MANAGEMENT GUIDE

Broiler

Hubbard

Introduction

This **Hubbard** Broiler Guide is full of practical experience involving:

- Genetics
- Nutrition
- Rearing
- Processing

The appreciation by broiler growers in terms of nutrition, feed security and quality is very variable depending on the country and the degree of technical knowledge in the integration.

We must therefore adapt ourselves to the production conditions, nutrition and understanding of the products.

The range of **Hubbard** broilers consists of 4 different types of product specifically selected for its market requirement:

- **Hubbard CLASSIC**
- **Hubbard FLEX**
- **Hubbard YIELD**
- **Hubbard COLOR**

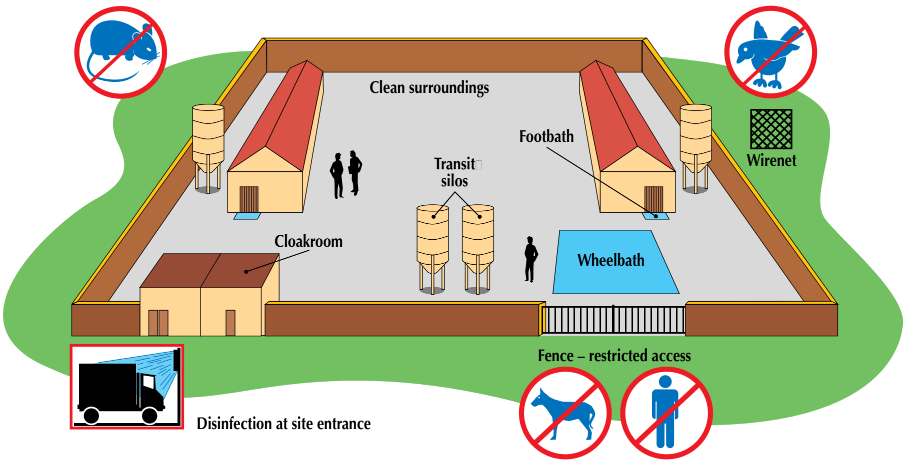
This guide mainly covers the **Hubbard CLASSIC**, **FLEX** and **YIELD products** and in certain sections the production of colored/alternative broilers under more conventional conditions (Certified).

Production of free-range and organic type products incorporates many of the management points discussed in this manual.

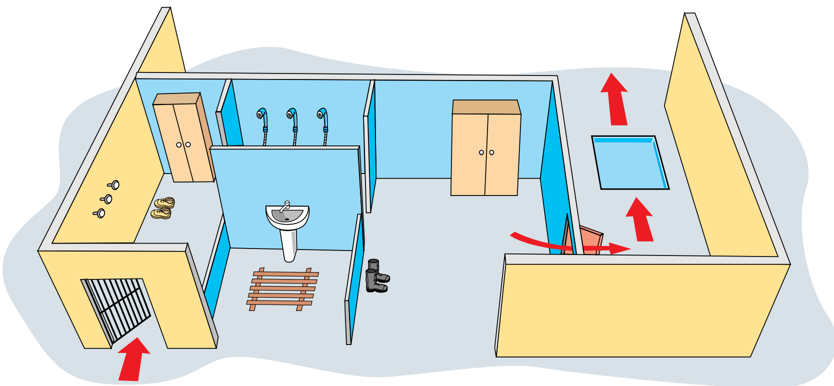
However, there are some subtle differences in terms of rearing, stocking density, equipment standards, feed specification systems and vaccination programmes to name a few. Please contact your local **Hubbard** technician and refer to specific technical bulletins for additional information.

The golden rule of broiler management is to have one age and one breed per site, so as to follow the "all–in, all–out" principle.

The choice of the site for the farm, as well as the layout of the houses must aim at keeping them free from any source of contamination. Protection is reinforced by hygiene controls.



A changing room should be made available at the entrance of the site and must be used by **everybody** entering the farm (change of clothes). It is better if a shower is installed.



When the old flock is removed and before the arrival of the new flock, all houses and equipment must be thoroughly cleaned and disinfected according to strict procedures and protocols (see details in the Disinfection section, page 56). This is followed by a resting period of at least 2 weeks.

EQUIPMENT STANDARDS

These general industry standards are constant for all houses so that the construction and housing conditions are standardised. This assures that the animals have the best rearing conditions when considering:

- insulation
- health control
- environment control.

In some countries government regulations may show standards different to those below. In this case follow the local regulations.

<table>
<tr><th></th><th>TEMPERATE CLIMATE</th><th>HOT CLIMATE</th></tr>
<tr><td rowspan="1">Heating</td><td>Local:
3500 w/700 – 800 chicks
Whole house:
80 – 100 w/m^2
4 thermometers/1000 m^2
linked to the ventilation controls</td><td>Local:
1400 w/600 – 700 chicks</td></tr>
<tr><td rowspan="2">Water</td><td>Drinkers
Round: 1/100 broilers
Trough: 2 cm/broiler
Nipples:1/10 – 15 broilers</td><td>Drinkers
Round:1/60 broilers
Trough: 3 cm/broiler
Nipples:1/6 – 10 broilers</td></tr>
<tr><td colspan="2">Nipples: ensure that water pressure is constant the complete length of the line</td></tr>
<tr><td rowspan="2">Feed</td><td>Chain feeders: 15 m/1 000 broilers
Pans: 1/60 – 70 broilers</td><td>Chain feeders: 25 m/1 000 broilers
Pans: 1/40 – 50 broilers</td></tr>
<tr><td colspan="2">Foresee a system for the control of both the quantity and distribution of the feed</td></tr>
<tr><td>Lighting</td><td colspan="2">Incandescent: 5 w/m^2
Fluorescent: 60 lux
Control of light intensity:
Light dimmer
Light programme</td></tr>
<tr><td rowspan="2">Ventilation</td><td>Power: 6 m^3/kg liveweight/hour</td><td>Tunnel ventilation:
Air speed 2 m/sec</td></tr>
<tr><td colspan="2">Natural: adapt bird density to the climatic conditions</td></tr>
<tr><td>Cooling</td><td colspan="2">- Fogging for 1 000 m^2:
High pressure pump: 600 litres of water/hour
Pressure: 110 – 120 bars
Nozzles: 60 nozzles of 10 μ
- Pad cooling 10 cm thick:
For 10 000 m^3/hour: 1.5 – 2 m^2
Minimum air speed at pad level: 1.5 m/s</td></tr>
</table>

DENSITY

The equipment standards, quality of house construction and climatic factors are the most important criteria that will determine the stocking density. However, other factors should also be taken into consideration:

- the well–being of the animal (legislation, recommendations)
- the type of product, market sector, slaughter weight
- the management level of the grower, by far the most determining factor.

EXAMPLES OF THE NUMBER OF DAY OLD BROILERS/M² AND KG/M² TO PLACE IN A VENTILATED HOUSE

Slaughter weight (kg)	Temperate climate		Hot climate	
	Birds/m²	kg/m²	Birds/m²	kg/m²
1.2	26 – 28	31.2 – 33.6	22 – 24	26.4 – 28.8
1.4	23 – 25	32.2 – 35.0	18 – 20	25.2 – 28.0
1.8	19 – 21	34.2 – 37.8	14 – 16	25.2 – 28.8
2.2	14 – 16	30.8 – 35.2	11 – 13	24.2 – 28.6
2.7	12 – 14	32.4 – 37.8	9 – 10	24.3 – 27.0
3.2	10 – 12	32.0 – 38.4	8 – 9	25.6 – 28.8

Local regulations in some countries may differ from the table above. Follow the local regulations in this case.

Overstocking lowers the potential for optimum performance due to:

- the reduced growth in the latter part of growing and poor uniformity
- the increase in:
  - F.C.R.
  - Mortality
  - Culls and rejects

For open–sided houses with minimum or no mechanical ventilation, do not place more than 10 birds/m² in all seasons.

● HOUSE PREPARATION

After the cleaning and disinfection period, the litter and all house equipment should be in place 3 days before the arrival of the chicks.

■ Litter

During brooding, the litter acts as insulation and comfort for the baby chicks.

The type of litter available is variable according to the area: shavings, chopped straw, rice hulls, recycled paper… Choose a dry product that is non-corrosive to skin and with good absorption properties. It should also be correctly treated to reduce the chance of bacterial contamination.

Good quality litter is indispensable in order for the birds to express their natural behaviour (picking and scratching in the litter).

The litter thickness will vary according to climatic conditions, density, ventilation control, feed formulation (maize/wheat based feed) and type of water system (nipple, round drinker, troughs). Nipple drinkers are the preferred drinking equipment to minimise water wastage.

Shavings or chopped straw can be used in a temperate climate (2 – 5 kg/m²) according to conditions.

In summer, in well-managed houses with concrete floors the depth can be below 2 kg/m².

In winter on dirt floors, 5 kg/m² is required. During this season it is very important to pre–warm the litter to eliminate condensation due to its contact with the cold floor. This is frequently seen when using dirt floors, which are wet or concrete floors.

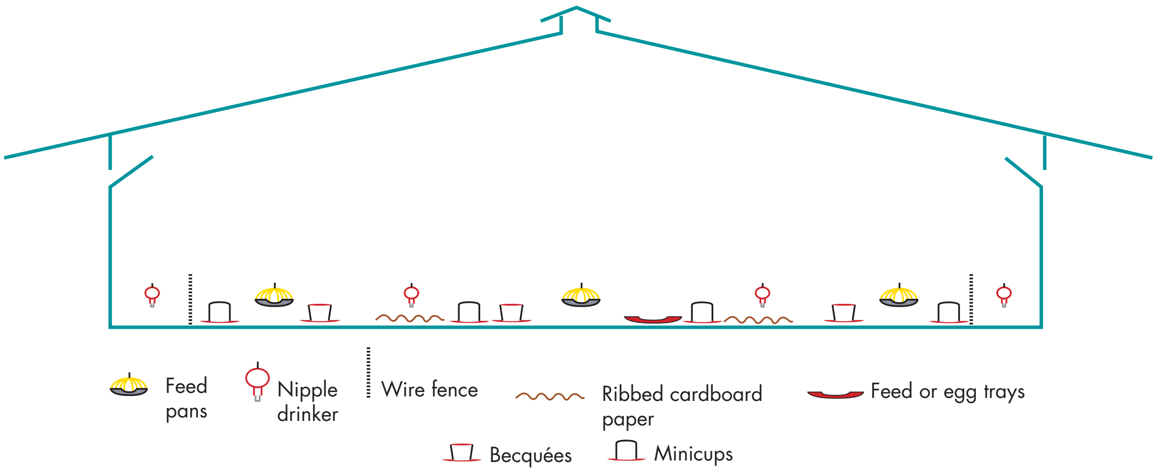
■ Organising the house

This will depend on 3 principal elements:

- the type of house and level of insulation
- the heating system (whole house or local)
- the watering system (round–type, nipple or trough).

■ Whole house heating

If the house is well insulated (or in a warm climate) use 80 to 100% of the house. This is the easiest method in terms of work organisation. If the sidewall insulation is not good, it is better to start the chicks in the centre of the house with a fence on each side, 2 – 3 metres from the wall.



For 1000 chicks: 5 plates or "becquées", 5 new egg trays, 6 – 7 m of paper under the nipples 0.70 m wide, 40 – 50 nipples, 5 "minicups".

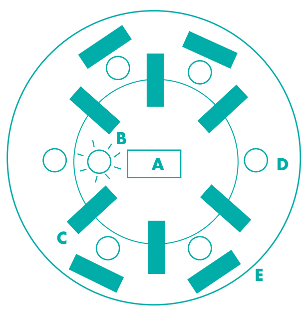
■ Localised heating

In poorly insulated houses, do not exceed 40 chicks per m² in the brooding area (650 chicks in a 5 m diameter circle).

This technique requires more work, as more brooder points are required.

The placement of the equipment should be such that the chicks can always find water and feed.

• Recommended layout for 650 chicks



A. One radiant of 1450 kcal for 650 chicks.

B. A light source of 75 w, 1.5 m above litter above radiant.

C. 10 feeders.

D. 2 – 3 adult drinkers + 4 mini syphons.

E. A surround of 5 m diameter made of cardboard in cold climates and of wire mesh in warm climates: 0.4 m high.

■ Partial house heating and open-sided houses with curtains

The heated area should be separated from the unheated area by a double plastic curtain.

Allow for the plastic curtain to be moved, as the chicks brooding area is expanded, until they have the use of the whole house.

■ Preheating

This is an important key to success. The preheating must be sufficient to heat the whole surface area from the litter through to the concrete or dirt floor and points of contact for the chick, to a level of 28 – 30°C. This is to eliminate chance of condensation between the litter and the floor, which can cause anaerobic fermentation and eventually ammonia. The preheating time must be longer when the outside temperature is colder, the litter depth is deeper and when the sidewalls are constructed from materials such as concrete, which absorbs a lot of heat and moisture. Open–sided houses in winter will require a good pre–warming period.

According to climatic conditions, insulation of the house and quantity of litter, the preheating time can vary between 36 and 48 hours.

Cold litter when the chicks arrive can be the origin of nephritis, diarrhoea and leg problems.

■ Final disinfection

When all the equipment has been re–assembled and the house temperature is 20 – 25°C, the final disinfection can be carried out 24 hours before the chicks arrive.

The house should be ventilated to exhaust any remaining gas from disinfection and gasses from the heating system (a minimum of 500 m^3/hour for each 1 000 m^2).

- Disinfection:
  - By "thermo–nebulisation": refer to the supplier's instructions.
  - By formalin gas (per 1 000 m^2):
    - formalin powder: 4 kg in an electric frying pan
    - formalin 30%: 16 litres plus 8 kg potassium permanganate plus 8 litres water.

It is the responsibility of each grower to comply with any health and safety regulations enforced by their local authorities, when using this type of disinfection.

● RECEIVING THE CHICKS

■ Delivery

All personnel involved in placing the chicks must respect the farm's bio–security precautions and wear clean uniforms and boots. The driver is not allowed to enter the house.

Sufficient personnel should be on hand to do the work quickly.

Spread the boxes (DO NOT STACK THEM) evenly throughout the house beside the drinker lines, which is the brooding zone for whole house brooding and close to the brooder surrounds for localised brooding. When all the chicks are in the house close the doors.

Perform any treatments such as spray vaccination etc. quickly and then empty the chicks carefully from the boxes to limit the chance of leg damage.

The chick boxes should be removed immediately from the house and burned, if they are made of cardboard.

■ Managing the flock

■ The signs of a good quality chick are:

- its activity
- some chirping
- absence of respiratory anomalies
- a properly healed navel.

Weight and uniformity are also important. Weigh 200 chicks at random for an accurate average.

If the broiler flock is supplied from different age breeders, the chicks from the young breeder flock must be separated from the start. This decreases the chance of poor uniformity, which starts very quickly when these smaller chicks cannot eat or drink properly.

■ The house

Check all the sensors, thermostats and variations in temperature and verify the humidity level, prior to the chick delivery.

■ The flock record

In organisations where all information is required, this record should contain all the data about the flock. In many European countries it is required by the health services that control the slaughterhouses.

The principal data required:

- hatch date
- chick origin, donor flock, hatchery
- daily mortality split into its different types (heart attack, locomotion, etc.). It is also recommended to write down if a bird has to be eliminated and if yes, for what reason
- bodyweight taken at their arrival and thereafter, each 5 days. This information is most important for the efficient control of the light and feed programmes
- feed company, delivery date, type of feed, quantity
- the knowledge of the flock's daily feed consumption is important in controlling the growth rate and the feed conversion
- daily water consumption and any variation is often the first sign of disease or a feed problem
- the vaccination dates, batch number, treatment, products, quantity (dosage and dates).

■ Weighing techniques

Automatic

Bodyweight control is easier when automatic systems are in use. They must be properly controlled, especially for **poor uniform flocks** and towards the end of the growing period when **the heaviest birds tend not to want to jump on the scale**. The number of birds weighed decreases with age, hence there is more risk of inaccuracy in the recorded weights. This type of weigh scale should be recalibrated every 2 weeks by weighing 100 birds manually and then resetting the scale.

Manual

The system of weighing every 5 days should be done using a screen and weighing all the birds caught (not less than 100 – 150 birds). At the end of the growing period, if the flock is not uniform, the pre-slaughter check weight for the slaughterhouse becomes more difficult. It requires **penning and weighing 100 broilers in three different places in the house, taking care to handle them carefully (holding by both legs) to limit stress,** to achieve a more accurate result.

● STARTING THE CHICKS

■ Environmental factors

At the start, the chick does not have a thermal regulatory system. Its comfort depends totally on the control of the exterior parameters, management skills of the grower and the quality of the house construction and equipment. The control of the environment is an understanding of multiple interactions.

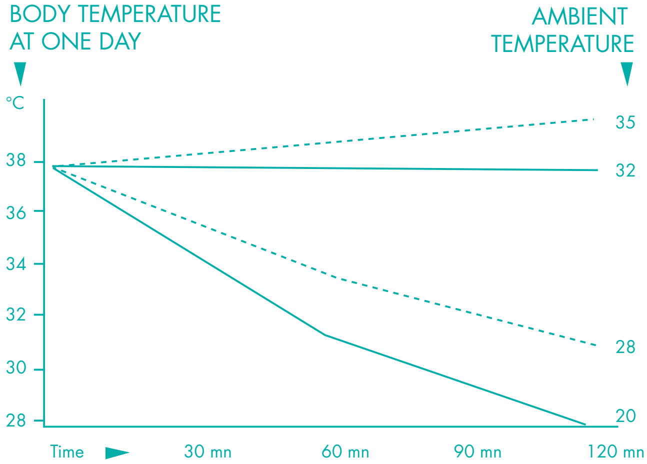
Temperature ⟷ **Humidity** ⟷ **Ventilation** ⟷ **Air speed**

- Firstly, observe the behaviour (position, chirping, attitude, feeding and drinking activity).
- This is followed by individual handling of the chicks. Feel the legs (hot or cold). Check that there is food in the crop.
- Check and record the temperature, humidity, air speed (observe the movement of the hanging ribbons and where the chicks are situated). Are the heating and ventilation systems working properly?

The adjustment of the equipment is based on observation of the chick's behaviour. This can be intuitive, depending on the experience of the grower and the knowledge of his house. Today, farmers rely on electronic controls more than in the past. It is important to understand these different relationships, so that fine–tuning adjustments can be made.

ADJUSTMENT OF THE EQUIPMENT ⟷ BEHAVIOUR AND THE WELL–BEING OF THE CHICK

Adjustments made from the feed–room are insufficient and very dangerous.



The temperature zone for the baby chick is very tight (31 – 33°C). Below 31°C, the chick is not capable of maintaining its body temperature.

Transport and farm receiving conditions vary from one flock to the next.

The recorded ambient temperature has no value unless it is measured at chick level.

HOUSE ENVIRONMENT

Age in days	Temperature			% Humidity	Ventilation
	Local brooding		Whole house heating		
	Under the brooder	Living area			
0 – 2	32 – 34	29 – 31	30 – 32	55 – 60	Level of ventilation: 0.8 – 1 m^3/kg liveweight from the start until 21 days. Elimination of carbon monoxide, removal of NH_3: Air speed < 0.1 m/s
3 – 6	31 – 33	28 – 30	28 – 30	60 – 65	
7 – 9	29 – 31	26 – 28	26 – 28	60 – 65	
10 – 12	28 – 30	25 – 27	25 – 27	55 – 60	
13 – 15	27 – 29	24 – 26	24 – 26	55 – 60	
16 – 18	26 – 28	23 – 25	23 – 25	65 – 75	
19 – 21	25 – 27	22 – 24	22 – 24	60 – 70	
Measure temperature at chick level					
22 – 25		21 – 23	21 – 23	60 – 70	Ventilation variation: 0.8 – 6 m^3/kg liveweight. Elimination of humidity
26 – 30		20 – 22	20 – 22	60 – 70	
31 – 35		18 – 20	18 – 20	60 – 70	

Each type of heating system has its limitations:

Localised brooding

The chick's position relative to the heat is an important indication.

Uniformly spread, active chicks	→	optimum situation
In groups near the sides of the house	→	temperature too high
Huddling under the brooder	→	temperature too low
Huddling in one area	→	avoid cold air currents

The position of the brooder depends on its heat output and the insulation of the house.

Radiants of 3 500 watts capacity and higher can be hung at a height of 1.50 – 2.50 m in well–insulated houses and used for whole house heating.

Radiants of 1 700 watts capacity operated in poorly insulated houses, should only be used for localised brooding and hung at a height of 1.20 m – 1.50 m. The height will vary according to the climatic conditions.

Whole house heating

The biggest difficulty is to obtain uniform temperature due to variations in house insulation, cold sidewalls, air inlets, air movement and poor placement of the heating appliances. Because of these factors, true judgement of chick behaviour is more difficult.

Correct heating: chicks are uniformly spread, with good feeding and drinking activity throughout the house.

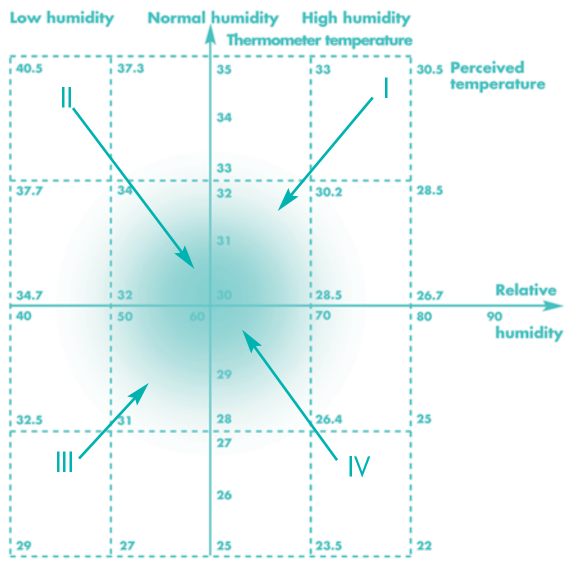
Overheating: chicks are sleepy and spread out over the litter with their beaks open. The risk of dehydration can be aggravated by low humidity or under ventilation and a risk of asphyxiation by gas emissions from the brooders. A build-up of CO_2 is very dangerous to both the grower and the chicken.

Underheating: chicks huddle in areas without any cold air currents. Feeding and drinking activity is low. In this case increase the temperature and reduce the air inlet space.

■ Temperature/relative humidity

The perceived temperature for the chick is linked to both temperature and humidity. The following diagram illustrates this point.

RELATION OF TEMPERATURE AND HUMIDITY



Zone I: High humidity – high temperature.
The chick lowers its temperature by losing sensible heat by conduction (humid air increases the conductivity). In this situation lower the temperature and increase the number of air changes.

Zone II: Low humidity – high temperature.
The chick lowers its temperature by panting and discharges water in vapour form (latent heat – 0.6 kcal/g of water evaporated). In this situation there is a risk of dehydration. Lower the temperature and increase the humidity by fogging.

Zone III: The temperature felt by the chick is correct, despite a low thermometer reading, but the risk of dehydration exists.

Zone IV: The perceived temperature is too low resulting in a loss of heat by conduction. Increase the temperature to lower the relative humidity and increase the number of air changes.

The perception of the different zones changes, as the chick becomes older and as conduction decreases (due to feathering). Once the chick is fully feathered, the above diagram does not apply.

■ Air changes and air speed

Ventilation is required from the moment the heating apparatus is started up to evacuate the toxic combustion gasses produced by the system (notably the toxic carbon oxides).

The minimum ventilation rate recommended is 0.8 – 1 m^3/kg liveweight/hour. This assures sufficient air exchange without risk to the chicks or personnel.

Insufficient oxygenation during the brooding stage has its repercussions on liveability later in the growing cycle. It enhances the risk of ascites: bad oxygenation overtaxes the cardiovascular system in order to ensure the correct metabolism of the feed for body heat regulation and growth.

EXAMPLE FOR 25 000 CHICKS

Age in days	Weight in g	Total weight in kg	Ventilation m^3/kg liveweight/hr	Time changes for a fan 10 000 m^3 cycling each 18 seconds	
				Time	%
0	40	1 000	1 000	18	10
5	100	2 500	2 500	45	25
10	220	5 500	5 500	100	55
15	310	9 500	9 500	171	+/- 100

For the baby chick, air speed lowers the temperature about 2°C for each increase of 0.1 m/s. As feather growth improves this effect is reduced. By 4 weeks the reduction is 1°C for an increase in air speed of 0.5 m/s.

During the brooding period reduce all possibility of air currents at chick level.

■ Feeding

All the feeding points (paper, new egg trays, trays, “Becquées”, pans, troughs) must be in place when the chicks arrive.

Three hours after the chicks’ arrival, 90% of the chicks when checked should show signs of eating (feed in the crop).

Remove the paper under the nipples or in the surrounds 24 hours after the chicks are placed. It may be necessary to replace the paper one or two times during this period to reduce the chance of contamination from a build–up of faeces.

The egg trays are used for the first 3 – 4 days. The feed is replaced twice daily, without permitting any accumulation of old contaminated feed (if necessary throw out any contaminated feed that remains when refilling the trays).

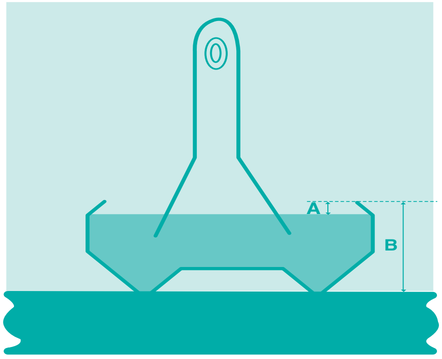
"Becquées", which are small gravity fed feed containers with about a 8 – 10 kg capacity, or trays ("Becquées" are better as the feed is less contaminated) are used for at least 10 days at the rate of 1 for 200 chicks. They are slowly removed so that the weaker chicks can accustom themselves to the new height of the pans or chain feeders.

Calculation of the chicks' access to the pan type feeder:

If the standard for A + B = 6 cm = 3 days **then the chicks' access to the pan is from the 3rd day.**

When the calculation is more than 6 cm, increase by 2 days for each 1 cm extra the time limit before the chicks can comfortably eat from the feeder pan.

I.e. A + B = 7 cm (3 days + 2 extra days = 5 days) before chicks can realistically start to eat from this style of feeder.



Sciences & Techniques Avicoles

Certain types of feeders are more difficult for the baby chick to access.
One should be more careful with the changeover period from manual to automatic feeding equipment, **especially with chicks from young breeders and poor uniform flocks.**

Feed clean–up period:

The techniques of controlling the light and feed programme to help improve the economical performance of the flock should start at a young age.

When the chicks are eating sufficiently from the pans or chain system, usually between 7 and 14 days according to the chick's ability to access and eat from the equipment, the empty no feed/clean–up period can start on a daily basis in the 3rd week.

■ Water

When the chicks arrive, the drinking water temperature should be 25 – 27°C.

It is important to quickly climatise the chicks to drinking, as they can be partially dehydrated depending on their transport conditions. They will lose 0.1 g per hour of transport after leaving the hatchery.

Minimise the use of products that reduce water consumption. Sugar and vitamin C improve interest in drinking.

Refilling and cleaning of the drinkers should take place several times per day during the first week. Adjust the height of the drinkers and the water level to avoid spillage. After this period, round type and trough drinkers should be cleaned daily.

Adjustment of the nipple drinker height and the water pressure varies between the different types of drinkers available in the market. Follow the manufacturer's instructions.

From the first day, record the daily water consumption.

■ Lighting

Use 23 – 24 hours light for the first 3 – 5 days to encourage feed and water consumption.

Light intensity should be strong in the brooding area, 5 watts/m^2 when using incandescent bulbs and 60 lux for fluorescent tubes. When the chicks are small and come from young breeder flocks increase light intensity by 20 – 25%.

In darkout and semi-closed houses, the intensity should be gradually reduced to 10 lux (0.5 w/m^2) between 5 and 10 days, depending on the growth programme selected for optimum growth.

The information on light and growth programmes is expanded on page 45.

● GROWING & FINISHING PERIOD

The flocks optimum technical and economical results are established right from the start and are finalised during this growing and finishing stage.

During this phase, the skill of controlling the environment becomes more important to maintain the biological and social equilibrium of the chicken house.

Biological equilibrium: bodyweight per m² increases rapidly and also the requirements for oxygen, water and feed. The following points must be kept in equilibrium:

Gas	Oxygen	→	CO_2: a maximum of 0.1%
			+ NH_3 emitted from the litter (max. 15 ppm)
Humidity	Water	→	Exhaled water and water in the faeces
Heat	Feed	→	Utilisation and evacuation of heat production from the broilers

Social equilibrium: Broilers are very sensitive to variations in temperature. They will group together in different spots in the house. During the last few days of the growout, broilers are less mobile due to the density and their performance depends greatly on the positioning of the feeding and water equipment.

■ Parameters for whole house heating in temperate climates

From the physiological point of view, the broiler's need for oxygen (0.03 to 0.13 m³/kg liveweight/hour), is adequately covered most of the time.

However, in temperate climates the parameters for the environment depend mainly on two factors:

● The thermal efficiency of the house

The quality of insulation and degree of "watertightness", the capacity for absorption of water from the litter, the degree of floor insulation and the outside environment, are all involved in keeping the humidity level inside the house low.

● Ventilation

The control and adaptation of ventilation and air circulation, that is based on the requirements of the flock and their age.

The heat calories produced by the broilers and the anaerobic fermentation from the litter are mostly responsible for the improvement in the atmosphere when these two factors are properly controlled. If this is not so, due to bad quality housing, poorly controlled ventilation, low temperature and/or high humidity, then the use of heat is required.

● Humidity

This is often the limiting factor in the environment. The maximum acceptable threshold is 70% relative humidity. Humidity is more difficult to control towards the end of the growing period, as feed consumption and water wastage is high.

Example: 1 000 m², 18 chicks/m², 2 kg liveweight and daily gain of 70 g/day (D.W.G)=(0.070 kg)

● Feed/broiler	165 g	water to feed	= 1.85
● Temperature	outside	10°C R.H. 90%	= 8 g of water/m³
	inside	20°C R.H. 70%	= 12 g of water/m³

● Daily water consumption 1 000 x 18 x 0.165 x 1.85 = 5 500 litres

● Distribution of water per day:

- tissue growth: 18 000 (chicks) x 0.070 (D.W.G) x 0.65 (body tissue) = 820 litres
  (65%, this is the level of water in the body tissue)
- water to be eliminated per hour: (5 500 – 820)/24 hours = 195 litres per hour

- Of the 195 litres eliminated per hour, 120 litres is through respiration, 75 litres in the faeces (this requires 600 kcal or 680 w for each litre of water to be evaporated).
- 195 000/4 g water/m^3 = 49 000 m^3/hour   49 000/36 000 = 1.3 m^3/kg liveweight/hour

  ↑   ↑

  (12 g water – 8 g water) = 4 g water/m^3 36 000 = 18 000 x 2 kg broiler

This example shows that it is easy to calculate the minimum ventilation required to maintain a base of 70% relative humidity, from knowledge of the water and feed consumption, daily weight gain, the inside and outside temperatures and humidity.

Of course, when the outside air becomes hotter and more humid, the ventilation requirements increase and in some situations it is impossible to respect this threshold.

In this case there are two possible solutions:

- when the inside and outside temperatures are similar and the relative humidity is high, it is necessary to both ventilate and heat to improve evaporation of water from the litter and at the same time to slightly increase the inside house temperature
- when the outside temperature is between 25 and 30°C with a relative humidity of 80 – 90%, only the air speed at bird level is helpful (2 m/second on full–feathered broilers reduces the perceived temperature by 4°C).

Ammonia

Ammonia produced in the chicken house must be eliminated. The tolerance level is about 15 ppm. Above this level the ammonia will provoke irritation of the mucous membranes, which can cause conjunctivitis and air sac lesions. The ciliary activity in the trachea will be reduced. There will be increased susceptibility to parasitic diseases such as coccidiosis and reduced growth through lower feed intake.

The key to controlling ammonia is to control the humidity level:

- respect for the basic management practices: stocking density, control of water consumption and the water equipment, adequate feed formulation, minimum ventilation to mention a few points
- correct use of timer fans in closed houses. This means watching the bird's behaviour and sensing the environment at the chick level. Settings can be made in the control panel, but this may need overriding based on observation of the flock and knowledge of the chicken house (insulation, construction, previous seasonal history, etc.)
- especially in open-sided houses, where it is more difficult to control air movement at baby chick level, it may be hard to control humidity. If, after respecting basic management practices, there is still a build–up of ammonia spread a thin layer of new dry wood shavings.

Sprinkling 200 g/m^2 of superphosphate every 5 days in the litter can help to reduce ammonia production.

Do not do this after 28 days of age in high density rearing.

■ Ventilation and air circulation

In this guide we can only talk about some basic principles.

The control of the incoming air

The air speed will be faster when the outside temperature is low, thus the air pressure must increase when the temperature is low and conversely. The entering air should be at a maximum speed of 3 – 4 metres per second. Above this, the pressure becomes too high and ventilation capacity is reduced (when everything is correct the door when opened should be sucked closed).

Air circulation

According to the type of ventilation system and the outside air pressure the airflow/current is different. Use ribbons as markers in critical areas of the house to help identify where the air speed is too fast (e.g. along the walls in houses with inlets on the sidewalls). The chick's behaviour will also indicate where the direction of the cold air current is coming from, as they will move away from this area. Use of tape hanging from the ceiling will give an idea of the direction of the air movement and its speed. When the pressure inside the house is correct the door should close itself firmly, without help.

Air outlets

The extraction rate of the fans according to the air pressure and the recycling of air is an important point to understand in order to obtain quality ventilation. The best results come from fans working in groups with different settings.

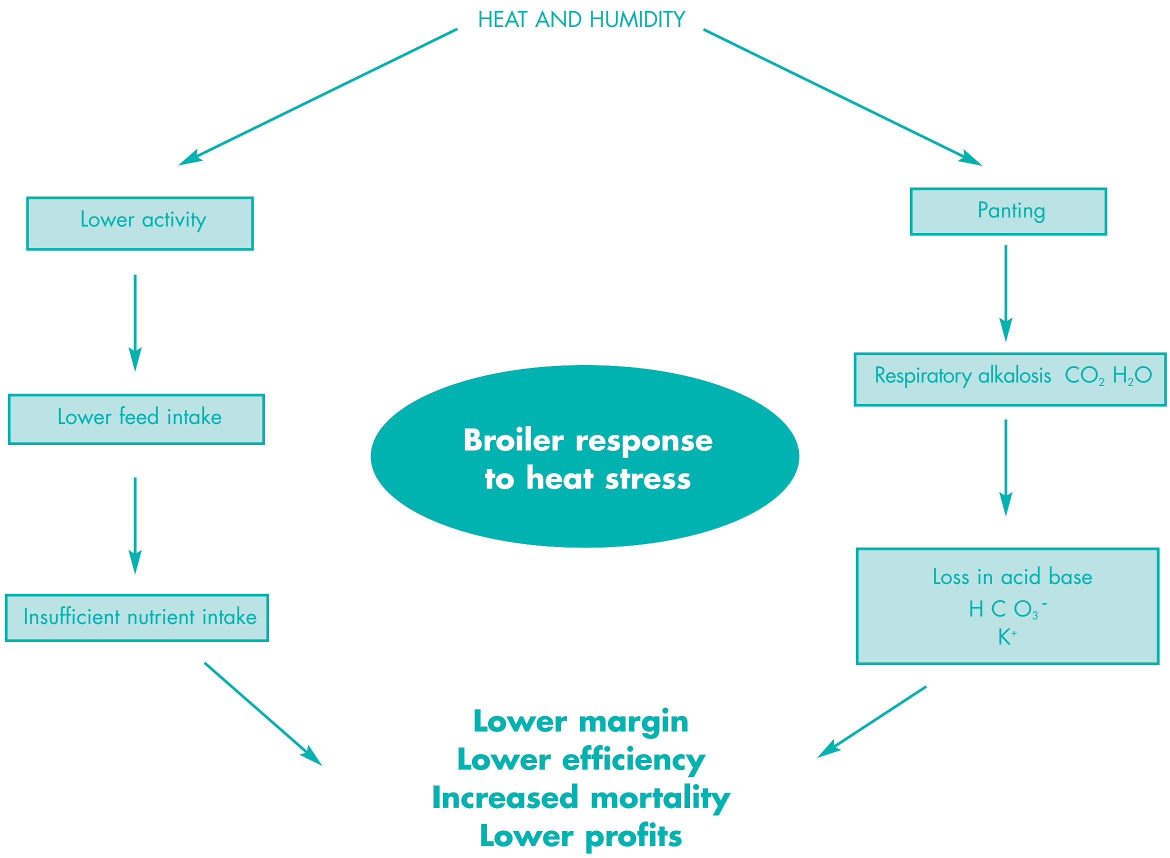
■ Feeding

During the brooding phase, the chicks are prepared for the system of weight management using the technique of emptying the feeders to ensure feed clean-up. This method is an important skill for managing a flock:

- a very short empty period of less than 1 hour can be used to stimulate the daily feed consumption and to ensure that all the fines are consumed. The feed will be fresher and more enticing to the broilers
- a longer feed clean–up period can be used to slow down the growth rate through reduced feed consumption. This method is discussed further in the growth control section.

● HEAT REGULATION

THE PHYSIOLOGICAL RESPONSE OF BROILERS TO HEAT STRESS AND THE EFFECTS ON PERFORMANCE



■ Water

During hot weather, the ratio of water to feed is rapidly increased to compensate for the water loss by the birds during panting.

- Make drinking easy:

Minimum equipment required: 1 drinker per 60 broilers
1 nipple per 10 broilers
2 cm of water trough per broiler.

- Ensure that the water depth for the drinkers and the water pressure for the nipple drinkers is correct. Check the drinking time and quantity.
- Maintain water temperature below 27°C. This can be achieved by bringing water directly from the underground into the water lines via a pressure regulator, insulated tanks or a water chiller. Regular flushing of the water lines 2 to 3 times per hour during the very hot periods to eliminate the hot water works well.
- To help lower respiratory alkalosis increase the potassium chloride 0.5 g/litre, sodium bicarbonate 0.5 g/litre and vinegar 1 litre/1 000 litres.

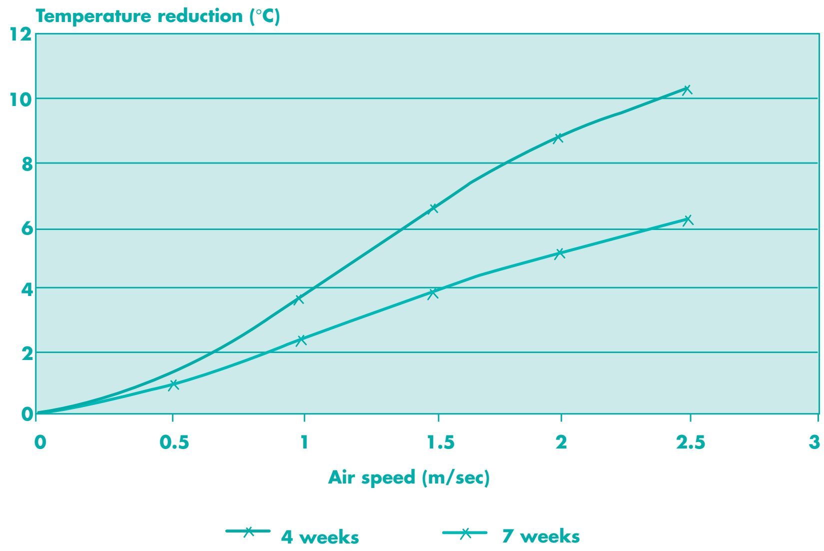
■ Temperature control in the houses

The techniques to control house temperature are very advanced. Whether they are used or not is mostly dependent on economics.

For non insulated open–sided houses, reduce density, try to make use of trees and bushes around the houses to create a more favourable microclimate. In very hot weather wetting the roofs and vegetation around the house can help to improve conditions.

Air movement increases the loss of sensible heat by conduction. However, the effectiveness of air movement depends on the age and the feather cover of the broilers. Chicks less than 4 weeks of age are more sensitive. The effectiveness is less when temperature is high.

THE EFFECT OF AIR SPEED ON TEMPERATURE FELT BY BROILERS AGED 4 AND 7 WEEKS



Air movement can be created by the use of circulating fans positioned to increase air speed at bird level. For houses of 10 metres wide and open-sided curtain houses use 40 000 m^3/hour capacity fans positioned every 20 metres down the length of the house.

Tunnel ventilation assumes that the house is closed by curtains and has a minimum roof insulation of 3 cm of polyurethane foam. In this case the ventilation capacity will depend on the air speed required at bird level.

VENTILATION CAPACITY RELATIVE TO THE AIR SPEED REQUIRED

Section (m²) / Capacity (m³/h)	40 Speed m/sec	50 Speed m/sec	70 Speed m/sec
40 000	0.33	0.22	0.16
80 000	0.66	0.44	0.32
120 000	0.99	0.66	0.48
160 000	1.32	0.88	0.64
200 000	1.68	1.10	0.80
240 000	1.98	1.33	0.93

(CNEVA Ploufragan, 1996)

It is important to carefully calculate the fan's real extraction rate, because air speed, obstacles, the length of the house and the dominant wind all reduce its actual capacity. Normally, when calculating ventilation requirements, allow an additional 20% for these losses.

Curtain sided houses can work without mechanical ventilation during hot weather.

Air speed that is too strong can be a cause of cooling, which can provoke enteritis in young chicks. Thus, a security system for low temperature that will stop the fans should be installed.

In hot, dry climates, it is possible to use water cooling to improve the reduction in temperature obtained by the air speed. The efficiency of this system is better when the relative humidity of the incoming air is low. This improves the evaporative capacity and then the cooling will be improved.

The technical limitation to water–cooling is shown by the effective temperature felt by the birds and is the combined result of temperature and relative humidity. For broilers of 5 weeks and older, suffocation and mortality of the birds occur when the air is saturated, because the evaporative level of the expired moist air whilst panting is reduced.

LIMITING VALUES OF TEMPERATURE/RELATIVE HUMIDITY

Dry Temperature °C	Relative Humidity %
34	**38**
32	**51**
30	**70**
28	**96**

(Sciences et Techniques Avicoles, September 1998)

Two techniques are available to help cool the broilers:

● Fogging

Independent of the atmospheric conditions the effectiveness of the system depends on:

- the available water pressure (up to 120 bars)
- the quality and maintenance of the nozzles and size of the droplets (less than 10 µ)
- the time sequence (3 – 4 seconds/20 seconds) to increase evaporation in the house
- the water quality. Use filters to avoid calcium deposits and blocking of the nozzles
- the air speed (ventilation level).

The total water required is controlled by the ventilation rate and the maximum quantity of water absorbed per kg of dry air.

Water flow (Litres/hour)	= kg/kg (dry air)	x	water flow (m^3/hour)	x	0.87 (density)

(Sciences et Techniques Avicoles, September 1998)

This technique of high pressure fogging gives results similar to pad cooling. If the nozzles are well maintained, the effectiveness is very good. The system can also be used to disinfect the houses.

- Pad cooling

This is a specific system used in hot dry climates. Theoretically, this is the most efficient system for lowering temperature.

For continental type climates where it is cold in winter, do not use pad cooling. It is better to use air inlets spaced the length of the sidewalls to avoid the tunnel effect, which is dangerous in winter.

The pad cooling system is based on the evaporation of water over a large surface area coming in contact with hot dry incoming air. Its efficiency depends on:

- the ratio between the exchange surface area and the ventilation capacity. In general allow 1.5 – 2 m^2 of 10 cm thick pad for each 10 000 m^3/hour
- the ventilation capacity (the effect of the tunnel and the air speed) and the length of the house (maximum 120 m long). These points should all be considered carefully when planning the system
- the cleanliness of the pad surface and the absence of blocked flutes by damage, dust, and calcium deposits due to the air and water quality (the water should be filtered). This point is essential for the effectiveness of this system. Often, early ageing of the pads is observed due mainly to poor maintenance
- for tunnel ventilated houses stop the water system at night–time and when the R.H. % is above 80%, only use the fans
- the system controls should limit the highs and lows of both temperature and humidity.
  - . Highs: this is the range between temperature and relative humidity allowing sufficient margin for security.
  - . Lows: do not cool excessively or too quickly. Stop the system when inside temperatures are below 25°C and work only with tunnel ventilation.

■ Other possible techniques

- Quietly walk through the flock to keep the birds spread out and encourage them to drink, but do not excite the birds during the hot part of the day.
- Reduce the stocking density of the house to maintain better litter quality. This limits fermentation and the release of more heat.
- Reduce the litter depth and thus the increased fermentation towards the end of the cycle. In a well managed house with a dry cement floor use 1 kg per m^2.
- Acclimatise the chicks to heat. It is possible to do this at about 5 – 6 days of age by increasing the temperature to 35°C for 6 hours.
- The use of roof sprinklers to wet the roof is well known to reduce some of the heat by a few degrees. This requires vast quantities of water. Good drainage is required. With filters, recycling of the water is possible.

■ Construction of open–sided houses in tropical climates

- Build the houses in an East to West direction and where there is continual air movement such as on a hill or a plain. The long axis should be across the prevailing wind for improved airflow. Where both conditions cannot be met then the wind factor should take precedence.
- The houses should be high with an open ridge for improved air movement.
- When building a number of houses take care that the wind does not blow directly from one house to the next.
- Around the house the grass should be well cut (bare dirt will reflect the heat). Use of bushes or leafy type trees that are placed sufficiently far from the house so as not to interfere with the airflow, but will block the direct sun from entering the house.
- The use of strong, reflective and if possible insulated roofing material. For traditional roofing, paint the roof with hydrated lime: 9 kg of hydrated lime per 18 litres of water.
- The roof should have an overhang of about 1 metre to stop the direct sunlight from entering the house.
- In some countries building the houses on stilts above the ground using bamboo slats for the floor is very successful. This allows for very good airflow.

INTRODUCTION

For many years, the principal measure for the quality of the feed was growth and F.C.R. Today the nutritionist is confronted by numerous and more complicated factors.

- The improvement of genetics has been very important to the point that broilers that eat too much cause many problems for the production network.
- The growing demand by the consumer for a wider variety of products, cut-up, further processing and products grown using nutrition without meat products, growth promoters or antibiotics.
- Environmental controls such as limiting the nitrogenous and/or phosphorous discharges.
- Tighter control on the grower of the climatic conditions, the houses, the management and bio-security.

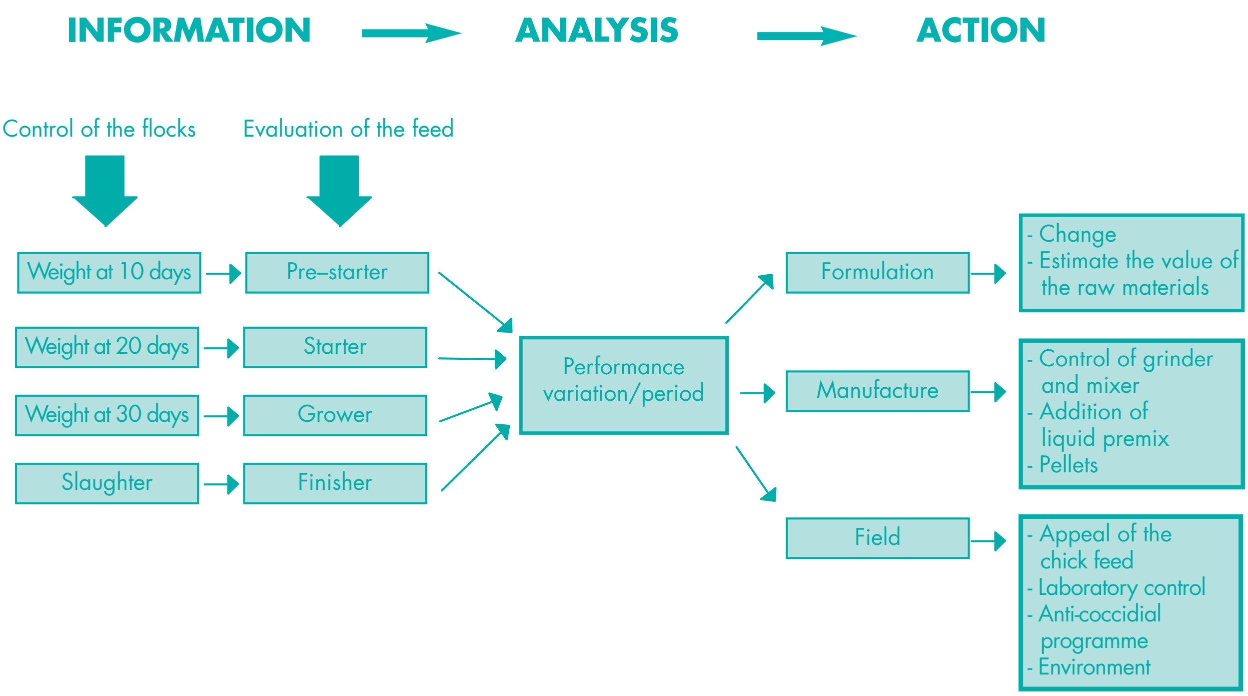
Finding the solution to these challenges is not easy. The choices vary between high energy feed in pellet form and low energy mash feed. Formulation must not only take into account the different aspects of pelleting and feed presentation, but also the feeding methods (ad libitum, controlled or restricted). It seems that ad libitum feeding is not the best way to improving feed efficiency and producing a good quality carcass.

This is why our standard nutritional recommendations can act only as a reference, but must be used taking into account the most economic efficiency for the type of production employed. In this case we can share the idea of Professor I. NIR at the W.P.S.A. Congress in Montreal, 2000: "The expression of the maximum genetic potential is sometimes only possible under conditions that are not always economic".

PRACTICAL FORMULATION

In practice, feed formulation must continuously evolve from regular information, which comes from the field results, slaughterhouse and analysis of the raw feed ingredients and final feed.

The close follow–up of results from the field is certainly the key to the feed quality.



Conclusion

This method when applied and controlled properly can limit the performance variations over time. It is an economical way to optimise costs in the production network.

● FEEDING THE YOUNG CHICK

Recent work has shown that early feeding of baby chicks stimulates the function and development of the digestive system (intestine, villi, liver and pancreas). In this case the yolk reserves are used first for the development of the nervous immune system (Bursa of Fabricius) and the cardiovascular and gastro–intestinal systems. The sooner the chick starts eating after hatching, the better the utilisation of the yolk for the essential functions will be.

EVOLUTION OF WEIGHT DURING THE FIRST 4 DAYS

Age	Day 0	From 0 to 2 days		From 2 to 4 days		At 4 days		% F/N
F= Feed N= No feed		F	N	F	N	F	N	
Feed consumed (g)		6.5	0	23.8	23.1	30.3	23.1	+ 30%
Liveweight (g)	45.2	+ 5.0	- 3.5	+ 16.9	+ 16.0	67.7	57.7	+ 16%
Yolk (g)	7.14	- 4.25	- 3.78	- 2.1	- 2.0	0.79	1.36	(+ 9%)
Intestine (g)	1.11	1.37	0.88	2.12	1.91	4.60	3.90	+ 18%

Y Noy & D Sklan, 1999

There is a lack of enzymes in the young chick during the first two weeks of life and many nutrients are poorly assimilated. The table below gives the apparent digestible values as a function of age.

Age	7 – 8 days	10 – 11 days	20 – 21 days
Organic material (%)	68	71	76
Protein material (%)	75	77	84
Lipids (%)	55	69	84

Zelenka, 1995

Raw materials rich in non-amylase polysaccharides (N.A.P.) are not well assimilated by the young growing bird. The energy values obtained by Mahagna 1995, at different ages, illustrate this.

In kcal per kg of dry matter

Age (days)	4 – 7	10 – 14	17 – 21
Soya cake	1 142	1 308	2 142
Wheat	2 811	2 924	3 386
Maize (corn)	3 118	3 328	3 505

The N.A.P. contained in the feed also reduce the energy values of animal fats.

Conclusions

- Give starter feed quickly to the baby chick and stimulate the feed intake through light intensity, baby chick size feeding equipment, regular feeding and easy access to the drinking water.
- Use raw materials that are more digestible. Do not use high energy by adding saturated fats.

● PROTEIN AND AMINO ACIDS

■ The concept of ideal protein

This concept defines the requirements for the amino acids (A.A.) relative to those of lysine, when the lysine value is 100. The relative values of the sulphur amino acids (S.A.A.), methionine + cystine, increase with age, because of the level of protein required for the feathers, which represents 5 to 6% during the first few days and 11 to 12% by the end of the growing period. The feathers are rich in S.A.A. compared to the carcass. The ratio S.A.A./lysine is 0.62/1 for the carcass and 5/1 for feathers.

The ideal protein as a function of age shown as a percent of digestible lysine (fixed at 100%):

Age / Amino acids	0/14 days	15/35 days	+ 35 days
Lysine	100	100	100
Methionine + Cystine	74	78	82
Methionine	41	43	45
Threonine	66	68	70
Tryptophan	16	17	18
Arginine	105	107	109
Valine	76	77	78
Isoleucine	66	67	68
Leucine	107	109	111

Methionine/Methionine + Cystine ≥ 55%

The male broilers coming from autosexing parent stock are slow feathering. In spite of this, it is important to assure the rapid growth of these slow growing feathers by respecting the S.A.A./lysine ratio. The faster feathering females cover their requirements quicker.

■ Protein levels

Protein levels should be reduced to limit the risks of litter deterioration and nitrogenous excretion. This is possible by using a wide range of raw materials, which contain complementary A.A. used in association with the synthetic amino acids (lysine, methionine and threonine).

Some margin of security should be taken into account for the protein levels.

Age (days)	Protein level	Metabolisable energy (M.E.)	M.E./Protein level
0 – 10	22	2 900 – 2 950	132
11 – 20	21	3 000 – 3 050	143
21 – 33	20	3 100 – 3 150	155
34 – 42	19	3 100 – 3 150	163
+ 42	17	3 150	185

■ Amino acid recommendations

These values are based on the tables for raw material amino acid content currently used in Europe (RPAN and other European tables) and the RPAN (Rhône Poulenc) tables for the values of the digestible amino acids.

Formulations made on the basis of other tables may give different results and it will be necessary to make corrections.

The recommendations given are for total amino acids, but we advise formulating on the basis of digestible amino acids.

■ Sulphur amino acids

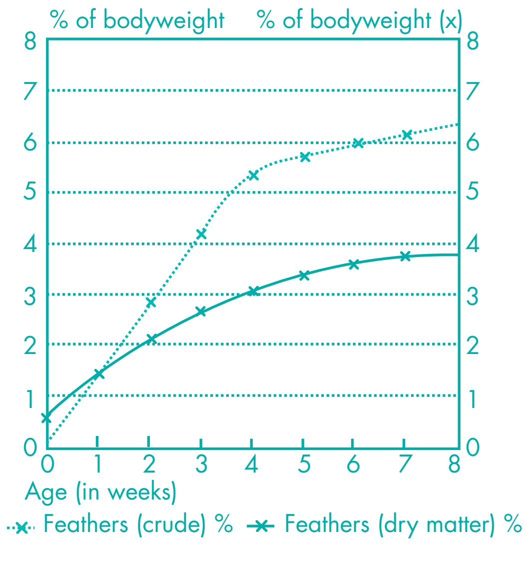
Part of the methionine ingested by birds is used as a source to synthesize cystine. For this reason the true requirements for methionine are less well known than are those for methionine + cystine. Accordingly, formulation should be on the basis of methionine + cystine.

However, the ratio of methionine/S.A.A. ≥ 0.55, must be respected when using raw materials rich in cystine, such as slaughterhouse by-products, feather meal, etc.). Conversely, when using 100% vegetable feed, methionine levels must be increased.

Taking into account the composition of the raw materials, the sulphur amino acids are the first limiting amino acids in poultry feed.

Also, the S.A.A./lysine ratio increases with age due to increased feather growth in the last half of the growing period.

PROPORTION OF FEATHERS AS WEIGHT INCREASES AS A % OF LIVEWEIGHT



Hancock & al. 1995 BPS

Daily feather growth reaches its maximum at around 6 weeks. The dry matter content continues to increase until at least 10 weeks.

A deficiency in S.A.A. will increase feed conversion, lower breast meat yield (see later) and increases the levels of fat. Feather growth has priority over muscle growth.

■ Lysine

Lysine is the second limiting A.A. in broiler feeds. Its requirements are well known.

Lysine requirements diminish rapidly with age, due to the low lysine content of feathers.

An excess of lysine increases the requirements for arginine.

■ Other amino acids

Using a maize, soya, meat meal based ration and with no synthetic lysine, the other essential amino acids are largely covered.

The use of synthetic lysine requires taking into consideration the following amino acids:

→ **THREONINE** → **VALINE** → **ARGININE**

According to the raw materials used they will be the 3rd or 4th limiting amino acids. In practice, isoleucine and tryptophan are not limiting amino acids.

Taking into account the composition of the raw materials, the use of synthetic lysine will change the order of the limiting amino acids. The 3rd limiting amino acid will be threonine, when peas, meat or fishmeal are used. Arginine and valine will be the 3rd and 4th limiting amino acids in maize–soya type rations.

One should note that the requirements for valine, arginine and isoleucine are not as well understood as compared to the sulphur amino acids, lysine or threonine.

■ The order of requirements

The full expression of the genetic potential depends on satisfying the birds' requirements for the amino acids. Performance measured in terms of growth, F.C.R. and carcass quality depends on satisfying the requirements for the most limiting amino acid.

The A.A. requirements for achieving the maximum growth potential are less than those required for the best F.C.R.

The requirements for achieving the maximum breast meat yield are the same as those necessary to achieve the lowest F.C.R.

Reduction in the carcass fat levels and abdominal fat is achieved by increasing the level of amino acids above the requirements for both growth and F.C.R.

The order for amino acid requirements is as follows:

1 – Feather growth

2 – Weight gain

3 – Breast meat yield – F.C.R.

4 – Fat content

For some nutritional researchers, the requirements for A.A. to optimise the F.C.R. would be slightly above that those required to optimise breast meat yield.

■ The influence of A.A. on breast meat yield

Any nutritional deficiency in one or more A.A. results in less breast meat yield.

Recent work shows that the breast meat yield is optimised when the A.A. requirements to obtain a minimum F.C.R. are used.

The response in terms of breast meat yield appears more important for the S.A.A. than for the other A.A. This seems to be due to the requirement for feather growth towards the end of the cycle.

■ Recommendations

The recommendations mentioned below are shown as grams of total or digestible A.A. per 1 000 kcal of metabolisable energy per kg of feed, according to the age of the birds. They have been calculated to optimise F.C.R. The margins of security are approximately 5% to allow for the variability in the raw materials.

The equation for each of the A.A. is as follows:

g/1 000 kcal/kg	Digestible A.A.	Total A.A.
Methionine + Cystine	2.87 – 0.095 X	3.30 – 0.105 X
Methionine	1.82 – 0.080 X	2.03 – 0.090 X
Lysine	3.80 – 0.157 X	4.47 – 0.183 X
Threonine	2.50 – 0.095 X	2.93 – 0.110 X
Arginine	4.30 – 0.168 X	4.90 – 0.200 X
Valine	3.00 – 0.120 X	3.50 – 0.140 X
Isoleucine	2.68 – 0.095 X	3.05 – 0.115 X
Tryptophan	0.69 – 0.030 X	0.80 – 0.035 X

X = the flock age in weeks

The concentration of amino acids for 1 000 kcal of energy per kg of feed is thus determined by the average age of the birds, which is calculated according to the average length of time that each type of feed is used for.

Example for calculating the level of lysine for a grower ration:

- grower feed used between 21 to 35 days and with 3 150 kcal M.E.
- average age: 4 weeks (21+35)/2 = 28 days/7
- lysine needs for 1 000 kcal: 4.47 – 0.183 x 4 = 3.74
- requirements per kg of feed: $3.74 \times \frac{3\ 150}{1\ 000} = 11.8$ g/kg (1.18%)

● THE ENERGY LEVEL OF FEED

■ Feed presentation

The role of feed presentation in broiler nutrition influences:

- feed consumption
- feed digestibility.

■ Feed consumption

The level and speed of ingestion are directly related to the feed presentation. The best result comes from a good quality pellet. The effect of pelleting is more important when the energy level is low. For high–energy feeds, the effect of pelleting is less, due in part to the difficulty to pellet this type of feed.

To have a better understanding of the comparison of a mash verses a pellet: the benefits of pelleting are maximised when comparing a fine ground mash, which a broiler would normally have difficulty to eat, with the same grinding procedure that is required for the production of a quality pellet.

THE EFFECT OF PARTICLE SIZE ON GROWTH AND CONSUMPTION OF THE BROILER BETWEEN 21 AND 39 DAYS

	Mash			Pellets		
Average particle size	**Fine**	**Average**	**Big**	**Fine**	**Average**	**Big**
Sorghum Ø mm	0.53	0.97	1.25	0.53	0.97	1.25
Feed Ø mm	0.48	0.77	0.90	0.48	0.77	0.90
Weight gain (g/d)	48.5	56.0	58.6	61.3	61.4	60.5
Consumption (g)	2 006	2 273	2 371	2 470	2 483	2 412

B. Leclercq – INRA, 1988

Feed used was sorghum + soya

	Mash				Pellet			
AME_n	2 460	2 670	2 955	3 060	2 572	2 772	2 950	3 217
Weight gain (g/d)	44.9	49.3	49.9	52.2	54.6	55.8	57.0	58.0
% abdominal fat/liveweight	2.2	2.3	2.3	2.4	2.4	2.5	2.5	2.5

B. Leclercq – INRA, 1988

THE EFFECT OF ENERGY LEVEL ON GROWTH AND FATTENING

Mash feed	Pelleted feed
Weight gain (g/d) = 20.1 + 0.01041 AME_n	Weight gain (g/d) = 12.6 + 0.00552 AME_n

The energy level has an effect on growth rate:

- the effect is greater when using mash feed
- mash feed with large particle size improves growth rate
- the energy level has little effect on growth when using pelleted feed (+ 0.55 g/d/100 kcal)
- the performance improvement achieved by pellets is mostly due to the reduced level of energy required to ingest the feed.

The use of whole cereal grains mixed in the feed is also based on the speed of ingestion (poultry are grain eaters) and the reduced energy requirement for this activity.

■ Feed digestibility

The digestion process depends on the original particle size of the mash, whether the final presentation is in mash or pellet form and also on the characteristics of the raw materials used.

The digestibility of feed, which is easily assimilated, such as corn and soya, is not so dependent on particle size. In this case, the breakdown of the feed by the proventriculus and gizzard is scaled down (reduced action by the gizzard) and the nutrients are easily absorbed in the upper part of the intestine.

On the other hand, feeds made from cereals rich in non–amylase polysaccharides (N.A.P.) and/or enriched with saturated fats must be of a larger particle size, in order to be broken down correctly in the proventriculus and gizzard. This means the action of hydrochloric acid, pepsin and the mucus secretions from the walls of the proventriculus will be increased in the presence of large size particles and the grinding action by the gizzard will be enhanced. This causes the movement into the duodenum to be delayed by 1 – 3 hours. This action is best on whole grains. This grinding action also favours any enzymes that may have been added to the feed (cellulase, xylanase, glucanase and phytase).

COMPARISON OF BROILER GROWTH RATE FROM 14 TO 28 DAYS EATING FEED BASED ON GROUND AND WHOLE BARLEY (55.3%)

	Whole barley		Ground barley	
Enzyme	0	+	0	+
Growth (g)	744	793	693	724
Consumption (g)	1 130	1 091	1 037	1 048
F.C.R.	1.50	1.38	1.50	1.45
Intestine viscosity (*)	6.64	3.39	7.64	3.45
% gizzard weight/Liveweight	4.23	4.25	3.92	3.16

S. Vihus et al, 1997

(*) Viscosity in certipoise

REDUCTION OF THE ALIMENTARY PARTICLE SIZE OF THE INTESTINAL CONTENTS AT 28 DAYS

		Whole barley		Ground barley	
Enzyme		0	+	0	+
Particle size Ø mm					
> 2.4 mm	Feed	58.8%	60.5%	0.6%	0.7%
	Intestine	2.2%	1.9%	1.2%	1.0%
2.4 mm < P > 1 mm	Feed	10.8%	10.5%	51.8%	53.2%
	Intestine	6.4%	5.7%	12.1%	10.9%
1 mm < P > 0.7 mm	Feed	24.4%	23.5%	16.8%	17.8%
	Intestine	3.3%	2.6%	5.3%	4.9%
P < 0.7 mm	Feed	6.0%	5.5%	30.8%	28.3%
	Intestine	88.1%	89.8%	81.4%	83.1%

S. Vihus et al, 1997

Normal function of the proventriculus/gizzard brings stability/regularity to the intestinal functions by controlling the speed of the feed particles passing into the duodenum, thus improving assimilation of the nutrients. This is important to understand when using risky formulations (the use of raw materials that are more difficult to digest).

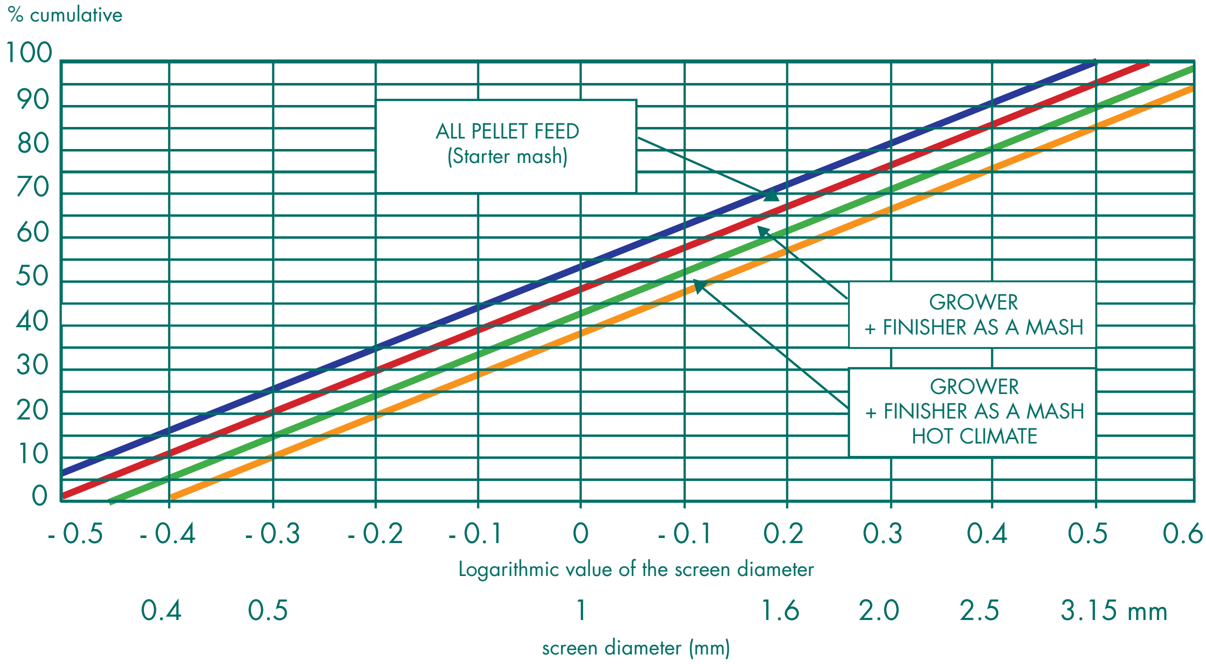
This makes the control of the bacterial flora easier, because better assimilation limits the number of feed particles in the lower part of the intestine. This in turn limits the growth of undesirable bacteria (E. coli, Clostridium perfringens). When there is stress such as sudden cold, over–eating, feed change, or excess water consumption, an acceleration of the intestinal movement may disturb this function.

Growth promoters and/or antibiotics also help to control the bacterial flora. However, due to the current industry trend to reduce, indeed to suppress these products, it now requires nutritionists to take into account the complete function of the whole digestive tract, to enhance the action of the alternative products, such as acidifiers, probiotics and enzymes.

Conclusions

- The digestibility of the classic type feeds using corn and soya is not so dependent on particle size.
- The use of "risky" formulations must take into account the feed presentation. A better control of the grinding process of the raw materials to improve the particle size and the uniformity of these particles is required. In this type of formulation using too fine a particle size and a very hard pellet, the intestinal viscosity is increased at the expense of the digestibility of the nutrients and the energy value of the feed.

MASH PARTICLE SIZE RELATED TO FEED PRESENTATION AND CLIMATIC CONDITIONS



■ The use of enzymes

Enzymes are mostly used to improve digestion of starch in cereals such as wheat, barley, oats and rye, which contain non-amylase polysaccharides. These increase the intestinal viscosity and thus assimilation of nutrients becomes poor.

Enzymes have a stronger effect on freshly harvested cereals when the energy level is low. There is then a reduction in the variability of the M.E.

The principal enzymes cellulase, xylanase (wheat) and glucanase (oats), can improve the energetic value by about 3 to 6% according to how they are used:

- the choice of the combination of enzymes to be used depends on variable factors related to the variety, regional differences and the year of harvest of the cereals
- the uniformity of distribution and stability of the enzyme in the feed is an important factor. Enzymes are added either, at the mixing stage before pelleting as a powder or as a liquid by spraying after pelleting. In both cases control of the technical points is most important.

Enzymes can also improve the digestibility in the ileum region, when using corn-soya rations by freeing starch from the amylopectins, or from the complex starch – protein – N.A.P. relationship (produced during pelleting or when drying maize at high temperatures). The enzyme protease also improves the digestibility of proteins, amino acids, starch and leguminous and protein plants, which contain anti-nutritional factors such as, pectin, lectin (soya) and galactoside.

The role of improving/saving energy is also acted upon by phytase, which by improving the digestibility and assimilation of phytate phosphorus by 30 – 50%, also frees up the amino acids and increases their digestibility by about 2%.

■ The evolution of consumption and feed conversion

The table below shows the feed and water consumption per kg of liveweight. It can be used as a guide when calculating the dosage for medication.

Liveweight	Consumption per kg L.W.	
	Feed (g)	Water (g)
100	220	385
200	200	350
350	160	280
500	140	245
750	120	210
1 000	107	190
1 500	90	160
2 000	80	140
2 500	70	120

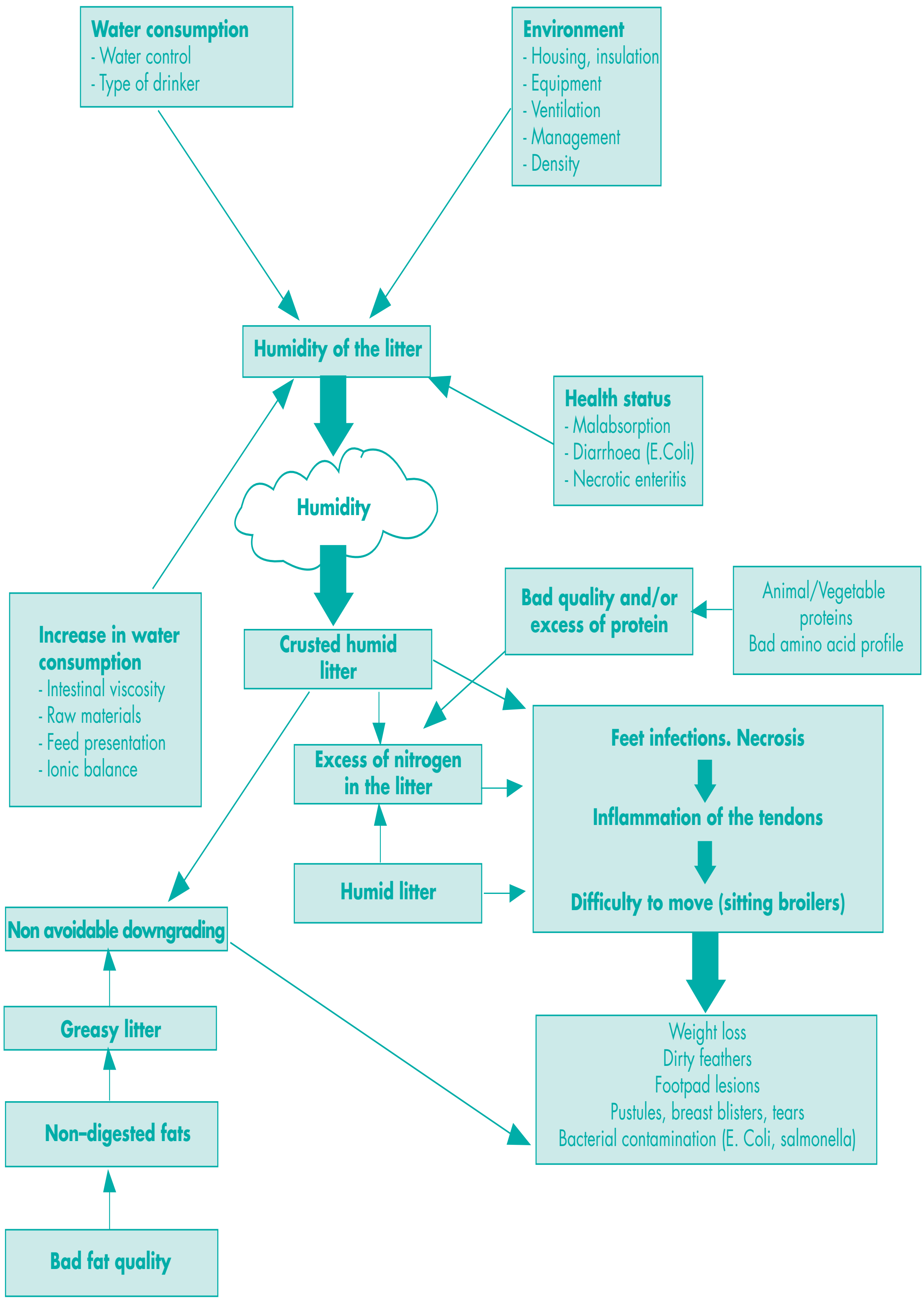
The weekly feed index (relation between the feed consumption and the growth) increases with age.

The table below shows the evolution of F.C.R. for each week.

Week	F.C.R. for week
1	1.20
2	1.35
3	1.60
4	1.80
5	2.00
6	2.30
7	2.60

● FEEDING AND QUALITY

THE CAUSES OF DOWNGRADING OF THE CARCASS



■ Litter quality and feeding

All the factors, which combine to increase water consumption and/or increase the speed of digestion, thus modifying the bacterial flora balance, are risk factors.

Increase in intestinal viscosity:

- Cereals/enzymes/fat
- Grinding/pelleting

Raw materials/change of formulation:

- New harvest
- Cassava
- Excess of vegetable proteins
- Fat quality
- Growth promoters
- Anticoccidial drugs

Ionic balance:

- Excess of K ($K < 0.8\%$)
- Excess of Na ($15 < Na < 18$)
- Excess of salt (chlorine) ($15 < Cl < 20$)

$$220 < K + Na - Cl < 240$$

K and Na are the most important factors when considering excess water consumption. However, the level of salt **in difficult conditions** (humidity, quality of cereals) should be limited to 0.20%. The use of sodium bicarbonate at 0.05 to 0.10% is useful.

A shortage of calcium and/or poor balance between calcium and the available phosphorus:

$$2.25 \leq Ca/av.P \leq 2.50$$

■ The factors affecting carcass composition

■ The influence of energy

Increasing the energy level by 100 kcal will increase lipids by about 0.5 to 0.6% and the abdominal fat by about 0.15%, which will lower eviscerated yield by 0.1 to 0.15%. The breast meat yield appears not to be affected by the energy level.

■ The influence of fat

The increase in energy level through added fat influences the carcass quality in two ways.

Fats added to the feed increase the level of lipids in the carcass. Either, because the productive energy of fat is higher, and/or there is a positive effect on the digestibility of saturated fats, when saturated and non-saturated fats are added together in the feed. In this case, there is a change in the ratio between energy and protein, which provokes an increase in fat deposits.

CARCASS QUALITY: ENERGY AND FEED PRESENTATION

Metabolisable energy (kcal/kg)	Presentation	% body fat	% abdominal fat
2 940	Mash	12.2	1.5
(2.5% fat)	Pellet	13.0	1.9
3 200	Mash	14.7	1.9
(7.3% MG = + 9% M.E.)	Pellet	14.8	2.1

Nir, 1999

The effect of pelleting reduces when the energy from fat sources increases.

The kind of fat in the carcass depends on what is used in the feed. The addition of unsaturated fats in a finisher feed produces oily carcasses, which have a shorter storage life because of the possibility of oxidation and rancidity.

Linoleic acid (C–18.2) is a good estimator for the expectation of carcass quality. Its maximum level is in the order of 15 – 17% of the body fat and 25% of the fat levels in the finisher feed.

Programmes using 100% vegetable feed must take into account these aspects and use less unsaturated fats such as rapeseed and palm oil.

■ The influence of protein

Increasing protein by 1% will reduce lipids by about 0.5%, abdominal fat by 0.1 to 0.15% and consequently increases the eviscerated yield by 0.1 to 0.15%.

The effect of increasing the protein level on carcass composition appears to be linear between 18 and 26% protein.

■ Feeding and leg problems

A number of deficiencies or marginal deficiencies in trace minerals and vitamins can be the origin of slipped tendon or bone deformation (choline, biotin, niacin, pyridoxine, pantothenic acid, folic acid, vitamin D_3, Se, Zn, Mn, Cu, Ni).

We mention this only for reference, as it is rare today to find such deficiencies.

■ Phosphorus and calcium balance

Many studies have shown that an imbalance between phosphorus and calcium can increase the incidence of tibia dyschondroplasia.

■ Interaction between fats and calcium

The use of animal fat rich in saturated fatty acids, particularly stearic and palmitic acids can cause the formation of soaps, which are poorly digested by the young chick and may reduce calcium absorption.

These poorly digestible soaps are formed in the body with most minerals. The use of large amounts of fat is often the cause of greasy litter. In addition, leg problems can occur when the calcium level is insufficient. During the first two weeks of the chick's life, the incorporated fat level should be limited to 2% vegetable fat only.

■ Reducing feed intake

Growth control from the 4th – 5th day has a beneficial influence on tibial dyschondroplasia, liveability and feed conversion.

This reduction in growth will depend on the type of production, and becomes more important, as the slaughter weight increases.

There are three useful techniques:

- reducing the energy level of the feed
- light programmes
- restriction from 8 – 10 days.

The control programme is set after weighing the chicks (every 5 days).

■ Na + K – Cl balance

Through the balance of Na + K – Cl, it seems that only an excess of chloride can be responsible for an increase in tibial dyschondroplasia.

The chloride level must be between 0.15 and 0.20%.

■ Toxicity factors

Most of the intoxication caused by mycotoxins alters bone development (aflatoxins, ochratoxins, fusarium,…). Also an excess of fluoride, which is present in certain phosphates, affects bone formation.

■ Slipped tendon

Occasionally one can see cases of slipped tendon and lameness in broilers, which can lead to condemnations.

The birds often show lesions of perosis with slipped tendons at a very young age.

Culling of the affected animals does not always eliminate the problem. New cases appear throughout the growing period. The lesions do not show signs of specific pathogens.

The different possible causes can be:

● Due to the breeders:

- a feed deficiency in the breeders transmitted through the egg, mostly from young breeders and old flocks towards the end of production
- eggs stored too long before setting
- incorrect management of the breeders, for example starting production too early, which produces a baby chick of poor quality and vitality.

● Broiler management factors:

- Management points such as the light programme, insufficient brooding temperature and cold litter.

■ Flavour quality and feeding

As we saw earlier, the quantity and type of fat in the carcass depends on that used in the feed, especially during the last 3 weeks.

Excess of fat increases the cooking losses. On the other hand, it seems that unsaturated fats, found under the skin, can lead to a better taste to both the meat and skin.

Lower energy feeds (mostly in mash form) without added fat, can by reducing the growth, delay the slaughter age and thus give a better taste.

If the carcass contains more unsaturated fats, which are more easily oxidised, supplementation of vitamin E (100 – 150 mg/kg) in the feed will reduce the chance of oxidation of the meat. It can also extend the shelf life and the flavour qualities.

■ Feeding and control of bacteria

In the growing house the sources of bacterial contamination are numerous. Feed is an important source of contamination especially for salmonella.

In order to produce quality day–old chicks, legislation for breeder feeds is tighter.

For broiler feed, control is taken at two levels:

- procure raw materials from controlled sources with minimum contamination levels
- at the feed factory act on the critical points.

- Maintain a high level of general hygiene throughout the factory: use of closed circuits, keep dust levels low, clean the bins, raw material controls, transfer systems for the finished products, elevators, mixers, conditioners, presses, sprayers, etc. For new investments to the factory, this aspect of hygiene must take priority.
- Pelleting is a good method for lowering contamination (reduction of the bacterial level by 5 to 10 times), but the risk of rapid recontamination after pelleting is high. This is mostly through condensation, which produces the correct media for new bacterial and mould growth.
- The cooler is a prime target area for this growth. It must be isolated and provided with clean and filtered air.
- Feed that is stored after bad cooling conditions is a high risk.
- The addition of various acid products helps to stabilise the levels of bacterial flora and mould, but can not bring about a complete decontamination of the raw materials.

● HOT WEATHER NUTRITION

■ The reaction to increased temperature

The increase in ambient temperature in the chicken provokes a general slowing down of all functions due to a drop in feed consumption. In turn, the body redirects its nutritional resources to maintain body temperature through accelerated breathing and evacuation of water vapour by panting, at the expense of bodyweight, muscle growth and feed conversion.

MALE BROILER PERFORMANCE FROM 4 TO 6 WEEKS

Treatments	22°C Ad libitum feed	22°C [1]	32°C Ad libitum feed
Consumption (g/day)	154.9	(- 34%) ➤ 117.4	118.3
Growth (g)	1 115	(- 24%) ➤ 845	(- 22%) ➤ 659
F.C.R.	2.06	2.19	(+30%) ➤ 2.85

Ceraert et al, 1996

[1] Animals at 22°C restricted on the base of ad libitum feed consumption at 32°C.

This experiment shows nicely the effect of heat on economical performance. With equal feed consumption to both groups and an increase in temperature of 10°C, growth rate is reduced by 22% and F.C.R. is increased by 30%.

A summary of the effects of increasing temperature:

- reduction of feed consumption by 1.5 to 2.5%/1°C above 20°C, resulting in increased water consumption

- growth rate slows and F.C.R. increases
- increase in the respiratory rate; panting ➛ water vapour + carbonic gas (HCO_3^-) ➛ risk of respiratory alkalosis, acid/base imbalance and increase in the blood pH
- reduction of muscle growth (mostly the white muscle), resulting in an increase in the fat level (mostly saturated)
- males are more sensitive than females
- lines with an ability to produce less fat resist better than those without this ability.

■ Theoretical answers

Replacing starch with fat lowers the effect of heat produced during digestion. Numerous researchers have shown interest in this method, but it seems more applicable for major heat waves rather than simply for hot weather.

Feeding pellets which reduces the eating time and accordingly the energy required for digestion is also a good method.

The digestion process and enzyme actions are also slowed down because of increasing blood pH levels. It is preferable to use feeds that are easily digested.

Energy level: the starch in maize is more easily digested than the starch in wheat or barley (the latter contain non–amylase polysaccharides which increase the intestinal viscosity). The use of enzymes can improve digestibility, but their activity can also be affected when using saturated fats.

Protein level: the latest information on protein nutrition contradicts the experiments of the past, which showed that increasing the protein level reduced the performance for feed conversion. This is explained by the effect of the extra heat produced during protein digestion.

The actual field information shows that an increase in protein level improves broiler performance and compensates for the slowing down of protein deposits. This is due to the slower level of protein synthesis and an increase in proteolyse. Amino acid digestibility is also modified (that of lysine being more stable than methionine).

Therefore, it is preferable to use good protein sources, with good digestibility and amino acid balance. This balance seems also modified, mostly the ratio of lysine to arginine, which may be increased by 10 – 15% to improve liveability during hot weather.

■ Practical answers

To improve ingestion, use a good quality pellet or a mash with large uniform particle size. The easier the feed is to ingest, eating time is shorter and the energy required for ingestion is reduced. Thus, more of the nutrients are converted to growth and maintenance.

To stimulate ingestion:

● **Feeding:** for feeding and nutrition 2 points must be considered:

- the increase of energy by using extra fat does not give better results, as it favours the effect of fattening due to the heat. Males are more sensitive to this effect
- in spite of the effect of the increased internal heat produced during digestion, an increase in the level of protein and amino acids improves muscular development and reduces fat deposits. The ratio of arginine/lysine can be increased by 10%. Increase sodium bicarbonate up to 0.5% to improve performance and reduce the mortality from built-up respiratory alkalosis.

Value	**m.Eq./kg**
	220 < Na + K – Cl < 250

- **Stimulating consumption:**

- the use of sufficient, well distributed feeding equipment throughout the house:

1 pan/40 – 50 broilers
4 – 5 cm/trough/broiler

- to acclimatise the flock to no feed periods before the hot weather starts. This can start from 10 – 14 days of age and can then be on a daily basis

- during very hot weather do not feed the flock during the hot period. Redistribute the daytime feed to the fresh night periods. If the feed presentation is correct 12 hours eating time is sufficient.

RECOMMENDED NUTRITIONAL SPECIFICATIONS FOR BROILERS SLAUGHTERED UP TO 1.5 KG

	Unit	Starter	Grower	Finisher
Period of use	Days	0 – 10	11 – 26	> 26
M.E.	Kcal / kg	3,000 – 3,050	3,050 – 3,100	3,150 – 3,200
Crude protein	%	22 – 24	20 – 22	18 – 20
Amino acids (crude/digestible)				
Lysine	%	1.40 / 1.23	1.25 / 1.06	1.10 / 0.90
Methionine	%	0.60 / 0.54	0.54 / 0.47	0.50 / 0.44
Methionine + Cystine	%	1.05 / 0.90	0.98 / 0.85	0.90 / 0.78
Threonine	%	0.90 / 0.78	0.85 / 0.72	0.77 / 0.64
Tryptophan	%	0.24 / 0.22	0.22 / 0.19	0.20 / 0.16
Minerals	%			
Calcium	%	1.00 – 1.05	1.00 – 1.05	0.85 – 0.90
Av. phosphorus	%	0.50	0.45	0.40
Sodium	%	0.16 – 0.18	0.16 – 0.18	0.16 – 0.18
Chloride	%	0.15 – 0.20	0.15 – 0.20	0.15 – 0.20
Potassium	%	0.85	0.80	0.75
Added trace minerals per kg				
Zinc	mg	80	80	
Copper	mg	10	10	
Iron	mg	60	60	
Manganese	mg	80	80	
Iodine	mg	1.0	1.0	
Selenium	mg	0.2	0.2	
Added vitamins per kg				
Vit. A	I.U.	15,000	12,500	10,000
Vit. D3	I.U.	3,000	2,500	2,000
Vit. E (*)	mg	50 – 100	30 – 100	30 – 100
Menadione K3	mg	3	2	2
Thiamine B1	mg	3	2	2
Riboflavin B2	mg	8	6	6
Pantothenic acid	mg	15	10	10
Pyridoxine B6	mg	4	3	3
Niacin PP	mg	60	40	40
Folic acid	mg	1.5	1.0	1.0
Vit. B12	mg	0.02	0.01	0.01
Vit. C	mg	200	200	200
Biotin	mg	0.2	0.1	0.1
Choline (Chloride) (***)	mg	(700)	(600)	(600)
Total choline (**)	mg	1,800	1,600	1,400

(*) The higher dose can help to increase immunity and improve the shelf life of the broiler meat.
(**) For choline, one must take into account the raw materials used to formulate like this.
(***) The value to use when ignoring raw material content.

Feed presentation

Age in days	Feed Presentation	Screen ∅ < 0.5 mm	Screen ∅ +2 mm
0 – 10	Crumble	=< 10 %	=< 30 %
11 – 20	Crumble	=< 5 %	=< 50 %
0 – 10	Mash	=< 25 %	=< 20 %
11 – 20	Mash	=< 20 %	=< 30 %
> 20	Mash	=< 15 %	=< 40 %

Pellets: 2.8 mm not before 10 – 12 days / 3.2 mm not before 16 – 18 days / 3.5 mm not before 20 – 22 days

RECOMMENDED NUTRITIONAL SPECIFICATIONS FOR BROILERS SLAUGHTERED UP TO 2.0 KG

	Unit	Starter	Grower	Finisher	Withdrawal
Period of use	Days	0 – 10	11 – 22	23 – 32	> 32
M.E.	Kcal / kg	3,000 – 3,050	3,050 – 3,100	3,150 – 3,200	3,200 – 3,250
Crude protein	%	22 – 24	20 – 22	19 – 21	17 – 19
Amino acids (crude/digestible)					
Lysine	%	1.40 / 1.23	1.25 / 1.06	1.15 / 0.98	1.05 / 0.90
Methionine	%	0.60 / 0.54	0.54 / 0.47	0.49 / 0.42	0.47 / 0.40
Methionine + Cystine	%	1.05 / 0.90	0.98 / 0.85	0.90 / 0.78	0.86 / 0.74
Threonine	%	0.90 / 0.78	0.85 / 0.72	0.78 / 0.67	0.74 / 0.63
Tryptophan	%	0.24 / 0.22	0.22 / 0.19	0.21 / 0.18	0.19 / 0.16
Minerals	%				
Calcium	%	1.00 – 1.05	1.00 – 1.05	0.90 – 0.95	0.85 – 0.90
Av. phosphorus	%	0.50	0.45	0.40	0.40
Sodium	%	0.16 – 0.18	0.16 – 0.18	0.16 – 0.18	0.16 – 0.18
Chloride	%	0.15 – 0.20	0.15 – 0.20	0.15 – 0.17	0.15 – 0.17
Potassium	%	0.85	0.80	0.75	0.70
Added trace minerals per kg					
Zinc	mg	80		80	
Copper	mg	10		10	
Iron	mg	60		60	
Manganese	mg	80		80	
Iodine	mg	1.0		1.0	
Selenium	mg	0.2		0.2	
Added vitamins per kg					
Vit. A	I.U.	15,000	12,500		10,000
Vit. D3	I.U.	3,000	2,500		2,000
Vit. E (*)	mg	50 – 100	30 – 100		30 – 100
Menadione K3	mg	3	2		2
Thiamine B1	mg	3	2		2
Riboflavin B2	mg	8	6		6
Pantothenic acid	mg	15	10		10
Pyridoxine B6	mg	4	3		3
Niacin PP	mg	60	40		40
Folic acid	mg	1.5	1.0		1.0
Vit. B12	mg	0.02	0.01		0.01
Vit. C	mg	200	200		200
Biotin	mg	0.2	0.1		0.1
Choline (Chloride) (***)	mg	(700)	(600)		(600)
Total choline (**)	mg	1,800	1,600		1,400

(*) The higher dose can help to increase immunity and improve the shelf life of the broiler meat.
(**) For choline, one must take into account the raw materials used to formulate like this.
(***) The value to use when ignoring raw material content.

Feed presentation

Age in days	Feed Presentation	Screen Ø < 0.5 mm	Screen Ø +2 mm
0 – 10	Crumble	=< 10 %	=< 30 %
11 – 20	Crumble	=< 5 %	=< 50 %
0 – 10	Mash	=< 25 %	=< 20 %
11 – 20	Mash	=< 20 %	=< 30 %
> 20	Mash	=< 15 %	=< 40 %

Pellets: 2.8 mm not before 10 – 12 days / 3.2 mm not before 16 – 18 days / 3.5 mm not before 20 – 22 days
Sex separate growing: Males: follow the standard programme
Females: 21 – 30 days Finisher, > 30 days change to Withdrawal

RECOMMENDED NUTRITIONAL SPECIFICATIONS FOR BROILERS SLAUGHTERED UP TO 2.5 KG

	Unit	Pre-starter	Starter	Grower	Finisher	Withdrawal
Period of use	Days	0 – 10	11 – 20	21 – 33	34 – 42	> 42
M.E.	Kcal / kg	3,000 – 3,050	3,000 – 3,050	3,050 – 3,100	3,150 – 3,200	3,150 – 3,200
Crude protein	%	22 – 24	22 – 24	20 – 22	19 – 21	17 – 19
Amino acids (crude/digestible)						
Lysine	%	1.40 / 1.23	1.40 / 1.23	1.25 / 1.06	1.15 / 0.98	0.95 / 0.81
Methionine	%	0.60 / 0.54	0.60 / 0.54	0.54 / 0.47	0.49 / 0.42	0.43 / 0.38
Methionine + Cystine	%	1.05 / 0.90	1.05 / 0.90	0.98 / 0.85	0.90 / 0.78	0.78 / 0.68
Threonine	%	0.90 / 0.78	0.90 / 0.78	0.85 / 0.72	0.78 / 0.67	0.67 / 0.57
Tryptophan	%	0.24 / 0.22	0.24 / 0.22	0.22 / 0.19	0.21 / 0.18	0.16 / 0.14
Minerals	%					
Calcium	%	1.00 – 1.05	1.00 – 1.05	1.00 – 1.05	0.90 – 0.95	0.80 – 0.85
Av. phosphorus	%	0.50	0.50	0.45	0.40	0.40
Sodium	%	0.16 – 0.18	0.16 – 0.18	0.16 – 0.18	0.16 – 0.18	0.16 – 0.18
Chloride	%	0.15 – 0.20	0.15 – 0.20	0.15 – 0.20	0.15 – 0.17	0.15 – 0.17
Potassium	%	0.85	0.85	0.80	0.75	0.70
Added trace minerals per kg						
Zinc	mg	80		80		
Copper	mg	10		10		
Iron	mg	60		60		
Manganese	mg	80		80		
Iodine	mg	1.0		1.0		
Selenium	mg	0.2		0.2		
Added vitamins per kg						
Vit. A	I.U.	15,000	12,500		10,000	
Vit. D3	I.U.	3,000	2,500		2,000	
Vit. E (*)	mg	50 – 100	30 – 100		30 – 100	
Menadione K3	mg	3	2		2	
Thiamine B1	mg	3	2		2	
Riboflavin B2	mg	8	6		6	
Pantothenic acid	mg	15	10		10	
Pyridoxine B6	mg	4	3		3	
Niacin PP	mg	60	40		40	
Folic acid	mg	1.5	1.0		1.0	
Vit. B12	mg	0.02	0.01		0.01	
Vit. C	mg	200	200		200	
Biotin	mg	0.2	0.1		0.1	
Choline (Chloride) (***)	mg	(700)	(600)		(600)	
Total choline (**)	mg	1,800	1,600		1,400	

(*) The higher dose can help to increase immunity and improve the shelf life of the broiler meat.
(**) For choline, one must take into account the raw materials used to formulate like this.
(***) The value to use when ignoring raw material content.

Feed presentation

		Screen Ø	
Age in days	**Feed Presentation**	**< 0.5 mm**	**+2 mm**
0 – 10	Crumble	=< 10 %	=< 30 %
11 – 20	Crumble	=< 5 %	=< 50 %
0 – 10	Mash	=< 25 %	=< 20 %
11 – 20	Mash	=< 20 %	=< 30 %
> 20	Mash	=< 15 %	=< 40 %

Pellets: 2.8 mm not before 10 – 12 days / 3.2 mm not before 16 – 18 days / 3.5 mm not before 20 – 22 days

Sex separate growing: Males: follow the standard programme
Females: 21 – 30 days Grower feed, > 30 days change to Finisher

RECOMMENDED NUTRITIONAL SPECIFICATIONS FOR BROILERS IN HOT CLIMATE

	Unit	Pre–starter	Starter	Grower	Finisher	Withdrawal
Period of use	Days	0 – 10	11 – 20	21 – 33	34 – 42	> 42
M.E.	Kcal / kg	3,000 – 3,050	3,000 – 3,050	3,050 – 3,100	3,150 – 3,200	3,150 – 3,200
Crude protein	%	22 – 24	22 – 24	20 – 22	19 – 21	17 – 19
Amino acids (crude/digestible)						
Lysine	%	1.40 / 1.23	1.40 / 1.23	1.25 / 1.06	1.15 / 0.98	0.95 / 0.81
Methionine	%	0.60 / 0.54	0.60 / 0.54	0.54 / 0.47	0.49 / 0.42	0.43 / 0.38
Methionine + Cystine	%	1.05 / 0.90	1.05 / 0.90	0.98 / 0.85	0.90 / 0.78	0.78 / 0.68
Threonine	%	0.90 / 0.78	0.90 / 0.78	0.85 / 0.72	0.78 / 0.67	0.67 / 0.57
Tryptophan	%	0.24 / 0.22	0.24 / 0.22	0.22 / 0.19	0.21 / 0.18	0.16 / 0.14
Arginine	%	1.40 / 1.23	1.30 / 1.14	1.30 / 1.14	1.30 / 1.14	1.20 / 1.06
Minerals	%					
Calcium	%	1.00 – 1.05	1.00 – 1.05	1.00 – 1.05	0.90 – 0.95	0.80 – 0.85
Av. phosphorus	%	0.50	0.50	0.45	0.40	0.40
Sodium	%	0.16 – 0.18	0.16 – 0.18	0.16 – 0.18	0.16 – 0.18	0.16 – 0.18
Chloride	%	0.15 – 0.20	0.15 – 0.20	0.15 – 0.20	0.15 – 0.17	0.15 – 0.17
Potassium	%	0.85	0.85	0.80	0.75	0.70
Added trace minerals per kg						
Zinc	mg	80		80		
Copper	mg	10		10		
Iron	mg	60		60		
Manganese	mg	80		80		
Iodine	mg	1.0		1.0		
Selenium	mg	0.2		0.2		
Added vitamins per kg						
Vit. A	I.U.	15,000	12,500		10,000	
Vit. D3	I.U.	3,000	2,500		2,000	
Vit. E (*)	mg	50 – 100	30 – 100		30 – 100	
Menadione K3	mg	3	2		2	
Thiamine B1	mg	3	2		2	
Riboflavin B2	mg	8	6		6	
Pantothenic acid	mg	15	10		10	
Pyridoxine B6	mg	4	3		3	
Niacin PP	mg	60	40		40	
Folic acid	mg	1.5	1.0		1.0	
Vit. B12	mg	0.02	0.01		0.01	
Vit. C	mg	200	200		200	
Biotin	mg	0.2	0.1		0.1	
Choline (Chloride) (***)	mg	(700)	(600)		(600)	
Total choline (**)	mg	1,800	1,600		1,400	

(*) The higher dose can help to increase immunity and improve the shelf life of the broiler meat.
(**) For choline, one must take into account the raw materials used to formulate like this.
(***) The value to use when ignoring raw material content.

Feed presentation

		Screen Ø	
Age in days	**Feed Presentation**	**< 0.5 mm**	**+2 mm**
0 – 10	Crumble	=< 10 %	=< 30 %
11 – 20	Crumble	=< 5 %	=< 50 %
0 – 10	Mash	=< 25 %	=< 20 %
11 – 20	Mash	=< 20 %	=< 30 %
> 20	Mash	=< 15 %	=< 40 %

Pellets: 2.8 mm not before 10 – 12 days / 3.2 mm not before 16 – 18 days / 3.5 mm not before 20 – 22 days

Sex separate growing: Males: follow the standard programme
Females: 21 – 30 days Grower feed, > 30 days change to Finisher

RECOMMENDED NUTRITIONAL SPECIFICATIONS FOR CERTIFIED BROILERS SLAUGHTERED AT 56 DAYS

	Unit	Starter	Grower	Finisher
Period of use	Days	0 – 21	22 – 42	> 42
M.E.	Kcal / kg	2,850 – 2,900	2,950 – 3,000	3,000 – 3,100
Crude protein	%	21.5 – 22.5	18.5 – 19.5	17 – 18
Amino acids (crude/digestible)				
Lysine	%	1.20 / 1.03	1.10 / 0.94	1.00 / 0.85
Methionine	%	0.54 / 0.48	0.50 / 0.44	0.45 / 0.39
Methionine + Cystine	%	0.95 / 0.84	0.85 / 0.74	0.80 / 0.68
Threonine	%	0.82 / 0.70	0.76 / 0.64	0.77 / 0.65
Tryptophan	%	0.24 / 0.22	0.22 / 0.20	0.20 / 0.17
Minerals	%			
Calcium	%	1.00 – 1.05	0.90 – 1.00	0.80 – 1.00
Av. phosphorus	%	0.48	0.42	0.38
Sodium	%	0.16 – 0.18	0.16 – 0.18	0.16 – 0.18
Chloride	%	0.15 – 0.20	0.15 – 0.20	0.15 – 0.20
Potassium	%	0.85	0.80	0.75
Added trace minerals per kg			Grower / Finisher	
Zinc	mg	70	70	
Copper	mg	10	10	
Iron	mg	50	50	
Manganese	mg	60	60	
Iodine	mg	1.0	1.0	
Selenium	mg	0.2	0.2	
Added vitamins per kg				
Vit. A	I.U.	12,500	10,000	10,000
Vit. D3	I.U.	1,500	2,000	2,000
Vit. E (*)	mg	30	30	30 – 100
Menadione K3	mg	2.5	2	2
Thiamine B1	mg	2.5	2	2
Riboflavin B2	mg	8	6	6
Pantothenic acid	mg	15	10	10
Pyridoxine B6	mg	3.5	3	3
Niacin PP	mg	40	30	30
Folic acid	mg	1.0	0.8	0.8
Vit. B12	mg	0.02	0.01	0.01
Vit. C	mg	30	-	-
Biotin	mg	0.2	0.1	0.1
Choline (Chloride) (***)	mg	(600)	(500)	(500)
Total choline (**)	mg	1,600	1,400	1,200

(*) The higher dose can help to increase immunity and improve the shelf life of the broiler meat.
(**) For choline, one must take into account the raw materials used to formulate like this.
(***) The value to use when ignoring raw material content.

Feed presentation

Age in days	Feed Presentation	Screen Ø < 0.5 mm	Screen Ø +2 mm
0 – 21	Crumble	=< 10 %	=< 30 %
> 21	Crumble	=< 5 %	=< 50 %
0 – 21	Mash	=< 20 %	=< 30 %
> 21	Mash	=< 15 %	=< 40 %

Sex separate growing: Males: 0 – 21 days crumble
> 21 days crumble
Females: 0 days to slaughter crumble

RECOMMENDED NUTRITIONAL SPECIFICATIONS FOR "LABEL" PRODUCTION

	Unit	Starter	Grower	Finisher	Complement 30% wheat
Period of use	Days	0 – 28	28 – 63	63 – 84	63 – 84
M.E.	Kcal / kg	2,850	2,900	2,950	-
Crude protein	%	21	19.5	17	19
Amino acids (crude/digestible)					
Lysine	%	1.17	1.02	0.78	0.97
Methionine	%	0.52	0.46	0.40	0.50
Methionine + Cystine	%	0.88	0.80	0.68	0.78
Threonine	%	0.77	0.68	0.51	0.59
Tryptophan	%	1.29	1.13	0.86	1.00
Minerals	%				
Calcium	%	1.05 – 1.15	0.90 – 1.00	0.80 – 1.00	1.20
Av. phosphorus	%	0.48	0.42	0.38	0.46
Sodium	%	0.16 – 0.18	0.16 – 0.18	0.16 – 0.18	0.19 – 0.21
Chloride	%	0.15 – 0.20	0.15 – 0.20	0.15 – 0.20	0.17 – 0.22
Added trace minerals per kg					
Zinc	mg	70			
Copper	mg	10			
Iron	mg	50			
Manganese	mg	60			
Iodine	mg	1.0			
Selenium	mg	0.2			
Added vitamins per kg					
Vit. A	I.U.	12,500	10,000	10,000	10,000
Vit. D3	I.U.	2,500	2,000	2,000	2,000
Vit. E (*)	mg	30	30 – 100	30 – 100	30 – 100
Menadione K3	mg	2.5	2	2	2
Thiamine B1	mg	2.5	2	2	2
Riboflavin B2	mg	8	6	6	6
Pantothenic acid	mg	15	10	10	10
Pyridoxine B6	mg	3.5	3	3	3
Niacin PP	mg	40	30	30	30
Folic acid	mg	1.0	0.8	0.8	0.8
Vit. B12	mg	0.02	0.01	0.01	0.01
Vit. C	mg	30	-	-	-
Biotin	mg	0.2	0.1	0.1	0.1
Choline (Chloride) (***)	mg	(600)	(500)	(500)	(500)
Total choline (**)	mg	1,600	1,400	1,200	1,200

(*) The higher dose can help to increase immunity and improve the shelf life of the broiler meat.
(**) For choline, one must take into account the raw materials used to formulate like this.
(***) The value to use when ignoring raw material content.

Feed presentation

Age in days	Feed Presentation	Screen Ø < 0.5 mm	Screen Ø +2 mm
0 – 28	Crumble	=< 10 %	=< 30 %
> 28	Crumble	=< 5 %	=< 50 %
0 – 28	Mash	=< 20 %	=< 30 %
> 28	Mash	=< 15 %	=< 40 %

Sex separate growing: Males: 0 – 28 days crumble
> 28 days crumble
Females: 0 days to slaughter crumble

● TWO PRINCIPLE OBJECTIVES

- To improve the skeletal quality thus preparing the broiler to support compensatory growth and obtain an improved feed conversion, with less mortality, culls and downgrades.
- To reduce the level of sudden mortality, late mortality and problems of ascites.

Growth control must start from the arrival of the chicks, by using the system of weighing the birds each 5 days, which in turn sets the control for the light and feed programmes. There is no fixed programme for broiler flocks.

Each house and flock is an individual case and should be treated for its particular requirements, which will vary according to the type of broiler being produced.

■ The main factors

- the breed and its genetic potential
- the type of production and target slaughter age
- the feed programme and type of feed
- the building, its equipment and feeding system
- the health situation and vaccination programme
- the climatic and seasonal effects.

■ The characteristics of a batch of chicks

- the weight and uniformity of the chicks
- the mortality and weight at 4 and 7 days.

■ The breed and its genetic potential

This is a reference that defines the performance of the given breed under optimal conditions, with no restrictions made at any stated age and with maximum growth occurring between 28 and 35 days.

In reality, however, these growth objectives would be better termed as economic growth objectives and are affected by:

- the skill of the growers
- the type of production (weight and age at slaughter)
- the feeding conditions
- the building type and density
- the flock health conditions.

Type of production and slaughter age

The objective is to obtain the most economical growth. Weight and age at slaughter define this objective. Generally the longer the growing period, the more the broiler chick growth must be slowed down between 5 and 15 to 20 days of age.

The day–old chick weight, followed by weighing them every 5 days, gives us a growth factor of **D.W.G./5 (daily weight gain/5).** This factor can then be used in conjunction with the table provided, to help determine the light programme and the period of time that the feeders should be empty.

The lighting pattern will greatly depend on feed quality. It must constantly be adapted in order to keep growth and liveability within the desired levels.

When the night period is very long, make us of 24 hour periodic programmes such as 3x8 hours or 2x12 hours.

■ Feeding programme and feed presentation

Feed must be distributed as soon as possible after the arrival of the chicks. This will complement the yolk, to present the chick with easily digestible nutrients, which are necessary for the development of the immune, digestive, skeletal and muscular systems.

A pre-starter feed is essential for:

UNIFORM GROWTH AND SUFFICIENT WEIGHT AT 4 TO 5 DAYS

The standard starter feed (2nd feed used between 11 and 20 days) can be adapted to the type of product:

- for birds to be slaughtered before 40 days, it will limit the effect of the light programme on the growth rate
- conversely, for the production of heavy–type broilers where sudden and late mortality is higher, one can slow down the growth using a lower level of nutrition fed as a mash.

Apart from the nutritional levels chosen for the grower and finisher feeds, feed efficiency is directly related to:

- the speed of feed intake, due to its presentation (coarseness and/or pellet quality)
- the feeding times, which should be spread out evenly over a 24 hour period to avoid the risk of gorging.

Under conditions of strong light stimulation, good pellet quality and when the feeders are empty, the dominant birds will quickly eat large quantities of feed. This leads to a rapid increase in oxygen requirements, which places a stress on the cardio–vascular system, culminating in the risk of heart failure.

In such cases, the light intensity and duration can be reduced, feed can be given as mash to regulate consumption and feeders can be left empty for a longer period.

STARTER FEEDS

Feed	Pre–starter	Standard starter	Heavy starter
Age (days)	0 – 10	11 – 20	11 – 20
Required per bird (g)	250	800	800
Feed type	Crumble	Crumble	Mash
Particles < 0.5 mm	≤ 10%	5%	20%
Particles > 3.15 mm	≤ 5%	15%	10%
Energy (RPAN)	2 900 – 2 950	3 000 – 3 050	2 950 – 3 000
Crude protein	21% – 23%	20% – 22%	21% – 23%
Fat	4%	5%	4%
Unsaturated fats	80%	70%	70%
Lysine (crude/digestible)	1.30%/1.10%	1.25%/1.06%	1.20%/1.02%
Methionine (crude/digestible)	0.55%/0.49%	0.52%/0.45%	0.50%/0.44%
Methionine + Cystine (crude/digestible)	0.96%/0.84%	0.93%/0.81%	0.91%/0.79%
Calcium	1.00% – 1.05%	1.00% – 1.05%	1.00% – 1.05%
Available phosphorus	0.50%	0.45%	0.45%

■ Building type and feeding equipment

Broiler houses with static or powered ventilation are seldomly, truly lightproof. This makes it difficult to use cyclical lighting programmes, especially during the summer. During the long summer days the dark period in the house is limited to the actual night–time and consequently any lighting programme becomes less efficient. To slow down growth, the empty feeder times must be synchronised with the natural light periods.

This technique of emptying the feeder pans can start between 10 to 14 days. This will be dependent on how low the feeding equipment can be placed, which itself controls the accessibility of the feed pans to the chicks. After 20 days, the empty period should be daily and can be from 4 to 8 hours long, depending on the growth rate of the flock. To avoid gorging after a long no–eating period, it is possible to use cycles of 12 hours (2 x 12 hours), or 8 hours (3 x 8 hours).

The technique of emptying the feed pans requires sufficient feeding space for all the birds to eat at the same time. With flocks where it is planned to remove part of the flock earlier, it is often observed that there are insufficient feeders for the initial bird density. A long dark period, or a long empty period will provoke competition and fighting, which leads to rejects at the processing plant (frequently seen in slow feather males). Under these conditions, feed must be distributed at the end of the dark period, before the lights come on.

- Feeding equipment

- before 35 days:	pans = 1/75 broilers
	trough = 1 metre of trough length/100 broilers
- after 35 days:	pans = 1/60 broilers
	trough = 1.5 metre of trough length/100 broilers

- Lighting

Provide a dimmer control unit, which gradually over the space of an hour will slowly increase the light intensity as the lights come on and decrease it, before the lights go off. For open–sided houses the lights on should be synchronised with the natural dawn.

■ Environment, health and vaccination programme

To help prevent ascites and cardiac problems, it is essential to control oxygenation and feed consumption. In the period when the light programme is increasing, at around 20 to 35 days, any respiratory problems (IB, Mycoplasma, etc.) will cause an increase in mortality. This is due to a simultaneous reduction in the bird's capacity to absorb oxygen (because of air-sacculitis, pericarditis) and an increase in feed consumption. Thus the effects expected from the light programmes become negative. In this situation, the light programme should be suspended, light intensity reduced, and the respiratory problem treated if time permits.

This makes it important to design a programme, which is adapted to the health status of the flock, especially for IB (including variants). Administer the vaccine in the water, rather than by spray, to limit the risk of respiratory complications, because the spray may be too fine.

Flocks affected by SDS (Sudden Death Syndrome), which generally occurs in the 2nd or 3rd week, should have their light programme adjusted to reduce their eating time until the glycogen function of the liver has recovered.

■ Climatic factors

In hot climates or during periods of hot weather, the classical light programme is only applicable in well-ventilated houses where temperature can be controlled.

If the houses are of the open type (hot climates) or of the static ventilation type, the light programme should be reversed by maintaining the house as dark as possible during the day to reduce bird activity and giving supplementary light at night. It is important in this situation to have enough feeding equipment well spread about the house (1 pan/40 – 50 birds). Conversely, in cold climates, long dark periods reduce activity and thus the production of body heat, which may lower the house temperature enough to provoke health problems.

■ Flock variations

■ Weight and uniformity of a flock

A chick is not a standardised product and a number of factors control weight and uniformity:

- age of the parent stock, age at the first egg and their health status
- incubation conditions (both physical and bacteriological)
- transport factors (duration and other conditions).

Even when all the factors are at the optimum level, this variability still exists.

CHICK WEIGHT UNDER NORMAL OPERATING CONDITIONS

Breeder age	26 – 30 weeks	31 – 44 weeks	+ 45 weeks
Average egg weight	50 – 55 g	56 – 63 g	64 – 67 g
Average chick weight	34 – 37 g	39 – 41 g	44 – 45 g
Chick weight range (95% of average)	30 – 41 g	34 – 46 g	39 – 50 g
% of total production	10 – 15	40 – 45	40 – 45

These day-old chick weights taken at the hatchery assume a CV of 8%.

The above shows us, for example, **that chicks from young breeders must be treated** carefully before subjecting them to a too severe lighting programme (of the heavy–bird type).

It is important for such chicks, that their access to water and feed is made easier by supplying extra equipment, brooder heat is increased to 32 – 33°C and that light intensity is higher (60 lux).

Even in good conditions, the programme cannot be started before 5 – 6 days.

■ Mortality, weight and uniformity at 5 – 7 days

Brooding conditions, temperature, feed quality, light intensity and ease of access to feed and water are the principal factors that determine mortality, weight and uniformity of the chicks at 4 – 5 days and thus allow the chick to express its genetic potential and develop immunity.

Clearly, if the brooding conditions are bad, the small chicks will have poor growth and higher mortality. In such a case, the light programme becomes a factor, which aggravates unevenness if it is applied too early.

Day old chick weight (g)	Weight at 5 days (g)	Mortality at 5 days (%)	Start the programme at
34 – 35	82	< 1.5	7 days
37 – 38	90	< 1.2	6 days
40 – 41	95	< 1	5 days
43 – 44	100	< 1	5 days

If the uniformity of the flock is below 80% (80% of the birds fall between the two values of ± 10% of the average) or the coefficient of variation is greater than 8%, **then the start of the programme must be delayed.** Conversely, in very good farm conditions and with good quality chicks, the programme may be advanced to start at 4 days, using a faster reduction of the light programme to attain the 10 day target weight.

■ Conclusion – Practical applications

- The start of the light programme after 4 to 5 days of age may be delayed a further 1 to 3 days (5 to 8 days) for chicks from young breeders.
- Allow feeders to empty from 10 to 14 days of age, depending on the height of the feeders. They should be empty every day from 20 days of age.
- Weigh the chicks upon arrival and then every 5 days. This will give the D.W.G./5, which is the control factor for the programme.
- Beginning at 20 days compare the actual growth situation with the growth objective:
  - if the D.W.G./5 factor is low, increase the hours of light and empty the feeders once per day at the end of the light period
  - if the D.W.G./5 factor is correct, maintain the programme
  - if the D.W.G./5 factor is high maintain the light programme, but increase the empty period of the feeders.

In not fully dark houses, programmes using 2 periods of 6 hours light and 6 hours dark or 3 periods of 4 hours light and 4 hours dark are useful. They reduce the risk of gorging after a long dark period. However, the no–feed period must be well synchronised with the natural light period.

Under these conditions the most economical growth will be achieved through reduced eating time and less electricity use for lighting.

In hot climates or during a hot spell, feed should be given at night or during the cooler hours.

Water

● THE QUALITY OF THE DRINKING WATER

The chicks and broilers must receive good quality water throughout their life. The table below indicates some microbiological and chemical standards.

	Units	Very pure water	Drinkable water	Suspect water	Bad water
Total germs	Number/ml	0 to 10	10 to 100	1 000 to 10 000	100 000
Salmonella	Number/ml	0	0	> 0	> 0
E. coli	Number/ml	0	0	10 to 50	100
Hardness		5 to 15°	15 to 30°	30°	30°
Organic matter	mg/litre	0	1	3	4.6
Nitrates	mg/litre	0	0 to 15	15 to 30	30
Ammonia	mg/litre	0	0	2	10
Turbidity			5 units		25 units
Iron	mg/litre		0.3		1
Manganese	mg/litre		0.1		0.5
Copper	mg/litre		1		1.5
Zinc	mg/litre		5		15
Calcium	mg/litre		75		200
Magnesium	mg/litre		50		150
Sulphates	mg/litre		200		400
Chlorides	mg/litre		200		600
pH		7	7 to 8.5		6.5 to 9.2

If some of the elements are above the standard for drinkable water, **suspect the water** as a cause for some digestive and other general problems. Without doubt the water **must be free of Salmonella and pathogens.**

The value of an analysis depends on when, where and how the sample was taken. It is better if the sample is repeated from the same place. Generally the laboratories making the analysis supply the material and the instructions in order to obtain a reliable result. Only an analysis of all the results from the same water source will allow an accurate evaluation of the true water quality.

Check the water quality periodically from the water pipes, especially at the end of the house at the last drinking point, **even when the main supply is shown to be clean.** The physical and chemical treatment of the water helps to lower the bacterial contamination and consequently mortality.

Any treatment must be sufficient to destroy all the germs in the pipes and drinkers. For this reason we advise using sodium hypochloride and to frequently check the level of residual chlorine in the water at the end of the system.

Frequently dangerous germs contaminate the water tank and pipes. It is important that they are cleaned and disinfected during the clean–out period.

● CLEANING THE DRINKERS

■ Baby chick fonts, round and trough type

These drinkers are often soiled by feed particles, which will eventually become contaminants.

To reduce the development of germs in these drinkers, they should be cleaned at least once daily, during the first two weeks of the chick's life and weekly afterwards.

In hot climates, the drinkers should be cleaned and disinfected daily. The water depth should be 15 mm.

■ Nipple drinkers

Flush the system regularly, especially after prolonged use of vitamins, vaccines or milk–based products. Failure to do this can lead to blocked nipples and a build–up of sediment that could cause bacteria to start growing.

Check the water pressure carefully and observe how the birds are drinking. In hot weather, water pressure may have to be increased to have sufficient water reaching the end of the line so that all birds may drink.

Often when equipping a house with this type of drinker, economics overrides technical standards. In very hot climates where maybe ventilation is not up to standard, this economy can turn out to be very costly with high losses due to failure to drink sufficient water.

● WATER CONSUMPTION

When the house temperatures follow the recommendations, **water consumption is generally 1.7 to 1.8 times the feed consumption.**

If they drink more or less, investigate the possible causes and check the adjustment of the drinking system (water pressure, depth of the water…).

The evolution of daily water consumption per kg of live bodyweight, **in a temperate climate** is as follows:

Age (days)	ml water per kg liveweight
7	370
14	270
21	210
28	180
35	155
42	135
49	125

One can use the above figures as a base when calculating for water treatments.

In hot weather, the water consumption can be double the figures shown above.

● CATCHING AND TRANSPORT OF THE ANIMALS

The true value of a broiler flock is only known after the culls, downgrades and output has been evaluated. This pickup, transport and slaughter phase is very influential, especially when it is poorly managed.

The catching and transport of the animals is highly stressful. It must be done as quickly as possible and under the best conditions.

The principal objectives are to minimise:

- the losses and stresses to the broilers
- the risks of contamination at the slaughter house.

The responsibilities are split between the grower and the slaughter house.

The grower for:

- The accuracy of the expected weights and numbers of broilers to slaughter
- The correct fasting period
- The organisation and supervision of the yard and the catching crews

The slaughterhouse for:

- The cleanliness of the transport crates or containers
- The synchronisation of the transport to minimise the waiting time before slaughter
- The quality of transport (number of birds per crate relative to their weight, distance and temperature).

An example of a standard programme prior to slaughter:

● 4 – 5 hours	total fasting and no water
● 1 – 5 hours	catching, according to the house size and slaughter capacity
● 1 – 4 hours	transport to the factory
● 1 – 2 hours	waiting at the processing plant

On average there is about 8 to 12 hours between the start of fasting and slaughter. The minimum time to limit the amount of contamination at the slaughterhouse from faecal ejection and feed left in the crop is 8 hours.

Above 8 hours, the weight loss is approximately 0.2% per hour under normal temperature conditions. Longer delays provoke dehydration and an excessive loss of water through the faecal ejection.

■ Fasting

A minimum of 4 hours after emptying or raising the feed system is required. Water should remain available until the moment catching starts. In some situations birds can still eat the waste food in the litter, so the lights should be dimmed to reduce this.

■ Catching the animals

The loading rate should be adapted to the truck capacity and the slaughter line speed.

The maximum rate is: 50 kg/m^2 in temperate climates
40 kg/m^2 in hot climates.

The transport material must be clean.

The work must be planned and carried out in a manner to reduce the risk of stress and injury to the animals.

Coveralls and boots for the catching crews should be mandatory, especially for partial pickups.

Every precaution should be taken to reduce suffocation, trauma (broken wings and legs, lying on their side, torn skin and scratches). These stresses are all the more important when the broilers are heavy and the distances from the house to the truck and to the processing plant are long, therefore:

- it is best to dismantle and remove all material that could cause injury to the animals during catching
- broilers should be caught by two legs, heavy broilers should be carried individually being held by two legs and supported by the other hand under the breast and placed in the crates
- limit the number of broilers to 3 per hand
- limit the handling time
- the height of the drawers and crates for the catchers is important. Broilers should be placed not thrown into the crates. They should not be left lying on their sides.

Catching at night-time is best. The broilers are calmer and the risk of scratches and suffocation is diminished. Diseased flocks will also show less resistance when being caught.

The working hours of processing plants requires pickup during daylight hours:

- avoid catching during the hottest periods
- cover the doorways with curtains to make it darker inside. Blue curtains can be placed in front of the windows (open–sided houses) without affecting ventilation too much
- use portable partitions to break up the house and increase observance of the flock for signs of pile–ups
- during hot weather, do not leave the trucks in the direct sunlight. Ventilation fans blowing air onto the trucks may also be required to help cool the birds
- the truck storage areas at the slaughterhouse should also be protected from direct sun and be supplied with ventilation and fogging equipment
- during winter, the broilers need to be protected against cold temperatures by tarpaulins during transport and need protected waiting areas at the processing plant.

● THE PROCESSING PLANT

■ Carcass yield

It is difficult to give values for carcass yield, cut-up, white and red meat. The figures are variable and depend on feeding, breed, transportation and management at the factory.

The values are relative and only comparable in the same factory. Therefore we will only show the values for the slaughter losses, which tend to be more stable. The figures are shown as % of liveweight.

● Blood	4%
● Feathers	6.2%
● Feet	4.5%
● Head	3%
● Viscera and losses	8.5 – 9.5%
● Neck	2%
● Neck skin	1.5%
● Liver	2.1%
● Heart	0.6%
● Gizzard	1.2%

■ Variation as a function of age and weight

The changes in yield given below are taken from work done by Veerkamp (1990) and are the result of a manual cut–up.

The variations in yield observed have been calculated based on an increase of one day in slaughter age with a daily weight gain of 65 g.

As % of liveweight	Variation/day
Heart	+0.002
Liver	- 0.023
Gizzard	- 0.015
Wings	- 0.015
Breast fillet	+0.090
Drumstick + thighs	+0.062
Abdominal fat + back skin	+0.052
Skeleton	+0.035
Thighs	+0.040
Drumsticks	+0.015
Neck	- 0.014
Neck skin	+0.014
Carcass with giblets	+0.170
Carcass without giblets. W.O.G.	+0.220

■ Other factors causing variation in yield

■ The weight of the feathers as a function of age

The weight of the feathers as a function of age and sex changes as follows:

Age in days	% of feathers		
	Males	Females	As hatched
28	4.7	5.2	4.9
35	5.0	5.6	5.3
42	5.7	6.8	6.2
49	5.9	6.7	6.3

Hancock, 1995

■ Influence of feed withdrawal

On liveweight

During the first 4 hours, the weight loss is about 3%. It then decreases linearly at 0.35% per hour, up to a total withdrawal time of 30 hours. These losses essentially result in lower carcass weight, because of weight losses from the digestive tract and the giblets.

On the digestive contents

The losses reach 2% during the first 4 hours, 2.7 to 2.8% after 8 and 12 hours, respectively. Thereafter they are stabilised at 2.9%. The gut content is then maintained at 1% of liveweight. **A feed withdrawal time of 4 – 5 hours before slaughter seems satisfactory.**

On the carcass weight

The losses are linear and reach **0.2% per hour** between 0 – 28 hours of withdrawal for the carcass weight including giblets and **0.17% for the carcass without giblets.**

On the intestinal weight

These losses are also linear and reach 0.1% per hour.

When the withdrawal period is too long the carcass weight is reduced by 0.2% for each hour of waiting.

■ Transport and waiting at the slaughter house

Influence on the yield

The losses continue at the rate of 0.2% liveweight per hour. The delay between weighing and slaughter translates into a reduction of carcass weight of 0.2% with giblets and 0.17% without giblets (Veerkamp). According to other authors these figures are slightly underestimated.

■ Slaughter and quality

■ Carcass quality

The following are some of the factors influencing the carcass quality and some of the possible causes:

- **Pustules:** litter quality, litter burns
- **Breast blisters:** killing weight, density per m^2, crusted litter, and insufficiently mineralised bones
- **Skin tears:** adjustment of the plucking fingers, presence of certain ionophores
- **Bruises:** care at catching, hanging on the shackles, insufficiently mineralised bones
- **Fractures:** rough handling, birds too nervous at the moment of stunning, scolding temperature, and adjustment of the plucking fingers
- **Red wings:** insufficient bleeding time (80 seconds), catching by the wings
- **Dark muscles:** current too high during stunning (pH of the meat is too high–alkaline, rigor mortis), birds stressed before electrocution
- **Haemorrhages and broken wings:** are also caused by faulty adjustment of the stunning equipment as well as poor handling during catching.

■ Flavour Quality

Post slaughter, the pH of the muscle is an indicator of the meat quality. A high pH is characterised by meat that is darker and drier, due for example to the stress of transport. A low pH level is characterised by a pale, wet looking meat (P.S.E. Pale Soft Exudate), due to stress at the time of slaughter.

Stunning plays an important role in the quality of bleeding and in obtaining a dark colour meat, through the pH changes of the meat. Voltage level and stunning time are important. Voltage of more than 80 Volts reduces the bleeding quality, whilst too long a stunning time will darken the meat.

Maintaining quality: a supplement of vitamin E will prolong the shelf life of the meat.

● PROTECTION AGAINST CONTAMINATION

■ Personnel and visitors

People are the most frequent carriers of contaminants. Representatives, truck drivers, technicians and visitors should not be allowed onto the farm without authorisation.

Employees should not go from one house to another. If it is absolutely necessary then they should change clothes and boots and wash their hands before entering the second house.

■ Delivery vehicles

Trucks, crates or containers should be carefully **washed and disinfected** before loading the broilers.

Feed trucks are a major concern, as they go from farm to farm and carry dust, which is full of contaminants.

If it is not possible to decontaminate the trucks and drivers at the farm entrance, the silo and broiler house should be fenced off and the feed truck and driver should remain outside the fenced area.

■ Washing, disinfection and rest period

Cleaning and disinfection of the houses, their annexes, surroundings and access ways are both essential to ensure good healthy broilers, and thus helps to improve profitability.

The following are the important points to follow:

■ Floor rearing

● Insect control

The first application of an organophosphorus type insecticide is made immediately after the broilers have been removed, when the house is still warm. The insecticide is sprayed on the litter and the lower part of the walls up to 1 metre high. Leave the insecticide to work for 24 hours.

● Operations prior to cleaning

Water tanks, pipes and nipples:
- emptying of the complete water system on the litter
- cleaning and descaling of the complete system with an acid solution and left for 6 hours to soak
- double rinsing with clean water.

All the equipment (feeders, drinkers, etc.) is removed and stored on a concrete area.

The entire ventilation system (air inlets and outlets, fans, heating and ventilation ducts if they are present) and individual radiant or pancake type brooders are brushed and vacuum cleaned.

Litter is removed.

● Washing

When washing, one should ensure that the dirty water is directed towards a pit or drain and does not run outside to the house surroundings or access ways.

<u>House</u>

Soaking and scouring of the remaining organic matter.

Application of a bactericidal and fat removing detergent, using an appliance capable of dealing with foam products.

Some hours after soaking, wash with a high pressure washer (>50 kg/cm^2), or with hot water, in the following order:
- first, the skylight
- internal surface of the roof, from the top down
- walls, from the top down
- finally, the dwarf walls and the concrete floor.

Drinkers and feeding equipment:

- soaking and scouring of the organic matter
- application of a bactericidal and fat removing detergent, using an appliance capable of dealing with foam products
- thorough washing followed by rinsing. Prior to the final rinsing, dip the small baby chick equipment (drinkers and feed trays) for 24 hours in a disinfection solution
- drying on a concrete area (different to that of washing).

● Placing the equipment back into the house

The vehicles that may be used for this operation must have been carefully washed and disinfected by spray.

● Disinfection

Water pipes

Prepare a highly concentrated chlorine solution (200 ppm) in the water tank. Open the tank to fill the pipes with this solution and leave for 24 hours. Afterwards, drain the water circuit. Do not forget to seal the water tank, to protect it from dust.

House

House and equipment disinfection is achieved using a homologous bactericidal, virucidal and fungicidal disinfectant, applied with a sprayer or a foam-producing machine.

The list of homologous disinfectants may vary from one country to another. We recommend that you consult the local Health Authorities.

Silos

Scrape, brush, wash and after drying, fumigate using fungicidal candles.

Heating and ventilation ducts (when they are present)

Disinfection with fungicidal, virucidal and bactericidal candles.

House surroundings and access ways

Spread a disinfecting product, such as:

- caustic soda (50 to 100 kg/1 000 m^2) – or quicklime (400 kg/1 000 m^2)

● Sanitary precautions

Place clean boots and overalls in the changing room. Replenish the footbaths with disinfectant.

● Rodent control

Rodents may be vectors of numerous bacterial diseases, salmonellosis for example. Control is often based on the use of toxic baits, which generally contain anticoagulants. These are left in the places frequented by the rodents. This gives variable results. We advise the use of a specialised rodent control service.

● Controls to determine disinfection efficiency

Visual examination

Check for dirt stains in the house and on the equipment.

Bacteriological analysis

Contact plates or swabs are applied to equipment and to various places in the house. These are then quickly forwarded to a bacteriology laboratory. The samples must not be allowed to become hot.

● Resting period

This starts only when all the above operations have been achieved and lasts for at least 10 days, in order for the house to dry properly.

- Before the arrival of the new flock:

- 3 days before the new flock arrives, a residual insecticide is sprayed on all surfaces
- fresh litter is placed (never use mouldy material) and its surface sprayed with a larvicidal insecticide
- equipment is prepared in the brooding area
- 24 hours before the new flock arrives, a second disinfection, by heat fogging (thermonebulisation) is made.

■ Rearing in cages or batteries

The procedures are the same except for the washing and disinfection of the house and cages.

In this type of housing much of the equipment is fixed and non-moveable, which makes it harder to clean properly. Cleaning the cages by using high-pressure pumps can increase the chance of corrosion. Disinfectants can also be corrosive to metal.

Industrial vacuum cleaners are best to remove the maximum of organic matter from the skylights, air inlets, cages, belts, etc.

Disinfection by heat fogging will significantly reduce the microbial population.

● HEALTH PROGRAMME

It is impossible to devise a health programme to adequately suit all geographic areas. For this reason, it is strongly recommended that a local specialist be consulted to help produce a prevention programme adapted to that region.

We limit our comments to a general description of some rules for the use of vaccines and other treatments. To be successful, respecting these rules is as important as choosing the right products.

- Staff should be properly trained to carry out veterinary operations. It is useful to create a Standard Operating Procedure Manual, that describes in detail the way to perform each vaccination or treatment.
- All the necessary equipment (sprayers, syringes, etc.) must be correctly maintained, and checked before each use.
- Each operation should be planned and supervised by a technically competent person.
- Vaccines and treatments should be stored under optimum conditions, in suitable quantities considering the needs. Both manufacture and expiry dates should be checked. Destroy empty bottles.
- Report carefully in the flock records the details of all operations: date, time, vaccine batch number, expiry date, administration method, etc.
- Finally, it is useful to have the help of a laboratory in order to anticipate health problems ahead of time and to assess the efficiency of the various vaccination and control procedures:

- control of disinfection, water and feed quality
- serological monitoring
- post mortem examination and routine parasite checks.

Vaccines should be purchased from companies, which conform to rigorous control standards. Transport should be in sealed, insulated containers and stored under the conditions specified by the manufacturer.

■ Preparation of the vaccine

Live freeze dried vaccines should be reconstituted in the correct diluent using as a minimum, physiological serum.

Vaccine bottles should be opened under water when vaccinating through the drinking water.

The name and batch serial number of the vaccine should be carefully recorded and the empty bottles destroyed.

■ Vaccination techniques

■ Mass vaccination

When mass vaccinating (by drinking water or by spray) ensure that all the birds have been vaccinated.

Vaccination in the drinking water should be done using water, which is free of **substances that are harmful to the vaccine.** The reconstituted vaccine should be diluted in sufficient water, which will be consumed within **1 hour**. The drinkers must be clean. The water depth should be sufficient so that contact is made with the nostrils and the eyelids. To neutralise the effect of antiseptics in the water use milk powder or sodium tri–sulphate.

We advise cutting off the water sufficiently ahead of the vaccination, taking into account the temperature (approximately 3 hours) in order to guarantee that all the vaccine will be consumed in the given time. The alternative is to proceed to vaccinate immediately after the lights come on, if a light programme is used.

Spray vaccination allows contact between the virus particles and the immune defence organs of the upper respiratory system, as well as the Harderian gland. In order to be sure of good results **the droplets produced from the sprayer must visibly fall quickly onto the birds before evaporating into the air. Adjustment of the sprayers is very important.** If using the horticultural type sprayers, maintain a distance of more than 80 cm from the boxes. **Never vaccinate under the brooders.**

■ Individual vaccination

Whether this is by eye drop, wing web or injection, **take the time to ensure that all birds are correctly vaccinated.**

Vaccination by eye drop guarantees contact between the virus particle and the Harderian gland.

Vaccination by injection can be subcutaneous or intramuscular. Due to the volume to be injected, be precise in order not to provoke deep lesions and future risk of downgrading when the flock is slaughtered. The needle size should be adapted to the size of the birds and the type of vaccine (live or killed).

● THE IMMUNE RESPONSE

The immune response is of two kinds:

■ Local immunity response

When the antigen is stopped at the mucous membranes, it is a local response. This response/reaction is valuable for blocking early entry of certain viruses.

■ General immunity response

This can follow a local response or appear after the antigen has penetrated the organism. It will provoke antibody production of variable duration.

A general immunity response can cause **a temporary depression** of the birds' defence mechanisms, which may be from maternal antibodies or antibodies from a previous vaccination.

During the post vaccinal period the birds should be protected against any other aggression or stress.

Only vaccinate healthy flocks. Delay vaccination of flocks that are not 100% healthy.

Re–vaccination should take into account the decrease in antibodies produced by an earlier vaccination. A reasonable time period must be respected between two vaccinations of the same type.

The time interval between two different types of vaccination acting on the general immune system must also be respected. This is about 2 weeks.

● VACCINATION CONTROL

The first and indispensable control for all water vaccinations is to ensure that the calculation for the water to be consumed and the drinking time is sufficient to ensure correct vaccination of the flock. The evening prior to vaccination use coloured dye in the drinking water. Observe the number of birds that drink during a given time period (they will be stained by the colorant). This will give an idea of the time required for the vaccination to be successful. The water tanks should then be cleaned (slightly acid) and rinsed ready for vaccination.

All vaccination programmes should be controlled by sending blood samples to a specialist laboratory. After taking the blood from the wing vein, and leaving the tubes on their sides for an hour or so, it is possible to collect the serum and if necessary to freeze it. Send it to a laboratory for qualitative and quantitative verification of antibody levels. For some antibodies, placing serum on a special paper can also be used.

Laboratory controls will verify the quality of the vaccination (uniformity levels and average titers obtained, etc.).

The value of information gained from this serology depends on the quality of the programme. Frequent tests of a sufficient number taken from correctly vaccinated flocks, allows for proper analysis and interpretation.

● VACCINATION PROGRAMME

It should be created based on knowledge of:

- the disease picture in any given country or region, which allows the main diseases to be identified
- the cleanliness and environment of each farm
- the immunity mechanisms and the rules for vaccination
- the serological controls (flock profiling).

● PREVENTION OF THE PRINCIPAL VIRAL DISEASES

■ Marek's disease

Vaccination is carried out at the hatchery with live virus vaccine, either heterologous or homologous or both together, which work to prevent the early multiplication of the field strain in the body and the later appearance of tumours.

It is well known that 85% of the flock on average is effectively protected and this is only after two weeks. For this reason we must protect the baby chicks from an early strong infection of the field virus.

It seems that the virulence of the field virus is increasing and that the protection offered by the vaccine itself is not sufficient, if sanitary protection is poor.

This Marek's vaccination is not required for all broilers, but is certainly necessary for the flocks that are killed at an older age.

■ Gumboro disease

The presence or absence of maternal antibodies will determine the Gumboro vaccine programme. It is very difficult to fix the level of passive (maternal) antibodies in a batch of chicks, since the transmission of antibodies from the parent flock varies widely. The absence of antibodies exposes the chicks to Gumboro disease, whose immunosuppressive effects concerning other infections (Marek, Newcastle, colibacillosis, and salmonellosis) are well known.

The vaccination of breeder flocks with inactivated oil–based killed vaccines, transfers a more uniform and longer lasting passive immunity to the chicks.

In farms with more contamination, create a vaccination programme based on the following principles:

- in the absence of maternal antibodies vaccinate at day 1, use a very attenuated live vaccine and repeat again during the first few weeks
- if maternal antibodies are present, vaccinate relative to the decline in maternal antibodies and the type of vaccine used
- if the maternal antibody level is not known or irregular, vaccinate at day old with a very attenuated vaccine and revaccinate at 3 weeks.

In known contaminated farms, the use of new strains of vaccine and a thorough review of the vaccination procedures have been known to improve results. However, it is noted that quite often the first time this approach is tried the results are not always perfect.

■ Newcastle disease

Protection can be based on:

- local immunity in countries where the virus is very virulent
- general immunity in countries where the virus is less acute.

The use of attenuated live vaccines, followed by inactivated oil–based vaccines gives good immunity.

The use of mixed vaccination, an attenuated live together with an inactivated vaccine at day old gives good results in countries where Newcastle disease virulence is high.

In countries which are free of the disease, there is no need to vaccinate, especially for standard weight broilers.

■ Chronic respiratory disease

Epidemiologists agree that environmental conditions can cause a greater problem than the disease itself. However several contaminants can intervene together or separately.

Infectious Bronchitis virus

Vaccinate at 1 day: the target organ is the Harderian gland. Spraying a full dose of an attenuated strain (0.5 litres of water/1 000 doses), as a course droplet has the same effect as an eye drop and is proven to be efficient. To avoid destroying the virus by heat, this work is best done at the hatchery or in the boxes when the chicks are still confined.

Mycoplasma

Mycoplasma gallisepticum is particularly aggressive. Check the chick quality as well as the possibility of horizontal transmission to/from other birds/sources. Unfortunately, serum tests at this early age are not very reliable. Several cultures must be made to have a statistically reliable result.

Mycoplasma synoviae is also a problem, but to a lesser degree. In some countries, the vaccination of parent stock with an inactivated vaccine will produce chicks free of the disease, but which carry antibodies.

Infectious swollen head syndrome, Big Head (TRT)

This infection is caused by a pneunovirus and is present in many countries. A live vaccine can be used with broilers. Vaccinating breeders with an inactivated vaccine will transmit maternal antibodies and delay the appearance of the syndrome in broilers.

Bacteria causing secondary infection

Potentially pathogenic colibacilli often invade a weakened body and can cause irreversible complications.

■ Malabsorption syndrome

This can show up as viral enteritis causing various clinical symptoms:

- poor uniformity
- slow growth
- lameness.

Vaccination of the breeders using vaccines made from various strains of Reovirus allows for the transmission of maternal antibodies. However, strict control of hygiene at the farm remains the best solution to controlling this truly complicated problem.

■ Chick anaemia or gangrenous dermatitis

This problem appeared more recently and results from vertical transmission or early infection. Here again, vaccinating the breeders and good farm management, help to control the problem.

● OTHER BACTERIAL INFECTIONS

■ Salmonella

Pullorum caused by Salmonella pullorum/gallinarum only originates from a contaminated environment. Strict control of breeding stock over many years has eradicated this problem.

Certain salmonella can also provoke health hazards for the consumers, notably Salmonella enteritidis and Salmonella typhimurium.

General hygiene measures, control of the raw feed materials, backed up by a well co–ordinated supervisory programme, can be designed to slow down contamination and to separate the contaminated products from the distribution chain.

Some countries have special rules:

- specific local standards for poultry houses and equipment that must be approved
- investigating contamination
- compensated slaughter of contaminated flocks by the state.

Certain countries are considering vaccination. The use of "competitive flora" has also been proposed to reduce the risk of contamination.

■ Staphylococcus

Usually located in the leg joints, seldom visceral and generally caused by accidental injury or skin lesions, which must be avoided to reduce the incidence of the disease.

● MANAGEMENT TO FOLLOW IN CASE OF HEALTH PROBLEMS

First, a precise diagnosis must be made. The grower is the first person to see the problem and be in a position to give precise information about flock behaviour (drop in water consumption or feed, prostration, respiratory signs, etc.) and be able to guide the necessary investigations.

An in-depth visit to the farm and sufficient autopsies should allow for a proper diagnosis, so that the correct emergency treatment can start. Carefully taken samples should be sent to a laboratory of veterinary biology, along with a written description of the problem and the flock history, to help complete the study.

The choice of treatment is a veterinary decision. It calls for good knowledge of the suitability and availability of the products, an understanding of how to use the product aided by the product instructions. A bad choice quite often provokes more losses than that caused by the illness itself (drop in consumption, toxication, impaired meat quality, etc.).

● TREATMENT OF BACTERIAL INFECTIONS

Regulations governing the absence of residual chemicals in slaughtered animals are becoming more and more precise in many countries today. The withdrawal periods are becoming longer, which makes it difficult to give treatment late in the life of the flock. The use of permissible additives (expectorants, diuretics, etc.) may limit the problems until slaughter.

Note

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