaces energy from gross energy. The DE represent the energy content of the digested nutrients

Metabolizable energy (ME)

The animal further loses energy containing-substances through excretion of urine and production of gases during metabolic processes. Metabolizable energy is what remains after subtraction of energy lost from urine and combustible gases resulting from the consumption of a feed. Loss of energy through methane (a combustible global warming gas) can be substantial, particularly for ruminants, hence can be of serious nutritive and environmental consequence.

Heat increment (HI)

The ingestion of feed by an animal is also followed by losses of energy not only as the chemical energy excreta and gases produced but also as heat. Animals are continuously producing heat and losing it to their surroundings, either directly through radiation, conduction and convection or indirectly through water evaporation from the body. The heat is generated through processes of digestion and metabolism of nutrients derived from the feed. For instance, the act of eating, which includes chewing, swallowing and secretion of saliva, requires muscular activity and this generates heat. Unless the animal is in a particularly cold environment, this heat energy is of no value to it, and must be considered, like the energy of the excreta, as a tax on the energy of the feed. Energy lost in this manner is referred to as Heat increment.

Net energy (NE)

The deduction of the HI of a food from its ME gives the Net energy, which is the energy available to the animal for useful purposes such as body maintenance and various forms of production.

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Protein requirements

Protein is the basic material for building body tissues, blood cells, hair and skin. Even bones are over ½ part protein, and protein is a major nutritional part of milk and eggs etc. Therefore it is necessary for an animal to eat enough protein to be able to grow well and to be productive whether in terms of milk meat or egg production. No other nutrient can replace protein in the diet.Cows can make protein from non-protein nitrogen containing materials such as Urea and poultry litter. Animals can not store much protein in their bodies and so it must be supplied in the daily ration every day in order to maintain high milk/egg/meat production.

If the amount of protein in ration is suddenly reduced, milk and egg production will drop rapidly and the animals will lose weight, growth rate of calves and heifers will be reduced also. Feeding too much protein to dairy cows is wasteful because the excess is broken down by micro-organisms in the rumen and excreted from the body. This should be prevented through careful and strategic feeding since protein is very expensive.

Proteins are built from what scientists call amino acids. Some amino acids can be generated by the cows in the rumen others cannot and have to be provided in the feed.

The amino acids that animals cannot produce themselves are called essential amino acids - meaning that it is essential for the animal to eat food containing these amino acids in order to be productive. When feed is analysed in the laboratory essential amino acids can be registered

in the analysis. Generally it is advisable to feed a mixture of different protein feeds in order to have a good chance of supplying all the essential amino acids.

Essential amino acids	Non essential amino acids
Arginine	Alanine
Histidine	Aspartic acid
Isoleucine	Citrulline
Leucine	Cystine
Lysine	Glutamic acid
Methionine*	Glycine
Phenylalanine**	Hydroxyproline
Threonine	Proline
Tryptophan	Serine
Valine	Tyrosine

***May be replaced in part by cystine**
**** May be replaced in part by tyrosine**

If one of the essential amino acids is lacking in the feed all the other feed cannot make up for this and the animal will be unthrifty and unproductive.

Biological value of protein

The biological value of protein in the feed is the percentage of the digestible protein of a feed or feed mixture which is usable as a protein by the animal. A protein which has a desirable balance of essential amino acids will have a high biological value and is said to be a protein of good quality. A protein which is extremely deficient in one or more essential amino acids will be called

a low quality protein.
Digestible Crude Protein (DCP) is that part of the protein the animals can utilize in their nutrition.

Ruminants such as cows and sheep can produce some of the essential amino acids above, but research is not conclusive on this point.
If animals are fed too much protein, the part that is not used in the building of the body and production can be converted into energy, but as proteins are generally expensive to buy and produce this scenario would not be common in Kenya.

High protein feeds

- **From animal origin such as fish meal, bone meal etc. Have high content of Vitamin B12, but are not essential in cattle feeding. Small quantities can be added to chicken and pig feeds**
- **From plant origin. These can be found in**
  - **Oil seed byproducts such as maize germ cake, cotton seed cake, sunflower seed cake, sesame seed cake, soy bean cake just to mention the more common ones. They vary in composition depending on how the oil was extracted and how much hull and/or seed coat was included (see Feeding section for details). Such protein feeds need to be bought by the farmer as it is not easy to produce on individual farms.**
  - **Green or preserved legume fodder. This includes all fresh cowpea, bean, desmodium, clover, and all the other legume leaves and stems - also the tree fodders promoted by agro-forestry people are good protein providers. Such protein can be grown on the farm quite cheaply and at the same time help improve soil fertility as the same legumes usually fix nitrogen from the atmosphere and use this for producing feed as well as soil nutrients to be used by the following crops (More details in the general fodder production section).**
- **Protein from non-protein source: Ruminants are able to produce protein from non protein nitrogen. The most commonly used non-protein nitrogen used in ruminant feeding is urea. Urea is also a by-product of protein metabolism in the body, so in small quantities is not poisonous to the animals. However if large quantities are fed the urea gets converted to**

ammonia which is quite toxic and can kill an anim al very quickly. If urea is to be used effectively for ruminant feeding without toxic results, it must be fed together with an adequate amount of readily fermentable carbohydrates such as maize, grain sorghum etc mixed with some type of molasses in order to keep pH of the rumen below 6.
Non-ruminants do not benefit from urea feeding.

Tables 1 and 2 give Kenya values nutritional content of some important feeds (Jack Ouda, KARI NARL 2009)

Table 1 Roughages fed to dairy cattle and their quality

Forage/Fodder	Dry matter (g/kg)	ME Energy (MJ/kg DM)	Crude Protein (g/kg DM)	Calcium (g/kg DM)	Phosphorus (g/kg DM)
Napier grass	180	8.5	88	5.0	3.0
Rhodes grass	280	8.5	90	- -	- -
Napier silage	280	9.0	75	- -	- -
Maize cobs	900	7.5	30	1.2	0.4
Fodder sorghum dry	890	8.9	75	4.0	2.1
Maize silage	320	10.5	80	4.0	2.7
Kikuyu grass	200	9.5	120	- -	- -
Rhodes hay	850	9.2	80	- -	- -
Lucerne hay	865	8.5	170	14.0	2.4
Sesbania leaves	260	8.5	260	22.1	2.8

Calliandra leaves	260	8.5	240	11.1	1.4
Leucaena leaves	280	8.4	230	15.5	2.1
Sweet potato vines	100	8.0	160	17.9	2.4
Green maize stalks	300	9	80	5.0	2.5
Maize stover	850	7.5	45	3.5	1.9

Table 3 Concentrates and minerals supplemented to dairy cattle and their quality

Concentrate/Mineral	Dry matter (g/kg)	ME Energy (MJ/kg DM)	Crude protein (g/kg DM)	Calcium (g/kg DM)	Phosphorus (g/kg DM)
High yielder dairy meal	920	12.0	180	- -	- -
Dairy meal	950	12.0	165	6.0	4.0
Calf pellets	920	12.0	180	- -	- -
Cotton seed cake	920	13.5	350	1.9	2.0
Maize germ	900	15.5	106	1.0	0.5
Maize bran	900	11.5	115	1.0	2.0
Wheat pollard	900	15.1	160	1.3	9.0
Fish meal (Omena)	880	15.0	470	60.0	32.0
Fish meal (Buta)	900	13.4	400	60.0	20.0
Poultry litter	880	10.6	160	- -	- -
Urea	950	0.0	2600	- -	- -
Brewers Yeast	930	12.6	340	1.0	14.0
Brewers grains	210	10.5	254	3.3	5.5

Magic protein	**900**	**11.9**	**480**	**- -**	**- -**
Wheat bran	**890**	**11.2**	**140**	**1.4**	**13.8**
Maize meal	**860**	**13.8**	**102**	**- -**	**- -**
Cassava tuber meal	**840**	**15.7**	**30**	**3.0**	**3.5**
Lupins	**860**	**14.2**	**342**	**- -**	**- -**
Pymarc					
Sunflower seed cake	**940**	**12.5**	**360**	**3.0**	**9.0**
Soya bean meal	**900**	**12.4**	**470**	**- -**	**- -**
Molasses	**750**	**12.2**	**35**	**9.0**	**1.0**
Maclick super	**980**	**- -**	**- -**	**185.1**	**110.0**
Limestone	**100**	**- -**	**- -**	**340.0**	**0.2**
Dicalcium phosphate	**970**	**- -**	**- -**	**220**	**193**

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Energy Feeds

Energy is the fuel that keeps all body functions working. Milk production requires a lot of energy. If energy in the ration is not enough, the animal will lose body condition and for milking cows, milk yield will drop, pregnant cows become ill after calving and the calf will usually be small in size. If there is excess energy in the ration, the animals becomes too fat. Cows that are

too fat at calving usually have difficult births, often have problems with retained placenta, displaced abomasums and may suffer from milk fever and ketosis.

Sources of energy are roughages and concentrate supplements fed to your animals Minerals are required in small amounts than the other nutrients but are important components of the ration. They are essential for cows to remain healthy and for the body to function properly, for the development and maintenance of strong bones and for successful reproduction and production of milk and eggs. Roughages form the main bulk of the dairy cow ration. Roughages are bulky feeds that have a low weight per unit volume. Generally feedstuffs with more than 18% crude fibre and low digestibility are considered as roughages.

A high yielding cow may not have enough capacity to consume the amount of roughage required to supply sufficient energy required due to limitation of stomach size.For this reason, supplementing roughage diets with feeds high in readily available energy is often recommended. Examples of energy sources (Forages and fodders, agricultural by-products, and concentrates) are shown in Tables 2 and 3.

The currently recognized energy feed nutrients include:

- **Carbohydrates such as Glucose, Fructose, Galactose, Sucrose, Maltose and Lactose, all different types of sugar**
- **Polysaccarides such as**
  - **Starch, found in roots and tubers as well as in grain,**
  - **Hemicellulose (somewhere between sugar and cellulose chemically speaking),**
  - **Cellulose, the principal constituent of cell walls of plants. Most abundant in more fibrous feeds, generally low in digestibility. Cattle, goats, sheep and horses digest cellulose fairly easily. Pigs and chicken do not digest cellulose very easily.**
  - **Lignin which essentially is not digestible to animals. Found in overmature hays, straws and hulls. High lignin content in feed may reduce the digestibility of cellulose and other nutrients.**
- **Fats and oils. Found in seeds, grains, avocadoes etc. Fats contain 2.25 times as much energy per kg compared to carbohydrates, but are usually expensive to produce.**

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Minerals

Minerals are chemical elements which form important component of animal feed ingredients. They are essential in ensuring normal and proper functions of the body as well as in maintenance of good health. When an element classified as essential lacks in the diet, the cattle will show deficiency symptoms, which are eradicated or prevented by inclusion of this particular element in the diet. Some elements are required in relatively large amounts compared to others. For this reasons the minerals have been classified as *'macro-minerals'* (required in larger amounts) and *'micro-minerals'* or *'trace-minerals'* (required in minute amounts).

Of the 20 elements that function in animal nutrition, carbon, hydrogen, oxygen and nitrogen are regarded as the non-mineral elements. The other 16 are referred to as the mineral elements which function in animal nutrition. Of these 7 are macro-minerals (required in fairly large amounts) and 9 are micro-minerals (required in very small or trace amounts). Micro-minerals are also sometimes called trace-minerals.

Different livestock types have different mineral requirements, which as far as possible will be described under each livestock type.

The macro-minerals are: Calcium, Phosphorus, Potassium, Sodium, Sulphur, Chlorine, Magnesium.

The micro- or trace minerals are: Iron, Iodine, Copper, Cobalt, Fluorine, Manganese, Zinc, Molybdenum, Selenium.

Macro-minerals

Dairy cows require more of the macro-minerals (Calcium, Phosphorus, Magnesium, Sodium, Potassium, Chlorine, Sulphur) than the micro-minerals (Iodine, Iron, Cobalt, Copper, Manganese, Molybdenum, Zinc, Selenium).If cows do not consume enough of the macro-minerals, this will cause reduced milk yield, infertility problems, weakness of the bone and increased incidences of non-infectious diseases such as milk fever (Due to insufficient Calcium). Deficiencies in micro-minerals (Trace elements) can cause a variety of diseases and conditions depending on which mineral is deficient. Cattle grazing in areas around Nakuru usually have Cobalt deficiency and may develop a wasting disease called Nakuritis. They become anemic and eventually die. The forages are deficient of mineral Cobalt because the soils naturally contain very low levels of this micro-nutrient. Special mineral supplements are available for cattle in such areas. Too much of the micro-minerals can cause poisoning.

Calcium and Phosphorus are of particular importance when formulating rations. Legumes tend to have more Calcium and Phosphorus than grasses. Grains are low in Calcium. Young dark green forage tends to have more minerals than old, dry and yellow forages. Most tropical forages are low in Phosphorus. Extra Calcium and Phosphorus usually need to be provided in the ration over and above that naturally present in the feed and mineral mix, especially for high yielding animals. Tables 2 and 3 shows examples of sources of mineral salts (Forages and fodders, agricultural by-products, concentrates and minerals).

- **Salt: (Sodium chloride) deficiency develops slow (weeks) but causes unthrifty appearance and low performance. Provision of ad lib salt licks are recommended.Plants tend to be low in both sodium and chlorine. It is therefore an important practice to give common salt to herbivores such as dairy cattle in order to prevent deficiency symptoms. Feeding diets deficient in salt may not show immediate symptoms, but chronic deficiency dairy cattle diets has been shown to lead to low appetite, low milk production and loss of weight. The addition of salt in the diet usually provide immediate cure.**
- **Calcium:**

Calcium is the most abundant mineral in the animal body. It is the most important constituent of the skeleton (bones) and teeth. Calcium also plays important roles in the activities of enzymes and hormones, which catalyze and/or balance the body metabolic processes. Agricultural lime, fish meal, milk, crushed shells, marble dust, some seaweed and green leafy forages, especially legumes, are good sources of calcium. Calcium tend to be low in old, dry and yellowing forages.

In dairy cows, a condition known as 'milk fever (*parturient paresis*) commonly occurs shortly after calving. It is characterized by a lowering of the blood calcium level (hypocalcaemia), muscular spasms, and in extreme cases paralysis and unconsciousness.

Deficiency symptoms: a) rickets in young stock. Joints become enlarged. Bones become soft and deformed. Condition may be corrected in early stages with calcium feeding. b) Osteomalacia or osteoporosis in older animals. Bones become porous and weak. Condition may be corrected by feeding calcium if bones do not break.Examples are known of cows fed too little calcium breaking their backs during mating

- **Phosphorus: is needed for bone and teeth formation, building body tissue (growth of animals), milk and egg production. Signs of phosphorous deficiency include animals eating soil, chewing on non feed objects, slow or poor appetite, slow gain of bodyweight, low milk or egg production.Low dietary intakes of phosphorus have also been associated with poor fertility, apparent dysfunction of the ovaries causing inhibition, depression or irregular oestrus.**

Sources of Phosphorous: Bone meal, Rock phosphate, Superphosphates such as TSP etc. Also many improved salt licks contain phosphorus.Cereal grains are a good source of Phosphorous, but hays and straws have very low phosphorous content.

- **Magnesium: is needed in proper functioning of the nervous system, carbohydrate metabolism and enzyme systems.**

Deficiencies: a) Hypermagnesemia also called grass tetany, grass staggers and wheat poisoning can occur when animals are grazing on young fresh grass or wheat heavily

fertilized with nitrogen and with very little content of magnesium.
Symptoms are hyper excitability and frequent death. More common in Europe than in Africa.
Prevention: use animal salts containing magnesium especially when animals are grazing on new young grass or grains such as oats.

- **Sulfur: Sulfur requirements of cattle and sheep are around 0.1-0.2% of ration dry matter. For non-ruminants sulphur should be in the form of sulfur-containing proteins. A deficiency of sulfur will express itself as a protein deficiency, general unthriftiness and poor performance.**

Micro-minerals

- **Iron: Necessary for blood and some enzyme formation. The precise minimum requirements have not been determined for various classes of livestock, but 80mg of iron per kg of diet is more than adequate for most animals. Deficiencies are most often found in young pigs (other animals much less sensitive): Laboured breathing, Flappy wrinkled skin, edema of head and shoulders, pale eyelids, ears and nose. Prevention/cure: A few drops of ferrous sulphate or similar daily during the first 3-4 weeks. Salt licks containing iron.**
- **Iodine: Needed for the production of Thyroxine in the thyroid gland. A level of 0.25 mg/kg air dried diet is considered adequate for most classes of livestock. Dairy cows should be provided with 0.5 mg iodine/kg dry matter feed.**

Deficiency symptoms: Goiter at birth or soon after, Hairlessness at birth, infected navels, dead or weak at birth. Prevention: mix normal iodized salt (table salt) into the salt licks of the livestock.

- **Cobalt: Needed in vitamin synthesis. For cattle and sheep, feed containing from 0.05-0.10 mg of cobalt/kg feed prevents any cobalt deficiency. For pigs cobalt is only needed as part of Vit B12. Several areas in Kenya have cobalt deficient soils, producing feed deficient in cobalt.particularly around Nakuru and Naivasha due to the absence of this element in the soils, leading to the absence in the pastures. A feed analysis will show whether feed in your area is cobalt deficient. Consult your livestock officer.**

Deficiency symptoms are simply those of malnutrition: poor appetite, unthriftiness, weakness,

anemia, decreased fertility, slow growth and decreased milk and wool production. There are number of disorders due to cobalt deficiency characterized by emaciation (wasting disease or *Nakuritis*), pining, anaemia and listlessness. Although excess cobalt can be toxic to animals, there is a wide margin of safety level. Thus cobalt toxicity is generally unlikely. Prevention and cure: Where cobalt deficiency is diagnosed, 12.5g of any cobalt salt, such as cobalt chloride, cobalt sulphate or cobalt carbonate can be mixed with 100 kg of normal cattle salt.

- **Copper: needed for blood and hair production as well as in the enzyme system. Where diets are not high in Molybdenum and/or sulphate the following levels of copper per kilo of diet dry matter have been found adequate:**
  - **Dairy cattle: 10 mg/kg**
  - **Beef cattle and sheep: 4-5 mg/kg**
  - **Pigs: 6 mg/kg**
  - **Horses: 5-8 mg/kg**

High levels of Molybdenum and/or sulphate may increase the copper requirements 2-3 times. Many areas in Kenya have copper deficiency in the soils and produce feed deficient in copper. Deficiency symptoms are not specific and may include any of the following: Bleaching of hair in cattle, abnormal wool growth in sheep, muscular incoordination, weakness at birth, anemia.Prevention and cure: Supplementation of livestock with copper in copper deficient areas is essential. This can be done by using trace mineralized salt containing from 0.25-0.50% copper sulphate. Pigs may be fed up to maximum 250g copper/kg dry feed. More than 100 mg copper per kilo dry matter may be toxic to cattle and over 50mg/kg will be toxic for sheep. It is also possible to repair your grazing areas for especially ruminants by upgrading the soil content of copper according to soil analysis recommendations. Generally grass and fodder deficient in copper have yellow or burnt leaf tips and low rates of production.

- **Fluorine: necessary for healthy teeth, but excess may weaken and stain the teeth. In Kenya fluorine deficiencies are not common, but drinking water especially from boreholes often contain very high levels of fluorine. If the levels of fluorine are too high water can be filtered through a filter containing burnt bones, which will absorb most of the fluorine. This is more**

practical for human water consumption than for livestock.
In Kenya the best advice for water treatment for excessive fluorine can be obtained from the Catholic Diocese in Nakuru.

- **Manganese: influences estrus, ovulation, fetal development, udder development, milk production, growth and skeletal development. Requirements:**
  - **Dairy cattle: 40 mg/kg of dry matter feed**
  - **Beef cattle and sheep: 5-20 mg per kg dry matter feed**
  - **Pigs: 10-20 mg/kg dry matter feed.**

Deficiency symptoms noted from areas deficient in soil manganese include: delayed estrus, reduced ovulation, abortions, resorptions, deformed young, "knuckle over" in calves, poor growth. Supplementation is easily done with trace mineralized salts containing 0.25% manganese.

- **Molybdenum: Important in poultry as it stimulates uric acid formation, and in ruminants stimulates action of rumen organisms. Molybdenum deficiencies have only been observed in poultry in special cases. Molybdenum supplementation is normally not recommended in livestock production.**
- **Selenium: works in vitamin E absorption and utilization.**

Requirements: about 0.1 mg or less per kg dry feed. Deficiency symptoms include: Nutritional muscular dystrophy in lambs and calves, retained placenta in cows, heart failure, paralysis, poor growth, low fertility, liver necrosis, pancreatic fibrosis in chicks. Many areas in Kenya are known to have selenium deficieny of the soils. If selenium deficiency is expected, a soil or feed sample can be sent to any of the major laboratories for analysis. Supplementation must be done very carefully as selenium in too large quantities is poisonous. 1 gram Selenium in the form of sodium selenite can be added to 10 kg dry feed in deficient areas (=10g or 2 teaspoons per 100kg feed- really not much).

- **Zinc: promotes growth and thriftiness. Promotes wound healing, related to hair and wool growth. Deficiencies mostly found in pigs fed on concrete floors. Deficiency symptoms include: general unthriftiness, poor growth, unhealthy looking hair, skin and wool, slow wound**

healing. Pigs can be supplemented with 50 mg of zinc per kg of dry feed or as trace mineralized salt.

A well balanced mineral salt mixture adjusted to local conditions is the easiest way to ensure good mineral balance in animal feeds.

Tables 3and 4 give mineral content of the most important feeds in Kenya (Jack Ouda, KARI NARL 2009)

Table 3:
Quality of some commonly available roughages in Kenya

Table 4

Quality of some commonly available concentrates and agro-industrial by-products in Kenya

Feed Name	DM %	NEM MJ/kg	CP %	CF %	ADF %	NDF %	Ash %	Ca %	Mg %	Na %	P %	S %	Cobolt ppm	Copper ppm
Pyrethrum marc	90	5.78	13	26	37	59	7							
Napier Grass, medium maturity	20.3	1.97	8	36.1	30.3	56.1	12.4	0.36	0.14	0.05	0.32	0	0.01	1.8
Rhodes Grass, medium maturity	30	2.97	6.8	40	30.3	54.1	10	0.36			0.32			
Kikuyu Grass, medium maturity	25	4,43	12.1	35.2	30	68.2	10.5							
Maize Stover	80	4,44	4.3	3.8	44	72.9	6.5				0.19	0.14		
Barley Straw	90	4.51	4.3	42		59	1.9	0.3			0.07			
Wheat Straw	90	3.14	3.6	27	50	80	7.8	0.18			0.05			
Lucerne, Fresh	16	6.45	22.9	18	28	39	11.5	1.82	0.33		0.33			
Lucern Hay	85	4.27	16	32	37.4	52.8	8.1	1.4			0.24			
Desmodium	22.3		18.3	30	43.2	71.4	11	1.27						
Leucaena			21.6		36.9	49.8	10.5	2.3			0.16			
Calliandra	21.9		22.4		48	53	12				0.15			
Sesbania	23.6		19.9		23.7	32.1	14.6							
Sweet Pot Vines	10.3	7.62	17.5	15	28.4	49.7	9.3							
Sorghum Silage	28	5.53	6	28.5	38	38	9.3	0.29	0.27	0.03	0.26	0.14	0.29	27
Columbus/Sudan Silage	45	4.77	10.8	33.1	42	68	9.8	0.46			0.21			
Lucerne Fresh (M)	20	5.53	18	24	32	43	8.6	1.41	0.33	0.14	0.22	0.28	0.16	11
Banana Pseudostem	6	7.16	6.8	20.5	40.5	58.7	11.5	1.16						
Rice Straw	88	3.98	6	34			21.4							

Feed name	DM%	NEM MJ/kg	CP%	RUP%	RDP%	CF%	ADF%	NDF%	Ash%	Ca%	Na%	P%	S%	Cobolt ppm	Copper ppm	Selenium ppm
Maize Bran	91	6.82	12			12	17	51	3	0	0	0.2	0.08			
Maize Germ Cake	91	7.12	14			15.2	17	51	7	0.08	0.1	0.5	0.4	0.08	30	1.1
Maize grain	89	8.12	10	5.2	4.8	2.6	3	9	1.6	0.03	0.03	0.29	0.12	0.05	4	14
Maize Germ meal	91	7.49	16			10	17	51	7	0.04	0	0.15				
Sorghum grain, ground	89	8.79	10.5	55		2	6	17	4	0.05		0.3	0.14			
Millet grain	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Brewers grains	21	6.36	25.4	12.4	12.9	14.9	23	42	4.8	0.33	0.23	0.55	0.32	0.1	23	0.76
[illegible] grain	89	7.99	13.4	3.61	9.78	8	11	23	3.6	0.05	0.02	0.37	0.18	0.1	9.1	0.22
Wheat Pollard	88.6	7.53	16.5			5	13	44	2.8	0.23	0.24	0.9	0.24	0.23	21	2
Wheat bran	1.81	6.15			12.5		18.9		7.7	0.13	0	1.4				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dairy Meal	90.2	7.79	15.6			12.2	12.3	25.2	7	0.6		0.45				
Cotton Seed Cake	[illegible]	[illegible]	32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Sunflower [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Soya beans whole	88	9.59	40	28		9	11	15	5	0.27		0.64	0.34			
Soya cake	93.5	8.79	42	6.3	35.7		6.6			0.29	0.03	0.68	0.37	0.2	24	66
Fish meal - Omena	90	8.29	50	24	16	2				0.14		3.2		0.14	9	2
Fish meal - Mbuta	88		27		25											
Cane Molasses	[illegible]	[illegible]	[illegible]						8.3							

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Vitamins

Vitamins in ruminant feeding

While all the different vitamins are essential for all livestock, under most conditions only vitamin A needs to be given attention in ruminant feeding. Carotene and/or Vit A can be stored in the liver and body tissues during periods of high intake and used during periods of low intake. Vitamin A is found in green plants, carrots and other feed stuff.
Vitamin B is usually synthesized in the rumen of ruminants.For other animals it is beneficial to include small amounts of feed from animal origin to supply vitamin B12, as this vitamin is only found in animal products. Vitamin C will most of the time be enough in the green roughages eaten by ruminants , but non-ruminants will need access to green vegetation or vegetables to cover their vitamin C needs. Vitamin D gets produced when animals are exposed to direct sunlight, for which reason it is always advisable to give livestock a chance to spend time in the sun.

Vitamin A deficiencies in ruminants may include:

- **Reduced feed intake**
- **Slow weight gains**
- **Night blindness**
- **Swollen hocks, knees, and brisket**
- **Total blindness**
- **Diarrhea**
- **Muscular incoordination**
- **Staggering gait**
- **Reduced sexual activity**

- **Low fertility in bulls**
- **Poor conception rates**
- **Abortion in cows**

For this reason it is advisable to supplement ruminant feed with Vitamin A (or carrots if available) during periods where little green fodder is available.

Vitamins in pig nutrition

Pigs need a lot more vitamin supplements than ruminants. As for ruminants Vitamin D can be produced by the pigs themselves if they are given a chance to spend time in direct sunlight. This does not always happen in today's pig production. So recommendations for vitamins to pigs look as follows:

- **Vitamin A: Add 2-3 % good quality Lucerne meal or similar (such as dried crushed comfrey or amaranth leaves) to the normal pig rations. Another alternative can again be carrots if cheap enough and available.**
- **Vitamin D: Try to expose the pigs to sunlight. If this is not possible addition of Vitamin D supplementation is needed.**
- **Riboflavin: This is found in Lucerne meal, green plants, fish meal or milk products. If none of these are used in the pig feed, supplementation with riboflavin is recommended.**
- **Niacin: As most feeds are short of this vitamin, supplementation is recommended. Some good sources of Niacin include: rice and wheat bran, sunflower meal, brewers yeast and fish meal.**
- **Pantothenic Acid: Supplementation recommended with for example rice or wheat bran, rice polishings, sunflower meal, Lucerne meal, fish- or peanut meal, brewers yeast.**
- **Vitamin B12: This vitamin is only found in animal products such as fish meal, blood meal, or for open range pigs and poultry: insects, grubs, etc. If your pigs are mostly fed on soya meal for their protein, a small addition of fishmeal will be beneficial.**
- **Choline: Is usually sufficient in pig rations.**
- **Vitamin E: Effective vitamin E utilization is dependant on adequate selenium, and selenium**

is sometimes deficient in feed from some areas. If selenium content of feed is a problem also the production of vitamin E will be a problem. Ask advice on Vitamin E from your livestock nutritionist.

The values in table 5 for vitamin content of feed stuffs, should only be used as guidelines, as vitamin content depends on weather conditions where the crops are grown. However it can be seen which crops are able to produce the various essential vitamins

Table 5: Vitamin content of some feeds - American values (From Cullison 1987) as Kenya values are not available. It is assumed that similar products in Africa do not differ substancially in Vitamin composition, so the values indicated can be used when choosing which ingredients to balance your feeds from.
Alfalfa = Lucerne, Copra meal = coconut meal, Corn = Maize

Essential amino acids in some important feeds

Alfalfa hay,

Feed Name and Description	Carotene mg/kg	Vitamin D_2 IU/kg	Vitamin E mg/kg	Vitamin K mg/kg	Biotin mg/kg	Choline mg/kg	Folic Acid (Folacin) mg/kg	Niacin mg/kg	Panto-thenic Acid mg/kg	Ribo-flavin mg/kg	Thiamine mg/kg	Vitar B_6 mg/
Corn germ meal	2.0	—	94.0	—	0.24	1,785.0	0.2	33.0	4.6	4.2	4.9	6.
Corn gluten feed	7.0	—	14.0	—	0.36	1,684.0	0.3	79.0	15.1	2.5	2.2	14.
Corn gluten meal	18.0	—	34.0	—	0.20	391.0	0.3	55.0	11.2	1.8	0.2	8.
Corn grain	3.0	—	25.0	0.2	0.08	567.0	0.3	28.0	6.6	1.4	3.8	5.
Cottonseed meal, mech. extd, 41% prot.	0.0	—	35.0	—	1.19	2,965.0	2.3	38.0	11.2	5.7	7.0	5.
Cottonseed meal, solv extd, 41% prot	—	—	17.0	—	1.06	3,056.0	1.5	45.0	15.0	5.2	7.3	6.
Feather meal, hydrolyzed	—	—	—	—	0.05	962.0	0.2	23.0	9.7	2.1	0.1	3.
Fish meal menhaden, mech extd	—	—	13.0	—	0.20	3,398.0	0.2	60.0	9.4	5.2	0.6	5.
Fish solubles, condensed	3.0	—	—	—	0.28	6,759.0	0.4	350.0	70.8	25.2	10.0	24.
Grain sorghum grain	1.0	29.0	12.0	0.2	0.42	737.0	0.2	43.0	12.5	1.4	4.7	5.
Grain sorghum grain, 8–10% prot	—	—	8.0	—	0.30	769.0	0.3	48.0	14.3	1.5	4.5	6.
Hominy feed	10.0	—	—	—	0.15	1,280.0	0.3	52.0	9.1	2.3	8.9	12.
Linseed meal, mech extd	0.0	—	9.0	—	0.36	1,962.0	3.1	41.0	15.8	3.5	4.6	6.
Meat meal, rendered	—	—	1.0	—	0.13	2,177.0	0.4	60.0	6.5	5.6	0.2	2.
Meat and bone meal, rendered	—	—	1.0	—	0.11	2,196.0	0.4	53.0	4.4	4.9	0.2	9.

Essential amino acids in some important feeds

Feed Name and Description	*Carotene mg/kg*	*Vitamin D_2 IU/kg*	*Vitamin E mg/kg*	*Vitamin K mg/kg*	*Biotin mg/kg*	*Choline mg/kg*	*Folic Acid (Folacin) mg/kg*	*Niacin mg/kg*	*Panto-thenic Acid mg/kg*	*Ribo-flavin mg/kg*	*Thiamine mg/kg*	*Vitamin B_6 mg/kg*
Milk, cow's dried	—	353.0	—	—	0.40	—	—	9.0	23.8	20.6	3.9	4.9
Milk, skimmed, dried	—	446.0	10.0	—	0.35	1,480.0	0.7	12.0	38.6	20.5	3.9	4.5
Oats, grain	—	—	15.0	—	0.31	1,116.0	0.4	16.0	8.8	1.7	7.1	2.8
Oat groats	—	—	16.0	—	—	1,264.0	0.6	11.0	15.4	1.3	7.2	1.2
Peanut meal, solv extd	—	—	—	—	0.36	2,120.0	0.7	188.0	50.7	9.8	6.2	6.9
Poultry by-product meal	—	—	2.0	—	0.09	6,451.0	0.5	50.0	11.8	11.2	0.2	4.7
Rapeseed meal, solv extd	—	—	—	—	—	7,278.0	—	161.0	8.8	6.4	1.7	8.0
Rice bran, with germ	—	—	66.0	—	0.47	1,357.0	2.4	330.0	25.2	2.8	24.7	—
Rye grain	0.0	—	17.0	—	0.06	479.0	0.7	21.0	9.1	1.9	4.2	2.9
Safflower seed meal, without hulls, solv extd	—	—	1.0	—	1.82	3,543.0	1.7	24.0	42.7	2.6	4.9	12.4
Sesame seed meal, mech extd	0.0	—	—	—	—	1,655.0	—	20.0	6.4	3.6	3.0	13.4
Soybean seed, heat processed	—	—	—	—	0.32	—	3.9	24.0	17.4	2.9	—	—
Soybean meal, solv extd, 44%	0.0	—	3.0	—	0.36	2,915.0	0.7	31.0	18.2	3.2	6.2	6.7
Soybean meal, dehulled, solv extd, 49%	—	—	3.0	—	0.36	3,054.0	0.8	24.0	16.4	3.2	3.4	5.5

Essential amino acids in some important feeds

Feed Name and Description	Carotene mg/kg	Vitamin D_2 IU/kg	Vitamin E mg/kg	Vitamin K mg/kg	Biotin mg/kg	Choline mg/kg	Folic Acid (Folacin) mg/kg	Niacin mg/kg	Panto-thenic Acid mg/kg	Ribo-flavin mg/kg	Thiamine mg/kg	Vitami B_6 mg/kg
Sunflower seed meal, without hulls, solv extd	—	—	12.0	—	—	4,430.0	—	288.0	43.9	4.2	3.4	14.8
Tankage, rendered	—	—	—	—	—	2,391.0	1.7	40.0	2.8	2.4	0.4	—
Triticale grain	—	—	—	—	—	514.0	—	—	—	0.5	—	—
Wheat bran	3.0	—	21.0	—	0.32	1,797.0	1.6	268.0	33.5	4.6	7.9	9.6
Wheat shorts, flour by-product, less than 7% fiber	—	—	61.0	—	—	2,050.0	1.9	121.0	25.3	4.7	21.7	8.2
Wheat germs, ground	—	—	160.0	—	0.24	3,468.0	2.4	81.0	22.8	6.8	25.8	12.9
Wheat grain	0.0	—	17.0	—	0.11	1,085.0	0.5	64.0	11.4	1.6	4.8	5.6
Whey, dried	—	—	0.0	—	0.38	1,921.0	0.9	11.0	49.6	29.4	4.3	3.6
Yeast, brewers, dried	—	—	2.0	—	1.08	4,227.0	10.3	482.0	118.4	38.1	99.2	39.8

Essential amino acids in some important feeds

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Fiber requirements and Water

Fiber Requirements

Domestic livestock require varying amounts of dietary fibre. Usually the fast growing animals such as broilers and piglets are fed a low fibre diet in order to be able to eat enough calories and protein for fast growth. This is however expensive, and it can be argued, results in lower quality meat production. Such low fiber diets also makes the animals susceptible to diseases, which has resulted in many feeds being added antibiotics as a preventative. Addition of antibiotics in animal feed has again led to traces of antibiotics in their meat, and the development of antibiotic resistant human disease bacteria, as humans are the ultimate consumers.

For animals to lead a healthy life, they must consume enough dietary fibre to keep the stomach/

rumen healthy and functioning. Higher fibre diets are healthier, as also humans are starting to realize. However there are limits; too high content of fibre (lignin, dry cellulose) will fill the stomach without bringing enough nutrients along. Various livestock species have different adaptabilities to high fibre diets.

Water

Water is a necessary compound of plants and animals. Growing plants contain 70-80% water and animals contain 70-90% water. Water has several important functions in the animal body such as regulation of body temperature, carrier of nutrients, regulation of tissue structure etc.Water is needed to make saliva for swallowing feed and for chewing the cud, for feed to be digested, to cool the body when it is too hot and to remove waste materials from the body in the urine and faeces. In addition a milking cow needs water for milk production. Lack of water will kill an animal faster then lack of any other nutrient. Lack of sufficient amounts of water or poor quality water will seriously reduce animal performance.

Cattle:

It takes 5 litres of water to produce 1 litre of milk. Ideally, water should be available to dairy cattle at all times. If this in not possible, a rule of thumb is to supply 1litre of water for every 10 kg of live-weight of the cow plus 1.5 litres of water per 1 litre of milk produced.

The amount of water dairy cattle will drink is influenced by the quantity of dry matter ingested, composition of the diet, characteristics of the water, environmental temperatures and physiological state of the animal. Table 6 shows water requirements for dairy cows at different ambient temperatures based on dry matter intake requirements for production of 20 kg milk per day (NRC, 1988)

Table 6:

Water requirements for dairy cattle

Temperature °C →	5	10	15	20	25	30	35
Dry matter intake (Kg)→	4.4	4.6	4.8	5.0	5.2	5.4	5.6
Live-weight (kg)							
350	59.4	62.1	64.8	67.5	70.2	72.9	75.6
400	63.8	66.7	69.6	72.5	75.4	78.3	81.2
450	68.2	71.3	74.4	77.5	80.6	83.7	86.8
500	70.4	73.6	76.8	80.0	83.2	86.4	89.6
550	74.8	78.2	81.6	85.0	88.4	91.8	95.2
600	77.0	80.5	84.0	87.5	91.0	94.5	98.0

Feed additives

A feed additive is defined as a feed ingredient of non-nutritive nature that stimulates growth or other type of performance or improves the efficiency of feed utilization or that may be beneficial in some manner to the health or metabolism of the animal. Examples of feed additives for dairy cattle are anti-helmintics (Dewormers), anti-bloat agents, rumen buffers (NaHCO3, MgO), flavouring agents (Molasses), rumen microbes for fibre digestion (Yea sac) and growth promoters or hormone-like substances. In Kenya, feed additives are not commonly added to dairy cattle rations

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Feed quality

At farm level, dairy cattle are exposed to many feeds, with diets varying in different regions and farming systems. The productivity of a dairy system is highly dependent on the quality of feeds. This is because the feed quality determines the intake and availability of ingested nutrients for utilization by the dairy cattle. Consequently, farmers are not only faced with the problem of knowing the quality of the feeds but also the factors that influence the quality. The objective of

this chapter is to provide highlights of information about quality indicators of cattle feeds and backgrounds of some measurements of feed quality often encountered in dairy industry. The highlights include physical indicators and some scientific feed evaluation methods that can be employed to determine feed quality.

Physical indicators of feed quality

The physical nature of the feeds can pose serious limitations to efficient utilization of a feed or a ration comprised of several feed resources. However, the influence of physical attributes of feeds on quality is often ignored. Some of the physical aspects that can limit the quality and utilization of feeds in dairy production are briefly discussed:

Stage of growth

Vetch (Vicia villosis) harvesting at the right stage of growth

The nutritive quality of forages varies as they grow towards maturity. Consideration of the stage at which both biomass yield and nutrient content are optimal is therefore important. After attainment of maturity, the forages generally depreciate in nutritive value. This is mostly due to increase fibrous material, particularly lignin. For many forages, the leaves die off systemically after attainment of maturity, and this reduces photosynthetic activities. As a result, there will be reduced accumulation of nutrients. These factors are important to be considered e.g. when harvesting forage for conservation as hay. For instance, when making hay from grass (e.g. Rhodes grass) and legumes (e.g. Lucerne) it is generally advisable that cutting be done at the onset of flowering upto the time of 50% flowering. For a vegetatively propagated forage such napier grass, cutting height is the most important physical consideration for quality. Studies have shown that optimum harvesting height for Napier grass range between 50-60 cm (dry season) and 130-140 (rainy season).

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Texture

Grass exhibiting difference in quality due to the impact of texture

Grass exhibiting difference in quality due to the impact of texture

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The physical/textural changes which occur as forages grow can impact on palatability, intake and animal digestive physiology. For instance, high intake of succulent young forages (e.g. Lucerne, vetch and Comelina spp) may cause bloat. At young stage the dry matter (DM) content of some forages can be very low (e.g. sweet-potato vines and napier grass), and this can limit the adequate intake of dry matter to support the desired level of production. The palatability can be compromised as the forages age because of increase in toughness. This can further complicate issues if some species and classes of livestock e.g. young ones are unable to consume old and tough forages or parts of.

Ratio of stem and foliage

It is important to have knowledge of the nutritive attributes of the various morphological

components of the individual forages. The leaf is in most cases the most nutritive component, hence the need to consider the utilization of a forage when the biomass yield and leaf:stem ratio are optimal.

Processing

Where the cattle are stall fed, the particle size may play an important role in selection, intake and digestibility. For instance, the chop length of ensiled maize stovers have been shown to influence the selection where leafy parts are consumed more and the overall intake is reduced with increase in chop length. Also, where different feed resources are to be mixed, the particle size must be considered to enable homogeneity in mixing.

Some ingredients necessary in the diets may not be in appropriate physical/textural form for cattle intake. Generally, cattle do not prefer powdery or finely processed feeds. Also, feed resources like molasses (semi-liquid) need to be mixed appropriately with a carrier feed. Some feed additives or supplements are better provided in pellet or lick block forms e.g. calf pellets and mineral licks.

Appearance and Colour

Generally, feeds have typical appearance, which the farmers are or should be familiar with. The appearance can be an important attraction to both farmers and animals. Deviation from the typical appearance should be taken seriously as this may have implication on quality. The colour of specific feed resources can be good indicators quality. Thus feed users need to know the typical colour of feeds so that when there is deviation from the norm, precaution can be observed. For most forages, green colour is a good indicator of quality. For instance, greenness may depict good growing conditions, hence abundance of nutrients. It may also indicate absence of diseases, pests and parasites. Appropriate colour can be used by farmers to judge the stage of harvesting.

Freshness

Freshness of the feeds can be indicated by e.g. colour, smell and/or presence of mould. Generally, the cattle intake will be negatively affected as the feed deteriorates in freshness. Consumption of stale feed can harm the cattle due to toxicity.

Mould infested maize stovers as a result of poor conservation practice.

Presence of visible undesirable objects is also a good pointer to poor quality. The foreign bodies may include pieces of glass, polythene, nails and metals and wood particles or rodent faeces. Visual inspection of feeds should not be neglegted, because this can lead to harmful or at worse fatal consequences for the animals being fed.

Mould infested maize stovers as a result of poor conservation practice.

Dairy meal contaminated with foreign objects.

Dairy meal contaminated with foreign objects
© JO Ouda, Kenya

Acceptability

Cattle, like most animals have natural instinct of preference. It is therefore possible that a good feed may be rejected because it unfamiliar. On other hand, rejection of certain feeds can be a good indicator of hidden factors which should be identified and eliminated to improve the intake. In this regard, it may be dangerous and unethical to provide such a feed in mixtures where the cattle are forced to consume it. It is therefore necessary to ascertain the factors causing rejection and the benefits of such a feed before its use.

Negative symptoms after feeding

Cattle may consume feeds normally, but there can be negative symptoms shown as result of the consumption of certain feeds. These may include diaorrhea, abnormal water intake, bloat, poor appetite, non-typical or unpleasant smells in products (e.g. milk) and excreta and of discomfort. Appropriate action must be to ascertain the quality aspects of the feed concerned when such negative effects are noted.

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Formulation of balanced dairy cattle rations

Dairy cattle production in Kenya is a serious business. However, in most cases dairy farmers are not able to meet family needs because of low profit margins. Inadequate nutrition is a major cause of low live-weight gains, infertility and low milk yields in dairy cattle. About 50-70 % of cost of dairy production is made up of cost of feeds.

Poorly nourished dairy cow and dairy cattle showing good nutrition status.

Good dairy cattle feeding practices can be implemented with due regard to different nutrient requirements for the various classes of dairy stock in order to avoid either overfeeding or underfeeding of the dairy cattle and hence wastage of scarce feed resources. Balanced dairy cattle rations can be formulated using various methods (Pearson square, simultaneous equations, least cost formulation using computer models). Although use of the methods give more accurate and reliable dairy cattle rations, the methods are a bit complicated and for some farmers may need the assistance of the local livestock Production Officer.

Dairy cattle feed requirements

General nutritional requirement for livestock is listed under chapter Principles of Animal Nutrition.

Tab. 6 Estimation of live-weight of dairy cattle using chest girth measurements

Calves		Heifers		Cows	
Girth size (cm)	Live-weight (kg)	Girth size (cm)	Live-weight (kg)	Girth size (cm)	Live-weight (kg)
45	15	108	112	172	420
47	17	110	118	174	435
49	19	112	124	176	451
51	21	114	130	178	467
53	23	116	137	180	483
55	25	118	143	182	500
57	27	120	150	184	516
59	29	122	158	186	534
61	31	124	166	188	552
63	33	126	174	190	570
65	35	128	182	192	590
67	37	130	190	194	610
69	39	132	198	196	631
71	41	134	206	198	653
73	43	136	214	200	675
75	45	138	222	202	697
77	47	140	230	204	720
79	49	142	239	206	
81	51	144	248	208	
83	55	146	256	210	
85	59	148	264	212	
87	63	150	272	214	
89	67	152	280	216	
91	71	154	290	218	
93	75	156	301	220	
95	79	158	313	222	
97	83	160	325	224	
99	87	162	353	228	
101	92	164	366	230	
103	98	166	378	232	
104	103	168	392	234	
106	106	170	406		

Dairy cattle feed requirements depend very much on their size and stage of production. Whereas most farmers do not have access to weighing scales that can weigh animals, a system has been developed whereby the weight can be determined by chest measurements using a simple measuring tape available everywhere.

Live-weight of dairy cattle

The amount of feed which will provide adequate nutrients to animals will depend on their body size (live-weight). Table 6 gives data which can be used by farmers to estimate live-weight of their cattle from girth measurements

Animal nutrition and feed rations

Kenya

Maximum dry matter intake

Animal feedstuff can be divided into two major components namely dry matter and water. The dry matter component consists of organic and inorganic matter. The organic matter consists of carbohydrates (source of energy), lipids and fats (source of energy), protein and vitamins. The inorganic matter is the source of macro- and micro-minerals. Since all nutrients are contained in the dry matter the animal must consume this portion in adequate amounts to obtain the required nutrients.

If a feed is high in moisture, the animal may not be able to consume enough of the feed to obtain the required nutrients due to limitation of rumen space. Table 9 shows the maximum dry matter intake by dairy cattle of various live-weights.

Dairy cattle under stall feeding; feed intake must adequately supply desired nutrients.

Table 7 Estimated maximum daily dry matter intake by dairy cows (kg)

	Cow live-weight (kg)					
Milk yield	350	400	450	500	550	600

(4% Butter-fat)						
10	10.5	11.0	11.5	12.0	12.5	13.0
15	12.0	13.0	13.5	14.0	14.5	15.5
20	13.5	14.5	15.5	16.0	17.0	17.5
25	15.0	16.0	17.0	17.5	18.5	19.5
30	16.5	17.5	19.0	19.5	20.5	21.0
35	19.0	20.0	20.5	21.0	22.0	22.5
40	21.0	22.0	22.5	23.0	24.0	24.5

Maximum dry matter intake may also be estimated from the following equations:
Maximum daily Dry matter intake (kg/cow) = 0.025 (Live-weight in kg) + 0.1 (Kg of daily milk yield) or 3.0 ? - 3.5 % of live-weight of cow (MAFF, 1975).

Nutrient requirements for maintenance

The nutrient requirements for maintenance of animals are influenced by their live-weight, activity (e.g. walking long distance) and environmental temperature (too cold or too hot). Table 6 shows nutrient requirements for maintenance of dairy cattle of various live-weights (NRC, 1988).

Table 8 Daily nutrient requirements for maintenance of a dairy cow

Cow live-weight (kg)	ME Energy (MJ)	Crude protein (g)	Calcium (g)	Phosphorus (g)
350	45.5	294	14	10
400	50.3	318	16	11
450	54.9	341	18	13
500	59.4	364	20	14

550	63.8	386	22	16
600	68.1	406	24	17

Nutrient requirements for growth

The amount of nutrients required by an animal is equal to the nutrients in the tissue gained. Nutrients concentrations in deposited tissue are influenced by the animal rate of weight gain and the stage of growth or live-weight. The nutrients required for growth by dairy cattle of various live-weights are given in Table 11 (NRC,1988).

Table 9

Daily nutrient requirements for growth of dairy cattle

Live-weight (Kg)	Daily gain (g)	ME Energy (MJ)	Crude protein (g)	Calcium (g)	Phosphorus (g)
Calves					
25	200	8.4	84	6	4
30	300	11.3	112	7	4
50	500	27.2	315	10	6
75	600	33.4	387	14	8
Heifers					
100	400	26.5	386	15	8
100	500	29.0	422	16	8
100	600	31.5	458	17	9
150	400	35.1	518	18	10
150	500	38.2	575	18	11
200	400	43.5	598	19	13
200	500	47.1	648	20	13
250	400	51.7	629	21	15
250	500	56.0	682	21	16
250	600	60.4	753	22	16
300	400	60.2	761	22	16
300	500	65.2	824	23	17
300	600	70.1	888	23	17
350	400	69.1	909	23	17
350	500	74.8	985	23	18
350	600	80.7	1062	24	18
400	400	78.5	1078	24	18
400	500	85.2	1169	24	19
400	600	92.0	1263	25	19
450	400	89.0	1276	27	19
450	500	96.7	1387	28	19
450	600	104.6	1500	28	19
Lactating cows					
4.5	1000	35.8	320	-	3.5	-	2.1

Nutrient requirements for milk production

When feeding a dairy cow the aim should be to maximize milk yield by meeting cow?s feed requirements. Requirements for milk production will depend on the amount of milk produced by the cow, energy content of milk which is indicated by fat content (the higher the fat content the higher the energy required).

Table 10 Nutrient requirements for production of 1 kg of milk of various butter fat contents

Milk BF (%)	ME Energy (MJ)	Crude protein (g)	Calcium (g)	Phosphorus (g)
3.0	4.5	78	2.7	1.7
3.5	4.8	84	3.0	1.8
4.0	5.2	90	3.2	2.0
4.5	5.5	96	3.5	2.1
5.0	5.9	101	3.7	2.3
5.5	6.2	107	3.9	2.4

In addition to nutrient requirements for milk production nutrients will also be required to cater for other functions such as reproduction (pregnant cows require more to cater for growth of

calf) and growth rate if she is not mature (in case of first calf cows).

Ration formulation guidelines

Dairy farming is a serious business and therefore farmers need to make profit in order to meet family needs. Feed rations fed to dairy cattle either originate from the farm or are purchased. In order to minimize feed wastage and to overcome the problem of low levels of production, dairy rations need to be efficiently utilized by the animal. A cow fed on balanced ration will utilize the feed more efficiently and hence it production will be better than a cow fed on imbalanced rations. Feed rations that are offered to dairy cows are considered balanced if they provide adequate nutrients (Carbohydrates, protein and minerals) to meet the animal requirements for maintenance, reproduction, growth and milk production.

Proportions of basal diet and supplement in a dairy cow ration

The cheapest feed for milk production is good quality roughage. However, quality of roughage fed to dairy cattle is usually low resulting in sub-optimal levels of production. Further increase in production can therefore be achieved by the use of supplements. Among the factors influencing the quantities of roughage and supplements offered are their quality and level of production of dairy cattle. Table 13 shows simple guidelines on proportions of basal diet and supplements depending on levels of milk production in dairy cattle.

Table 11: Proportion of basal diet and supplements in dairy cattle rations

Milk yield (kg/day)	Basal diet DM (%)	Supplement DM (%)
10-14	70	30
15-19	60	40
20-24	50	50
25-29	40	60

30-34	30	70
35-40	20	80

Total mixed rations (TMR's)

Dairy cattle feeding as practiced by most farmers (roughage feeding followed by concentrate feeding at milking), may not meet all the nutrient requirements of the animal. Fluctuations in rumen fermentation and supply of nutrients to the mammary glands occur when basal diet and concentrates are offered to dairy cattle at different times. This has a negative effect on productivity of the animal because requirements are met mostly for one nutrient and not the other nutrient and thus the ration is not balanced. To overcome this problem, a total mixed ration can be formulated (Tables 11 and 12).

Limitations of Total Mixed Rations

- **Lack of technical skills and knowledge by farmer and extension officers**
- **Narrow feed resource base at farm level**
- **Cost of feed ingredients, processing and mixing equipment may be high for small scale farmers**

Advantages of TMR's

- **Nutritional balanced diet is supplied to the animal 24 hours a day for maximum productivity**
- **Convenience of feeding a single meal per day**
- **Minimise selection and hence wastage of feed by the animal**

Table 12 Simple total mixed ration for a dairy cow (DM basis)

Feedstuff	%
Rhodes hay	66
Dairy meal	33

Maclick super	1
Total	100

Table 13 Total mixed ration made from several feed ingredients (DM basis)

Feedstuff	%
Napier grass	65
Lucerne hay	4
Maize germ	18
Wheat pollard	4
Soya meal	2
Cotton seed cake	6
Maclick super	1
Total	100

Proportions of energy, protein and minerals in concentrates

Concentrates are needed to promote better utilization of low quality roughage and increase dairy production. Since availability and cost of commercial concentrates are limiting factors to small holder dairy production, formulation of inexpensive home-made concentrates is a necessity. Various combinations of feed ingredients can be compounded depending upon the costs of ingredients and costs per unit protein and energy (Table 14).

Table 14 Proportion of energy, protein and minerals in concentrates for dairy cattle

Nutrient	%
Energy feed ingredient	68
Protein feed ingredient	30

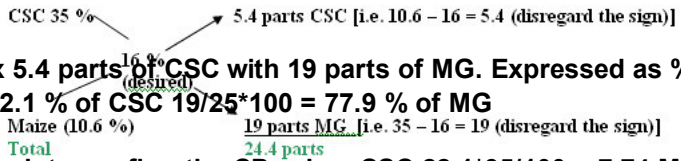
Mineral feed ingredient	**2**
Total	**100**

Table 15 Example of how to mix a high yielder home-made concentrate

Nutrient	%
Maize germ	66
Cotton seed cake	20
Poultry litter	8
Fish meal	4
Maclick super	2
Total	100

a) Formulation of rations using a single Pearson square

Assume you want to make a dairy meal with 16% crude protein (CP) using cotton seed cake (CSC) and maize germ (MG). The CSC provides 35 % CP while MG provides 10.6 % CP. Arrange the information as shown in the square below. In the middle of the square is desired value of the nutrient. On the left are the two ingredients with their nutrient content. Subtract diagonally (lesser from the larger) or disregard the sign.



Mix 5.4 parts of CSC with 19 parts of MG. Expressed as % (100 kg feed) this gives: 5.4/24.4*100 = 22.1 % of CSC 19/25*100 = 77.9 % of MG

Check to confirm the CP value. CSC 22.1*35/100 = 7.74 MG 77.9*10.6/100 = 8.26 Total 16

One ingredient must be higher in the nutrient (e.g 35 % CP for CSC) than the desired value (e.g. 16 % CP for dairy meal). The other ingredient must be lower in the nutrient (e.g. 10.6 % CP for MG) than the desired value for dairy meal. No ration can be mixed with a higher value than the highest of the ingredients or vice versa. This method balances only one nutrient from two feedstuffs at a time

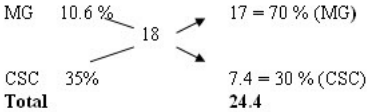
b) Formulation of rations using several Pearson square

In many instances, more than two feedstuffs and for more than one nutrient need to be balanced. A double Pearson square method may be used with four feedstuffs and two nutrients. This is accomplished using three Pearson squares.

Example: Make a ration for a lactating cow of 18 % CP and ME of 12.0 MJ/ kg DM of ME using MG (10.6 % CP and 15.5 MJ/ kg DM), Poultry litter(PL) (16 % CP and 10.6 MJ/ kg DM), Cotton seed cake (35 % CP and 13.5 MJ/ kg DM) and Soyabean meal (47 % CP and 12.4 MJ/ kg DM).

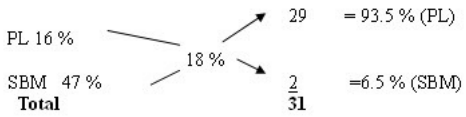
Normally, two sets of a high energy and a high protein concentrates are chosen. The first two Pearson squares are used to balance for the first nutrient in both sets. The densities of the second nutrient in either mixture are calculated. Then the two mixtures are balanced in the third set for the second nutrient.

Mix 1: CP=18 %, ME>12.0 MJ/ kg DM



Note: for ME to be >12.0 MJ/kg DM, MG must be used. For CP = 18 %, either CSC or soybean (SBM) can be used. Compute for ME in mix 1. MG (70*15.5/100) + CSC (30*13.5/100) =14.9 MJ/ kg DM

Mix 2: CP=18 %, ME< 12.0 MJ/kg DM



Compute for ME

PL (93.5*10.6/100) + SBM (6.5 *12.4/100) = 10.7 MJ/ kg DM

Mix 3: CP=18 %, ME=12.0 MJ/ kg DM Mix 1 = 14.9 1.3 = 31.0 % (Mix 1) 12.0 Mix 2 = 10.7 2.9 = 69.0 (Mix 2) Total 4.2

Calculate ingredient composition

To avoid mixing three times, calculate the ingredient composition of the final mix.

Table 16 Final mix of raw materials when two nutrients are balanced

Ingredient	Mix 1	Mix 2	Amount of Mix 1 in Mix 3	Amount of Mix 2 in Mix 3	Final composition of ration
Maize germ	70	0	31.0	0	70*31.0/100 =21.7
Poultry litter	0	93.5	0	69.0	93.5*69.0/100=64.5
Cotton seed cake	30	0	31.0	0	30*31.0/100 =9.3
Soy bean meal	0	6.5	0	69.0	6.5*69.0/100 =4.5

Table 17 Check for ME and CP

Ingredient	% In Ration	CP %	ME, MJ/kg DM	CP contribution	ME contribution
Maize germ	21.7	10.6	15.5	2.3	3.4
Poultry litter	64.5	16.0	10.6	10.3	6.8
Cotton seed cake.	9.3	35.0	13.5	3.3	1.3
Soybean meal	4.5	47.0	12.4	2.1	0.6

Total				**18.0**	**12.1**

c) Formulation of rations using an alternative procedure

If the following information is provided: A cow weighing 450 kg and producing 20 kg/day of milk (4 % butter fat) is fed on a basal diet of Napier grass supplemented with dairy meal and Maclick super. How much of the Napier, dairy meal and minerals will meet the cows requirements.

STEP 1

From table 7 estimate maximum dry matter intake for a 450 kg cow producing 20 kg of milk (4 % butter fat) = 15.5 kg

STEP 2

From table 11 estimate proportions of Napier and dairy meal for a cow producing 20 kg/ day of milk Napier grass = 15.5*50/100 = 7.75 kg Dairy meal = 15.5*50/100 = 7.75 kg

STEP 3

From tables 3 and 4 estimate nutrients supplied by the feedstuffs and from tables 5 and 6 estimate nutrient requirements by a 450 kg cow producing 20 kg/ day of milk (4 % butter fat)

Table 18 Nutrients supplied by feeds and requirements to produce 20 kg/day of milk

	DMI	ME	CP	Ca	P
	(Kg/day)	(MJ/kg)	(g/day)	(g/day)	(g/day)
Feedstuffs	**15.6**	**155.8**	**1938**	**102.1**	**64.2**
Requirements	**15.6**	**158.9**	**2141**	**82.0**	**53.0**
Difference	**0.0**	**-3.1**	**-203**	**+20.1**	**+11.2**

STEP 4

Estimate amount of feed to be fed to the cow per day Napier = 7.75*1000/180 = 43.1 kg fresh Napier With 5 % wastage allowance = 43.1 + (43.1*5/100) = 45 kg of fresh Napier Dairy meal = 7.75 = 8.0 kg Maclick = 100 g

d) Formulation of rations using computer software

Feeding standards are considered as minimum; hence the final mix should have at least the stated amounts. The Pearson square and the alternative method cannot give a least cost formulation.
Where more than two feed ingredients are available and more than two nutrients must be balanced and costs must be considered then linear programming (LP) must be used. The technique allows for simultaneous consideration of economical and nutritional parameters. The formulator must have a good understanding of the specifications and the techniques of formulation so as to enable interpretation of results.
Most of the performance drill of linear programming is a black box but it is good to know the basic concept to enable verification, interpretation and reformulation of formulas when necessary. A host of LP programs are available. In LP the fewer the constraints the more accurate are the results. But because of nutritional considerations these are necessary. However, with each additional constraint, cost of feeds increases.

Advantages of least cost formulation

- **Avail cheap supply of nutrients**
- **Avoid unnecessary costs when one ingredient's price increases**
- **Determines critical price ranges before reworking the problems**

Dairy cattle under stall feeding; feed intake must adequately supply desired nutrients.

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