

Agrodok 4

Small-scale poultry production in the tropics

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Foreword

Our Agrodok series missed, until now, a practical manual on poultry keeping in the tropics. Four students of the Wageningen Agricultural University in the Netherlands were prepared to fill that gap. They gathered the necessary information and wrote this clear booklet for practical use. We are very grateful to them for the effort and care they put into making this Agrodok.

Special thanks are due to Prof.Dr.E.H.Ketelaars, a specialist on tropical poultry keeping, for his willingness to comment on and edit the manuscript. His contribution was indispensable for obtaining the final result.

A thank you also to Jeannette Kreuger for her comments and help in finalizing the Agrodok.

Agromisa

Wageningen, May 1990

We have made some alterations to chapter 4 and 5 in this second revised edition. Hopefully this Agrodok will continue to be a help to produce your own poultry.

Chapter 4 was reviewed by Peter Hoffs.

Chapter 5 was reviewed by DIO (Diergeneeskunde In Ontwikkelings-samenwerking, Utrecht, The Netherlands).

Corrections were done by Sara van Otterloo.

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1 Introduction

This booklet is intended to serve as a manual for small-scale poultry raising in the tropics. Although poultry is raised all around the world under very different circumstances, the main objective is always the same: maximum production with as few costs as possible.

Two main forms of small-scale poultry raising can be distinguished. Subsistence poultry farming is the keeping of a small amount of poultry for home consumption. More large-scale commercial poultry farming can be a source of extra income. Two points concerning commercial poultry farming should be stressed. For a successful business a market for eggs and poultry products and a steady supply of low-cost feed must be available and guaranteed. If poultry is only kept for personal consumption, costs should be kept to a minimum while still ensuring a supply of eggs and meat. Use of locally available resources and material is important.

This manual can be of use to both beginning and experienced poultry raisers when confronted with problems which arise. The manual focuses on keeping laying chickens. Keeping broiler poultry presents different problems and requires certain expertise. Nevertheless, some attention will be given to the keeping of cocks as they also need to be fattened. The following aspects of chicken raising will be dealt with in this booklet.

Two possibilities of replacing chickens will be considered.

- On subsistence farms the breeder maintains the level of the chicken population himself.
- New chicks or mature birds are regularly bought elsewhere.

There are different possibilities for housing poultry. These will be discussed briefly, including as many advantages and disadvantages as possible to help the reader make a choice.

On subsistence farms, feed for the birds will usually not be optimal. However, there are possibilities for raising production while keeping feed costs as low as possible. Chicken-feed can be bought elsewhere. A balanced composition of the feed is important.

Chicks cannot always be bought. Therefore, a chapter on natural breeding and raising of chicks has been included.

The health of chickens is essential and requires special attention.

On all farms, especially commercial poultry farms, a simple form of business administration is essential to ensure that the correct measures are carried out.

Good farm management receives special attention throughout the booklet as it is the most important aspect of ensuring a successful business.

2 Chicken breeds

Certain chicken breeds are best for laying eggs, the so-called layers. Other breeds are better suited as broiler chickens. The latter type are usually heavier birds which grow quicker and tend to have more muscle.

Among the group of layers, light breeds such as the white chickens (White Leghorns) can be distinguished from the heavier breeds. The latter ones are meatier but still lay many eggs.

White Leghorns are known to lay a large amount of white eggs. Besides this, they need less feed due to their small size. White Leghorns can therefore be considered very efficient layers, but at the end of the laying period they give relatively little meat.

The heavier breeds are better for dual-purpose production: production of eggs and of meat. In general, these chickens have brown feathers but this can vary per breed. They lay brown eggs. Heavier breeds are very suited to small-scale chicken raising in the tropics. They are usually sturdier than the light breeds.

Besides White Leghorns there are other layer breeds, such as the brown-coloured Rhode Island Red and the light-brown New Hampshire. Nowadays, hybrids (the result of cross-breeding) are common. These hybrids are much more productive and are the result of combining special strains of chickens raised for this purpose. In Third World countries cross-breeding between pure breeds is also common, such as White Leghorn crossed with Rhode Island Red.

Medium-weight and heavy chicken breeds are raised for meat production. These breeds can quickly reach a high slaughter weight when given plenty of good quality feed. It has been mentioned that raising broiler chickens requires special skills, and it is usually the supply of high quality feed which presents problems. Nevertheless, cocks of the medium-weight chicken breeds can be kept for slaughtering.

2.1 Local breeds

If you want to breed your own stock of chickens you cannot use the hybrids mentioned above. If you continue to breed with hybrid chickens, their high productive characteristics will diminish. You can only get high production with hybrids if you buy new chickens regularly. If you want to breed your own chicks it is advisable to use local breeds which are often much cheaper.

Another advantage of local chicken breeds is that they are better adapted to local conditions than hybrids. They will suffer less from local diseases than the more fragile hybrids. However, local chickens are less productive. Local chickens in rural areas of the Third World lay about 50 eggs per year, while modern hybrids can lay 250-270 eggs a year under excellent conditions. Local breeds are usually lighter and their eggs are smaller. Local chickens are more suitable to be kept around the home as they make better use of garbage than hybrid chickens.

There are different ways to reach medium to high levels of production with local breeds. These will be discussed further on in the booklet.

2.2 Choosing a chicken breed

Several factors are important when choosing the best breed of chickens for your situation.

Price

The price will determine your choice. Modern hybrids are very expensive. They also need very good care and require high quality and balanced feed to be able to produce efficiently and well. Local breeds are cheaper and better adapted to local circumstances. With adequate care they are reasonably productive. However, if you want to raise chickens on a larger scale and decide to buy balanced feed, it is better to choose the more expensive hybrids.

Market situation

The local market situation is important to consider. Medium-weight hybrids should only be chosen if the market situation is excellent. A

good market for eggs and meat and a steady supply of good, balanced chicken-feed must be available. If you want to concentrate on selling eggs, you can consider buying lighter (white) layers. In all other situations, the heavier (usually brown) breeds would be a better choice. If you live far from a market and mainly want to produce for home consumption, only selling extra eggs and meat locally, you are best off with a local breed.

Experience

If you have no experience with raising chickens, it is best to start with a cheaper, local breed.

Farm management

If farm management is good, you can decide to buy the more expensive hybrids which can then be more profitable.

Local preferences

In some countries brown eggs are preferred.

Locally available breeds

Hybrids are not always locally available and you are dependent on what can be obtained in your area.

3 Housing

Although chickens can be kept in many different ways, there are two main forms: extensive and intensive. On extensive chicken farms the level of capital and labour investment in the farm is low. The best known example of this type of farming is free-range chicken farming, in which the chickens are free to roam on the farm grounds. On intensive chicken farms more capital and labour are invested in housing and extra facilities. All housing systems with special poultry houses (with or without roaming facilities) belong to this category.

3.1 Free-range chickens

In the traditional free-range system, chickens are free to walk everywhere on the farm grounds and search for their own food. Eggs are laid outside in simple nests and are mainly used to keep the number of chickens at a certain level. In many cases, up to 75% of the eggs have to be hatched because the mortality rate among baby chicks is high. Few eggs remain for consumption and the chickens themselves do not give much meat.

The advantage of this system is that little labour is needed and that waste food can be used efficiently. Very low costs can offset low production levels so that keeping chickens around the house can be profitable if certain improvements are made.

The free-range system is most suitable if you have a lot of space, preferably covered with grass. At night, the chickens can be kept in any kind of shelter which should be as roomy, airy and clean as possible. Loss of chickens due to illness or theft can be kept to minimum in this way. If you have enough space for the chickens to roam freely, a mobile chicken house is best. One example of this type of housing is shown in figure 1. (Re)infection by parasites in the chicken faeces is prevented in a night shelter that is raised above the ground and has an open floor. Such a floor can be made of chicken-wire, wooden slats or bamboo sticks 5 cm apart. The chickens are also safe from predators in this type of shelter. If you want to collect a maximum number of

eggs, it is advisable to train mature layers to use laying nests in the chicken house at an early stage in the laying period. It is best to place the laying nests in the chicken house before the chickens start laying and to keep them in a bit longer in the morning. Remember to provide fresh drinking water.

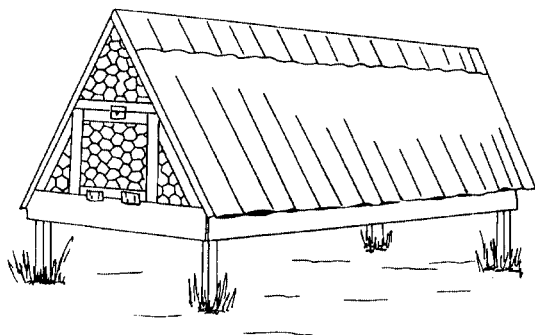


Figure 1: A simple mobile chicken house.

To limit mortality among baby chicks in the free-range system a number of measures are necessary.

- The mother hen and the chicks need a simple, separate shelter with plenty of room and air to protect them from predators, thieves and rain. The cage must have the possibility to be closed completely. Especially draught and low temperatures during the first few days are dangerous for the baby chicks. Although it is handy to have a run, it is also risky, for example due to possible infection with worms. Especially in moist weather it is important to regularly change the location of the run.

A very suitable type of mobile housing for young chicks are fold units (figure 2 and 3). These cages can house 20 young hens and contain feeders, drinkers and a perch. It is obvious that you will need enough space to move the fold units around regularly.

- In areas where dogs or predators are a problem, building a shelter well above ground level (e.g. 1.20 m high) is worth considering. Tin can be placed around the supporting poles to keep out rats and other small animals (figure 4).

- Always ensure a steady supply of fresh and pure drinking water. other small animals.
- Give your chicks extra feed including greens which are especially rich in vitamins.
- If possible, vaccinate the chicks against the most common contagious viruses, such as New Castle Disease (NCD). Make local enquiries about the nearest veterinary service.

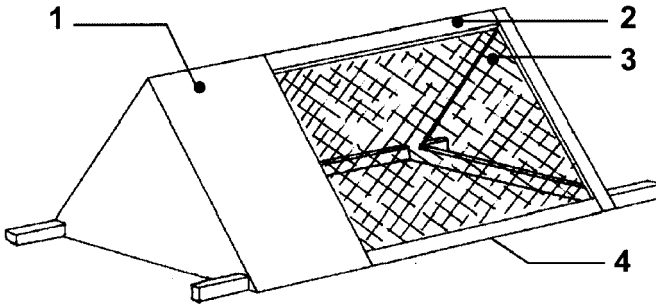


Figure 2: Fold unit for housing young chicks. 1. boarded section, 2. wooden framework, 3. wire mesh, 4. wired floor.

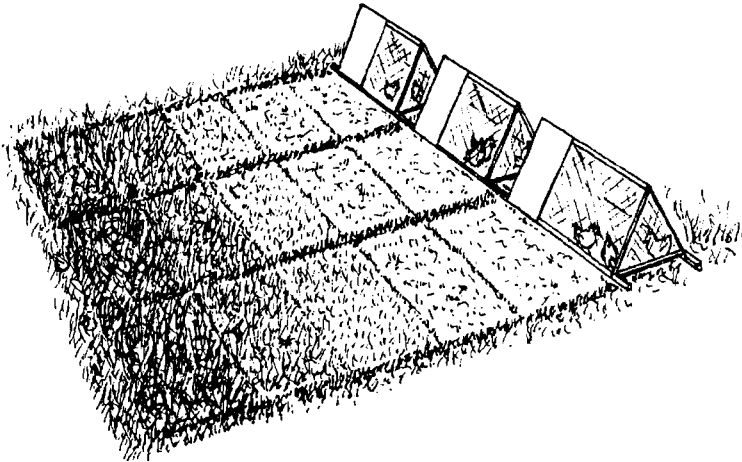


Figure 3: Systematic daily movement of fold units.

Advantages and disadvantages of the free-range system:

Advantages:

- Exercise in the open air keeps chickens healthy.
- Feed, even if it is not well-balanced, presents few problems.
- (Re)infection with parasites is minimal if enough space is available.
- Little or no labour input is needed.
- The chickens help limit the amount of rubbish in a productive way.
- Direct costs of the system are low.

Disadvantages:

- Free-range chickens are difficult to control.
- The loose chickens, especially the young chicks, are easy prey for predators.
- Chickens also eat sown seed when looking for food.
- A large percentage of the eggs can be lost if the laying hens are not accustomed to laying nests.
- Mortality rates are usually high.

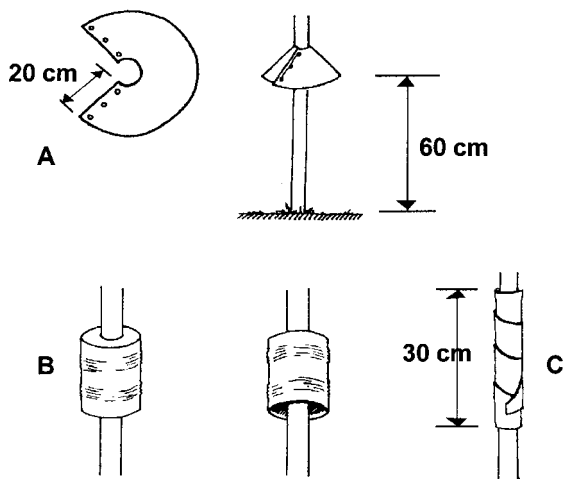


Figure 4: Examples of rat baffles. The baffle must fit tightly to keep even the smallest rodent from climbing between the baffle and the pole. A. Metal collar, B. Metal can upside down, C. Metal band around post.

3.2 Housing

If you decide to keep your chickens in a special poultry house, you will first have to consider the following aspects.

- You will make extra costs.
- You will need to make sure that the materials needed are locally available.
- You will need to choose between a chicken house with or without a run. If you choose for a house with a run, check if there is enough space to regularly change the position of the run.
- You will need to decide about continuing to breed your own stock of chickens or buying new stock. If you breed your own stock, you will need to build more houses to keep the chicks of different ages separately.

We will mention these aspects in more detail later. In any case, you will always have to design the housing taking into consideration the specific demands of the local climate.

3.3 Housing and climate

Chickens can tolerate high temperatures but some negative effects appear when they are too warm. To avoid such effects make sure of the following aspects when building a poultry house.

- If possible, build the house in an east-west direction. The chickens will be less exposed to direct sunlight.
- Place the house so that there is grass and such like around it.
- Plant trees around the house so that its roof stays in the shade.
- Make sure that the roof has a large overhang (90 cm or more) to limit direct sunlight and prevent rain from wetting the inside of the house.
- Keep the bottom 50 cm of the side walls closed and the rest open. There will always be enough fresh air in the house. Close the top part of the side walls with chicken-wire or some other suitable material.
- Build the roof as high as possible above the floor. It will then be less hot inside the chicken house and ventilation will be better.

- You could consider covering the roof against the heat, for example with leaves or some other material. However, one disadvantage of this is that pests such as rats and mice can nestle in the covering.
- Try to limit the occupancy of the chicken house as much as possible. Many birds in a small house can cause problems due to the extra warmth they create and the increased chance of parasitic infections. In case of floor housing, there should be no more than 3 chickens per square meter. In houses with wire netting or slatted floors instead of hard floors, a higher chicken density is possible.
- To stimulate feeding, turn on a light in the house before sunrise and after sunset when it is cooler. This also helps to keep a steady level of egg production.

3.4 General prerequisites for a chicken house

When building a poultry house, not only the climate is important. It is also necessary to make sure that the house is easy to clean and, if possible, easy to disinfect. For this, a poultry house will need a concrete floor. An important condition for permanent housing in closed houses is the permanent availability of feed. A constant supply of fresh water is also essential.

If the housing is to contain a large number of chickens, a separate working space in front of the house is necessary. Feed can be stored there and eggs can also be kept there temporarily. To avoid deterioration of the quality of the eggs, they should not be kept here longer than one week. It is best to keep the eggs in a cool space, at about 20°C. This can be done by keeping the number of windows in the storage space to a minimum and only ventilating at night when the air is cooler.

3.5 Some housing possibilities

There are many different kinds of housing in which to keep chickens. There are four main types:

- 1 Housing with a run.
- 2 Housing with litter and without a run.
- 3 Housing with a partial or complete slatted floor (wire netting or wooden slats)

A general description of each type of housing will be given below together with its advantages and disadvantages.

1 - Housing with a run

A chicken house with a run has one or more fenced off runs in which the chickens can roam. The run is attached to the house to which the birds have access day and night. We strongly recommend that you have more than one run so that access to the runs can be changed every two weeks. Then runs covered with grass or other vegetation get a chance to recover from the pecking and scratching of the chickens, and the risk of parasitic infections decreases. An example of this type of housing is shown in figure 5.

A second important aspect when considering a house with a run is that the run must remain dry. It is clear that the house must, of course, satisfy all other general criteria and those specified by the climate in which it is built.

Advantages and disadvantages of a limited run:

Advantages:

- The chickens can move in the open air.
- Better control is possible than with free-range chickens.
- Protection against predators is better than without fencing.
- The chance of infection is less than with permanently closed coops.
- Housing density can be a bit higher than when no run is available.

Disadvantages:

- A limited run can get too wet and increase the risk of infection with parasites.
- Predators still have a chance to get at the chickens.

2 - Housing with litter and without a run

With this type of housing the chickens stay in the house day and night. The floor is covered with litter to absorb the moisture of the chickens' faeces. The most important condition for this type of housing is that the litter must remain dry. Moist litter produces too much ammonia, which damages the health of the birds. It also encourages the development of all kinds of parasites. To keep litter dry, the following must be done.

- Use litter which absorbs moisture. Wood shavings are best but will not always be available everywhere. Chopped up straw and other materials are also suitable.
- Make sure the house is well ventilated.
- To avoid wet spots in the litter, make sure not to spill water on the floor. Preferably place the drinkers on a small elevation covered with chicken-wire.
- Litter must be turned regularly and replaced once a week.

Advantages and disadvantages of housing with litter:

Advantages:

- There is complete control over the chickens: the feed, the eggs, etc.
- The birds are well protected against predators.

Disadvantages:

- Litter cages are more expensive than a range or cages with a run.
- The risk of infection is higher.
- You are dependent on the amount and kind of litter that is available locally.

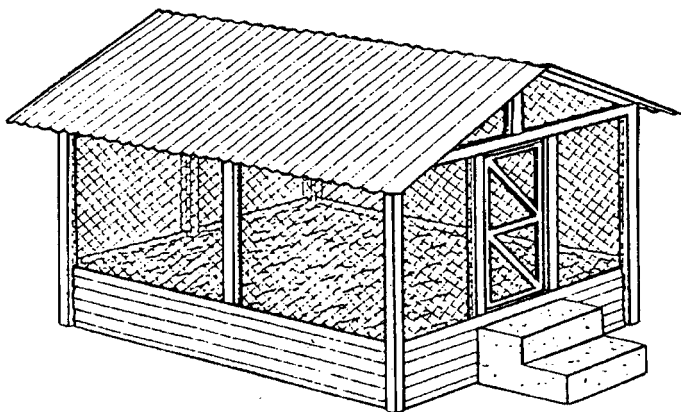


Figure 5: A deep litter house. Corrugated metal and weld mesh have been used in the construction of this house.

3 - Housing with a slatted floor

In many countries with a temperate and moist climate, a large part of the floor area is covered with slats. With slats, the risk of wet litter and therefore of parasitic infections is less. The housing density with this kind of housing can be higher, for example 5 or 7 birds per square meter instead of 3. The slats can be made of wood or bamboo. The space between the slats must be wide enough for the bird droppings to drop through but should not hamper the movement of the birds. Thin slats stay cleaner than wide slats. Slats with a width of 1.5 cm and a height of 4 cm laid 2.5 cm apart, give good results. These slats are generally laid in sections of 120 cm by 120 cm.

Instead of slatted floors, you can also use wire netting. This is usually laid in sections of 250 cm by 200 cm. The netting usually has a mesh of 2.5 cm by 7.5 cm. The wire should be about 3 mm thick. Perches are fixed onto the wire netting so that the birds can move comfortably and have a place to sleep at night.

To collect as much of the manure as possible under the open floors, the drinkers and feeders are best placed on the slats or wire. You can cover part of the floor, for example one half or a third, on both sides or

in the middle, with slats or wire netting. Sometimes the entire floor is covered with slats or wire but this can damage the feet of the chickens and cause loss of eggs.

To make regular removal of the manure easy, place netting or slats at the sides of the housing and making the space underneath easy to reach.

Advantages and disadvantages of wire or slatted floor housing:

Advantages:

- The chickens have less contact with their own manure which decreases the chance of parasitic infections.
- Housing density (birds per square meter) can be increased.
- Litter costs are lower.

Disadvantages:

- This type of housing requires a higher investment than houses with litter.
- Cleaning the housing is more work.
- There is a higher risk that the feet of the chickens will be damaged.

4 Poultry housing equipment

In all poultry housing for laying hens, drinkers, feeders, perches, and laying nests need to be installed. You can also add lighting and a system to collect manure.

4.1 Feeders

Theoretically it is not necessary to have feeders in poultry houses that have runs as the chickens find their own food. However, it can be useful to give extra feed in feeders. This can raise production, especially at times when there is less food available outside. For all other types of housing, feeders are essential. You will always lose some feed if you scatter it on the ground.

If there are only a very small number of chickens, feeders that you fill by hand are the best. They can be made in different ways. Figures 6 and 8 give examples of rectangular wooden troughs.

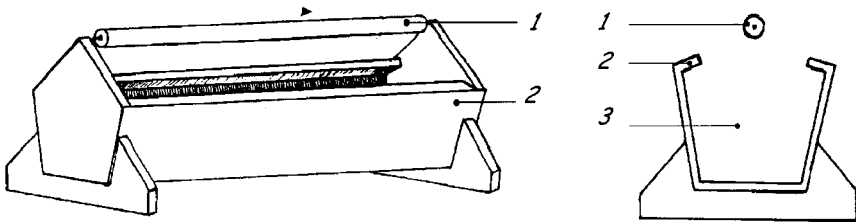


Figure 6: Through feeder on platform. 1. spinner, 2. lip, 3. trough.

There are some important considerations concerning feeders.

- Make sure that there are enough feeders. With rectangular dishes, each animal needs at least 5 cm of space along one side of a dish. This gives the birds enough opportunity to feed during the day. If all the chickens need to feed at the same time, more space is necessary: approximately 15 cm per bird. With round dishes the space per bird is considerably less (table 1).

Table 1: Space at the feeder needed for each bird in relation to its age in weeks.

Age (in weeks)	Space (in cm)	
	Rectangular dish	Round dish
0-16	4	1.5
6-18	8	3
> 18	10	4

- It is a good idea to place a stick which rotates above the feeder to prevent the birds from sitting in the feeder and dirtying the feed.
- To reduce the amount of feed wasted, put only small amounts of it in each feeder at one time. This means that you will need to feed the chickens several times a day. Another advantage of several daily feedings is that feed intake can increase. Intake is often not optimal in warm climates. For this reason it is also best not to feed at the hottest time of the day.
- Build lips around the edges of the feeders to catch spilt feed, as is shown in figure 6.
- Place the feeders at different locations in the poultry house so that it is easy for the birds to find a dish. Make sure that feeders are no more than 5 m apart.
- In housing with wire or slatted floors most, if not all, feeders should be placed on the wiring or slats.
- Although chickens seem to enjoy moist feed, it is very doubtful if this is good to give in tropical climates as wet feed will spoil quickly.

When there are more chickens, so-called storage containers can be installed. These are containers with an extra storage space so that daily feeding is no longer necessary. An example of a rec-

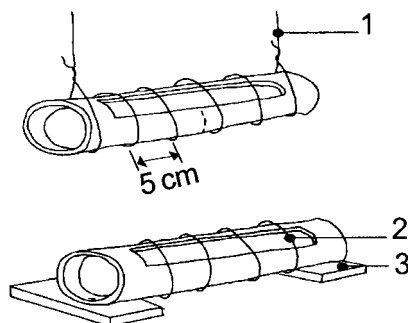


Figure 7: Bamboo feeders. 1. hanging wire, 2. wire rap, 3. wood brace to prevent tipping.

tangular wooden container is shown in figure 8. Sometimes hanging feeders are also used (figure 7 and 9).

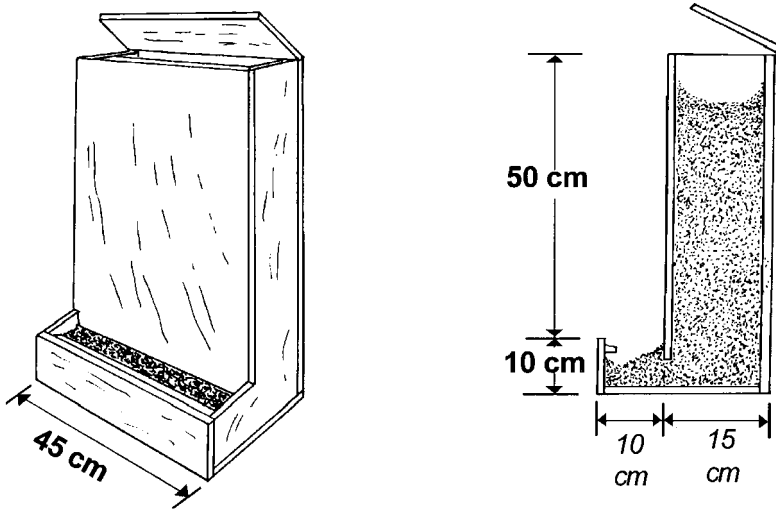


Figure 8: Rectangular wooden container.

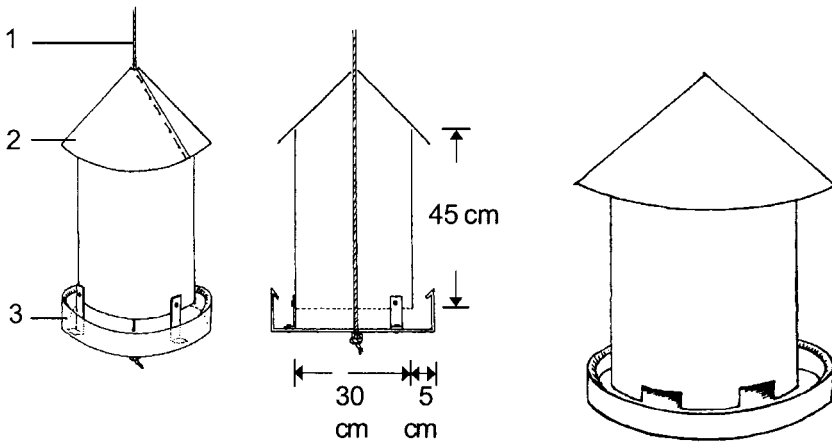


Figure 9: Hanging metal feeder. Such a feeder with a tray of 40 cm in diameter is sufficient for 10 mature layers. 1. hanging wire, 2. cover: sheet metal cone, 3. tray: sheet metal.

4.2 Drinkers

In tropical areas it is **very** important to supply enough and above all cool, clean and fresh water to chickens. There are a number of ways to do this. For small numbers of chickens, an upside-down bottle is cheap and easy (figure 10). Another possibility is buying simple round metal or plastic bowls. The advantage of a drinker with a reservoir is that water is available for a longer period of time and the chance of the water getting dirty is less.

There are some important considerations to think about when installing drinkers.

- Make sure that water is always available.
- Make sure that the water is clean and as cool as possible.
- Clean the drinkers daily.
- In litter cages, place the drinkers on a small elevation of chicken-wire to prevent spilt water from wetting the litter. If no elevation is installed, the drinkers need to be moved to a new spot every day. In all other types of housing, it is best to place the drinkers on wire or slats.
- Drinkers need to be placed at different locations in the poultry house but should not be further apart than 3 to 5 m.
- Make sure there is enough space around the drinkers (table 2).

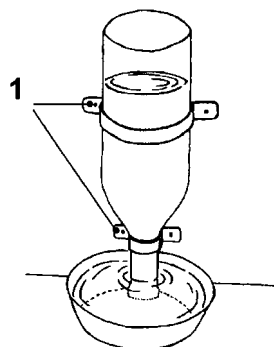


Figure 10: Upside-down bottle. Bottle is filled with water and inverted into an open container. 1. straps of leather or tin for fixing to wall.

Table 2: Space at the drinker needed for each bird in relation to its age in weeks.

Age (in weeks)	Space (in cm)
0-6	1
6-18	2
> 18	3

4.3 Perches

Chickens like to spend the night on perches in high places. During the day the more nervous birds can also quickly find shelter there. You will need to have a space under the perches which catches the bird droppings. The litter will get less moist and it is also easier to collect the manure.

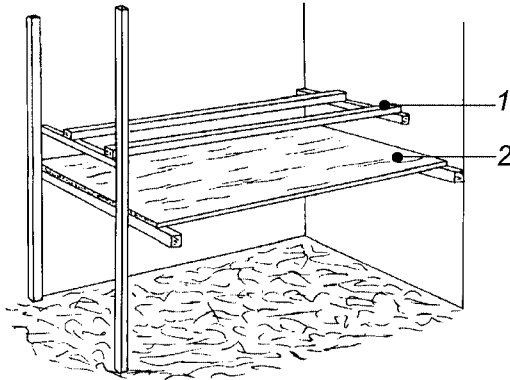


Figure 11: Perch with dropping board. 1. perch, 2. droppings board is cleaned daily.

Perches are usually made of wood and are small slats 5 cm wide and 5-7 cm long. It is best to place them about 35 cm apart. Each chicken needs approximately 15 cm (or more) of sitting space, depending on the size of the birds. Although perches are indispensable in all kinds of chicken houses, the kind of perch and its location differ per house.

In housing with litter it is a good idea to place a wooden floor under the perch to catch most of the droppings (figure 11). The manure can then be removed regularly, preferably once a week. Usually this wooden floor is installed about 75 to 80 cm above the ground, so that the perches are placed 1 m above the ground. To prevent the chickens from coming into contact with their droppings, close the front opening between floor and perch.

In cages with wooden slats, perches are not necessary. However, they should be installed if the floor is made of chicken-wire. This enables chickens to spread themselves evenly over the wire floor at night.

4.4 Laying nests

In all poultry houses except battery cages, eggs are collected by hand from nests on which one hen sits. These individual nests need to be about 30 cm wide, 35 cm long and 40 cm high. They can be made of wood or of other locally available materials, such as bamboo or hard types of grass. They need to be filled with a thick layer of litter to prevent eggs breaking. To keep the litter in the nest, make a little partition about 10 to 15 cm high at the front of the nest. Hens usually prefer to lay eggs in a protected nest like this than simply on the floor of the house (figure 12 and 13).

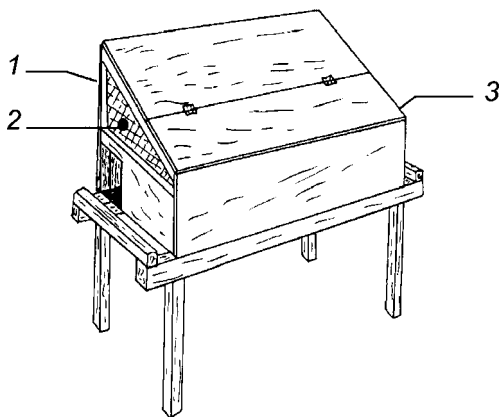


Figure 12: Laying nest. 1. wire netting back to nest box, 2. wire netting also provides ventilation at the side, 3. entrance hole also at this end.

It is best to install a sloping cover over the nest box to prevent chickens from sitting on the nests and making them dirty. Laying nests are usually placed above the ground, for example at 1 m height. You will need to place a jumping perch in front of the nests.

Nests are usually grouped together in blocks along one or more walls of the chicken house (figures 14-17). In open housing, however, we recommend placing the nests along the width of the house so that air circulation is restricted as little as possible. Floor eggs are often a big problem in litter housing and housing with slatted or wire floors. Those eggs are usually dirty and require extra work. During the first weeks of the laying period, the percentage of floor eggs will reach a maximum of 5-10% after which it should decrease quickly to 1 or 2% at the most. The following measures will help limit the number of floor eggs.

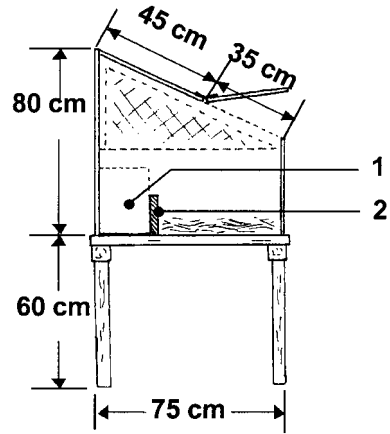


Figure 13: Laying nest. 1. peephole, 2. inner litter retaining board.

- Place enough laying nests, at least one per five laying hens.
- Place the nests on time, at least 2 to 4 weeks before the laying period in the poultry houses starts.
- Collect the floor eggs several times a day at the beginning of the laying period to discourage the hens from continuing to lay them.
- Try to disturb the roosting hens as little as possible in the morning. Later on in the day the eggs need to be collected as often as possible to prevent them from breaking.
- Keep the nests as dark and cool as possible.
- Maintain a thick and comfortable layer of litter in the nests.
- Make sure the nests can be reached easily. Remember to install jumping perches.

Communal nests which can be used by several (for example ten) hens at the same time are probably not very suitable for tropical conditions. The hens cannot get rid of their excess body heat very well.

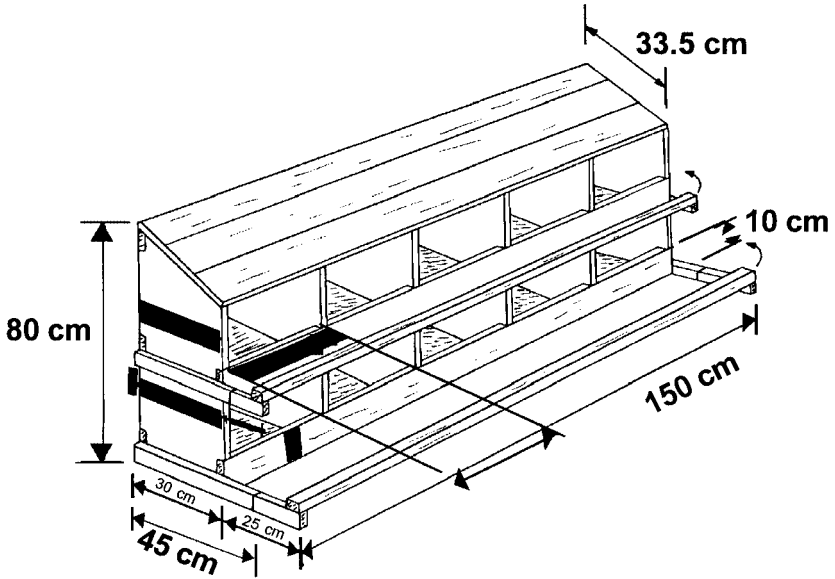


Figure 14: Laying nest. Nests to be closed with perches during the night.

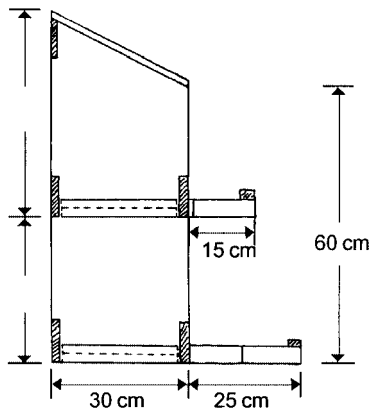


Figure 15: Laying nest. Nests to be closed with perches during the night.

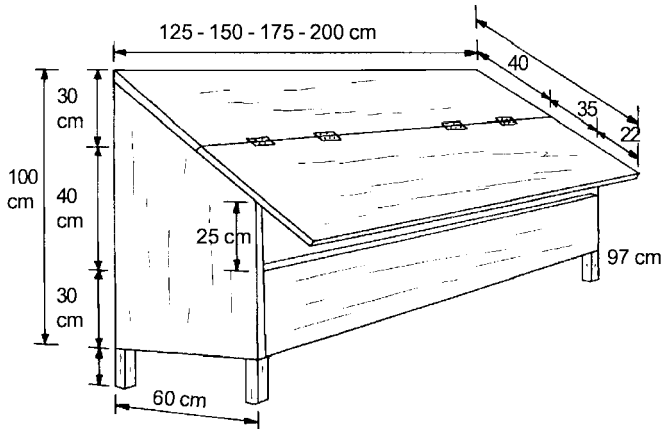


Figure 16: Community laying nest with open front and backside for ventilation.

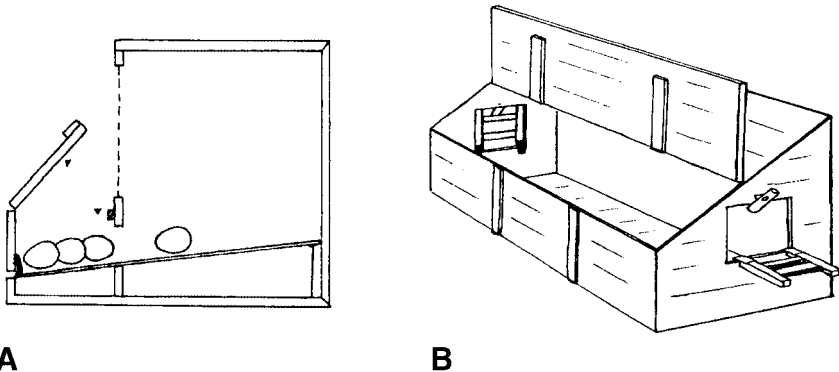


Figure 17: Different laying nests. A: roll-away nest. B: community laying-nest.

4.5 Transportation crates

To prevent chickens from dying during transportation, spacious and airy crates must be used. These crates can be made of wood or other locally available materials.

4.6 Lighting

There are two ways to try to raise the production of chickens by using artificial lighting.

- If the housing is lit in the cooler hours before sunrise or after sunset, the chickens are able to eat more.
- If the day length is increased by using artificial lighting, laying hens are encouraged to lay more eggs.

However, day length must not be increased during the growing period of the young chicks until just before they start laying. Otherwise, it can lead to a premature laying maturity. It is best to start raising the chicks at the time of year that the day length decreases. If you need to start the growing period at the time of year with lengthening days, try to artificially ensure a constant day length. Just before the laying period starts, lengthen the days by one hour a week until you have 14 hours of light per day. After production rates have reached a maximum, lengthen the amount of light per day by one hour a week until the day has 16 hours of light. Once day length has been increased from, for example, 12 to 14 hours, you will need to provide artificial light after sunset to maintain the extra day length. If you do not do so, egg production will decrease due to the shorter day length.

If you are raising laying hens in a period when the day length increases, you do not have to provide extra light to stimulate egg production. However, the hens will probably eat more if the housing is lit during the cooler periods of the day.

Regardless of the kind of light that you install, you will always need enough light intensity for it to be effective. To do this you will need to place enough oil lamps in the cage. Oil lamps need to be located in the centre of the chicken house and should be screened off with thin slats or wire gauze. Even if you hang a lamp in the chicken house, it will need to be screened off from the birds. If you have electricity, a chicken house can be lit with normal light bulbs. 40 watt bulbs need to be placed 3 m apart and 60 watt bulbs should be about 5 m apart.

5 Poultry nutrition

In this chapter we describe the nutritional requirements of chickens, but where differences between chickens and other species exist those differences will also be pointed out.

The diet of poultry must include the following essential nutrients:

- water
- energy sources
- protein (amino acids)
- vitamins
- minerals
- other ingredients

First we consider these essential nutrients. Then some attention will be paid to feeding methods and feed composition.

5.1 Water

Poultry should have a continuous supply of clean fresh water available.

A lack of water can seriously retard growth and impair egg production. This is particularly true in tropical countries where deprivation can lead to death of poultry within a very short period of time.

The body of a bird is made up of 60% water and eggs are approximately 65% water. The presence of clean and fresh water is essential so that nutrients can be absorbed and toxic materials removed from the body.

Water is also essential for the control of body temperature by the bird in a hot environment. Panting is an essential heat loss mechanism under these conditions, and lack of water quickly leads to death caused by overheating. Birds consume considerably more water at high ambient temperatures than at low ambient temperatures.

It is undesirable to restrict water intake of any bird, particularly in the tropics, where deprivation can lead to death within twenty-four hours. Even a 10% restriction in the amount of water available can reduce the growth rate and food conversion (amount of food needed per kg growth) efficiency of broilers. With layers the effect is even more devastating. Short periods of deprivation can result in moulting and cessation of egg production.

5.2 Energy requirements

The amount of energy contained in foodstuffs fed to poultry is normally expressed in units of metabolizable energy per unit weight, e.g. kilojoules per gram (kJ/g). The energy requirement of poultry is expressed in terms of metabolizable energy per day (kJ/d). The metabolizable energy refers to that portion of the food which is available to the bird for the production of meat and eggs and for the maintenance of vital functions and of body temperature (see figure 18).

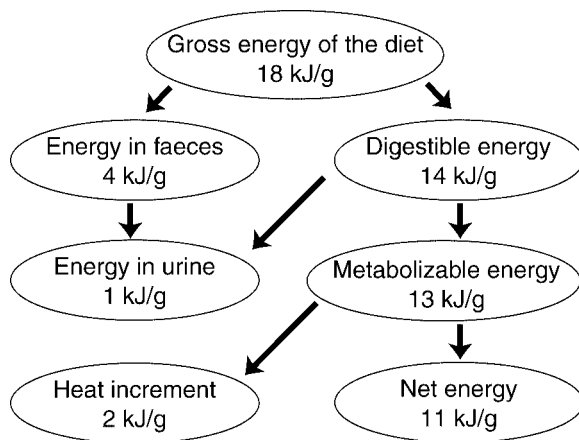


Figure 18: Energy losses between gross energy and net energy derived from the diet.

The energy in the diet is derived largely from carbohydrates but some is also derived from fat and some amino acids. In most cases poultry

are given free access to food and the birds are allowed to consume as much food as they wish. Poultry usually consume just enough food to meet their nutrient requirements. This control of intake is based primarily on the amount of energy in the diet.

Birds eat to satisfy their energy requirements. Thus, increasing the concentration of energy in the diet decreases intake, and vice versa. This is true provided the diet offers a sufficient amount of all other essential nutrients, and that bulk, texture, inaccessibility or palatability do not limit intake. Therefore, when a diet is being formulated the levels of the constituents are stated in relation to the energy content of that diet.

5.3 Protein requirements

Food containing high levels of protein are expensive to purchase, so a diet which is too high in protein is unnecessarily expensive. The excess protein is broken down and used as an energy source and the excess nitrogen is excreted as uric acid. The synthesis of protein in the body tissues requires an adequate supply of about twenty different amino acids. Ten of these cannot be synthesised by the bird and must therefore be provided in the diet (Table 3).

Table 3: Classification of amino acids.

Essential	Non-essential	Difficult to classify
lysine methionine threonine tryptophan isoleucine leucine valine phenylalanine histidine arginine	alanine aspartic acid glutamine	tyrosine ^{..} cysteine ^{...} glycine ^{...} serine ^{....} proline ^{....}

^{..} tyrosine can be formed from phenylalanine

^{...} cysteine can be formed from methionine

^{....} glycine and serine are interconvertible, but synthesis is sometimes inadequate

^{....} proline's rate of synthesis is sometimes inadequate for body functions

These ten amino acids are termed essential. Of the remaining ten, three can be readily synthesized by the body. These are called non-essential. The remaining seven are less easily classified. The quality of protein can only usefully be described in terms of the amino acids which it supplies to the bird. It is, however, still useful to specify total requirements for crude protein in addition to specifying requirements for each essential amino acid, since this will ensure that the diet contains sufficient precursors for the non-essential amino-acids. In most nutrient tables, only the percentages of lysine and methionine are given. In those cases these percentages should be regarded as a standard for all essential amino acids.

5.4 Vitamin requirements

Vitamins are often involved in enzyme systems. Unlike protein, energy and some minerals, they are required by the bird in small quantities. An imbalance of vitamins can lead to serious disorders. Housed poultry are entirely dependent on the vitamins present in their compounded food so it is important that they are provided in the correct amounts. All vitamins are available in a synthetic form at a commercial price. These synthetic vitamins may not be available in tropical countries and without them it is difficult to formulate a balanced diet using tropical foodstuffs (see Appendix 2).

5.5 Mineral requirements

Calcium and phosphorus

The main function of both calcium (Ca) and phosphorus (P) is production and maintenance of the bones of the body. The skeleton accounts for about 99% of the calcium and 80% of the phosphorus in the body. The two minerals interact with each other both before and after their absorption from the digestive tract. Large amounts of either mineral can interfere with the utilization of the other.

The requirements of poultry for calcium and phosphorus are influenced by the amount of vitamin D in the diet. In general the requirements for calcium and phosphorus increase as the level of vitamin D

decreases and vice versa. To a lesser extent supplies of both manganese and zinc also affect the utilization of calcium and phosphorus. The ratio of Ca:P for growing birds should be within the range 1:1 and 2:1. However, laying birds need a ratio of up to 6:1 and they require in the region of 4.0 g per day of calcium for egg shell formation.

Supplements, such as steamed bone flour or bone-meal, are added to chick and grower diets to provide extra phosphorus and calcium. For laying birds the extra requirement of calcium is provided by oyster-shell grit fed separately or by limestone flour added to the diet. The main criteria for determining the requirements of calcium and phosphorus for the laying hen are egg production and shell thickness.

Specifications for calcium requirements should be in terms of amount of calcium per day rather than percentage in diets. This consideration is particularly important in the tropics, where reduced intake caused by high ambient temperatures may result in too little calcium being consumed each day.

The other essential minerals are described in appendix 2.

The mineral requirements of poultry are defined in terms of the separate mineral elements, although minerals are always added to diets in the form of compounds. It is useful to know what proportion of these compounds are made up of the appropriate element so that the correct amount of this element can be added to the diet. See table 4.

Table 4: Percentage of the elements in mineral compounds.

Compound	Chemical formula	% of element in compound
Limestone flour Calcium carbonate	CaCO ₃	40% Ca
Zinc carbonate	ZnCO ₃	52% Zn
Anhydrous iron oxide	Fe ₂ O ₃	70% Fe
Manganese sulphate	MnSO ₄	36% Mn
Copper sulphate	CuSO ₄	

5.6 Other ingredients to be added to poultry diets

Up to this point we have considered the energy, amino acid, mineral and vitamin content of poultry diets. Other ingredients that should be added include coccidiostats and antioxidants. Vitamins and minerals can be added in the form of premixes to diets of laying hens and broilers.

A coccidiostat should be introduced at a prophylactic level in every broiler diet. It should be used according to the directions of the manufacturer, including its complete withdrawal towards the end of the fattening period. As coccidiosis may occur in flocks treated with a coccidiostat at prophylactic levels it is advisable to have a concentrated coccidiostat available which can be used to medicate the water at a curative level.

Commercial feed preparations should contain antioxidant, which acts as a preservative.

5.7 Feeding methods

1. Free-range chickens

If a chicken breeder has free-range chickens, he can do little to influence what kinds of food the chickens eat. He will simply have to trust that a chicken will eat whatever it needs. However, a chicken can only have a good diet if it can find all the nutrients it needs. In many free-range situations a chicken will certainly not be able to find everything it needs all year round.

During harvest time or other periods when a lot of grain can be eaten, the chickens will usually get enough energy. However, at such times they usually get relatively too little protein to grow and lay as well as possible. It is important that the chickens then get extra, especially animal protein, such as worms, snails, etc. Otherwise, they must be given extra protein-rich feedstuffs such as soya cake, fish-meal, etc.

In dry periods, a vitamin deficiency can quickly develop. By adding ashes and maybe dried greens to the chicken's diet, they will get some of the minerals and vitamins they need.

2. Housed chickens

As soon as chickens are kept in a poultry house, the chicken raiser must give the chickens all the food they need himself. If the chickens have a limited run, they can find some of the minerals and vitamins they need themselves. However, in that case the run must have enough vegetation. It must also be shifted regularly, for example every two weeks, to reduce the risk of infection with parasites.

There are different chicken-feeds available for the different age categories. In general, there are two kinds of feed for the raising period (the period from 0 to 18 weeks in which the chick matures until it can start laying). There are also usually one or more kinds of chicken-feed available for laying hens, but it is possible to use only one kind of good feed.

Broilers are given the same feed as growing chicks. Never give this to laying hens! The main differences are in the amount of protein found in the different feeds, and especially the amount of calcium (lime) they contain. Laying hens need much more calcium to enable them to make eggshells. As a rule, you will always need to give extra lime to the chickens to be sure that they get enough calcium.

Chickens kept in a closed chicken house must be given (extra) grit. This is necessary for the grinding up and digestion of their food.

It is strongly advisable to check how much the chickens eat, as far as this is possible. Any deviation from the normal feed intake is an indication of change in production level and health status. It is very important to have a reliable supplier of chicken-feed! Feed can only be stored for a short time. If it is kept long, the quality of the feed, in particular the vitamin content, will decrease. Be sure to buy fresh feed. If you have to store it, try to do so in a dry and, if possible, a cool place. Keep it out of reach of rats, cockroaches, etc. You must not store the feed for more than one week.

5.8 Voluntary food intake

Appetite or voluntary food intake is the amount of food that a bird consumes when it has unlimited access to a diet. Knowledge of a bird's appetite is important because if a flock consumes less than the predicted level of intake it may experience nutritional deficiencies and production will be below that predicted. Also, a reduction in food intake can be a useful warning of errors in management or outbreak of disease. If intake is above the predicted level food is wasted and certain types of bird may grow fat.

The most important factors affecting food intake are the following:

- 1 body weight;
- 2 rate of live weight gain;
- 3 output of eggs;
- 4 quality of food;
- 5 environment.

1 - Body weight

Heavy birds consume more food than light birds. The control of food intake of light-bodied laying hens is very precise and they adjust to considerable variation in the energy levels in the diets and will maintain their daily intake of energy at a constant level. Heavy birds, on the other hand, will consume more energy on a high energy diet than a low energy diet and become fat.

2 - Rate of live weight gain

Birds that grow faster than average normally consume more food than average. Faster growth means better food conversion, because a greater proportion of the food is used for production. At a given weight, immature birds of broiler strains consume more food than birds of an egg laying strain.

3 - Output of eggs

The intake of dietary energy by laying hens is related to their rate of egg production. An increase in egg production is associated with an

increase in food intake. For example if one extra egg of 65 grams is produced, the food intake of the hen will be 130 grams extra.

4 - Quality of food

The major dietary factor which affects food intake is the concentration of energy in the diet. An increase in dietary energy results in a decrease in food intake. The concentration of nutrients other than energy in the diet does not influence appetite so long as the level does not go outside the range which is acceptable for normal health and production.

The intake of pelleted food can be up to 8% greater than the intake of the same food presented as a meal. This is partly because pellets are partially cooked and partly because the pellets are more convenient to consume. This high intake of pellets is desirable in young birds since it promotes growth rate, but in adults it can lead to increased fat deposition and obesity.

5 - Environment

Light intensity and day-length have some effect on voluntary food intake. With laying birds this occurs indirectly due to the effect of day-length on egg production. Longer days stimulate egg production and therefore encourage hens to consume more food. With chicks, light has a more direct effect upon food intake by regulating behaviour patterns and extending food activity. Maximum food intake and growth rate are obtained when chicks are reared in continuous light. With broilers too much light may increase activity and therefore reduce efficiency of food utilisation.

5.9 Restriction of energy intake

The effect of restriction of energy intake on pullets of egg producing strains is different than the effect on meat producing strains.

1. Pullets of egg producing strains

It is not usual practice to restrict the food intake of growing pullets being reared for egg production. Restriction of food intake during the

laying period is not a normal practice and it is a rather risky procedure because a comparatively small restriction can cause a dramatic drop in egg production.

2. Pullets of meat producing strains

Pullets of heavier stock are not normally allowed unlimited access to feed during the growing stage. Their food intake is restricted so as to reduce live weight gain and in particular to limit the amount of body fat at the onset of egg production. The amount of restriction depends upon the particular breed involved but the level of restriction is much more severe than that applied to birds of laying strains.

Various methods of restriction of food intake can be used. These include skip-a-day feeding, low protein diets, high fibre diets and low lysine diets.

Skip-a-day feeding is probably the system of choice. With this system if birds are to be rationed to 70% of their voluntary intake, they are fed 140% of their daily intake every two days. This technique ensures that every bird, including those low down the pecking order, is able to obtain its fair share of food. If birds are rationed to 70% of their food intake every day birds high up in the pecking order will achieve 100% of their desired consumption, whereas birds lower down the pecking order may consume less than 50%. With birds of modern broiler strains much more severe levels of restriction (less than 50% of appetite) are applied, particularly in the rearing phase.

The best advice for any farmer keeping modern broiler strains is to follow the advice of the supplier of the chicks.

5.10 Feed composition

Of course you, as poultry breeder, cannot determine what the chicken-feed you buy is made of. However, you must take care that the feed contains all the elements the chickens need. A summary of the nutrient requirements is given in appendix 2.

Food represents approximately 60% of the cost of producing table poultry or eggs for human consumption. Savings in the use of poultry food can make a major contribution to the economics of production. It is therefore important that the cheapest suitable food is used in the correct ratio in poultry diets. It is also important to know what foods are available and how they should be used in poultry diets. Foods used in poultry diets can be classified into five broad classes:

- cereals
- other energy foods
- animal proteins
- vegetable proteins
- mineral supplements

Poultry diets can be calculated by using the Pearson Square. An example of the calculation of a diet for a laying hen, making use of four different protein resources is presented below:

Table 5: Calculation of a diet for a laying hen.

Resource	% of protein
maize	8
sorghum	10
soya bean meal	44
fish meal	65

The various foodstuffs are put into two groups. The averages could be weighted if different amounts of each ingredient are to be used. Suppose it is easier to get maize than sorghum and it is cheaper to use soya bean meal than fish meal; You can use two parts of maize (8%) and one part of sorghum (10%) and 3 parts of soya (44%) and one part of fish meal (65%):

Cereals - weighted mean

maize	$2 \times 8\% =$	16%
sorghum	$1 \times 10\% =$	10%
Weighted mean for cereals	$26\% / 3 =$	8.7% protein

Protein food - weighted mean

soya bean meal	$3 \times 44\% =$	132%
fish meal	$1 \times 65\% =$	65%
Weighted mean for protein food	$197\% / 4 =$	49.3% protein

These weighted means would be used on the left-hand side of the Pearson square:

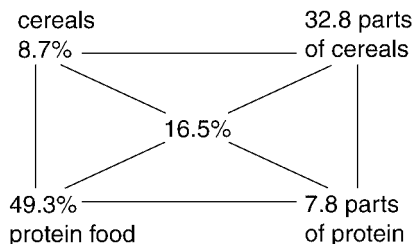


Figure 19: Pearson square

The protein level required in the complete diet is placed in the middle of the square and the percentage protein content of each food on the two left-hand corners of the square.

To work out the proportion of each foodstuff that is required subtract diagonally across the square the small number from the larger one as shown below. The proportion of each ingredient to achieve a diet containing 16.5% protein is given at the right-hand side of the square.

Thus a ratio of 32.8 parts of cereals is required to be mixed with 7.8 parts of protein food to achieve a diet containing 16.5% protein.

Expressed in percentage terms the diet will be made up as follows:

$$\frac{32.8}{32.8 + 7.8} \times 100\% = 81\% \text{ cereals}$$

$$\frac{7.8}{32.8 + 7.8} \times 100\% = 19\% \text{ protein food}$$

The cereals feed consists of maize and sorghum:

$$\frac{81\%}{3} = 27\% \text{ of sorghum and } 54\% \text{ of maize}$$

For the protein food the same:

$$\frac{19\%}{4} = 5\% \text{ of fish meal and } 14\% \text{ of sorghum}$$

Finally we must check whether this diet will meet the other nutrient requirements as well:

Table 6: Calculation of an alternative diet for a laying hen.

resource	energy kJ/g	protein %	crude fibre %
maize	7.9	4.3	1.1
sorghum	3.9	2.7	0.5
soya bean meal	1.6	6.3	0.9
fish meal	0.6	3.1	0.0
total	14.00	16.40	2.50

The energy content of 14 kJ/g exceeds the minimum of 12, the protein level is good and the crude fibre does not exceed 7%. You just need to add some limestone and bone-meal to meet the calcium and phosphorus requirements in a ratio of 6:1, with 4.0 g calcium per day. See mineral requirements.

6 Health care

On small-scale chicken farms in rural areas, young and old birds will be kept together. As old, contaminated birds pass on diseases to younger chicks, it will be difficult to get rid of contagious diseases. For more commercially-oriented farms, it is advisable to break each cycle of infection by applying the "all in-all out" principle. This means that after every period of production, all the chickens got rid of and replaced, after thoroughly cleaning and disinfecting everything.

6.1 General hygienic measures

It is very important to keep the chance of infection by contacts with sources of infections to a minimum. Germs can be spread via animals and via people. Infection is also possible through contact with infected objects such as crates or cars. All kinds of diseases can be transferred by birds, vermin, insects and other parasites. Remember that feed and dirty drinking water can also carry germs.

The following measures are important to prevent disease.

- Keep the chickens housed instead of letting them roam around freely.
- Do not locate the farm near other farms, keep it at least 100 m away.
- Only allow visitors that have been disinfected thoroughly near the chickens.
- Clean drinkers and feeders regularly.
- Clean the housing after getting rid of the old, non-laying hens. Remove all installations from the housing. Soak off all the dirt and clean it well.
- Clean the chicken house well with lots of water and let it dry completely.
- Disinfect the empty housing with disinfectant.
- Control rodents (mice and rats) and flies.
- Remove dead birds immediately from the chicken house.

➤ Renew the litter regularly. Get rid of old litter immediately.
When disease has broken out in your area, it is especially important to carry out these measures well.

If you want to place new, bought stock (for example cocks) with your own home-bred birds, it is a good idea to keep the new birds separate for some time. If a contagious disease appears, the chance of infection will be less than if you immediately place the new birds with the old stock.

6.2 Diseases and their causes

Diseases can be caused by a number of things. There are three main causes:

- 1 Infections.
- 2 Parasites.
- 3 Deficiencies of a certain kind of nutrient.
- 4 Other abnormalities, such as feather pecking and cannibalism.

1 - Infectious diseases

Infectious diseases can be caused by bacteria, viruses, fungi and parasites. An overview of the most important diseases can be found in Appendix 1.

One of the most important parasitic diseases is the much feared coccidiosis. This is especially common among young birds. The symptoms of the disease are thin blood-streaked faeces and weight loss by the chickens.

Preventive measures are:

- Hygiene:
- Before the birds are put in their housing, clean it thoroughly, especially the floor.
 - Limit contact between the birds and faeces as much as possible.
 - Keep the drinkers and feeders clean.
 - Make sure there are no wet spots in the litter.

- Vaccination
- Prophylactic use of anti-coccidial agents

2 - Parasites

External parasites (ectoparasites), such as fleas, lice, mites and ticks are very common. Fleas are usually found in the laying nests. They feed on the chickens' blood and therefore cause production to drop. Make sure to clean the nests several times a year. Use carbolic soap to clean nests that have been emptied.

Lice can be found on the skin of the birds, especially around the rectum and under the wings. They cause itching which makes production drop. If necessary treat the chickens with a disinfectant. This needs to be done twice in succession, the second time to kill the insects that hatch out of the insect eggs.

Mites are the most troublesome ectoparasites. They hide in the cracks and chinks of the housing and perches, and come out of their hiding places at night. Mites suck the chickens' blood which harms production. Bloodsucking mites like *Liponyssus* and especially *Dermanyssus* can cause reduced egg production and anaemia. *Dermanyssus* can also transmit the protozoa *Borrelia*, which can cause sickness with signs as fever, depression, cyanosis of the head and anaemia. Penicillin and a number of other antibiotics are very effective against *Borrelia*. *Liponyssus* and invasive species like *Cnemidocoptes* never leave the host. To combat mites you will need to clean the woodwork well, especially the perches.

Ticks are often carriers of germs, like *Spirochates*, which can make the birds sick. Ticks spend most of their time off the host, hidden in cracks and crevices. They suck blood from their hosts for short periods at night. Apart from causing anaemia, anorexia, weight loss and decreased egg production, the tick can transmit *Borrelia*.

Good hygiene is the basis for controlling ectoparasites. When using chemicals, make sure that you only use chemicals that are approved

for poultry and use them in the prescribed manner. Some chemicals are best applied to the environment, to the birds or to both.

3 - Deficiencies and deficiency-related diseases

➤ Lack of energy:

In general chicken-feed should contain at least 2400 kcal per kg. When the energy content of the feed drops below this level, the chickens simply cannot eat enough and will therefore have an energy deficiency. This results in slow or little growth, light eggs, and a decrease in production.

➤ Protein deficiency:

If the feed contains too little protein, the young birds will grow slowly. With old chickens, a protein deficiency will result in a drop in egg weight and then in the number of eggs laid.

➤ Mineral deficiencies:

These deficiencies are very specific. One example of this is a calcium deficiency which weakens eggshells.

➤ Vitamin deficiency:

Deficiencies of certain vitamins are common. They are also very specific. This means that the symptoms vary per type of deficiency which may make it easier to diagnose. More general vitamin deficiencies have general symptoms, such as poor growth, low production or death.

An overview of the most common types of deficiencies is given in appendix 1. The diseases or abnormalities that are a result of a deficiency can be prevented by giving good feed.

An excess of certain nutrients can also cause abnormalities. This is especially so for minerals. An example is an excess of NaCl (table salt), which can be present in the chickens' feed and drinking water. An excess causes increased water consumption and by hence wet dropping problems as 'burnt hock'. On the other hand, if drinking water is restricted, frank signs of toxicity may develop.

4 - Other abnormalities

- Laying distress (bulging of oviduct)
Laying distress is caused by an egg that is too big. It is most common among young layers. As this will often lead to vent picking followed by cannibalism and other abnormal behaviour, it is best to slaughter the hen immediately.
- Water belly
The cause of this can be any common infection, but can also be due to a shortage of oxygen at higher altitudes.
- Cannibalism
It is difficult to determine the exact cause of cannibalism. Insufficient feeding and drinking space, high-density stocking, too much heat during brooding, excessive light in pens and cages, boredom and vent picking can be predisposing factors. Such housing conditions must be improved. Pellet feeding will often lead to an outbreak of cannibalism. Injured birds can be treated with oil.

6.3 Some common problems and their possible causes

When you have noted certain abnormalities among your chickens, it is not always easy to determine what the problem is. Maybe the following tips can help you.

High mortality rate among young chicks

When a large number of chicks die during the first days and weeks, the following are possible causes:

- Shortage of feed and/or water
- Diseases, especially those caused by infections.

You can avoid many problems by taking good care of the day-old chicks.

High mortality rate among layers

Possible causes are:

- Nutritional disorders, for example shortfall of sodium chloride.

- Fatty liver syndrome; contributory factors include ad libitum given high-carbohydrate/low-fat feed, high temperature, lack of exercise and stress.
- Infections like Colibacillosis.

Respiratory disorders

Respiratory disorders can be noticed when a chicken yawns, sneezes, rattles its throat, has teary eyes and produces phlegm. Possible causes are:

- Too little ventilation causing an excess of ammonia. This is easy to smell. Provide more fresh air in the chicken house.
- Diseases, such as NCD (with watery faeces and nervous disorders), IB (with deformities of eggshells), ILT (infectious laryngotracheitis), CRD (much sneezing and teary eyes), diphtheria, etc.

Try to note what the specific symptoms are. If these occur often, it is advisable to vaccinate the chickens.

Digestive disorders

Problems with the digestion of chickens result in slow growth and diarrhoea. This can be indicated by dirty stomach feathers or wet litter. It can be the result of:

- Bad chicken-feed, for example feed containing too much table salt (NaCl).
- Diseases, such as coccidiosis, Salmonellosis, NCD (often greenish faeces), the disease of Gumboro, etc.

Coordination disorders

Symptoms are paralysis, limping, twisted necks, and slow-moving birds. Possible causes are:

- Nutrient deficiencies in the feed. Too little vitamin D causes rickets (deformities) among young chicks; too little calcium and/or vitamin D causes rickets among chickens of all ages; too little manganese causes deformities of the feet among older chickens (twisted feet).
- Diseases, such as: NCD (twisted necks), the sickness of Marek (nervous disorders and therefore paralysis), synovitis (tendon infec-

tions with foot joints which feel warm), aviary encephalomyelitis (AE), etc.

Low production and egg deformities

Low egg production can have many different causes.

➤ Feeding disorders.

An energy deficiency in the feed, too little and bad quality protein, mineral and vitamin deficiencies. To trace the problem, you could visit another chicken farmer who uses the same feed to see if the same problems occur there. Feeding disorders can also be caused by diseases (which can also occur on other chicken farms!). Possible diseases are: NCD, IB (with distinct egg deformities), EDS (egg drop syndrome with discolouration of brown eggshells), pox-diphtheria, CRD (with much sneezing and teary eyes), and all kinds of parasites.

➤ Unhealthy climate in the housing, for example too cold housing.

Avoiding health problems in short:

The best prevention of diseases is good hygiene and disinfection. Be careful with adding new chicks to your stock. Best is to use the 'All-in-all-out' system. It depends on your situation (small/large scale farm, country, problems with certain diseases in the past) whether you should vaccinate against some diseases or use anti-coccidial agents. If you have got serious problems you should consider to slaughter your whole stock and start anew, after thoroughly cleaning and disinfection instead of treating the animals.

7 Hatching and raising chicks

On small subsistence farms eggs will mainly be hatched using brooding hens. On more commercial farms, artificial hatching using a small incubator is also possible. This will depend primarily on how many chicks you wish to hatch at the same time. To make sure that a business with many chickens runs well, it is important that all the chicks hatch at the same time. This is very difficult to ensure using brooding hens because the hens do not all become broody at the same time. Buying a small incubator can then be a good idea. It may be possible to buy it together with a few other poultry breeders.

7.1 Hatching using brooding hens

One brooding hen is capable of hatching 8-10 eggs at the same time. If about 70% of the chicks hatch, this means that each brooding hen gives 6-7 chicks. However, the mortality rate among young chicks can be very high. The experience you have and the extent to which you can minimize the deaths among young chicks determine, therefore, how many brooding hens you will need.

You must choose which eggs to hatch using the following criteria:

- The eggs selected must, of course, be fertilized. This is rarely a problem if there is a cock present. On average, one cock is needed for every 10 hens. If normally a cock is not kept with the hens, he must be put with the hens two weeks before the hatching period.
- Use undamaged and clean eggs which are neither too small nor too large. The best results can be expected if you choose medium sized eggs from hens which lay well.
- Collect the eggs regularly, for example three times a day. Let the eggs cool down as quickly as possible.
- If necessary, the eggs can be saved up for a few days, but preferably for not more than one week. If the eggs must be kept for one week, they must be stored at a temperature below 15°C. If the temperature cannot be kept below 15°C, a shorter storage period is necessary.

Eggs can be kept for only three days at 20°C. Write the date on which an egg is collected on the egg, in pencil. This is to help you remember how long the egg can be stored at most.

If a hen shows broody behaviour for two days, she can be used for brooding. Brooding hens must be healthy and not too small. A broody hen can be recognized by:

- a characteristic broody sound
- a wrinkled comb
- an unwillingness to leave her nest
- the collecting of as many eggs as possible in her nest.

Before allowing a hen to brood, it is best to treat her with an insecticide against flies and lice. If flies and lice are a problem, the treatment should be repeated after 10 days. In the beginning, the hen will brood irregularly until she can sit on 6 to 12 eggs. It is best not to let the hen sit on selected eggs during this period. Only when she broods regularly can the eggs be replaced with specially selected eggs. Large hens can brood on 14 eggs, but is best to let a smaller, local hen brood on 8 eggs at most.

Use a clean and parasite-free brooding coop. The coop should be about 35 x 35 cm, and 40 cm high. The nest consists of straw, hay or dry leaves, and is about 25 cm. To stimulate the brooding process, you can place the coop in a dark and cool place, or partially cover it. The brooding place must be free from other chickens and protected against dogs, rats, snakes and such like. It is a good idea to add a run onto the brooding coop. Place good feed and clean and fresh water in the vicinity of the brooding hen.

7.2 Artificial hatching

It is possible to buy small incubators which hatch out a larger number of eggs at the same time. You can, however, also build such a device yourself using relatively simple materials. To find out how to actually make such a device, please see **Agrodok nr.34: "Hatching eggs by a**

hen or in an incubator" That booklet describes how to construct an incubator capable of hatching 50 eggs at the same time.

The most important requirements for artificial hatching are:

- You must be able to regulate the temperature you need. This must be about 38°C (100°F). Only a simple heat source is needed (see the Agrodok "Hatching eggs"). The temperature must be kept as constant as possible.
- The relative humidity of the air must be quite high, about 55-60%. Towards the end of the brooding period, i.e. after the 18th day, it must be increased to about 75%. Bowls of water are placed in the incubator to achieve this. Naturally you must keep them filled.
- Fresh air must be circulated regularly through the incubator.
- The eggs must be turned regularly (at least seven times a day). To turn an egg, you must rotate it 90° about its longest axis.

With the proper care and effort you can achieve almost the same results with artificial hatching as the hen achieves. Still, it is usually better to count on a slightly lower success rate, e.g. 65-70% instead of 75-80%. The brooding period should be timed so that the chicks hatch in the dry season.

7.3 Raising the chicks

After 21 days of brooding, the chicks hatch. If the eggs have been hatched by a hen, she will immediately take care of the chicks. It is a good idea to keep the hen with her chicks in a separate coop during the first few weeks. The very first thing the chicks need is fresh water. This must therefore always be available. They only start needing food after one day.

If you are not able to use bought feed, you can try to make as good a feed as possible by mixing the following ingredients: broken maize or millet, to which you must add something which provides protein (for example boiled eggs) during the first few days. You can also add kitchen and slaughter wastes, and greens such as leaves, grass, etc. The vitamins the chicks need must come mainly from the greens.

If the chicks have been hatched artificially, you must take care of them yourself from the very beginning. Place the chicks in a thoroughly cleaned space and make sure that the temperature is correct. The temperature the chicks need changes roughly as follows during the first weeks.

Table 7: Heating guidelines.

Age (weeks)	Required ambient temperature (°C)
0-1	35-32
1-2	32-29
after two weeks chicks are allowed to go outside	
2-3	29-26
3-4	26-23
4-5	23-20

Usually it is therefore not necessary to give extra heating after four weeks, excepts perhaps at night.

An oil or petroleum lamp or a light bulb can be used to heat an area. There are a number of ways in which these heat source can be used. The chicks are placed in a separate coop. A petroleum lamp is put in the coop and is fenced off with some wire gauze to protect the chicks against too much heat. The top of the coop is also wired off to protect them against rats, dogs and cats. The best way to see if the temperature in the coop is just right for the chicks is by observing their behaviour. If it is too cold, the chicks huddle together; if it is too hot, they stay as far away from the heat source as possible. When the temperature is just right, they will use all of the available space.

Raising coops can have a bottom made of chicken-wire. The wire should be covered with newspaper or something else for the first week, which should be replaced every day. When the chicks are capable of walking on the wire, this cover is no longer necessary. In this way, chances of infection with parasites is minimized since the chicks then do not step in their own faeces.

Make sure that the chicks receive much light during their first few days so that they can find their water and food. After that the light in-

tensity is less important. Too much light can, in fact, causes damage because it can stimulate the chicks to start pecking each other.

See Agrodok 34: Hatching eggs for more detailed information.

At about four to five months, depending on their genetic potential and the environment, the first hens start to lay eggs. The age at which modern hybrids reach laying maturity is constantly becoming earlier: 20 weeks or even earlier. As was mentioned in chapter 4, hens can be stimulated to reach laying maturity earlier by artificially lengthening the days during their growing period. However, it is a good idea not to stimulate the hens to start laying too early. That is why you should avoid extra lighting in this period. If you still wish to make the chickens eat more, give extra lighting in such a way that as the chickens get older the daylight period remains the same.

If you have no artificial lighting, it is best to raise the chicks during the season with the shortest day. Then the hens start laying as the days get longer, which stimulates egg production.

8 Ways of improving local chickens

Local chickens are usually no longer pure-bred animals. This is probably because lots of cross-breeding took place in the past.

Chickens in the tropics have a low body weight, which is why they lay small eggs. Due to a long adaptation process, they are more resistant to high temperatures and probably also better adapted to more difficult circumstances. However, their production is low, about 50 eggs per year. Many small farms must, therefore, use a large part of the eggs laid to keep the chicken population at a constant level. The production of local chickens can be improved in two ways:

- Replacing the local cocks with cocks of more productive breeds;
- Culling of unproductive animals.

Such measures must always be done together with measures for improving the conditions of the poultry farm.

8.1 Cock exchange programmes

In various countries, cock exchange programmes have been successfully carried out. In such programmes all the existing local cocks are replaced with new ones. Cocks of an outside breed, such as the Rhode Island Red, can be used as replacements. It is also possible to use hybrid cocks. Pure-bred cocks can be found in some places if a cross-breeding programme is being carried out there. Such a programme usually tries to spread the cross-bred offspring to small chicken farms. Depending on a farm's management, the first generation of chickens which come after the cocks are replaced will produce more.

A cock exchange programme should be repeated from time to time, e.g. every five years. During this period it is also advisable to very regularly replace your cocks with those of a neighbour or someone else in order to avoid in-breeding.

8.2 Culling

Culling is used to immediately remove unproductive hens and sick chickens from the population during the production period. This increases the production efficiency because you then do not waste feed on unhealthy or unproductive chickens.

You can already start culling during the growing period. Several weeks before the hens start laying you can make a rough selection, removing those chickens which are too light, pale, or underdeveloped. You could immediately get rid of those chickens. Sometimes, though, it is worthwhile to place those slow developers in a separate space, so that they are given the chance to catch up.

You can then regularly cull during the production period. The difference between good and poor layers can be seen with the help of the following traits:

Table 8: Difference between good and poor chickens.

Trait	Productive chicken	Unproductive chicken
general condition	lively	dull
weight	good	usually fairly light
wattle and comb	soft; bright red	pale and rough
eyes	lively	dull; yellow rims
pigment (yellow breeds)	disappears	stays longer
cloaca	large, soft, moist	shrivelled, dry
distance between lay bones	large (± 5 cm)	small (± 2 cm)
distance between breast-bone and lay bones	large (± 8 cm)	small (± 4 cm)
skin	soft, loose	skin

A dull hen with a pale and rough wattle and comb can be picked out easily and looked at further. Very fat, healthy-looking chickens can be selected to further check the distance between their lay bones. If it is less than 2-3 cm, they will not lay eggs.

Should a hen become broody when you do not want her to, it can be stopped. Place the hen in a separate coop with a floor of chicken-wire and feed her well. After a few days she will start laying again.

9 Poultry products and by-products

9.1 Eggs

Eggs have a high nutritional value. Both the egg-white and yolk contain high quality protein (for both this is at least 10% of their own weight). The egg-yolk has about 33% fat. Eggs also have a lot of vitamin A and D, and some vitamin B.

If you wish to sell eggs, you need a good storage place for them. Only store fresh and clean eggs which have an undamaged shell. The storage place for the eggs must be clean and as cool as possible, especially if the eggs must be kept for more than one week. A dark space is therefore most suitable. If the eggs have been fertilized, it is even more important to have a cool storage place. At high temperatures (e.g. above 25°C), embryo development starts to take place.

9.2 Poultry meat

Usually the hens which have stopped laying will be used for feeding your family. In case of selling the meat it is usually better to sell live chickens. Poultry meat is a high quality and healthy food. The average protein content of the meat is about 20%. It also contains relatively little fat ($\pm 7\%$), especially under the skin. In all places there is usually a strong preference for the meat of local chicken breeds. The characteristic taste of a chicken is more probably due to its age than because it is of a special breed.

9.3 Poultry manure

Chicken manure is very rich in nitrogen and other minerals, especially phosphorus, calcium and potassium. It is therefore a very good fertilizer. Manure which is stored for a long time will lose part of its value as fertilizer. Keep the manure as dry as possible. This minimizes the loss of minerals, and reduces problems with flies. Regularly removing the manure under a poultry house will also reduce the amount of minerals lost.

Table 9: The average composition of chicken manure.

	Fresh manure	Litter manure
Dry matter (%)	20-22	50
Nitrogen (%)	1-1.5	1-2
Phosphorus (% P ₂ O ₅)	1-2	2
Potassium (% K ₂ O)	0.7	1
Calcium (% CaO)	2.2	3

Chicken manure can also be put into fish ponds. Part of the manure is eaten directly by the fish. Most of it, though, is used by the plants to grow which are then eaten by the fish.

In many countries dried poultry manure is fed to cattle or goats, for example in combination with grains and molasses. In that case the manure must not be too old, and must be dried quickly so that it keeps as many of its nutrients as possible.

A biogas digester can be used to make gas from the manure. The slurry which is then left over is still a very good fertilizer for use on the land and in fish ponds.

9.4 Slaughter waste

Slaughter waste produced on your farm is a very good feed supplement if it is ground up and dried well. The waste must be sterilized or else there is a large chance of transmitting diseases.

It is also very important that carcasses of birds which die during the production period are removed as quickly as possible. This should be done by burying or burning them.

10 Farm records

When your business grows larger, it is strongly advisable to improve your business administration so that you record the most important production figures. You can use this data to locate the weakest points in your business, so that you can better tackle those problems. To be able to do this well, it is necessary to have some idea of the most important data of an egg-laying business.

10.1 Laying percentage and length of the laying period

In countries where the poultry industry is well-developed, the hens start laying when they are about 20 weeks. The production of the whole chicken stock then rises quickly to a peak after another eight weeks. At that point, most of the chickens lay an egg almost every day. Each day there are almost as many eggs to be gathered as there are chickens. This ratio of number of chickens to number of eggs gathered on one day is the so-called "laying percentage". When the peak in production is reached, for example when the chickens are 28 weeks, the laying percentage can be as high as 90%.

The general characteristics of poultry stock which is productive are the following:

- Production rises quickly to a peak.
- Peak production is high.
- The high peak production is maintained for some time, and then only slowly decreases. This means that there is a high average laying percentage over the whole laying period.

Depending on the production level, the price of eggs and of non-productive chickens at the end of the laying period, the laying period lasts 12-14 months for a well-developed poultry business. After this the chickens are sold or slaughtered. This can be shown on a so-called production curve.

Instead of getting rid of the chickens at the end of the laying period, they can be given a rest period, that is they are allowed to moult. They can then go through a second laying period, and perhaps even a third. Chickens in the tropics are said to naturally start moulting after laying for a year, especially in the season with shorter days. The moult can be stimulated by using extra artificial lighting.

It is possible to trick the chickens into moulting. Limit the first production period of the chickens to only 8-10 months. Then force them to moult by giving them less and poorer quality feed. After the moult, the production increases again and the quality of the eggshells is then also better.

Making use of a moult can be worthwhile if:

- the purchase price of chickens is high
- the egg price is low at that moment
- the price received for old chickens is also low
- the better eggshells raise the price received for eggs.

Usually the price received for old hens which have stopped laying is high in the tropics. Since it is difficult and risky to get all the chickens to moult at the same time, it is probably preferable to keep layers for only one laying period.

10.2 The weight of the eggs

In many countries eggs are sold by weight, so the weight of eggs is also of importance. The first eggs at the start of the laying period are small. The weight of the eggs increases until the end of the laying period. The egg weight depends partially on the chicken breed. It can also be influenced by the feed given and the environment, in particular the temperature. The egg weight is measured by weighing a number of eggs from time to time.

10.3 Feed consumption

Feed costs are, as a rule, the greatest expenditure of a poultry farm. Therefore, it is important to have a good idea of how much feed is

eaten, in particular the amount of feed needed per egg or per kg of eggs or meat. That is called the feed conversion.

On a commercial poultry farm using bought compound chicken-feed, the feed consumption per chicken per day is 100 to 120 g. This depends on the kind of chicken (light or medium weight), the feed quality and the air temperature. If you give the chickens self-made feed consumption may be higher, especially if the feed contains a lot of crude fibre such as bran.

10.4 Chicken losses

During the laying period chickens will regularly die. In general, a reasonably well running poultry farm loses a total of about 6-8% of its chickens each year, or just over ½% per month. If you lose more than this, it is important to find out what the cause is.

10.5 Business administration

There are many ways of organizing your administration. For larger businesses, a financial administration is very useful. It is important to calculate the cost price of the eggs produced so that you do not, for example, sell the eggs for less than it costs to produce them. Make a distinction between costs which keep coming back, and immediate costs. One example of how to organize your administration is given below.

Cost price of eggs

Basic data to be specified:

1 Investment costs of buildings and equipment:

Depreciation of the buildings 5%, of the equipment 10%

Maintenance of the buildings 2%, of the equipment 3%

Interest: the going rate, divided by 2 (depreciation from 100% to 0%!))

2 Purchase costs of chicks or pullets.

3 Feed consumption and feed price.

4 Production.

Cost price calculation

A. Direct costs

➤ Cost of pullets	----
➤ Feed costs	----
➤ Oil or petroleum lamp or electricity	----
➤ Water	----
➤ Health care costs (medicine, disinfection, vaccinations)	----
➤ Litter	----
➤ Interest over stock [$\text{interest \%} * \frac{1}{2}(\text{pullet} + \text{feed costs})$]	----
➤ Miscellaneous	----
Subtotal	_____

B. Calculated (fixed) costs

➤ Housing	----
➤ Labour	----
Total gross costs	_____

subtract:

C. Secondary products

➤ Manure sold	----
➤ Hens sold	----
Total net costs	_____

Remarks:

It is also possible not to include the labour costs. If you then subtract the total net costs (excluding labour costs) from the income provided by the eggs, you will have calculated the sum you have earned with your labour (the labour income). A good administration must be kept up to date daily. This takes time and money, but it is the only way to make sure that the business is run efficiently.

Appendix 1: Infectious diseases

Table 10: Infectious poultry diseases: prevention and treatment

Name	Cause	Symptoms	Prevention	Treatment
New Castle Disease	Virus	Respiratory troubles, nervous signs, green diarrhoea, egg drop	Vaccination	None
Infectious bronchitis	Virus	Respiratory troubles, egg drop, misshapen eggs	Vaccination	None
Fowl pox (avian pox)	Virus	Lesions on comb wattle and face, yellow membranes in mouth cavity	Vaccination	None
Chronic Respiratory disease	Mycoplasma (MG)	Respiratory signs	Sanitation, monitoring, use of MG-free flocks	Antibiotics
Avian encephalomyelitis (epidemic tremor)	Virus	Paralysis, nervous tremors	Vaccination	None
Cholera	Bacterium Pasteurella multocoda	Swollen joints and wattles, darkened heads	Sanitation	Antibiotics, sulfa drugs
Fowl Typhoid	Bacterium	Mortality	Sanitation, monitoring	Sulfa drugs, antibiotics
Infectious bursitis (Gumboro disease)	Virus	Watery diarrhoea	Vaccination	None
Coccidiosis	Protozoa (Eimeria)	Diarrhoea	Sanitation, dry litter, anti-coccidial agents	Sulfas
Worm infections	Various kinds of worms	Diarrhoea	Sanitation, fresh litter, avoid exposure and overcrowding	Various anti-worm drugs
Infectious Coryza	Bacterium Haemophilus paragallinarum	Nasal mucus, swollen wattles, rales and face	Vaccination	Antibiotics like sulphathiazole, streptomycin, tetracyclines

Name	Cause	Symptoms	Prevention	Treatment
Pullorum disease	Bacterium Salmonella pullorum	White diarrhoea, respiratory distress, increase dead-in- shell chicks and deaths shortly after hatching	Eradication programmes	Elimination is recommended
Avian Influenza	Virus	Respiratory signs, swollen face, ceased egg laying, high mortality	Eradication programmes or vaccination	None
Colibacillosis	Bacterium Escherichia coli often secondary to viral infection	Listlessness, respi- ratory signs with a characteristic 'snick- ing'	Good health of the chickens	Antibiotics like furazolidone and chlortetra- cycline

Appendix 2: Poultry nutrition: tables

Table 11: Some examples of formulated rations for layers

layers diet number	1 %	2 %	3 %	4 %
Rice bran	<u>57</u>	15	<u>20.5</u>	10
Broken rice	8	<u>20</u>	<u>19</u>	-
Ground yellow maize	7	<u>29.5</u>	<u>20</u>	<u>25</u>
Wheat bran	-	-	-	<u>15</u>
Ground wheat	-	-	-	<u>15</u>
Wheat	-	-	-	<u>15</u>
Ground barley	-	-	-	-
Barley	-	-	-	10
Millet	-	-	-	-
Ground soy bean cake	4	5	-	-
Ground groundnut cake	5	5	-	-
Bean	-	-	-	5
Ground sesame oil cake	-	-	<u>22</u>	5
Decorticated cotton seed meal	-	-	-	10
Coconut or copra meal	5	5	-	-
Ground dried legume leaf	3	3.5	-	-
Fish meal	7	15	-	2
Blood meal	-	-	12.5	-
Meat scraps	-	-	-	3
Shark or codliver oil or vitamin A + D3	1	-	0.5	0.5
Dried skim milk	-	-	-	-
Bone meal	-	-	1.5	2
Ground limestone	-	2	-	0.5
Ground shells	2	-	1.5	-
Common salt	1	-	0.5	0.5
Mineral mix	-	-	2	-

- The diets are based on different ingredients. If mainly ground maize is available, diet 2 or 3 can for instance be chosen. The most bulky ingredients of the diet are underlined.
- Green fodder (Barseem Trif. Alexandrium) was offered at mid meals in case of diet 4.

Table 12: Some examples of formulated rations for chicks

chicks diet number	1	2 (0-8)	3 (8-12 weeks)
Rice bran	26	10	10
Broken rice	16	-	-
Yellow maize	16	20	20
Ground wheat	-	20	15
Wheat	-	10	10
Barley	-	10	20
Groundnut cake	5.4	-	-
Sesame oil cake	10.5	10	5
Decorticated cotton seed meal	-	5	10
Bean	-	10	5
Fish meal	10.5	2	2
Blood meal	2	-	-
Meat scraps	-	3	3
Milk	5.5	-	-
Gram	5.5	-	-
Cod liver oil	0.5	1	1
Bone meal	-	1	1
Salt	-	0.5	0.5
Limestone	-	0.5	0.5
Mineral mixture	2	-	-

Table 13: Vitamins, sources and functions

Vitamin	Function	Source
A	appetite, digestion, prevention of Xerophthalmia, maintenance of mucus membranes	green grass, lucerne meal, fish meal, corn gluten, yellow corn
B1 thiamin	appetite, digestion, health of nerves, prevention of polyneuritis	green grass, lucerne meal, wheat by-products, milk by-products
B2 riboflavin	growth, hatchability, prevention of curled toe paralysis	green feeds, milk by-products, distiller's, solubles
B12 cyanocobalamin	growth, hatchability	fish meal, meat scraps, deep litter, fermentation products
D3	mineral assimilation, egg production, hatchability, rickets prevention, egg shell thickness	fish oils, animal fat, yeast
Biotin	prevention of fatty liver kidney syndrome	soy bean meal, cottonseed meal
Niacin nicotinamide	growth, feathering	liver, yeast, milk
Pantothenic acid	growth, hatchability, prevention of dermatitis	green feeds, milk byproducts, meat scraps
Choline	growth and bone development, egg production, perosis prevention, prevents fatty degeneration of liver	green feeds, whole grains
K	blood clotting, anti-haemorrhagic	green feeds
E	health of reproduction organs	green feeds, whole grains

Table 14: Other essential minerals

Mineral	Function	Source
Manganese	bone formation, shell strength, fertility of eggs	limestone flour, manganese sulphate, manganese oxide
Iron, copper, cobalt	formation of haemoglobin	supplement
Iodine	prevention of lethargy	iodised salt
Salt (sodium chloride)	utilization of protein, prevention of hypertension, egg production	common salt, (0.5% in diet)
Zinc	growth, feather development	zinc carbonate, galvanised feeding containers

Table 17: Nutrient content of cereal grains used in poultry foods in the tropics and sub-tropics (in air-dry material)

	Corn and cob	Maize (white)	Maize (yellow)	Munga	Sorghum
Lysine ** %	0.20	0.24	0.27	0.20	0.22
Methionine ** %	0.12	0.14	0.16	0.27	0.18
Crude fibre %	6.00	2.00	2.00	2.00	2.00
Metabolizable energy (kJ/g)	-	14.69	14.57	13.92	14.48
Crude protein % (N x 6.25)	7.60	8.00	9.00	10.50	10.00
Calcium (Ca) %	-	-	-	0.05	0.05
Manganese (Mn) (mg/kg)	13.00	5.00	5.00	5.00	13.00
Sodium chloride (NaCl) %	0.07	0.08	0.08	0.05	0.13
Total phosphorus (P) %	0.35	0.40	0.40	0.40	0.30
Zinc (Zn) (mg/kg)	20.00	23.00	23.00	20.00	15.00
Choline (mg/kg)	360.00	440.00	440.00	440.00	700.00
Niacin (mg/kg)	14.00	16.00	16.00	16.00	32.00
Pantothenic acid (mg/kg)	3.00	3.30	3.30	3.30	9.00
Riboflavin (mg/kg)	0.60	0.66	0.66	0.50	1.00
Vitamin A (IU /kg)	-	-	4400.00	-	-
Vitamin D ₃ (IU/kg)	-	-	-	-	-

International unit

** The amount of amino acid varies according to the total amount of protein.

NB Values obtained by methods of chemical analysis should take precedence over the average figures given in the table above.

Table 18: Nutrient content of other energy sources used in poultry foods in the tropics and subtropics (in air-dry material)

	Cane molasses	Hominy chop	Maize bran	Maize germ	Sugar	Wheat bran	Wheat pollard
lysine ** %	-	0.30	0.30	0.35	-	0.60	0.75
Methionine** %	-	0.08	0.08	0.14	-	0.30	0.20
Crude fibre %	-	6.00	13.00	5.00	-	12.00	10.00
Metabolizable energy (kJ/g)	10.16	7.20	6.38	14.69	17.52	7.02	12.85
Crude protein % (N x 6.25)	3.00	9.00	7.00	10.00	-	14.00	16.00
Calcium (Ca) %	0.70	0.05	0.03	0.04	-	0.10	0.10
Manganese (Mn) (mg/kg)	42.00	7.00	7.00	13.00	-	120.00	110.00
Sodium chloride (NaCl) %	-	-	-	0.25	-	0.12	0.05
Total phosphorus (P) %	0.10	0.50	0.50	0.50	-	1.10	1.10
Zinc (Zn) (mg/kg)	-	23.00	23.00	20.00	-	130.00	130.00
Choline (mg/kg)	850.00	440.00	440.00	500.00	-	1000.00	1000.00
Niacin (mg/kg)	33.00	50.00	40.00	0	-	200.00	90.00
Pantothenic acid (mg/kg)	38.00	7.00	5.00	40.00	-	29.00	16.00
Riboflavin (mg/kg)	3.30	2.00	1.50	4.00	-	3.00	1.60
Vitamin A (IU*/kg)	-	-	-	3.00	-	1000.00	1000.00
Vitamin D3 (IU/kg)	-	-	-	-	-	-	-

* International unit

** The amount of amino acid varies according to the total amount of protein

NB Values obtained by methods of chemical analysis should take precedence over the average figures given in the table above.

Table 19: Nutrient content of animal protein foodstuffs used in poultry foods in the tropics and subtropics (in air-dry material)

	Blood-meal	Fish-meal	Meat and bone-meal	Skim milk (dried)	Whale meal
Lysine ** %	7.00	5.00	3.00	2.50	4.00
Methionine ** %	0.90	1.80	0.50	0.80	1.00
Crude fibre %	1.00	1.00	1.00	-	1.00
Metabolizable energy (kJ/g)	11.77	12.60	10.11	11.12	12.09
Crude protein % (N x 6.25)	80.00	65.00	48.00	33.00	80.00
Calcium (Ca) %	0.28	5.00	12.50	1.30	2.00
Manganese (Mn) (mg/kg)	5.00	40.00	12.00	2.00	290.00
Sodium chloride (NaCl) %	1.50	2.50	1.75	1.65	0.50
Total phosphorus (P) %	0.22	2.70	5.50	1.00	0.50
Zinc (Zn) (mg/kg)	-	68.00	100.00	-	-
Choline (mg/kg)	750.00	3000.00	1500.00	1100.00	2200.00
Niacin (mg/kg)	30.00	60.00	40.00	11.00	66.00
Pantothenic acid (mg/kg)	1.10	8.00	3.00	3.00	3.00
Riboflavin (mg/kg)	1.50	6.00	3.50	20.00	2.20
Vitamin A (IU /kg)	-	-	-	260.00	-
Vitamin D ₃ (IU/kg)	-	-	-	-	-

International unit

** The amount of amino acid varies according to the total amount of protein

NB Values obtained by methods of chemical analysis should take precedence over the average figures given in the table above.

Table 20: Nutrient content of vegetable protein foodstuffs used in poultry foods in the tropics and subtropics (in air-dry material)

	Cottonseed cake meal		Groundnut cake meal		Lucerne meal	Soya bean	Soya bean (full fat)	Sun-flower cake meal
	1	2	1	2				
Lysine ** %	.60	.40	.80	1.20	.00	1.90	1.40	.50
Methionine ** %	1.52	1.43	1.15	1.43	1.15	1.60	1.51	1.80
Crude fibre %	14.00	18.00	5.00	5.00	30.00	6.00	4.00	12.00
Metabolizable energy (kJ/g)	9.68	9.32	10.67	10.75	2.90	11.17	14.50	11.79
Crude protein % (N x 6.25)	40.00	36.00	48.00	52.00	16.00	44.00	37.00	40.00
Calcium (Ca) %	0.20	0.20	0.16	0.16	1.40	0.25	0.22	0.41
Manganese (Mn) (mg/kg)	20.00	20.00	18.00	18.00	50.00	30.00	26.00	23.00
Sodium chloride (NaCl) %	0.50	0.50	0.12	0.12	0.50	0.34	0.29	-
Total phosphorus (P) %	1.20	1.20	0.80	0.80	0.30	0.60	0.52	0.95
Zinc (Zn) (mg/kg)	-	-	-	-	35.00	28.00	24.00	-
Choline (mg/kg)	2300	2000	2000	2000	800	2000	1730	280
Niacin (mg/kg)	40	40	200	200	25	20	17	250
Pantothenic acid (mg/kg)	10	10	30	30	14	12	23	38
Riboflavin (mg/kg)	5	5	5	5	13	26	22	3
Vitamin A (IU*/kg)	300	300	330	330	20000	340	290	-
Vitamin D3 (IU/kg)	-	-	-	-	-	-	-	-

* International unit

** The amount of amino acid varies according to the total amount of protein

NB Values obtained by methods of chemical analysis should take precedence over the average figures given in the table above.

Table 21: Nutrient content of substances used as mineral supplements in poultry foods in the tropics and subtropics (in air-dry material)

	Bone-meal	Di-calcium phosphate	Limestone flour	Mono-calcium phosphate	Monosodium phosphate
Crude fibre %	2.00	-	-	-	-
Metabolizable energy (kJ/g)	5.20	-	-	-	-
Crude protein % (N x 6.25)	25.00	-	-	-	-
Calcium (Ca) %	22.00	22	37.00	16	-
Manganese (Mn) (mg/kg)	30.00	700	1000.00	-	-
Sodium chloride (NaCl) %	0.80	-	0.10	-	-
Total phosphorus (P) %	9.00	18	0.04	20	22
Zinc (Zn) (mg/kg)	425.00	-	-	-	-
Niacin (mg/kg)	4.00	-	-	-	-
Pantothenic acid (mg/kg)	2.00	-	-	-	-
Riboflavin (mg/kg)	0.90	-	-	-	-

NB Values obtained by methods of chemical analysis should take precedence over the average figures given in the table above.

Appendix 3: Other foodstuffs

Other cereals

Bulrush millet (Pennisetum typhoides)

It has very small grains and resembles maize in composition and feeding value but is considerably higher in protein value. It has a similar feeding value to barley and like barley promotes the production of white fat. This cereal is very prone to infection by the fungus *Claviceps purpurea* in the dry season which can produce toxins that are dangerous to both humans and poultry.

Finger millet (Eleusine coracana)

This grain has the advantage that the grain will not shatter if the crop is left unharvested after the rains. It has a lower protein but slightly higher fibre content than bulrush millet. It can be used in diets for both growing and laying poultry.

Wheat (Triticum aestivum)

It is mainly used for human consumption, particularly for bread making. It has a slightly lower energy content than maize. Hard wheat has an average protein content of 13-15% whereas soft wheat has a much lower average content of about 10%.

Barley (Hordeum vulgare)

Its protein level is 10% and its fibre content is 5% which makes it an unsuitable ingredient for inclusion in diets for highly productive laying birds and broilers, especially under hot climatic conditions. It could be a useful ingredient in the diet of broiler breeders where the desire is to reduce food intake.

Rice (Oryza sativa)

Threshed rice has a thick fibrous husk which contains up to 20% silica and in this form it is unpalatable to poultry. The outer casing is easily removed and a much more palatable product, brown rice, is produced.

This food is high in starch and low in oil and is a valuable poultry food.

Cereal by products

Rice-bran

This is a by-product arising from the milling of rice. It is high in fibre and also in oil. The oil may cause problems of rancidity in food during storage. It probably should not be added to poultry diets at levels above 20% of the total ration.

Maize bran

This consists of the outer coating of the maize kernel. It contains 15% fibre and is low in metabolizable energy. It is not a suitable ingredient for inclusion in the diet of high producing broilers or laying hens.

Brewer's dried grains

Normally a by-product of barley but those obtained from sorghum have a very similar composition. The protein content is in the region of 20% and fibre content 14%. This high fibre content means that they are of limited value for poultry.

Dried brewer's yeast

This is produced by drying waste yeast from breweries. It contains practically no fibre or oil and the ash is very rich in phosphate. It also contains 40-45% of a very high biological value. It is very rich in vitamin B and riboflavin but is deficient in vitamin B₁₂.

Other energy foods

Cassava, tapioca, yucca

It is not recommended that fresh cassava be fed to poultry because of its low dry matter content and the presence of cyanogenetic glucosides. The intact tubers of cassava contain little free cyanide but any cutting or bruising releases free cyanide. If the tubers are chopped into thin slices and left in the sun and allowed to dry to a moisture content

below 14% (from 65%) the cyanide content is reduced to an acceptable level. This dried cassava can then be milled and fed to poultry. The major problem is that it has a low protein content and a balance of amino acids very different to that required for poultry. In West Africa certain types of cassava contain virtually no protein. This lack of protein can cause serious nutritional problems in poultry if adequate amounts of high protein foods are not added to the diet.

Final molasses

This is the residue left once raw sugar has been extracted from clarified sugar cane juice. It contains sugars and 10-12% soluble mineral matter. It is unsuitable for feeding to poultry because it leads to diarrhoea and wet droppings, and also sticks to the feathers of poultry.

Oil seeds and by-products

Sunflower seed

The seed contains about 25% oil and so its use as a poultry food is limited. The oil content accounts for its exceptionally high metabolizable energy value.

Linseed meal from flax

The protein of linseed meal does not effectively supplement the protein of maize or other grains for poultry. It is not suitable as a main component of poultry rations. Linseed meal has a fair calcium content, averaging 0.37% and is rich in phosphorous with an average of 0.86%.

Animal protein foods

Feather meal

Producers of large numbers of broilers can usefully dispose of the feathers produced by preparing feather meal. This is best produced by processing the feathers in steam and grinding the product. Feather meal is a rich source of protein, high in leucine and cysteine but deficient in lysine, tryptophan and methionine. Beware of the dangers of

infecting birds with disease, particularly those caused by salmonella bacteria.

Other animal proteins

Another animal protein that could be used for feeding to poultry is blood-meal. This and all other animal protein products must be thoroughly sterilized before being mixed into food to avoid infecting birds and eggs with disease.

Further reading

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