ROSS

ROSS

Broiler Management Manual

Foreword

ROSS BROILER MANAGEMENT MANUAL

The aim of this manual is to assist farm staff and owners of Ross broilers to achieve the highest possible performance from their birds. It is not intended to provide definitive information on every aspect of stock management, but draw attention to important features, which if overlooked may depress flock performance. The management techniques contained in this manual are considered to be the most appropriate to achieve good performance, consistent with maintaining the health and welfare of the birds. In this connection due regard has been paid to the welfare recommendations for livestock detailed by the UK Department of the Environment, Food and Rural Affairs (DEFRA). Aviagen also encourages owners and managers of Ross stock worldwide to adopt a similar policy in this respect.

BIRD PERFORMANCE

Performance can be influenced substantially by many factors including flock management, feed quality, health status and climatic conditions. Data contained in the manual indicate those levels of performance which can be achieved under good management and environmental conditions.

Every attempt has been made to ensure the accuracy and relevance of the information presented. However, Aviagen accepts no liability for the consequences of using the information for the management of broilers.

Variations may occur for a variety of reasons. For example, feed consumption can be affected significantly by form of feed, energy level of feed and house temperature. Data presented in this manual should not, therefore, be regarded as Specifications but as 'Performance Objectives'.

NOVEMBER 2002 REVISION

The information presented in this revision combines the results of research and development, scientific knowledge and expertise, and practical skills and experience of Aviagens' Technical Development and Technical Service teams. Changes in style have been made to make the information easy to access and understand. Clear objectives for each part of the process are identified, principles and management techniques are explained in detail and key points are emphasised. Aviagens' Technical Development and Technical Service teams expect that by applying the techniques described in this manual, users of Ross broilers will see continuous improvement in performance.

TECHNICAL SERVICES

For further information on the management of Ross stock please ask your local Technical Service Manager or contact the Technical Services Department at Aviagen Limited, Newbridge.

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November 2002

Using this Manual

Finding a Topic

Printed tabs appear on the right-hand side of the manual. These allow readers immediate access to those sections and topics in which they are particularly interested.

The contents list presented here gives the title of each section and subsection.

There is also an alphabetical Key Words Index at the rear of the manual.

Key Points

✓ **Where appropriate, key points have been included which emphasise important aspects of husbandry and management. They are highlighted by a red heading and red ticks in the left-hand margin alongside the text.**

Certain danger points have been given emphasis using this sign and bold text.

DANGER

Performance Objectives

Performance Objectives have been reproduced as a separate booklet which is enclosed at the rear of the manual. This will allow for regular updating.

Contents

INTRODUCTION

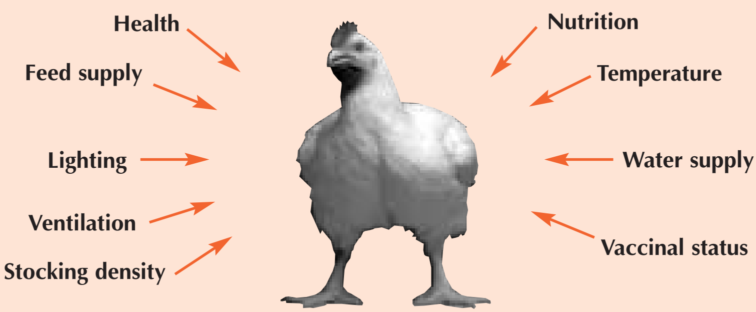
Aviagen produces a range of genotypes suitable for different sectors of the broiler market. All Aviagen products are selected for a balanced range of parent stock and broiler characteristics. This approach ensures that the products are capable of performing to the highest standards in a wide variety of environments. The range of Ross genotypes allows users to select the Ross product which best meets the needs of their particular operation.

Aviagen also applies a balanced approach to genetic progress in characteristics of commercial importance e.g. growth rate, feed conversion ratio (FCR), liveability, meat yield, whilst improving bird welfare e.g. leg health, cardiovascular fitness and robustness. Achievement of genetic potential in any livestock species depends on the following:

- Genotype is capable of delivering the required performance.
- Environment is managed to provide birds with all their requirements e.g. temperature, air quality etc.
- Feed delivers enough nutrients in the correct proportions.
- Immune status is appropriate and disease is controlled.

All of these are interdependent. If any of these elements are sub-optimal, then broiler performance will suffer. The range of factors which can limit broiler performance is shown in Diagram 1.

DIAGRAM 1: LIMITS TO BROILER GROWTH AND QUALITY



Economic and commercial issues continue to affect the management of broilers. The following issues are of major importance in commercial broiler production:

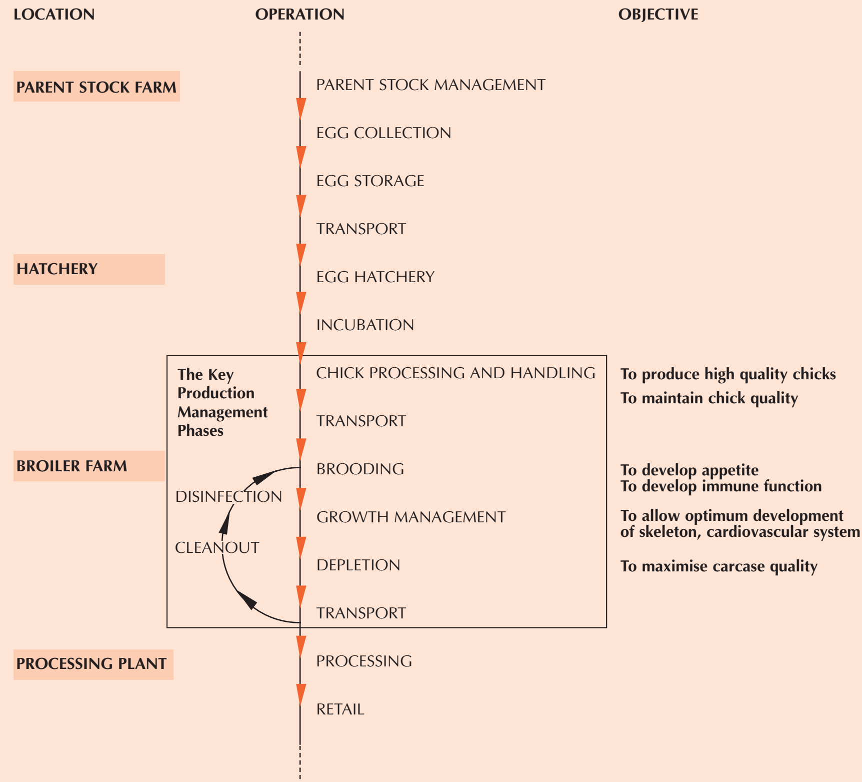
- Increasing consumer demand for product quality and food safety.
- Necessity for flocks of broilers which can be grown to predictable, pre-defined specifications.

- Requirement to minimise variability within flocks, and hence variability of the final product.
- Welfare of broilers
- Improved genetic potential for FCR, growth rate and meat yield.
- Minimal levels of metabolic diseases. e.g. Ascites or leg health.

As the sophistication of broiler production systems increases responsive management, based on good information, is essential.

The broiler-growing phase is an integral part of the total meat production process, which encompasses parent stock farms, hatcheries, broiler growing units, processors, retailers and consumers. (See Diagram 2).

DIAGRAM 2: PRODUCING QUALITY BROILER MEAT - THE TOTAL PROCESS



The objective of the broiler manager should be to achieve the required flock performance in terms of liveweight, feed conversion, uniformity and meat yield. Development of the vital support functions such as the cardiovascular, pulmonary, skeletal and immune systems is crucial to this objective. Critical periods for development of these physiological systems occur during incubation and the first two weeks of life. Therefore, particular attention must be given to management during these periods. (See Diagram 2).

In order to maximise performance, hatchery procedures, chick handling, brooding and early growth management are all of major importance. Broiler production is a sequential process, with ultimate performance being dependent on each step being completed successfully. For maximum performance to be attained, each stage must be assessed critically and improvements made wherever required. Changes may be necessary in the hatchery, on the broiler farm, in the processing plant or in transport. (See Diagram 2, page 5)

Diagram 2 demonstrates that within broiler production there are several stages of development of the bird. The hatchery deals with hatching eggs and chicks. The broiler farm deals with chicks and growing broilers. The processing plant deals with broilers and carcases. Successful broiler production requires that the transitionary phases are managed with the aim of minimising stress to the bird. The key transitions in broiler production are:

- change to being a net producer of heat in OVO
- pipping and emergence of the chick
- take off, storage and transport of the chick
- development of good appetite in the young chick
- change from supplementary feeding and drinking systems to the main system
- catching and transport of the broiler at depletion

The transitionary phases require special attention when optimising the whole process.

The complexity of broiler production means that livestock managers must have a clear understanding of the factors affecting the whole production process as well as the principles of bird management. Aviagen's Technical Development Team have designed this manual with the following principles in mind:

- consideration of bird welfare at all times
- understanding of the production chain and transitionary phases
- attention to quality of the end product throughout the entire process
- responsiveness to the changing requirements of the bird i.e. responsive management*

  **The requirements of the bird change constantly. The purpose of responsive management is to satisfy these requirements by observation of changes in the birds and their environment and alter inputs in an appropriate way.*

No two broiler houses are completely identical, and every flock of broilers will differ subtly in its requirements. The broiler farm manager should understand the birds' requirements and, through application of responsive management as described in this manual, supply the individual requirements to ensure optimum performance in every flock.

Section one

Chick Management

Objectives

To establish a healthy flock through the final stages of incubation and the brooding stage on-farm. To promote early development of feeding and drinking behaviour, which will allow the target bodyweight profile to be achieved with maximum uniformity and good welfare.

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CHICK MANAGEMENT

Principles

Recent research has shown that factors during incubation can have profound effects on early gut and immune development and hence performance of newly hatched chicks. For the best broiler performance, embryo temperatures must not be allowed to rise too high, the hatch must be taken off at an appropriate stage after the chicks emerge and the chicks should then be fed as soon as possible.

For chicks to receive the best possible start on farm, they must be provided with the correct environment (i.e. temperature, humidity and house layout) which should be managed to meet all their requirements. During the first 10 days of life, the chicks' environment changes from that of the hatcher to that of the broiler house. Chicks must be able to adapt successfully and establish healthy appetites, feeding and drinking behaviour if they are to achieve their genetic potential for growth and other aspects of performance. Deficiencies in the brooding environment will depress final flock performance by preventing the chicks from achieving their growth potential during the first week.

The potential 7 day liveweight of Ross broilers is 160g or above. Seven day liveweight should be routinely monitored and action taken where target liveweight is not achieved.

INCUBATION, CHICK QUALITY AND BROILER PERFORMANCE

Final broiler performance and profitability are dependent upon attention to detail throughout the entire production process. This involves good management of healthy parent stock, careful hatchery practice, efficient delivery of chicks, which are of good quality and uniformity. Chick quality may be influenced at every stage of the process.

Planning

Broiler flocks should be planned to ensure:

- differences in age and/or immune status of donor parent flocks are minimised. One donor flock per broiler flock is the ideal. If mixed flocks are unavoidable, keep similar parent flock ages together.
- vaccination of donor parents maximises maternal antibody protection in the offspring and is successful in protecting broilers against diseases which compromise performance (e.g. Chick Anaemia Virus, Reovirus).
- the time at which eggs are set is adjusted to take account of differences in parent flock age so as to minimise the time between emergence and delivery of chicks.
- Setting times are adjusted so that the chicks are removed from the incubator at their optimal stage of development. This will be when the weight of the chicks is between 66 and 68% of the initial egg weight at set.

$$\text{i.e. } \frac{\text{average chick weight}}{\text{average egg weight}} \times 100 = 66\text{-}68\%$$

Incubation

Aspects of incubation and their effect on broiler performance are covered more fully in *Ross Tech 02/41.*

For a flock of broilers killed at 40 days, 35% of the total growth period will take place in the egg. During incubation, chicken embryos develop from the germinal disc found in the fertile egg when it is laid, into fully functional, live chicks. To do this, they need heat. The heat has to be supplied by the incubator for roughly the first half of incubation. Then, after about 15 days embryonic heat production increases, and it will be necessary to cool the incubator.

If during the second half of incubation the embryo temperature as measured at the shell surface exceeds 39.5°C, then hatchability and chick quality will both suffer. Modern, high-yielding broiler breeds tend to hatch slightly earlier. In addition, high incubator loads can result in the the cooling system being overloaded towards the end of the incubation period. Hot spots can develop in corner trays and trays most distant from the fans. These problems can often be difficult to locate and to remedy in a modern, highly automated hatchery.

Excessive embryonic temperatures can not only affect hatchability and culling rates, but can also limit subsequent broiler performance. Chicks that have been heat stressed in the hatcher may have relatively immature immune systems and dysfunctional intestines. Their guts may also be damaged in ways that limit their potential for generation and regeneration of the gut lining. These chicks will not grow or convert as well as their unstressed flock-mates, and can be more susceptible to enteric infections.

Overheated chicks or temperature variation within incubators or hatchers will result in underperformance of the broiler.

Early access to feed and water has been shown to improve broiler performance and meat yield. Immediate feeding assists the chick to convert from obtaining its' nutrients from the residual yolk, to obtaining nutrients solely from feed. The gut is better-developed and less susceptible to enteric infections and the birds lay down more breast meat.

To maximise chick quality the hatchery and transport system should ensure that:

- embryo temperature, as measured at the egg surface around the equator after 15 days incubation, does not exceed 39.5°C (103°F).
- airspeeds across all the eggs are in excess of 0.2m/second
- chicks are fed as soon as possible after hatch
- after take-off, chicks are held in an area in which the environment is controlled correctly. (See Table 1, page 10).
- chicks are held in a darkened area to allow them to settle before transport
- chicks are loaded through controlled-environment loading bays in to preconditioned lorries for transport to the broiler farm.
- pre-determined standards of hygiene are achieved consistently to minimise cross contamination and yolk sac infection.
- the correct vaccines are administered at the correct dosage and in the correct form; all chicks are vaccinated equally.

Excessive dehydration of chicks results from poor control of hatchery and transport environment. DANGER

TABLE 1: SUMMARY OF OPTIMUM CONDITIONS - CHICK HOLDING AND TRANSPORT	
Chick holding conditions	24°C (75.2°F) Ambient Temperature 50% Relative Humidity (RH) 1.42m³/min (50cfm) per 1000 chicks Air Exchange
Transport conditions	24°C (75.2°F) Ambient Temperature 50% Relative Humidity (RH) 1.42m³/min (50cfm) per 1000 chicks Air Exchange

Note: These conditions in the storage area or transport vehicle should give temperatures of 30-35˚C and RH of 70-80% amongst the chicks.

Key Points

- ✓ **Plan placements to minimise physiological and immune differences between chicks. Use single donor flocks if possible.**
- ✓ **Avoid embryo (shell surface) temperatures over 39.5˚C after 15 days of incubation.**
- ✓ **Hold and transport chicks in conditions which prevent dehydration and other types of stress in chicks.**
- ✓ **Feed the chicks as soon as possible after take-off from the hatcher.**
- ✓ **Maintain high standards of hygiene and biosecurity in the hatchery and during transport.**

PREPARATION FOR CHICK ARRIVAL

All sites should be single age (i.e. all in-all out). Vaccination and cleaning programmes are more difficult and less effective on multi-age sites.

Recurrent outbreaks of disease due to recycling of pathogens may occur within multi-age sites. DANGER

Houses, the surrounding areas and all equipment must be thoroughly cleaned and disinfected before the arrival of the chicks. (See Hygiene and Health, pages 57-63 and *Ross Tech 00/38, Poultry House Cleanout Procedures.*)

Litter material should be spread evenly to a depth of 3-10cm (1-4in) and then levelled and compacted in the brooding area.

Uneven litter can restrict access to feed and water and may lead to a loss in flock uniformity. DANGER

The necessary equipment must be assembled in the appropriate configuration. During the brooding phase, the equipment in the house (i.e. feeders, drinkers, heaters and fans) must be arranged to allow chicks to maintain body temperature without dehydration and to find feed and water easily. The best configuration will depend on the brooding system (i.e. spot or whole house) and on other equipment being used. Chicks should be tipped on to paper and feed at placement, and should not have to move more than one metre to find feed or water during the entire brooding phase. Supplementary feeders and drinkers should be placed so that the chick makes an association between the supplementary system and the main system.

Lack of uniformity and poor growth will result from inadequate provision of heat, feed and water during brooding.

DANGER

Houses should be pre-heated and the temperature and relative humidity stabilised for at least 24 hours prior to chick arrival. Both temperature and relative humidity should be monitored regularly to ensure a uniform environment throughout the whole brooding area.

The environmental control systems must be capable of supplying air of optimum quality at bird level and removing waste gases produced by the chicks and the heating systems. (See Housing and Environment, Ventilation and Air Quality, Section 6, pages 81-83). Care must be taken to avoid draughts.

Failure to remove waste gases from the birds' environment can lead to heart and lung disease.

DANGER

Adequate clean water must be available. It should be within the correct temperature range. (See Housing and Environment, Water Quality, Section 6, pages 89-92). All chicks must be able to eat and drink immediately on placement in the house.

Initially, textured feed should be provided as dust-free, sieved crumbs, on feeder trays or on paper to give a feeding area occupying at least 25% of the brooding area. Organise the layout so that chicks can be tipped directly on to paper so that feed is immediately available.

Feeders and drinkers should not be placed directly under a heat source.

DANGER

If the mixing of chicks from different parent flocks is unavoidable, chicks from each source flock should be brooded in separate areas within each house.

Key Points

- ✓ **Provide chicks with biosecure, clean housing.**
- ✓ **Control spread of disease by using single age, (i.e. all in-all out) housing.**
- ✓ **Spread litter evenly.**
- ✓ **Arrange equipment to enable the chicks to reach feed and water easily and associate supplementary feeders and drinkers with the main feeding and drinking system.**
- ✓ **Pre-heat the house and stabilise temperature and humidity prior to arrival of chicks.**
- ✓ **Ventilate to provide fresh air and remove waste gases.**
- ✓ **Make feed and water available to the chicks on arrival.**

CHICK PLACEMENT

Prior to delivery of chicks, a final check must be made of feed and water availability and distribution within the house. The expected delivery time of the chicks must be established beforehand so that they may be unloaded and correctly placed as quickly as possible. The longer the chicks are in the boxes, the greater the degree of dehydration. This may result in early mortality and reduced growth as indicated by 7 day and final liveweight.

Full chick boxes must not be stacked in the brooding area as this can lead to rapid overheating and suffocation.

Chicks must be tipped quickly, gently and evenly on to paper and feed over the brooding area. Water should be freely and immediately available. The empty boxes should be removed from the house without delay.

Chicks should be left to settle for 1-2 hours to become accustomed to their new environment. After this time, a check must be made to see that all chicks have easy access to feed and water. Adjustments must be made to equipment and temperatures where necessary.

From 2-3 days of age, existing feeders and drinkers should be repositioned and adjusted and additional ones introduced as the illuminated area is increased. The distribution pattern of chicks should be monitored closely for the first 3 days to ensure that chicks are able to find food and water as they begin to use more of the floor area.

Key Points

✓ **Unload chicks and place quickly.**

✓ **Check feed and water availability and distribution.**

✓ **Leave chicks to settle for 1-2 hours with access to feed and water.**

✓ **Check feed, water, temperature and humidity after 1-2 hours and adjust where necessary.**

ENVIRONMENTAL CONTROL

Temperature and relative humidity should be monitored frequently and regularly i.e. at least twice daily in the first 5 days and daily thereafter. Temperature and humidity measurements should be made as close to chick level as possible. Sensors for automatic systems must be sited at chick level. Conventional thermometers should be used to cross check the accuracy of electronic sensors controlling automatic systems.

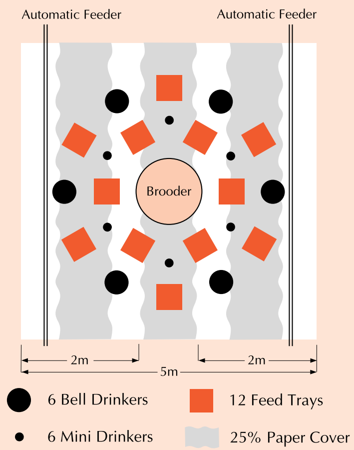
BROODER MANAGEMENT

Two basic systems of temperature control are used for broilers:

– Spot Brooding
– Whole House Brooding

Spot Brooding

DIAGRAM 3:
TYPICAL BROODING LAYOUT (1000 CHICKS) FOR DAY ONE



In spot brooding a temperature gradient is provided. (See Diagram 4).

Heat is provided by conventional canopy brooders. Surrounds may be used, but more usually, birds are confined by lighting only the brooding area and extinguishing the remaining house lights.

It is common practice in curtain sided houses to brood in one half of the house to reduce amount of space and energy required.

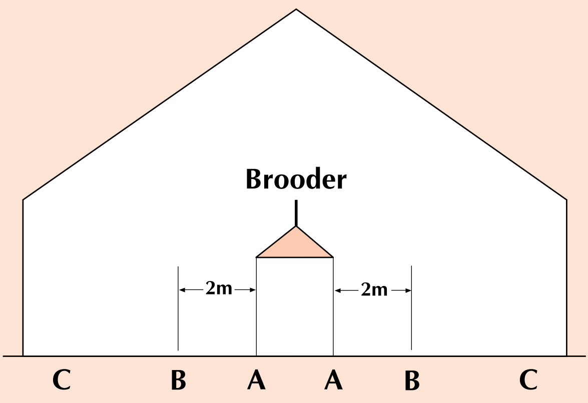
Table 2 contains a guide to temperatures required when using spot brooding.

TABLE 2: BROODING TEMPERATURES

WHOLE HOUSE		SPOT BROODING			
Age (days)	**Temp °C***	**Age (days)**	**Temp °C**		
			Brooder Edge A	**2m B**	**House C**
Day Old	29	Day Old	30	27	25
3	28	3	28	26	24
6	27	6	28	25	23
9	26	9	27	25	23
12	25	12	26	25	22
15	24	15	25	24	22
18	23	18	24	24	22
21	22	21	23	23	22
24	21	24	22	22	21
27	20	27	21	21	21

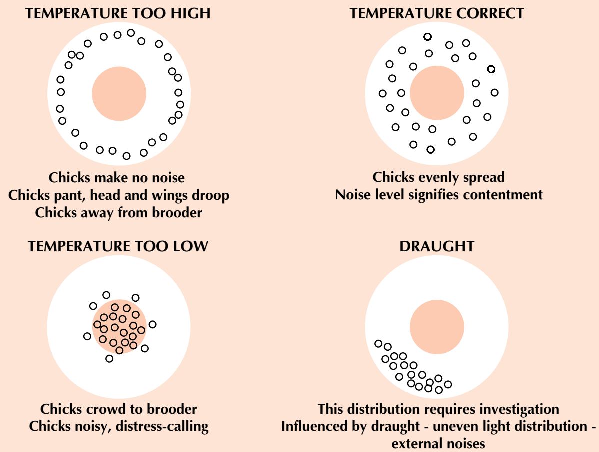
** Temperature at RH of 60 - 70% - See also Table 3, page 18.*

DIAGRAM 4:
SPOT BROODING - AREAS OF TEMPERATURE GRADIENTS



Chick behaviour is the best indicator of correct brooder temperature. With spot brooding, correct temperature is indicated by chicks being evenly spread throughout the brooding area. (See Diagram 5).

DIAGRAM 5: BIRD DISTRIBUTION UNDER BROODERS



If chick behaviour indicates incorrect temperature then temperature settings must be checked and adjusted.

DANGER

Whole House Brooding

In whole house brooding there is no temperature gradient within the house. Brooders or other sources of radiant heat may be used to supplement this system.

Diagram 6 illustrates the typical layout of whole house brooding systems.

The main heat source can be direct or indirect. The indirect system is usually gas- or oil-fired, and blows hot air into the house at one or more points. The suggested temperature profile is shown in Table 2, page 14.

Chicks should be placed evenly throughout the brooding area. The use of supplementary internal house fans will enhance air quality and uniformity of temperature and relative humidity.

DIAGRAM 6: TYPICAL LAYOUT OF A WHOLE HOUSE BROODING SYSTEM

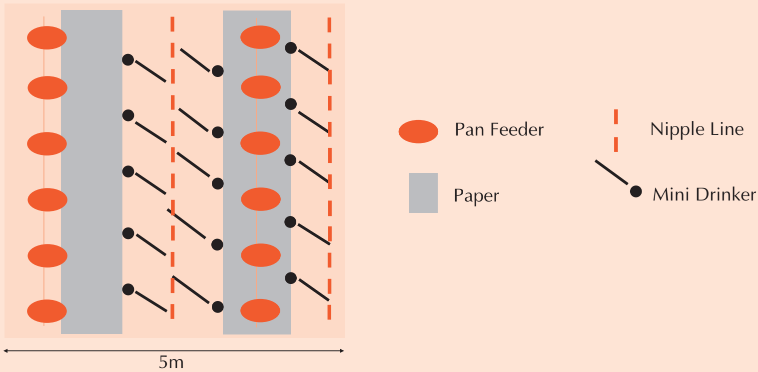
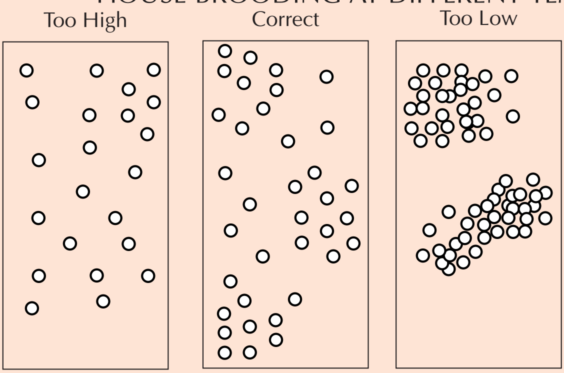


DIAGRAM 7: TYPICAL BEHAVIOUR OF CHICKS IN WHOLE HOUSE BROODING AT DIFFERENT TEMPERATURES



As with spot brooding, chick behaviour is the best indicator of correct temperature. Diagram 7 shows the different distribution of chicks in whole house brooding at different temperatures. With whole house brooding, correct temperature is indicated by chicks forming groups of 20-30, with movement occurring between groups. There should be continuous feeding and drinking within the flock.

When whole house brooding is practised, particular attention must be paid to monitoring and controlling house temperature and relative humidity. (See Interaction Between Temperature and Humidity, page 18).

In both spot and whole house brooding systems, the objective is to develop appetite as early as possible. Activity and appetite are stimulated when chicks experience temperature at the lower end of their comfort zone. In order to stimulate appetite, temperature should be maintained at a level slightly below the figures indicated in Table 2, page 14 and Table 3, page 18.

If chick behaviour indicates incorrect temperature then temperature settings should be checked and adjusted.

DANGER

HUMIDITY

Relative Humidity (RH) in the hatcher, at the end of the incubation process will be high (approx. 80%). Houses with whole house heating, especially where nipple drinkers are used, can have RH levels as low as 25%. Houses with more conventional equipment (i.e. spot brooders which produce moisture as a by-product of combustion and bell drinkers which have open water surfaces) have a much higher RH, usually over 50%. To limit the shock to the chicks of transfer from the incubator, RH levels in the first 3 days should be around 70%.

RH within the broiler house should be monitored daily. If it falls below 50% in the first week, chicks will begin to dehydrate, causing negative effects on performance. In such cases action should be taken to increase RH.

Poor performance and loss of uniformity can result from low relative humidity in the first week.

DANGER

If the house is fitted with spray nozzles (i.e. foggers) for cooling in high temperatures, then these can be used to increase RH during brooding. Chicks kept at appropriate humidity levels are less prone to dehydration and generally make a better, more uniform start.

As the chick grows, the ideal RH falls. High RH from 18 days onwards can cause wet litter and its associated problems. As the broilers increase in liveweight, RH levels can be controlled using ventilation and heating systems.

INTERACTION BETWEEN TEMPERATURE AND HUMIDITY

All animals will lose heat to the environment by evaporation of moisture from the respiratory tract and through the skin. At higher RH, less evaporative loss occurs increasing the animals' apparent temperature. The temperature experienced by the animal is dependent on the dry bulb temperature and RH. High RH increases the apparent temperature at a particular dry bulb temperature whereas low RH decreases apparent temperature. The temperature profile in Table 2, page 14 assumes RH in the range 60-70%.

Table 3 shows the predicted dry bulb temperature required to achieve the target temperature profile over a range of RH. The information in Table 3 can be used in situations where RH varies from the target range (60-70%).

TABLE 3: DRY BULB TEMPERATURES REQUIRED TO ACHIEVE TARGET APPARENT EQUIVALENT TEMPERATURES AT VARYING RELATIVE HUMIDITIES

Age (days)	Conventional		Temperature at RH%			
				Ideal		
	Temp°C	RH% range	50	60	70	80
0	29	65-70	33.0	30.5	28.6	27.0
3	28	65-70	32.0	29.5	27.6	26.0
6	27	65-70	31.0	28.5	26.6	25.0
9	26	65-70	29.7	27.5	25.6	24.0
12	25	60-70	27.2	25.0	23.8	22.5
15	24	60-70	26.2	24.0	22.5	21.0
18	23	60-70	25.0	23.0	21.5	20.0
21	22	60-70	24.0	22.0	20.5	19.0
24	21	60-70	23.0	21.0	19.5	18.0
27	21	60-70	23.0	21.0	19.5	18.0

If RH is outside the target range, the temperature of the house at chick level can be adjusted to match that given in Table 3. At all stages, chick behaviour should be monitored to ensure that the chick is experiencing an adequate temperature. If subsequent behaviour indicates that the chicks are too cold or too hot, the temperature of the house should be adjusted appropriately.

When RH falls below 50% during brooding, action to increase RH is required to prevent chicks becoming dehydrated.

DANGER

Key Points

- ✓ Achieve target 7-day liveweight by managing the brooding environment correctly.
- ✓ Use chick behaviour to determine if temperature is correct.
- ✓ Use temperature to stimulate activity and appetite.
- ✓ Expand the brooding area gradually to allow chicks access to all feeders and drinkers.
- ✓ Monitor temperature and RH frequently and regularly.
- ✓ Maintain RH above 70% for the first 3 days and above 50% for the remainder of the brooding period.
- ✓ Adjust temperature settings if RH increases above 70% or falls below 60%, whilst responding to changes in chick behaviour.

VENTILATION

Air quality is critical during the brooding period. Ventilation is required during the brooding period to maintain temperatures and RH at the correct level and to allow sufficient air exchange to prevent the accumulation of harmful gases such as carbon monoxide, carbon dioxide and ammonia. It is good practice to establish a minimum ventilation rate from one day of age, which will ensure that fresh air is supplied to the chicks at frequent, regular intervals. (See Housing and Environment, Ventilation and Air Quality, Section 6, page 81).

Internal circulation fans can be used to maintain evenness of air quality at chick level.

Accumulation of waste gases can lead to heart and lung disease if not removed effectively.

DANGER

Key Points

- ✓ Establish a minimum ventilation programme to supply fresh air and remove waste gases.
- ✓ Maintain good air quality within the house using circulation fans.

LIGHTING

Conventionally, the system used by broiler growers has been that of continuous lighting. Its use is intended to maximise daily weight gain. This system consists of a long continuous period of light, followed by a short dark period (e.g.$^{1}/_{2}$ -1 hour) to allow birds to become accustomed to the darkness in the event of a power failure.

Other lighting programmes have been devised to stimulate growth to follow profiles designed to minimise FCR or reduce mortality. (See Growth Management, Growth Modification Using Lighting Programmes, Section 2 page 28). All lighting programmes should provide for a long daylength (e.g. 23 hours light-1 hour dark) in the early stages, to allow chicks to develop a good appetite.

TABLE 4: LIGHT INTENSITY AND DAYLENGTH

AGE (days)	INTENSITY (lux)	DAYLENGTH (hours)
0 - 7	20 minimum	23 light 1 dark
7 - 21	20 - 10 (gradual reduction)	23 light 1 dark
21 - slaughter	10	23 light 1 dark

Low levels of light intensity (<20 lux) in the initial brooding period reduce feeding activity.

DANGER

Reducing daylength too early will reduce feeding activity and depress 7-day liveweight

DANGER

Light intensity should then be gradually reduced so that by 21 days it is around 10 lux. (See Table 4). Improvements in welfare have not been demonstrated in light intensities higher than 10 lux. Light intensity should be uniform throughout the house.

Light source can be either tungsten filament or fluorescent. Research has indicated no significant difference in bird performance between the 2 types of light source. Fluorescent lighting will give significant savings in electricity costs after the extra cost of installation has been covered.

Key Points

- ✓ **Provide chicks with long periods of light for the first week.**
- ✓ **Use high intensity of light of (>20 lux) in the first 7 days, then reduce gradually.**
- ✓ **Light intensity should be uniform throughout the house.**

Section two

Growth Management

Objectives

To enable the maximum number of birds in each flock to achieve the liveweight and uniformity required by the specification. To ensure that defined end product quality specifications are met accurately, predictably and efficiently.

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GROWTH MANAGEMENT

Principles

The requirements of food retailers will continue to become more exacting. Poultry producers are most profitable when they maximise the proportion of the birds grown which meet the specification. Flocks that exhibit predictable and uniform growth are most likely to achieve this objective.

Active and effective genetic selection in Ross broilers has improved leg health and cardiovascular function. Growth management may sometimes be helpful to the overall welfare of the flock, but the details must be carefully thought through if overall biological performance is not to be lost. There is a danger that loss of performance may occur if excessive control is applied.

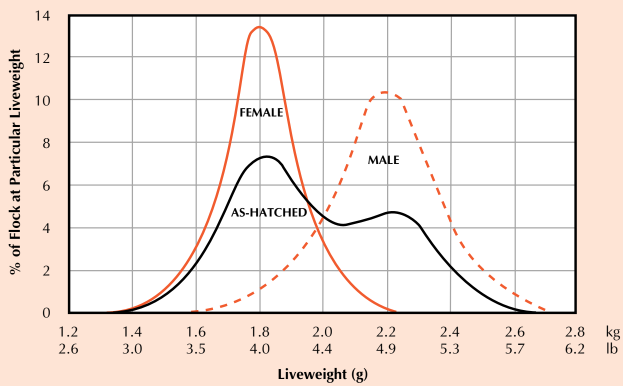
Growth management may be achieved by controlling food intake directly, by limiting the amount of light and hence feed intake, or by diluting the diet. These methods are only useful for birds being grown to heavier weights (i.e. >2.5 kg) where slower, early growth rates may benefit lifetime performance. Alternatively, to ensure predictability of performance, growth control can be applied so that all flocks achieve slightly below their growth potential.

Successful application of growth modification programmes depends upon having a uniform flock of broilers which has achieved good early growth. i.e. target 7-day liveweight is achieved through good management during brooding.

FLOCK UNIFORMITY

As in any biological system, broiler liveweight will follow a normal distribution. The variability of a population is described by the coefficient of variation (CV%) which is the standard deviation of the population expressed as a percentage of the mean. Variable flocks will have a high CV%, uniform flocks a lower one. Each sex will have a normal distribution of liveweight with the as-hatched flock having a wider CV% than single sex flocks. (See Diagram 8).

DIAGRAM 8: DISTRIBUTION OF LIVEWEIGHTS IN A FLOCK OF AS-HATCHED BROILERS



SEPARATE SEX GROWING

The number of birds which achieve liveweight at, or close to the flock mean can be predicted from the CV% of that flock, and it follows that improvements in uniformity can be attained by growing flocks in single-sex populations. The technique of feather sexing is described in Appendix 5, page 107.

Diagram 9 shows weight distributions at different CV% for 3 sexed flocks, all achieving a target liveweight of 1900g. The percentage of birds falling within a given target liveweight band, (expressed as the mean liveweight of 1900g, ±100, 200 or 300g), at different CV% can be calculated. At each target liveweight, the lower the CV%, i.e. the less variable the flock, the more birds achieve the target. (See Diagram 10, page 24). However, for the narrowest target liveweight band (i.e. 1800 - 2000g), even at a CV% of 8, only 58% of the birds achieve required liveweight. An understanding of the effects of biological variability forms the basis of effective planning in processing plants.

The advantages of separate sex growing can be best exploited when males and females are housed separately. Both sexes can be managed more efficiently with regard to feeding, lighting and stocking density. Separate sex growing has the added advantage that the different nutrient requirements of each sex can be satisfied. Males grow faster, are more feed efficient and have less carcase fat than females. Growth rate response to increasing protein to energy ratio is greater in the male than in the female. Details of appropriate rations for males and females are given in Appendix 2, Table 30-31, pages 96-97.

Conversely, lighting programmes which are helpful in growing heavy males may be detrimental to females killed at lighter weights. Where sexed flocks are placed in either end of a single house, and with common environment and feed supply. Very careful thought will be needed to optimise the growth management for each sex without limiting the other.

DIAGRAM 9: EFFECT OF CV% ON LIVEWEIGHT BANDS IN A FLOCK OF SEXED BROILERS

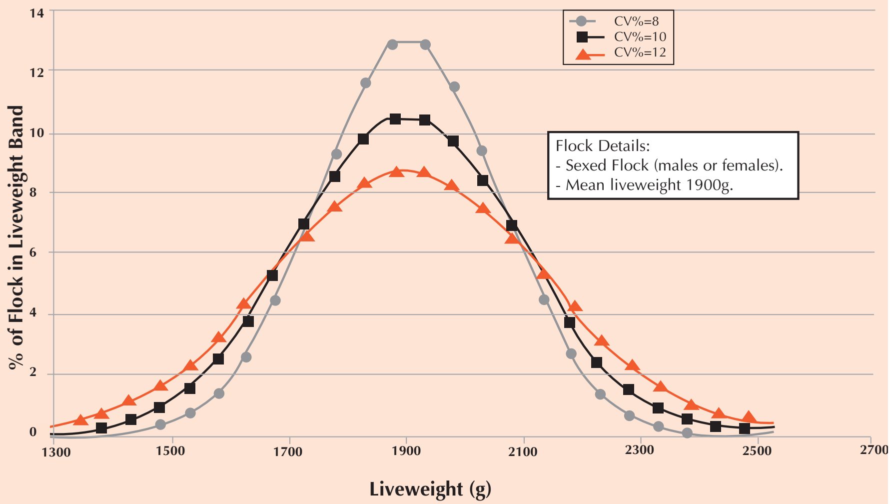
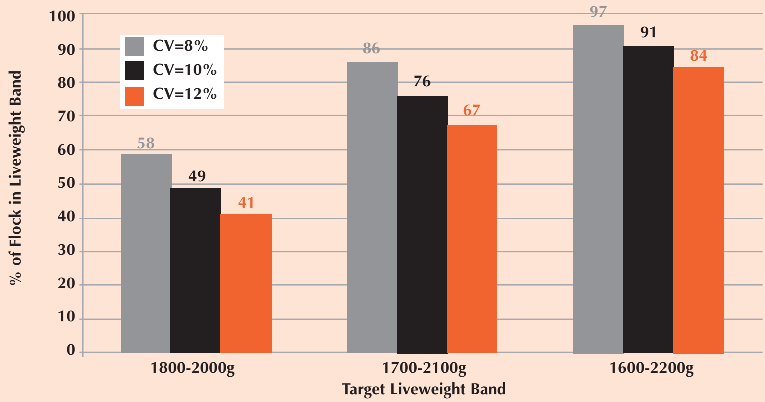


DIAGRAM 10: EFFECT OF CV% ON PROPORTION OF BIRDS IN TARGET LIVEWEIGHT BAND



PREDICTABILITY OF LIVEWEIGHT

Accurate information on liveweight and CV% for each flock is essential in planning the appropriate age for slaughter and to ensure that the maximum numbers of birds fall into the desired weight bands after slaughter. As growth rate increases, and slaughter age becomes earlier, prediction of liveweight gain over more than 2-3 days is less accurate. Accurate estimation and prediction of flock liveweight at slaughter requires large numbers of birds (i.e. >100) to be repeatedly sampled close to slaughter age (i.e. within 2-3 days). (See Table 5).

TABLE 5: NUMBER OF BIRDS IN A SAMPLE TO GIVE ACCURATE ESTIMATE OF LIVEWEIGHT

RELIABILITY OF ESTIMATE	CORRECT 95% OF THE TIME			CORRECT 99% OF THE TIME		
Accuracy of measurement*	**1%**	**2%**	**5%**	**1%**	**2%**	**5%**
CV% = 8	246	61	10	422	106	17
CV% = 10	384	96	15	660	165	26
CV% = 12	553	138	22	950	238	38

** i.e. to ± x % of actual liveweight.*

Table 5 shows the number of birds required to be sampled to give a liveweight estimate of defined reliability and accuracy within flocks of differing variability.

e.g. to estimate the liveweight to within ± 2% of the actual liveweight and be correct 99% of the time in a uniform flock (i.e. CV% = 8), a sample size of 106 birds is required.

MEASURING LIVEWEIGHT

When control of feed and nutrient intake and lighting programmes are used to improve predictability, liveweight and the response to any change in management should be monitored. Birds can be weighed using manual or automatic weighing scales. Any unexpected change in liveweight should be investigated.

When using manual scales the birds should be weighed at least 3 times per week. On each occasion, samples of 50-75 birds should be taken at 2 locations in each house.

Automatic weighing systems (i.e. auto-weighers) for broilers are available. They should be located where large numbers of birds congregate and where individual birds will remain long enough for weights to be recorded. Older and heavier males tend to use auto-weighers less frequently, which biases the flock mean downwards. Readings from any auto-weigher should be regularly checked for usage rate, (i.e. number of completed weights per day), and the mean liveweights achieved should be crosschecked by manual weighing at least once per week.

Inaccurate liveweight estimation may result from small sample sizes.

DANGER

Key Points

✓ **Minimise flock variability by monitoring and managing flock uniformity.**

✓ **Grow sexes separately to reduce variability.**

✓ **Uniform flocks (low CV%) are more predictable in performance than uneven flocks .**

✓ **Weigh sufficiently large samples, frequently and accurately to ensure effective prediction of liveweight at slaughter.**

MODIFIED BROILER GROWTH

Modified growth techniques have been designed to meet evolving processing and consumer demands. The principle components of modified growth techniques include:

- Good, uniform growth to 7 days of age as indicated by 7-day liveweight.
- Growth is managed to less than the maximum, potential daily weight gain in the period 7-21days, to optimise the early development of the cardiovascular, immune and skeletal systems. (See Diagram 11, page 27).
- Growth is managed, after 21 days, to achieve target liveweight profiles, which may be less than the maximum growth rate if predictability of weight at slaughter is required.

- Benefits in FCR and liveability from compensatory growth and the birds' genetic potential for liveweight gain post 21 days. (See Diagram 11, page 27).

- The ideal growth profile for a flock, depends on sex, final target liveweight, any intermediate partial depletion (i.e. thinning), current liveweights, and required carcase yield.

The two main methods of growth modification used are nutritional (i.e. control of feed and nutrient intake) and lighting programmes (i.e. reduced access to feed). Early growth is regulated giving benefits in liveability and FCR, with only minor sacrifices of liveweight or carcase yield. Recommended reductions in growth for different target processing weights are given in Table 6.

TABLE 6: GUIDELINE REDUCTIONS IN GROWTH TO MEET TARGET PROCESSING WEIGHTS

PROCESSING WEIGHT (g)	SEX	% REDUCTION IN LIVEWEIGHT*	
		14 DAYS	21 DAYS
2000-2500	As-hatched	6-8	4-6
	Male	10-12	8-10
>2500	Male	12-14	10-12

** When designing growth modification programmes, the target % reduction in liveweight should be regarded as a maximum. Percentage reduction is calculated relative to unrestricted growth under the same environment and nutrition. At 21 days a 5% reduction in liveweight is about 40g*

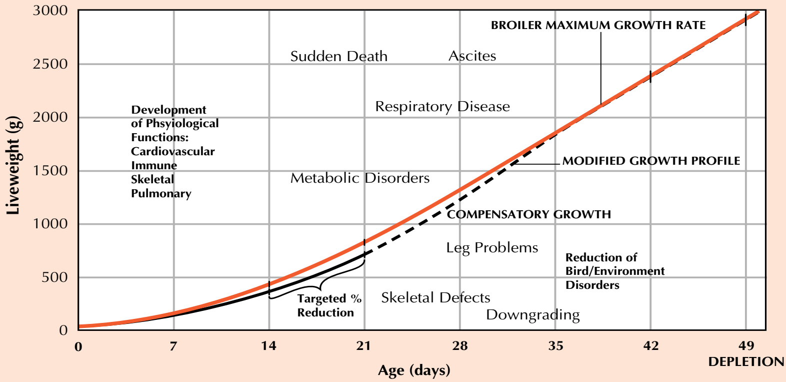
In designing a growth modification programme, gradual changes, over several flocks should be planned to achieve that reduction in liveweight which will gives the desired improvement in performance.

The effectiveness of growth modification programmes should also be periodically assessed by comparing treated flocks with flocks which are fed *ad libitum* and receive 23 hours light and 1 hour dark. Comparisons should be made of growth, feed conversion and liveability. Continuous genetic improvements in leg strength and resistance to cardio-vascular problems may make the use of growth control programmes unnecessary.

Excessive growth restriction at 21 days will lengthen the time that the birds take to reach target liveweight, and make it more difficult to regain lost carcase and meat yield. Males recover from growth regulation better than females. Growth regulation is most likely to be successful in birds grown to heavy liveweights (i.e. requiring a longer growing period).

If growth control to 21 days is excessive, then the flock may not recover completely in terms of liveweight, and will be unlikely to recover meat yield.

DIAGRAM 11: THE RELATIONSHIP BETWEEN MODIFIED GROWTH AND THE DEVELOPMENT OF VITAL PHYSIOLOGICAL SYSTEMS AND THE CONSEQUENCES OF THEIR UNDERDEVELOPMENT



CONTROL OF FEED AND NUTRIENT INTAKE

Controlling the feed intake of broilers is now common to give better control of growth and to enhance feed efficiency (by minimising feed wastage and exploiting compensatory growth). If growth control is properly implemented, liveability and leg health may sometimes be improved. Manipulating the hours of daylight is one way of controlling feed intake, and although this can have some problems, it is probably one of the simplest methods. However, when the broiler house is equipped correctly, direct feed intake control is possible, and has the advantage of allowing greater accuracy and predictability.

The feed distribution system should be capable of allowing all the birds equal access to feed. Both feeding space and distribution times are critical. With all feeding systems it is good practice to allow the birds to clear the feeders (i.e. consume all the feed available in the tracks or pans) 3 to 4 times per day. This will stimulate appetite and reduce feed wastage which results in improved FCR.

Increases in scratching damage at processing may indicate inadequacies in feed distribution and feeder space.

DANGER

Feed intake control requires a means of weighing feed daily and birds at least 3 times per week. When feed is available, birds become more active and house temperatures can rise quickly; therefore attention must be given to ventilation at this time. Extra control of water intake may be necessary, if litter quality appears to be suffering.

Broiler feed intake control requires skilled management and careful attention to detail. Implementation demands a thorough knowledge of normal and potential performance on the site, and careful monitoring of the consequences of each change. Birds are unlikely to recover fully from liveweight depressions greater than 10% at 21 days.

On withdrawal of feed, it is good practice to raise feeders before they are empty. This reduces the risk of damage to birds from scratching. Where feeders cannot be raised, light intensity should be reduced.

In order to maximise the benefits of compensatory growth, the birds should have access *ad libitum* to feed over the last 10 days prior to depletion.

Control of nutrient intake may also be achieved by feeding a diet with a lower concentration of one or more essential nutrients. Such diets will often be effective in reducing growth rate, but the birds will increase feed intake in an attempt to maintain nutrient intake, and both FCR and yield will suffer. The method has the disadvantage that the effects are unpredictable and are likely to reduce performance.

Key Points

- ✓ **Aim for a percentage liveweight reduction at 21 days of age which is appropriate to the final killing weight required, and adjust according to required performance targets.**
- ✓ **Weigh feed daily.**
- ✓ **Weigh birds 3 times per week.**
- ✓ **Provide access *ad libitum* to feed throughout the last 10 days prior to depletion.**
- ✓ **Allow all the birds equal access to feed and water. Both feeding space and distribution times are critical.**

Inaccurate information on daily feed intake and growth rate results in poor growth control. DANGER

GROWTH MODIFICATION USING LIGHTING PROGRAMMES

Broilers are conventionally grown on 23 to 24 hours of light per day. Research in several countries has shown that programmes with less than 23 hours light can have a number of benefits.

Modified lighting programmes for broilers fall into 2 main categories, either short day or intermittent lighting programmes.

The short day is usually imposed from about 7 days of age, and may be held for the life of the flock (usually after a single increase in daylength), or steadily increased after about 21 days, to stimulate feed intake and hence growth.

When imposing lighting control, care must be taken to ensure that the flock is growing well. If birds are significantly under target liveweight at 7 days, then the restriction of feed intake using lighting control may permanently reduce potential for growth.

Intermittent programmes consist of blocks of time containing both light and dark periods, which are repeated throughout the 24 hours. The light period within each block of time is increased as the birds age, to enable them to eat sufficient food to maintain the desired growth rate. Intermittent lighting programmes tend to be combined with feed control programmes.

Short day programmes are perceived to confer greater welfare benefits than intermittent programmes. Both types of lighting programme have the following advantages:

- Bird activity is increased. This may result in significant improvements in leg health sometimes reducing mortality.
- Slower early growth rate which improves cardiovascular function may reduce the incidence of Ascites and Sudden Death Syndrome.
- Improvement in FCR due to less feed wastage.

Broilers also benefit from a defined pattern of light and dark (i.e. day and night) by having distinct periods of rest and vigorous activity. Many commercially important physiological processes, such as bone mineralisation and digestion, exhibit diurnal rhythms. Defined cycles of light and dark allow the birds to show natural patterns of growth and development.

Daylengths of less than 16 hours will cause a significant reduction in feed intake and liveweight gain compared to constant light or a 23-hour light period. The use of short daylength to control liveweight gain is particularly effective in the period from 7 to 14 days. The skeletal, cardiovascular and immune systems develop before the peak demands of lean tissue growth.

If the flock is not receiving a minimum of 23 hours of light at least one week before the first birds are slaughtered, excessive levels of activity may make the catching process difficult.

DANGER

Light intensities are given in Table 4, page 20. Care should be taken to avoid light seepage through air inlets, fan housings and door frames etc. In practical terms this means that a light intensity of less than 0.4 lux (0.04 foot candles) should be achieved during the dark period. Regular tests should be carried out to check the efficiency of the light proofing.

Birds adapt their feeding behaviour to reduced daylength. A change in daylength from 24 to 12 hours of light initially will cause birds to reduce feed intake by 30-40% for the first 3 days. However, 8 days later, the reduction in feed intake is less than 10%. Birds change their pattern of feeding in the light period by 'cropping up' (i.e. filling their crops) in anticipation of the dark period. They may also eat when the lights are off. These behavioural changes are thought to improve feed consumption and feed efficiency over the life of the flock.

Dimmer switches, as part of the lighting control system, will allow simulation of dawn and dusk. 'Dusk' acts as a cue to birds that the dark period is imminent. 'Dawn' avoids crowding behaviour at feeders and drinkers. The transition from light to dark and *vice versa* should be completed over a period of 40-50 minutes, in at least 5 steps.

e.g. Dark –> 0.4 lux –> 0.8 –> 1.6 –> 3.2 –> 6.4 –> 10 lux.

As with feed modification programmes, all birds should have equal access to feed. Feed and water must be available as soon as the lights are switched on.

When using lighting programmes to modify growth, birds should be fed *ad libitum* with an appropriate broiler ration during the period of light.

In order to develop a suitable lighting programme, the following points must be considered:

- The extent and nature of any recurrent problem of liveability.
- Target processing weight.
- The slaughter programme (including partial depletions).
- Whether the sexes are grown together or separately.
- Nutrition and feeding regimes.
- Effectiveness of light proofing in the house.

The design of appropriate programmes must be a responsive process. As an initial guide, Table 6, page 26 gives an indication of the target liveweight reduction at 21 days of age.

Local knowledge prescribes the most appropriate programme and monitoring of flocks allows further refinements to be made. The ideal lighting programme for each situation evolves by making gradual changes which meet the required improvements in performance.

Liveweights should be monitored at least 3 times per week so that subsequent adjustments to daylength ensure that target liveweight-for-age is achieved.

Short Day Lighting Programmes

Lighting programmes can be applied to both closed and open-sided houses. When applying lighting programmes to open-sided housing, the ability to set a minimum daylength is defined by local natural daylength. Natural dawn and dusk will have beneficial effects. Natural dawn prevents a rush to feeders and drinkers. Natural dusk provides a clear cue to birds which stimulates 'cropping up'.

It is important that the light used to extend the daylength is at least 30% of the natural light intensity and that there is a clear transition from dark to light.

Short Day – Gradual Increase

These types of programme combine short daylengths in the critical 7 to 14 day period, with steadily increasing daylengths at later ages. They have been found to be particularly effective for male and as-hatched flocks grown to average liveweights of 2kg or above. (See Table 7, page 31).

TABLE 7: EXAMPLE OF A PROGRAMME OF SHORT DAY GRADUALLY INCREASING LIGHT, SUITABLE FOR MALE OR AS-HATCHED FLOCKS SLAUGHTERED ABOVE 2KG (4.41LB)		
AGE	**LIGHT (hours)**	**DARK (hours)**
0-6 days	23	1
***7-21 days**	18	6
22-28 days	20	4
29 days-depletion	23	1

** Growth control programmes should only be started at less than 7 days of age where birds are known to be achieving target liveweights.*

Short Day – Single Step Increase

These combine short daylength, in the critical 7-21 day period with daylength increasing in a single step. These are simple to manage and are particularly effective in as-hatched flocks. (See Table 8).

TABLE 8: EXAMPLE OF A SHORT DAY PROGRAMME SUITABLE FOR FLOCKS GROWN TO 2KG (4.41LB)		
AGE	**LIGHT (hours)**	**DARK (hours)**
0-6 days	23	1
***7-21 days**	20	4
22 days-depletion	23	1

** Growth control programmes should only be started at less than 7 days of age where birds are known to be achieving target liveweights.*

Lighting programmes are unlikely to be of benefit when growing flocks to less than 2kg at slaughter.

Intermittent Lighting Programmes

Although the exact mechanism is not fully understood, it is thought that by giving broilers discrete meals (i.e. short feeding periods) followed by longer periods for digestion (i.e. dark periods), the efficiency of feed utilisation (i.e. FCR) is improved. The extra activity caused by the regular pattern of light and dark is thought to be beneficial in improving leg health and carcase quality (e.g. lower incidence of hockburn, breast blisters etc.).

TABLE 9: EXAMPLE OF INTERMITTENT LIGHTING PROGRAMME SUITABLE FOR FLOCKS DEPLETED AT 42 DAYS

AGE	LIGHT/DARK (hours)		LIGHT/DARK (hours)		LIGHT/DARK (hours)		LIGHT/DARK (hours)	
0-6 days	23	1						
***7-35 days**	5	1	5	1	5	1	5	1
36-42 days	23	1						

** Growth control programmes should only be started at less than 7 days of age where birds are known to be achieving target liveweights.*

Intermittent lighting programmes can also be of great value in reducing the effects of heat stress on broiler performance. (See Table 10). The extra activity induced by the regular changes from dark to light helps to dissipate the heat which builds up between birds. In extreme climates, the combination of intermittent lighting and intermittent feeding (i.e. feeding only in the cool parts of the day) will significantly reduce mortality caused by heat stress and will improve performance.

TABLE 10: EXAMPLE OF AN INTERMITTENT LIGHTING PROGRAMME TO REDUCE THE EFFECTS OF HEAT STRESS

AGE	DAYLENGTH
0-6 days	24 hours light
7-21 days	23 hours light 1 hour dark
22 days-depletion	2 hours light/2 hours dark or 1 hour light/3 hours dark

Key Points

- ✓ **Make feed and water available to all birds as soon as lights come on.**
- ✓ **Provide light periods greater than one hour for adequate stimulus to the birds.**
- ✓ **Ensure that birds are close to target 7-day liveweight before beginning a lighting programme.**
- ✓ **Incorporate a break of one hour of light with longer dark periods (>6 hours). This reduces dehydration in chicks where water supply is inadequate or environmental humidity is low (RH< 40%).**
- ✓ **Use dimmer switches (if available) to simulate dawn and dusk. Complete the transition from light to dark and *vice versa* within 40-50 minutes in at least 5 steps.**
- ✓ **Ensure effective light proofing, (<0.4 lux during the dark period).**
- ✓ **Allow all birds equal access to feed and water.**
- ✓ **Feed *ad libitum* during the light period.**
- ✓ **Weigh birds at least 3 times per week and adjust daylength accordingly.**
- ✓ **Increase feeder and drinker space per bird, when using any lighting programmes to allow for the short periods of time available for feeding and drinking.**

Section three

Pre-Processing Management

Objectives

To manage the final phase of the production process so that broilers are transferred to the processor in optimum condition, ensuring that the processing requirements are met and high standards of welfare are maintained.

page contents

PRE-PROCESSING MANAGEMENT

Principles

The maintenance of high quality in broilers during catching and transport requires detailed attention to management of the environment and to welfare of the birds.

The planning and organisation of procedures should permit efficient catching and transfer of the birds from the broiler house to the transport system and subsequently into the slaughter house.

PREPARATION FOR CATCHING

When modified growth has been practised by the application of lighting programmes, it is essential to return to 23 hours of light at least 7 days prior to first depletion. This will ensure that the birds are calm during collection.

A withdrawal ration must be fed for sufficient time prior to slaughter to eliminate the risk of anticoccidial residues or other prescribed medicines in the meat. Statutory withdrawal periods for coccidiostats and other prescribed medicines as specified in product data sheets should be followed.

Where thinning (i.e. partial depletion) programmes are used, it may be necessary to keep the birds on withdrawal rations for longer than ideal, prior to slaughter.

Feed should be withdrawn 8 to 10 hours before processing. This period should include catching time and the time spent in transit. If feed withdrawal time is prolonged, water absorbed from body tissues accumulates in the digestive tract resulting in deterioration in yield. Faecal contamination will be increased.

The presence of watery droppings from broilers awaiting processing is an indication of excessive feed withdrawal times.

DANGER

Whole wheat, if included in the diet, should be removed 2 days before processing, to avoid the presence of whole grain in the gut.

Unlimited access to water should be available for as long as possible. Multiple drinker lines, separation of birds into pens and the progressive removal of individual drinkers will prolong access to drinking water. Water should be removed only when absolutely necessary.

It is inevitable that some weight loss will occur during the feed withdrawal period due to loss of gut contents. These losses will have little effect on the carcase weight (i.e. eviscerated yield will improve). However, care should be taken to ensure that the withdrawal period does not become excessive resulting in dehydration, when bird welfare will be compromised and carcase yield will be reduced.

Key Points

- ✓ **Use withdrawal feed (i.e. without coccidiostat) as necessary to avoid residues in meat.**
- ✓ **Allow 7 days on full light (i.e. 23 hours light and one hour dark) to avoid problems during catching.**
- ✓ **Appropriate feed withdrawal will ensure that the digestive systems are empty before catching commences, limiting faecal contamination during transport and processing.**
- ✓ **Remove whole wheat from the ration 2 days before slaughter.**
- ✓ **Delay the removal of drinkers for as long as possible.**

CATCHING

Catching and handling will cause stress to broilers. Appropriate procedures will minimise the stress experienced by the birds.

Most downgrading observed at slaughter will have occurred during the previous 24 hours, when the birds were being caught and handled. Catching is an operation therefore, which should be planned carefully in advance and supervised closely at all stages. The handling of birds or operation of machinery (i.e. harvesters, forklifts etc.) must be carried out by appropriately trained, competent personnel. They should aim to avoid unnecessary struggling by the birds and to minimise bruising, scratching or other injuries.

Prior to catching, all feeding equipment should be raised above head height (i.e. >6ft), removed from the house or positioned to avoid obstruction to the birds or personnel.

In larger houses, separation of birds into pens will avoid unnecessary crowding. It will also allow access to water for birds not immediately due for catching.

Light intensity within the house must be reduced to a minimum, but must be sufficient to allow safe and careful catching. Blue light has been found to be satisfactory for this purpose. The best results are achieved when birds are allowed to settle after lights have been dimmed and when there is minimum disturbance.

The use of curtains over main doors of the house is helpful when catching during daylight hours. The opening of doors and removal of birds will affect ventilation of thermostatically controlled environments. The ventilation system should be monitored and adjusted carefully throughout the catching procedure.

Broilers should be held by the feet and shanks, never by the thighs. They should be caught and held by both legs to minimise distress, damage and injury, which might otherwise result if they were able to struggle and flap. The birds should be placed carefully into modules, loading from the top down or crates. Modules have been shown to result in less distress and damage than conventional crates. Crates or modules should never be overfilled. The number of broilers per crate or module must be reduced in high temperatures. Transport time should be within the local current guidelines or legislation.

Overheating, stress and increased mortality can result from overfilling of crates/modules.

DANGER

At all times from loading to the lairage (i.e. livebird storage area) adequate protection from the elements is essential. Ventilation, extra heating and/or cooling should be used when necessary. Vehicles should be designed to protect the bird from the elements. Stress on the birds will be minimised in trailers designed to provide adequate ventilation.

Heat stress will develop rapidly when the transport vehicle is stationary, particularly if on-board ventilation is not available or in hot weather. The journey plan should allow the vehicle to leave the farm as soon as loading is completed, and driver breaks should be short. Unloading to the lairage must be completed without delay. Supplementary ventilation will be required if delay is unavoidable.

Key Points

- ✓ **Supervise catching and handling methods carefully to minimise trauma injuries to the birds.**
- ✓ **Remove or raise obstructions such as feeders or drinkers before beginning the catching operation and use partitions in large houses to avoid injuries caused by crowding.**
- ✓ **Reduce light intensity prior to catching to keep the birds calm and minimise damage and subsequent stress.**
- ✓ **Adjust bird numbers in crates/modules to allow for bird weight, and ambient temperature.**
- ✓ **Plan journey and bird reception**
- ✓ **Monitor welfare continuously**

PROCESSING

Successful production of the maximum number of high quality carcases with good yield depends on effective integration of the growing and processing operations. Careful planning and communication between the farm and processing plant will allow processing to proceed effectively. Management on the farm can influence the efficient operation of the killing, plucking and evisceration processes.

Close attention should be given to litter quality, stocking density, feed withdrawal times, catching methods and transport and holding times so that faecal contamination carcase damage and downgrading are minimised.

Excessive carcase damage may be an indication of problems on the broiler farm.

DANGER

Key Points

- ✓ **Deliver clean birds to the processor**
- ✓ **Maintain good litter quality, depth and condition to minimise Hockburn and other carcase quality problems.**
- ✓ **Scratching damage may be increased under high stocking densities, or when feeder or drinker spaces are inadequate especially when lighting or feed control is used.**
- ✓ **Minimise transport and holding times to reduce stress and dehydration.**

ROSS

Section four

Nutrition

Objectives

To supply a range of balanced diets which satisfy the nutrient requirements of broiler stock at all stages of their development and production, and which optimise efficiency and profitability without compromising bird welfare.

page contents

NUTRITION

Objective

To supply a range of balanced diets which satisfy the nutrient requirements of broiler stock at all stages of their development and production, and which optimise efficiency and profitability without compromising bird welfare.

Principles

Feed is a major component of the total cost of broiler production. Broiler rations should be formulated to give the correct balance of energy, protein and amino acids, minerals, vitamins and essential fatty acids, to allow optimum growth and performance. Factors such as stocking density, climate and disease status may depress liveweight gain and increase feed conversion ratio, leading to altered nutrient requirements.

A response to improved nutrition will only be achieved in broiler flocks when nutrient supply, rather than other management factors, is limiting performance.

DANGER

The diet specifications proposed in this manual will allow good performance in healthy broilers, kept under the management conditions specified elsewhere in this manual.

Local market structure, product value and local variations in feed ingredient supply must all be considered in ration specification, so that economic and nutritional requirements are satisfied. There may also be local preferences e.g. for carcase skin colour, which will influence diet formulation. The local Technical Services Manager of Aviagen and/or the feed manufacturer should be consulted for more specialised situations, and for advice on local market circumstances.

SUPPLY OF NUTRIENTS

ENERGY

The correct energy content of broiler feeds is determined, primarily, by economic criteria. In practice, the choice of energy level will also be influenced by many interacting factors e.g. supply of feed ingredients, milling constraints etc. A distinction should be made between nutrient density and energy level in the feed. Both are expressed in energy units, but nutrient density has the additional condition that nutrient : energy ratios are held constant as energy level varies. Nutrient density in the feed, rather than energy content, is the main determinant of broiler performance.

The conventional method of expressing the energy content of the feed is as the apparent metabolisable energy level corrected to zero nitrogen retention (AMEn). Data on energy contents expressed in this way are available from many sources; in this manual energy values are based on World Poultry Science Association (WPSA) tables.

The AMEn values of some ingredients, especially fats, are lower in young chicks than in adult birds. Formulating diets for broilers using chick AMEn will overcome this problem by reducing the level of fats and less digestible raw materials. Net Energy systems of expressing energy content overcome the differences in the utilisation of ME when it is derived from different substrates (i.e. fat, protein or carbohydrate) and used for different metabolic purposes. The adoption of these new energy systems improves the consistency and predictability of broiler performance.

In practice, dietary fat level is associated with the energy content of broiler feeds. There is an upper limit to the inclusion of fat, above which pellet quality is likely to suffer. Fat interacts in a complex way with other dietary components and this may further limit the use of fat as an energy source. When feeds contain soluble, non-starch polysaccharides originating from wheat, barley or rye, the fat digestibility is reduced. The reduction is greater when saturated fats are used. The problem is less severe when maize is used as the main cereal. The inclusion in the feed of enzymes, organic acids or other additives, which modify the gut microflora, will also help to overcome this problem.

Some typical energy levels for broiler feeds are indicated in Appendix 2, Tables 29-31, pages 95-97. This information is a practical guide and does not represent the requirements of the birds. The energy levels, which will give the best economic return, should be determined under the local conditions in which the broilers are grown. When energy levels are changed, however, nutrient levels should also be adjusted to maintain the nutrient density of the feeds.

Key Points

✓ **Make distinction between energy level and nutrient density in the feed.**

✓ **Include enzymes, organic acids or other additives in the feed, if digestibility problems occur.**

✓ **Consider using chick AMEn in formulating broiler diets to reduce levels of less digestible raw materials**

There is a reduction in fat digestibility when feeds contain soluble, non-starch polysaccharides originating from wheat, barley, rye and sorghum.

DANGER

PROTEIN AND AMINO ACIDS

The level of protein in the feed must be sufficient to ensure that requirements for all essential and non-essential amino acids are met. It is preferable to use high quality protein sources where these are available, especially for broilers under heat stress. Poor quality or imbalanced protein can create metabolic stress, there is an energy cost associated with its excretion and wet litter may also result.

Broiler feeds should be formulated using available or digestible amino acid levels. In this manual amino acid levels are based on true fecal digestibility. Amino acid levels are listed in Appendix 2, Tables 29-31, pages 95-97, for those 9 amino acids that may be limiting in practical feeds. The levels of protein suggested in this manual should be seen as a guide and not as precise statements; the protein level will vary according to the feed ingredients.

Appendix 2, Table 32, pages 98-99 lists typical digestibility coefficients for some common feedstuffs.

Amino acid levels in feeds must be considered together with energy levels. The principles of using feeds with different nutrient density levels have been discussed. (See Supply of Nutrients, Energy, page 38-39).

Higher ratios of digestible amino acids to energy have been shown to improve profitability by increasing broiler and processing performance. This is especially true when growing broilers for portioning or meat stripping (*see Ross Tech 00/39 'Broilers Protein and Profit'*). The optimal digestible lysine : energy ration should be determined within each operation. The levels of other amino acids may then be calculated using the 'ideal' protein ratios suggested in Table 11.

The ratio between arginine and lysine indicated in Table 11, reflects the requirements for growth. There is evidence that the use of higher arginine : lysine ratios may help to protect the birds against heat stress, Ascites and bacterial infections.

TABLE 11: RATIOS OF DIGESTIBLE AMINO ACIDS IN 'IDEAL' PROTEIN

DIGESTIBLE AMINO ACID	STARTER	GROWER	FINISHER
Arginine	105	107	109
iso-Leucine	66	67	68
Lysine	***100***	***100***	***100***
Methionine	37	38	39
Methionine + Cystine	74	76	78
Threonine	63	64	66
Tryptophan	17	17	18
Valine	74	75	76

Note: the information in this table is derived from field experience and published literature.

Key Points

- ✓ **Consider amino acid levels together with factors affecting feed intake (i.e. energy levels or feed intake control programmes) when formulating broiler diets.**

- ✓ **Use high quality sources of protein especially in circumstances when broilers are likely to suffer heat stress.**

> **Poor quality proteins can cause metabolic stress. Their excretion has an energy cost, and wet litter can result.**
> DANGER

MAJOR MINERALS

The provision of correct levels of the major minerals and of an appropriate balance between them is important because of the high performance of broilers. The minerals involved are calcium, phosphorus, magnesium, sodium, potassium and chloride.

Calcium: The level of calcium in the diet of broilers influences growth, feed efficiency, bone development, leg health and the immune system. These responses may require different calcium levels to allow optimum expression, so a compromise must be made when choosing a level of dietary calcium.

With the widespread change to all-vegetable broiler feeds in many countries, dietary levels of phytate have increased. High levels of phytate in broiler diets may adversely affect the availability of calcium. Free fatty acids in the diet will also reduce calcium availability.

> **High levels of phytate and free fatty acids in broiler diets will reduce calcium availability.**
> DANGER

Phosphorus: Phosphorus recommendations in this manual are based on the classical availability system. Digestible phosphorus is used in some countries to overcome the problems of assessing phosphorus availability in poultry feeds. Care should be taken to use consistent data on available phosphorus content of feed ingredients and bird requirements.

The use of phytase enzymes will increase the available phosphorus content of vegetable feed ingredients. In general, the use of such enzymes will be beneficial in broiler production. The reduction in phytate arising from the use of enzymes will increase availability of calcium and other minerals.

Magnesium: Requirements are normally met without the need for supplementation. Excessive magnesium (>0.5%) will cause severe scouring.

Sodium, potassium and chloride: It is important to control sodium and chloride levels as suggested in Appendix 2, Tables 29-31, pages 95-97. In particular, chloride should be accurately controlled by the use of sodium bicarbonate and sodium chloride. In feed formulation all dietary sources of chloride should be carefully identified e.g. in lysine hydrochloride and choline chloride.

Electrolyte balance (EB) is important to broilers, especially in heat stress conditions. The anion content of both vitamin and mineral premixes should always be included in the calculation of ionic balance in finished feeds. With practical potassium levels of about 0.7%, and the recommended levels of sodium and chloride, an EB (sodium + potassium - chloride) of about 210mEq/kg will be obtained. This is satisfactory and, as indicated, most emphasis should be given to the control of chloride levels.

Key Points

- ✓ **Describe phosphorus in feed ingredients and bird requirements in the same units.**
- ✓ **Control chloride levels accurately by using both sodium chloride and bicarbonate as feed ingredients.**

TRACE MINERALS

Conventional levels of supplementation are recommended for these nutrients. Care should be taken to ensure that suitable forms of each mineral are included in the premix. Organic trace elements have a higher availability in general. There is evidence that enhancement of the zinc and selenium status of broilers may improve feathering and the immune response of the birds.

ADDED VITAMINS

Appropriate vitamin supplementation depends on feed ingredients, feed manufacture and local circumstances. A major source of variation in supplementation for some vitamins is cereal type. Accordingly, separate recommendations have been made for vitamin A, nicotinic acid, pantothenic acid, pyridoxine (B6) and biotin in maize- and wheat-based feeds.

The recommendation for choline is given as a minimum specification in the complete feed and not quoted as a component of the premix.

Vitamin C may have a role in reducing heat stress.

Many circumstances, (e.g. stress, disease incidence), may make birds responsive to vitamin levels higher than those recommended in Appendix 2, Tables 29-31, pages 95-97. Increases in the levels of vitamins supplied, in the feed or via the water, must be based on local knowledge and experience. In general, the longer-term strategy should be to remove or reduce any stress factors, rather than to depend on permanent use of excessive vitamin supplementation.

The basic requirement of broiler chickens for vitamin E is 10-15mg/kg. The need for extra supplementation will depend on the level and type of fat in the diet, on the level of selenium and on the presence of pro- and antioxidants. Heat treatment of feeds results in the destruction of up to 20% of vitamin E. Enhancement of immune response and improvements in shelf-life of broiler meat are observed at vitamin E levels up 300mg/kg. The levels suggested in Appendix 2, Tables 29-31 are suitable for production of healthy broilers under normal conditions but there may be situations (e.g. disease outbreaks) in which higher levels of vitamin E are justified.

Key Points

✓ **Reduce or remove stressors rather than depend on excessive vitamin supplementation.**

✓ **Control total choline level, taking account of the contribution of feed ingredients. Avoid using choline chloride in vitamin supplements.**

NON-NUTRITIVE FEED ADDITIVES

The feed may be used as a carrier for a wide range of additives, drugs and other non-nutritive substances. It is not possible to give a comprehensive list and Aviagen cannot recommend or endorse particular products. The more important classes of additive that might be considered for use in broiler feeds are listed here. Local legalisation may control the use of these products.

Enzymes: There is growing evidence that feed enzymes act partly by modifying the gut microflora in a beneficial direction. This may lead to complex interactions between the use of enzymes, antibiotic growth promoters and dietary substrates, such as soluble non-starch polysaccharides. Control of these interactions, especially when wheat is used as the main cereal, is important in successful broiler feeding.

Carbohydrase enzymes will allow higher levels of barley to be included in the ration. These enzymes will also be economically beneficial in wheat-based feeds. Enzymes are also available for maize-soya feeds. Phytase may be used to enhance phytate phosphorus utilisation. Increasing use of heat processing of broiler feeds leads to loss of enzyme activity. This may be avoided by spraying enzymes on to the feed at the end of processing.

Medicinal and Prophylactic Drugs: A wide range of drugs e.g. coccidiostats, antibiotics etc. may be administered through the feed. Veterinary control and authorisation in accordance with local regulations is essential.

Antibiotic Growth Promoters / Digestion Enhancers: Although these products are being phased out in some parts of the world, their use is still widespread. The mode of action is complex, but will normally involve modification of the gut microflora, with consequential changes in nutrient utilisation. They are probably more effective, and more important, in wheat- or barley-based feeds or with other sources of soluble, non-starch polysaccharides. (See *Ross Tech 99/37, Antibiotic Growth Promoters).*

Probiotics: Probiotics introduce live micro-organisms into the digestive tract to assist with the establishment of a stable and beneficial microflora.

Prebiotics: Prebiotics are a group of substances which stimulate the growth of beneficial, at the expense of harmful, micro-organisms. Oligosaccharides form the largest group of these products at present.

Organic Acids: Acidification of feed is of growing importance in broiler production. Organic acid products can reduce bacterial contamination of the feed (e.g. after heat treatment) and can also encourage a beneficial microflora to develop in the bird's digestive tract.

Absorbents: Absorbents are used specifically to absorb mycotoxins. They may also have a beneficial effect on general bird health and nutrient absorption. Various clay products, charcoal and proprietary products are used as absorbents.

Antioxidants: Antioxidants can provide important protection against nutrient loss in broiler feeds. Some feed ingredients e.g. fishmeal and fats, will usually be protected. Vitamin premixes should be protected by an antioxidant unless optimum storage times and conditions are provided. Additional antioxidants may be added to the final feed where inadequate or prolonged storage conditions are unavoidable.

Anti-mould Agents: Mould inhibitors may be added to feed ingredients, which have become contaminated, or to finished rations to reduce growth of fungi and production of mycotoxins.

Pelleting Agents: Pelleting agents are used to improve pellet hardness. Pellet binders (e.g. hemicellulose, bentonite, guar gum) may be added at levels up to 2.5% of the diet.

Other products of possible use in broiler production, include essential oils, nucleotides, glucans and specialised plant extracts.

BROILER DIET SPECIFICATIONS

Diet specifications for broilers are given in Appendix 2, tables 29-31, pages 95-97 for a range of popular production and market situations.

As-hatched or female; 1.6-1.8kg (3.5-4.0lb) liveweight	Appendix 2, Table 29
As-hatched; 2.3-2.5kg (5.1-5.5lb) liveweight	Appendix 2, Table 30
Male; 3.0kg (6.6lb) liveweight	Appendix 2, Table 31

These specifications may need to be modified for the conditions prevailing in particular markets. Factors to be considered are:

- The supply and price of feed ingredients
- Age and live weight at slaughter
- Yield and carcass quality
- Market requirements for skin colour, shelf-life etc.
- Use of sexed growing

The most appropriate diet specification will give performance which maximises the margin over cost for the product, or products, required by the processing plant. *(See Ross Tech 00/39 'Broilers Protein and Profit').*

BROILER STARTER FEEDS

The objective of the brooding period (0 to 10 days of age) is to establish good appetite and achieve maximum early growth (see Section 1 Chick Management page 7-20). The target is to achieve a seven day liveweight of 160g or above. Broiler Starter should be given for 7-10 days. The Starter represents a small proportion of the total feed cost and decisions on Starter formulation should be based on performance and profitability rather than cost.

The digestible amino acid levels described in Appendix 2 will allow the bird to achieve maximum early growth. This is important in all modern broiler systems and is of particular importance in the production of small birds, in challenging conditions or when breast meat production is at a premium.

The digestive system of the young chick is immature and care must be taken to ensure that the raw materials used are highly digestible. In challenging conditions specialised pre-starters (0 to 3/7 days) have been of some benefit. These may feature:

- Use of highly digestible ingredients
- High nutrient levels, especially amino acids, vitamin E and zinc
- Use of pre- and probiotics
- Stimulants of immunity; essential oils, nucleotides etc.
- Intake stimulants; feed form, high sodium, flavours etc.
- Other specialized additives.

In wheat-feeding areas the use of some maize may be beneficial. Total fat levels should be kept low (<5%) and saturated animal fats should be avoided especially in combination with wheat.

High levels of saturated fats, especially in combination with wheat, will limit early growth.

DANGER

BROILER GROWER FEEDS

Broiler Grower feed will normally be given for 14 to 18 days after the Starter. Starter to Grower transition will involve a change of texture from crumbs to pellets.

There is a continuing need for a good quality Grower feed to maximise performance. If any growth restriction is required it should be applied during this period. Use of management techniques (eg meal feeding, lighting) to restrict feed intake is preferred (see Section 2 Growth Management page 25). Growth restriction by diet composition is not recommended.

BROILER FINISHER FEEDS

Broiler Finisher feeds account for the major cost of feeding and economic principles should applied to the design of these feeds. Changes in body composition can be rapid during this period and excessive fat deposition and loss of breast meat yield need to be carefully considered.

> **Finisher feeds with low nutrient levels will increase fat deposition and reduce meat yield.**
>
> DANGER

The use of one or two Broiler Finisher feeds will depend on desired slaughter weight, the length of the production period and the design of the feeding programme. Withdrawal periods for drugs may dictate the use of a special withdrawal finisher feed. This feed should be adjusted for the age of the birds but the practice of extreme nutrient withdrawal during this period is not recommended.

SEPARATE FEEDING OF MALE AND FEMALE BROILERS

When male and female broilers are grown separately there may be an opportunity to increase profitability by using different feeds for the two sexes. Diets for mixed-sex flocks are correct for male birds, so the major opportunity is for feed cost saving in females. Differences in requirements are mostly concerned with amino acid levels. However, separate sex growing will often be associated with different markets and this may diminish the opportunity for feed cost saving in females. For example, females grown for slaughter at low weights should be well-fed throughout life because of the requirements of this market. This consideration may override the opportunity to exploit small differences in nutrient requirements.

All broilers need good early growth rates and there is no opportunity for using different starter feeds for males and females. Most opportunity for cost saving is in the finisher phase provided that this is compatible with market requirements. Differences in requirements may also be exploited by varying the feeding programme but using the same feed compositions.

Key Points

- ✓ **Design broiler diets to maximise profitability of the whole production chain.**
- ✓ **Formulate Starter feeds to maximise performance (i.e. achieve or exceed target 7 day liveweight) rather than to minimise cost.**

QUALITY OF FEED AND FEED INGREDIENTS

It is important that the ingredients used to manufacture feeds for broilers are fresh and of high quality. Successful broiler production is achieved using a wide range of ingredients. It is very important that suitable quality control procedures are applied and appropriate feed technologies are used.

When poorer quality ingredients are fed, non-utilisable nutrients must be catabolised and excreted by the birds, using up energy and creating metabolic stress. Cereals and vegetable feed ingredients are susceptible to fungal growth if stored in hot, humid conditions. Fungi produce mycotoxins that dependent on degree of contamination, may reduce growth rate and feed conversion of broilers. Litter condition may be adversely affected, which in turn could result in increased downgrading of broiler carcases. Long-term storage of ingredients may lead to the presence of spoilage products that reduce feed intake or have other detrimental effects on broiler performance. When freshness of ingredients cannot be assured because of market restrictions or prices, quality control becomes even more important.

Long-term storage of feed ingredients or feed can lead to formation of spoilage products with a negative effect on performance.

The nutritional value of feed ingredients will vary with feed processing methods, climate and season. The feed formulation matrix of ingredients should be appropriate to the geographical area. The matrix should be supported by routine chemical analyses and examination for contamination (e.g. salmonellae, mycotoxins). The feed ingredient matrix printed in this manual should only be used as a general guide. (See Appendix 2, Table 32, pages 98-99). Local information about feed ingredients must always be used in preference.

Some quality issues relating to individual classes of feed ingredient are listed in Appendix 2, Table 33, page 100. The development of appropriate quality control procedures and the use of suitable technological methods to control and enhance feed quality are topics beyond the scope of this manual. However, these topics are important to successful broiler growing and should be given high priority.

The range of feed ingredients available for least-cost formulation must be suitable for broilers. Limits should be set on the inclusion of ingredients known to give problems when consumed in excess (e.g. tapioca, low-protein soya). Appendix 2, Table 34, page 101 indicates some practical limits for common feed ingredients. These should be adopted as far as possible, but may have to be exceeded under some conditions. The use of several comparable feed ingredients in ration formulation will reduce dependency on any one. The greater the use of a single ingredient, the more important is effective quality control.

Poor quality control of feed ingredients is a common cause of problems in broiler production. DANGER

Key Points

- ✓ **Use good quality, fresh ingredients for broiler feed whenever possible.**
- ✓ **Use local feed ingredient matrix whenever possible.**
- ✓ **Set formulation limits on raw materials known to cause problems.**

VITAMIN AND MINERAL PREMIXES

A general recommendation is given in Appendix 2, Tables 29-31, pages 95-97 for supplementation of feeds with vitamins and trace minerals. Occasionally, circumstances may arise which cause an increase in vitamin requirements, e.g. disease incidence. This enhanced vitamin requirement may be met more economically by use of water-soluble vitamin products.

Aviagen does not endorse the practice of removing vitamin premix during the final stages of the birds' growth, because of welfare considerations.

Practical vitamin supplementation should take into account losses, which might occur between premix manufacture and feeding. Selection of vitamin products, storage times and conditions at all stages and feed processing are the most important factors in vitamin losses. The use of separate vitamin and mineral premixes and the exclusion of choline chloride from the premixes are strongly recommended because of oxidative losses. Storage conditions should be cool, dry and dark to reduce the risk of oxidation and careful stock control should be exercised. The incorporation of antioxidant in premixes is recommended. Appendix 2, Table 35, page 102, shows the probable losses of vitamins occurring in a broiler feed under a small range of practical conditions. Vitamin losses will be higher than this if heat treatment is used for biosecurity of feed.

Key Points

- ✓ **Ensure appropriate storage times and cool, dark storage conditions between manufacture of premixes and feeding. Supplement level must take account of probable losses.**
- ✓ **Include antioxidant in vitamin premixes.**

Vitamin losses during feed manufacture require special attention when broiler feeds undergo heat treatment for reasons of biosecurity. DANGER

The combination of trace minerals and vitamins in the same premix and inclusion of choline chloride are significant causes of oxidative losses.

DANGER

FAT SOURCES

Fat of either animal or vegetable origin may be added to rations. Animal fats, other than poultry fat, contain more saturated fatty acids, which are less digestible, especially in the immature digestive system of the chick. In starter and grower rations, it is advisable to use fat blends containing higher percentages of unsaturated fats.

In finisher rations, this type of fat blend is not suitable, as the high levels of unsaturated fats may have a detrimental effect on carcase greasiness and storage quality. Fat blends used in finisher rations should have a higher percentage of 'hard' fats.

It is important that the quality of fat ingredients is carefully controlled (see table 12).

TABLE 12: REQUIRED QUALITY CRITERIA FOR FEED FATS

CRITERIA REQUIRED FOR FEED FATS	
Moisture, impurities and unsaponifiables	max 5%
Monomeric fatty acids	min 92%
Non-elutable material	max 8%
Free fatty acids	max 50%
Oxidised fatty acids	max 2%
Antioxidant	present
Herbicide and pesticide residues	controlled
Pathogens	controlled

Recycled animal fats should not be used unless pathogen control is effective.

DANGER

Key Point

✓ **Use fat blends containing higher percentages of unsaturated fats in starter and grower rations.**

FEED PROCESSING AND FEED FORM

Broiler growth and FCR will generally be better if the starter feed is crumbled and the grower and finisher feeds are pelleted. There is evidence that the 'cooking' effect of the pelleting process improves nutrient availability and gives a significant reduction in microbial contamination. Reductions in the energy cost of feeding activity by the bird can explain much of the benefits of pelleting on performance. Feed processing should be carried out with care. When feed is heat-treated to improve biosecurity, compensation should be made for any heat-induced degradation of protein and vitamins which may occur. Heat treatment/processing can cause wet litter.

Heat-treated feed can increase the frequency of problems with wet litter.

DANGER

To help lubricate the pellet die, at least 0.5-1.0% added fat may be included in the pellet. The balance of the added fat may be sprayed on to finished pellets to increase the energy value of the feed, without reducing their hardness and durability. The use of some feed ingredients, especially wheat, will increase pellet hardness. If pellet quality is poor, pellet binders may be added.

To achieve full growth potential, correct feed texture and pellet sizes are important.(See Table 13).

TABLE 13: FORM OF FEED BY AGE IN BROILERS

AGE	FEED FORM AND SIZE
0-10 days	sieved crumbs
11-28 days	2-3mm diameter pellets
29 days to processing	3mm diameter pellets

However, satisfactory broiler performance can be achieved if pelleting is not available, especially where maize is the principle cereal. When feed is in the form of mash, special attention should be paid to having coarse grist (i.e. particle size) and uniform grist distribution.

As for pellets, mash feeds will benefit from the inclusion of some fat in the formulation to reduce dust.

Key Points

✓ **Use pelleted feed for optimum growth and FCR.**

✓ **Aim for optimum grist size and appropriate cereal source when pelleting is not possible.**

If processing conditions for pellets are made more severe to achieve better control of microbial contamination then nutrient losses, especially of vitamins, may occur.

DANGER

WHOLE WHEAT FEEDING

The practice of presenting broilers with a mixture of compound feed (pellets) and wheat has been most widely used in Europe. However, it should be feasible to use any whole cereal.

The feeding of whole grain saves costs in feed manufacture and possibly in transport. Whole grain feeding supports a better gut microflora, enhances digestive efficiency and improves litter condition. There is some evidence that the feeding of whole wheat may increase coccidiosis resistance. It may be used to facilitate a smoother transition of nutrient supply during the growing period. Against these advantages must be set the loss of eviscerated yield and breast meat. Extra costs will be incurred in treating wheat with organic acids to control salmonellae.

The level of inclusion of whole wheat should be accounted for in formulating the compound feed. When the compound feed or balancer feed is not adjusted for the amount of whole wheat, birds will achieve a poor growth and FCR, have less breast meat and become more fat. Both the amount of wheat to be used and the composition of the compound feed (or balancer feed) must be considered carefully. The aim is to provide sufficient intakes of all nutrients from the combination of compound feed and wheat. Individual birds satisfy, to some extent, their own nutrient requirements by selecting an appropriate mixture of the 2 feeds. Care must always be taken, to ensure that drug and micronutrient intakes are sufficient at the dilution rates planned.

Used together with the broiler specifications in this manual, safe inclusion rates of wheat are given in Table 14. These inclusion rates of whole wheat should be formulated within the ration.

TABLE 14: SAFE INCLUSION RATES OF WHOLE WHEAT IN BROILER RATIONS

Ration	Inclusion Rate of Wheat
Starter	nil or introduction to wheat (1-2%) from 4-7 days
Grower	gradual increase to 10%
Finisher	gradual increase to 15%

Note: these inclusion rates require a balancer ration to be formulated.

Whole wheat must be removed from the feed 2 days before slaughter, to avoid problems in evisceration at the processing plant.

Dilution of diets with whole wheat may reduce performance in terms of growth rate, fcr and yield when the compound of balancer feed is not adjusted.

DANGER

Key Points

✓ Account for the inclusion level of whole wheat when formulating the compound feed.

✓ Maintain intakes of micronutrients and drugs at required levels.

✓ Store grain carefully, and treat with organic acid to make sure disease organisms are not introduced to the flock.

Always remove whole wheat from the diet 2 days before slaughter, to avoid problems of slow gut clearance and contamination.

DANGER

ROSS

Section five

Hygiene and Health

Objectives

To attain optimum performance and bird welfare. To provide assurance to the consumer on food safety issues. To minimise or prevent the effects of disease or infections.

page contents

HYGIENE AND HEALTH

Principles

Predictable expression of full genetic potential in terms of growth and efficiency is only possible in broilers that are free from disease and infection. Broiler chicks should be produced from parent stock which have good health status. Parent stock should have a high and uniform level of maternal antibody against those diseases that reduce broiler performance.

The environment in which the broilers are grown should be clean and free from pathogens. Equipment should be maintained so that the broilers can feed and drink, without restriction or damage. The feed should be nutritionally balanced and free of pathogens or other factors likely to cause depression in performance (e.g. mycotoxins).

Management procedures should stimulate performance, minimise physiological problems (e.g. Ascites) and promote musculoskeletal health.

The consumer requires meat that is free of bacterial contamination (e.g. salmonella, etc) and of residues (e.g. coccidiostats or antibiotics).

Increasing pressure from governments and consumers may reduce the range of medicines available for use in poultry production. This emphasises the need for preventative management of disease.

CHICK QUALITY

The quality of chicks produced by individual hatcheries can be assessed by monitoring broiler mortality in the first week of each flock. Excessive mortality i.e. > 1% in the first week may indicate a problem in the hatchery or in the delivery process (i.e. from hatching to arrival at the farm) or on the farm. Where such problems occur, each aspect of the hatchery and delivery process should be investigated as well as husbandry practices. (*See Ross Tech 98/35, Investigating Hatchery Practice*).

The condition known as Femoral Head Necrosis (FHN), can have its origin in hatchery contamination but incidence is also influenced by farm management factors e.g. drinker hygiene, immunosuppressive disease challenges. (*See Ross Tech 01/40, Leg Health in Broilers*).

High early mortality may indicate problems in the hatchery. DANGER

Problems with FHN may originate in the hatchery or from poor farm hygiene practices. DANGER

FOOD SAFETY ISSUES

Pathogens

Contamination of chicken products with certain salmonella and campylobacter has been associated with outbreaks of food poisoning in humans. Prevention of such outbreaks is ensured when broilers are produced which are free of these pathogens.

Control of salmonella is becoming increasingly important for commercial broiler production operations. The programme of salmonella control adopted may be designed in consultation with the retailer. Aviagen supplies breeding chickens which are free of salmonella. Strict biosecurity can maintain this status though to the broiler generation and on to slaughter.

Feed can be a major source of pathogens. Contamination by salmonella may be found not only in feedstuffs of animal origin, but also for example, in soya beans and derivatives. All raw materials should be monitored routinely for salmonellae.

The most reliable programme of control of contamination of feedstuffs by salmonellae involves heat treatment in combination with feed biosecurity. A temperature of 86°C (187°F) held for 5 minutes will reduce salmonella contamination of feed to negligible levels under normal feed mill practices. Feed specifications may require modification to allow for degradation of vitamins, which may occur because of the heat treatment process. Counts for total enterobacteriaceae, carried out on feed at unloading, should be <10 enterobacteriaceae/g of feed.

Salmonella reduction programmes may involve the removal of meat and bone meal from broiler diets, pelleting (or extrusion) of feed or contaminated raw materials and the addition of organic acids to prevent recontamination.

Vaccination of parent stock against salmonella can be invaluable in controlling the incidence of *Salmonella enteriditis* (SE) and/or S. *typhimurium* (ST) in parent stock as well as in their broiler progeny. Vaccination of broilers against salmonella may also be useful. Competitive exclusion (CE) i.e. the use of commercially available preparations of non-pathogenic gut bacteria may also have a role in preventing salmonella infection.

Some commercial broiler production companies are attempting control of campylobacter. Unlike salmonella, transfer by vertical transmission i.e. from parent to progeny, is not significant in campylobacter infection. Campylobacter can be introduced into broiler houses on footwear and equipment where good hygiene is not practised. Footwear must be changed on entry to the broiler house for control of campylobacter to be successful. Application of CE may also prevent campylobacter infection.

Chemical Residues

Chemical residues (e.g. coccidiostats, medicines, pesticides, etc) in broiler products can be prevented by auditing the quality and treatments of raw materials (e.g. feedstuffs, water, litter etc), and controlling the use of pesticides. Special care should be taken to observe withdrawal times for health treatments and coccidiostats.

Key Points

✓ **Test for salmonellae in quality control of feedstuffs.**

✓ **Reduce risk of infection with pathogenic bacteria by monitoring and controlling movement of feed, equipment and personnel on to the farm.**

✓ **Follow manufacturers' recommended withdrawal periods to avoid drug residues in broiler products.**

BIOSECURITY

Isolation of broilers from all other poultry and livestock is the single most important aspect of biosecurity.

Movement of people, feed, equipment or animals on to the broiler site should be controlled to prevent the introduction of pathogens. Single age sites are preferable, so that recycling of pathogens is minimised. Sites should be fenced and access restricted. There should be a barrier to prevent unauthorised entry and a clearly defined changing area for staff and necessary visitors to the farm at the farm perimeter. Staff and visitors should be provided with, and should wear appropriate, clean protective clothing on each farm. Hands should be washed and boots should be dipped between visits to each house. If more than one farm visit has to be made in one day, the youngest birds should be visited first.

All points of entry, during the life of a flock, where people, feed, material or equipment are brought on to the farm represent biosecurity risks. Staff education on biosecurity and its implementation will help to ensure its effectiveness. The following are examples where the risks should be balanced against the economic advantages:

- Partial depletion i.e. thinning. Where vehicles must enter the site, they should be thoroughly cleaned and wheels washed and disinfected.
- Dilution of feed with whole wheat.
- Delivery of feed. The most hygienic method of bulk delivery of feed is for it to be blown through pipes from a vehicle parked on the perimeter of the site. When feed is delivered in bags, the reuse of bags is a biosecurity risk.
- Vermin control is very important. If this operation is subcontracted to a commercial pest control firm, clear biosecurity protocols must be provided and followed.
- Litter delivery and storage. Litter must be protected from the weather and from access by vermin during delivery and storage.

Water must be of good quality, (see Table 26, Housing and Environment, Section 6, page 90) and should not be sourced from holding ponds or dams without subsequent treatment. If water hygiene is suspect, then treatment by ultra-violet (UV) light or chlorination at the point of water entry to the house will reduce bacterial contamination. Chlorination to give between 1 and 3ppm at drinker level will reduce bacterial count, especially where drinker systems with open water surfaces are in use.

Key Points

- ✓ **Adopt a single age policy for each site, to limit stock movement and to reduce transfer of disease between stock of differing age.**
- ✓ **Admit only essential visitors on to the site; they must wear protective clothing.**
- ✓ **Wash hands and dip boots between visits to each house.**
- ✓ **Keep out wild birds and rodents.**
- ✓ **Spray wheels of all vehicles entering the site.**

HYGIENE

Broiler houses should be designed to allow easy cleaning and disinfection. Cleaning out should be undertaken after depletion of every flock. It must be carefully planned and the correct procedures followed. (*See Ross Tech 00/38, Poultry House Cleanout Procedures*).

SITE CLEANING

Objectives

To clean and disinfect the poultry house so that all potential poultry and human pathogens are removed and to minimise the numbers of residual bacteria, viruses, parasites and insects etc. between flocks minimising any effect on health, welfare and performance of the subsequent flock.

House Design

The house and equipment should be designed to enable easy, effective cleaning. The poultry house should incorporate concrete floors, washable (i.e. impervious) walls and ceilings, accessible ventilation ducts and no internal pillars or ledges. Earth floors are impossible to clean and disinfect adequately. An area of concrete or gravel extending to a width of 1-3m surrounding the house can discourage the entry of rodents and provide an area for washing and storing removable items of equipment.

Procedures

Planning: A successful cleanout requires that all operations are effectively carried out on time. Cleanout is an opportunity to carry out routine maintenance on the farm and this needs to be planned into the cleaning and disinfection programme. A plan detailing dates, times and labour and equipment requirements should be drawn up prior to depleting the farm to ensure that all tasks can be successfully completed.

Insect Control: Insects are significant vectors of disease and must be destroyed before they migrate into woodwork or other materials. As soon as the birds have been removed from the house and while it is still warm, the litter, equipment and all surfaces should be sprayed with a locally recommended insecticide. Alternatively the house may be treated with an approved insecticide within 2 weeks prior to depletion. A second treatment with insecticide should be undertaken before fumigation.

Remove dust: All dust, debris and cobwebs must be removed from fan shafts, beams, exposed areas of unrolled curtains in open-sided houses, ledges and stonework. This is best achieved by brushing so that the dust falls on to the litter.

Pre-spray: A knapsack or low-pressure sprayer should be used to spray detergent solution throughout the inside of the house, from ceiling to floor, to dampen down dust before removal of litter and equipment. In open-sided houses, the curtains should first be closed.

Remove equipment: All equipment and fittings (drinkers, feeders, dividing pens etc.) should be removed from the building and placed on the external concrete area.

Remove litter: The aim should be to remove all litter and debris from within the house. Trailers or rubbish skips should be placed inside the house before they are filled with soiled litter. The full trailer or skip should be covered before removal, to prevent dust and debris blowing around outside. Vehicle wheels must be brushed and spray disinfected on leaving the house.

Litter disposal: Litter must be removed to a distance of at least 1.5km (1 mile) from the farm, and disposed of in accordance with local government regulations in one of the following ways:

- spread on arable crop land and ploughed within 1 week.
- buried in a 'landfill' site, quarry or hole in the ground.
- stacked and allowed to heat (i.e. compost) for at least one month before being spread on livestock grazing land.
- Incinerated.

Litter must not be stored on the farm or spread on land adjacent to the farm.

DANGER

Washing: Firstly check that all electricity in the house has been switched off. A pressure washer with foam detergent should be used to remove the remaining dirt and debris from the house and equipment. Following washing with detergent the house and equipment should be rinsed with clean fresh water using a pressure washer. During washing, excess floor water can be removed using "squeegees". All equipment, that has been removed to the external concrete area must be soaked and washed. After equipment is washed it should be stored under cover.

Inside the house, particular attention should be paid to the following places:

- fan boxes
- fan shafts
- fans
- ventilation grilles
- tops of beams
- ledges
- water pipes

In order to ensure that inaccessible areas are properly washed, it is recommended that portable scaffolding and portable lights be used.

The outside of the building must be also be washed and special attention given to:

- air inlets
- gutters
- concrete pathways

In open-sided housing, the inside and outside of curtains must be washed. Any items that cannot be washed (e.g. polythene, cardboard) must be destroyed.

When washing is complete there should be no dirt, dust, debris, or litter present. Proper washing requires time and attention to detail.

DANGER

Many different industrial detergents are available. Manufacturers instructions should be followed when using detergents.

Staff facilities should be thoroughly cleaned at this stage. Humidifiers should be dismantled, serviced and cleaned prior to disinfection.

Cleaning Water and Feed Systems

All equipment within the house must be thoroughly cleaned and disinfected. After cleansing it is essential that the equipment is stored under cover.

The water system. The procedure for cleaning the water system is as follows:

- Drain pipes and header tanks.
- Flush lines with clean water.
- Physically scrub header tanks to remove scale and biofilm deposit. Drain to the exterior of the house.
- Refill tank with fresh water and add an approved water sanitiser.
- Run the sanitiser solution through the drinker lines from the header tank ensuring there are no air locks.
- Make up header tank to normal operating level with additional sanitiser solution at appropriate strength. Replace lid. Allow disinfectant to remain for a minimum of 4 hours.
- Drain and rinse with fresh water.
- Refill with fresh water prior to chick arrival.

Biofilms will form inside water pipes and regular treatment is needed to prevent decreased water flow and bacterial contamination of drinking water. Biofilms begin as aggregations of lipopolysaccharide (LPS) capsules from bacteria. Pipe material will influence rate of biofilm formation. For example alkathene pipes and plastic tanks have electrostatic properties that assist bacteria to adhere. The use of vitamin and mineral treatments in drinking water can increase biofilm and aggregation of materials. Physical cleaning of the inside of pipes to remove biofilms is not always possible. Between batches of chickens biofilms can be removed by using high levels (140 ppm) of chlorine or peroxygen compounds to partially digest. These need to be flushed completely before birds drink. High local water mineral content (especially calcium or iron) may lead to increased need for modification of cleaning to include acid scrubbing. Metal pipes can be cleaned the same way but corrosion can cause leaks. Water treatment before use should be considered for high mineral waters.

Evaporative cooling and fogging systems can be sanitised at cleanout using a bi-guanide sanitiser. Bi-guanides can also be used during production to ensure that water in these systems contains minimal bacteria and reduce bacterial spread into the poultry house.

The feed system. The procedure for cleaning the feed system is as follows:

- Empty, wash and disinfect all feeding equipment i.e. feed bins, track, chain, hanging feeders.
- Empty bulk bins and connecting pipes and brush out where possible. Clean out and seal all openings.
- Fumigate wherever possible.

Repairs and Maintenance

A clean, empty house provides the ideal opportunity for structural repairs and maintenance. Once the house is empty, attention should be given to the following tasks:

- Repair cracks in the floor with concrete/cement.
- Repair pointing and cement rendering on wall structures.
- Repair or replace damaged walls and ceilings.
- Carry out painting or whitewashing where required.
- Ensure that all doors shut tightly.

Rodent and Wild Bird Control

It is necessary to prevent rodents and wild birds from entering the building because they transmit disease and eat feed. The following procedure should be adopted:

- Check all walls, panels and ceilings for holes, and repair these if necessary.
- Ensure that the fan/inlet boxes are bird proof.
- Check that all doors close firmly and tightly, with no gaps.
- Check for any leaks in the feed system. Easily accessible feed attracts vermin.
- In open-sided housing, the building must be made bird-proof, and repaired where necessary.

An area of concrete or gravel extending to a width of 1-3m (3-10ft) around the house can discourage rodents from entering.

Disinfection

Disinfection should not take place until the whole building (including external area) is thoroughly clean and all repairs are complete. Disinfectants are ineffective in the presence of dirt and organic matter.

Disinfectants, which are approved by governments for use against specific poultry pathogens of both bacterial and viral origin, are most likely to be effective. Manufacturers' instructions must be followed at all times. Details of commonly used disinfectants are listed in *Ross Tech 00/38 Poultry House Cleanout Procedures.*

Disinfectant should be applied by the use of either a pressure-washer or a knapsack sprayer. Foam disinfectants allow greater contact time thus increasing the efficacy of disinfection.

Heating houses to high temperatures after sealing can enhance disinfection.

Most disinfectants have no effect against coccidial oocysts. Where selective coccidial treatments are required, compounds producing ammonia should be used by suitably trained staff. These are applied to all clean internal surfaces and will be effective even after a short contact period of a few hours.

Formalin Fumigation

Where formalin fumigation is permitted, fumigation should be undertaken as soon as possible after completion of disinfection. Surfaces should be damp. The houses should be warmed to 21˚C (70˚F). Fumigation is ineffective at lower temperatures and at relative humidities of less than 65%.

Doors, fans, ventilation grilles and windows must be sealed. Manufacturers' instructions concerning the use of fumigants must be followed. After fumigation, the house must remain sealed for 24 hours with NO ENTRY signs clearly displayed. The house must be thoroughly ventilated before anyone enters.

After litter has been spread, all the fumigation procedures described above should be repeated. For further guidance, reference should be made to local Health and Safety regulations, which should be adhered to at all times.

Fumigation is hazardous to animals and humans. Protective clothing i.e. respirators, eye shields and gloves must be worn. At least two people must be present in case of emergency.

Local health and safety regulations must be consulted before fumigating.

DANGER

Cleaning External Areas

It is vital that external areas are also cleaned thoroughly. Ideally, poultry houses should be surrounded by an area of concrete or gravel, 3m (10ft) in width. Where this does not exist, the area must:

- be free of vegetation
- be free of unused machinery/equipment
- have an even, level surface
- be well drained, free of any standing water

Particular attention should be paid to cleaning and disinfection of the following areas:

- under ventilator and extractor fans
- access routes
- door surrounds

All concrete areas should be washed and disinfected as thoroughly as the inside of the building.

Evaluation of Farm Cleaning and Disinfection Efficiency

It is essential to monitor the efficiency and cost of cleaning out and disinfection. Effectiveness is evaluated by undertaking total viable bacterial counts (TVC). Table 15, indicates the standards to be achieved. Monitoring trends in TCV's will allow continuous improvement in farm hygiene and comparison of different cleaning and disinfection methods.

When disinfection has been carried out effectively, the sampling procedure should not isolate Salmonella species.

TABLE 15: EVALUATION OF CLEANING AND DISINFECTION

SAMPLE SITE	RECOMMENDED NO OF SAMPLES	MAXIMUM TVC*	SALMONELLA
Stanchions	4	100	Nil
Walls	4	100	Nil
Floors	4	1000	Nil
Feed Hopper	1		Nil
Crevices	2		Nil
Drains	2		Nil

* Total viable count in colony forming units / cm^2

Key Points

- ✓ **Design houses that are easy to clean.**
- ✓ **Clean and disinfect after every flock.**
- ✓ **Clean and disinfect water system after every flock.**
- ✓ **Plan the cleaning-out procedure.**
- ✓ **Monitor the effectiveness of cleaning-out by assessing the residual bacterial counts on surfaces (TVCs).**
- ✓ **Leave houses empty for as long as is economically appropriate between flocks.**

HEALTH MANAGEMENT

Vaccination

Vaccination programmes for broilers should be designed for local circumstances in consultation with local poultry veterinarians. Substantial economic savings can be made by combining effective, specific vaccination programmes with good biosecurity rather than by adopting a 'blanket' vaccination policy. Successful vaccination will also depend upon a supply of good quality day-old chicks.

Design of a vaccination programme for broilers is inter-dependent on the parent stock vaccination programme. The parent programmes should provide uniform levels of maternal antibody so that timing of vaccine administration to broilers can be adjusted and the effectiveness of the vaccine ensured.

Protection through maternal antibody titre is particularly important for Gumboro i.e. Infectious Bursal Disease (IBD), as maternal antibody can inactivate some vaccine strains. This effect varies according to the residual virulence of the vaccine strain. It should also be noted that levels of IBD maternal antibody in progeny will decline as the parent flock ages. This effect in parent flocks is less pronounced with other viruses.

Vaccination in the hatchery, at day old, for Infectious Bronchitis (IB) and, if necessary, Newcastle Disease (ND), using specialised spraying equipment, has been shown to be more effective than vaccination on the farm after delivery of chicks. The use of two strains of IB vaccine during the life of the broiler may give broad, cross immunity to a wide range of strains of IB virus.
In most areas of the world, a minimal broiler vaccination programme would include IB and IBD (Gumboro) vaccines. (See Table 16). ND vaccination by spray is also necessary in some areas.

TABLE 16: MINIMAL VACCINATION PROGRAMME FOR BROILERS GROWN TO 2.5KG FROM PARENT STOCK HYPER-IMMUNISED FOR IBD

DAY	VACCINE	METHOD
1	IB	Spray at hatchery
17	IBD intermediate strain	In water
28	IBD intermediate strain	In water

Vaccination Guidelines

The following guidelines are appropriate for successful vaccination of broilers:

- Follow the recommendations of the vaccine manufacturer in terms of transport, storage of vaccine and dose per bird, route and method of administration.
- Vaccinate so that all birds receive the same dose of vaccine.
- Record vaccine details and check expiry dates. Do not use vaccine, which is beyond its expiry date.
- When administering live vaccines in water, it is essential to neutralise chlorine in the water, which would otherwise inactivate the vaccine. Methods to achieve this include the addition of skimmed milk (powder or liquid).
- Cease UV and chlorination treatments of water during vaccine administration.
- Do not vaccinate sick birds.

In ovo vaccination may have a role in control of Mareks Disease, IBD and some other infections in parts of the world.

When broilers are grown to heavier liveweights and/or inspection of individual broiler carcases is undertaken at processing, Mareks Disease can become an important source of loss. Efficient house cleaning and provision of new litter material for each successive flock reduce the losses due to Mareks Disease. In such circumstances, vaccination against Mareks Disease is usually of marginal economic benefit.

The reuse of litter for successive batches of broilers is undesirable because of the increased risk of Mareks Disease.

DANGER

Key Points

- ✓ **Combine vaccination with good biosecurity.**
- ✓ **Design vaccination programmes for specific local circumstances in consultation with local poultry veterinarians.**
- ✓ **Use knowledge of the immune status of parent stock to define an appropriate vaccination programme for broiler progeny.**
- ✓ **Vaccinate against IB and ND (if necessary) at the hatchery rather than on the farm.**

Antibiotic Growth Promoters / Digestion Enhancers

Antibiotic growth promoters deliver production advantages to the broiler industry by improving growth rate and FCR. They also provide effective control of Necrotic Enteritis and other associated conditions. Increasing pressure from governments and consumers may restrict the use of antibiotic growth promoters in future. Broiler production in the absence of antibiotic growth promoters therefore poses a challenge for broiler producers. For a further discussion on this topic see *Ross Tech 98/36, Necrotic Enteritis* and *Ross Tech 99/37, Antibiotic Growth Promoters*.

Coccidiosis

Coccidial infection is ubiquitous in broilers. Coccidia form oocysts (i.e. spores) which are very resistant to destruction by disinfection. Coccidiosis can have a damaging effect on performance without necessarily causing an increase in mortality. Control of Coccidiosis is achieved mainly by the addition of coccidiostats to feeds. It is important to monitor the efficiency of control of Coccidiosis. This is achieved by means of a programme of scoring of Coccidiosis lesions in broilers taken for examination at various predetermined ages.

Broiler coccidiosis vaccines, similar to those used in parent stock, but containing a reduced number of strains of coccidia have been developed. However, use of these vaccines in broilers has a disadvantage. Certain coccidiostats (e.g. ionophores) are associated with control of Necrotic Enteritis, and this effect will be lost where these coccidiostats are replaced with vaccine.

Competitive Exclusion

Competitive exclusion products can be used in the control of salmonella infection in broilers and may also help in the control of Necrotic Enteritis and campylobacter. (See Food Safety Issues, page 55).

Metabolic Diseases

The major metabolic diseases of broilers are Ascites, Sudden Death Syndrome (SDS) and problems with leg health. Ascites (also known as 'Water Belly') is an accumulation of fluid in the abdominal cavity, associated with elevated pressure in the pulmonary arteries (Pulmonary Hypertension Syndrome - PHS). SDS (also known as 'Flipover') is caused by ventricular fibrillation. These are separate diseases. Incidences of Ascites and SDS are influenced by many factors. (See Table 17, pages 66-67).

When high incidences of Ascites are observed, the following parameters should be checked:

- Ventilation rate in hatchery and on farms is sufficient to remove waste gases and to supply sufficient oxygen.
- Temperature profile is appropriate and not fluctuating.
- Nutrition. Feeding of mash as opposed to pellets for 7-10 days will control an outbreak of Ascites.

If chronic problems of Ascites are occurring, a growth modification programme should be considered. (See Growth Management, Modified Broiler Growth, Section 2, page 25).

TABLE 17: SUMMARY OF KNOWN FACTORS INFLUENCING THE INCIDENCE OF ASCITES AND/OR SDS[1].

FACTOR	COMMENT	ADVICE
Altitude of hatchery and/or farms	>1000m causes increased incidence of Ascites.	Use non-susceptible breed.
Ventilation	Under-ventilation or poor air quality will increase incidence of Ascites.	Pay attention to minimal ventilation during brooding.
Respiratory disease	Aspergillosis. Other respiratory infections (IB[2], ART[3] and Mycoplasma) are expected to increase Ascites.	Control respiratory disease.
Genetics	Variation in susceptibility has been used to select resistant lines.	Genetic selection in Ross lines produces continual improvement in resistance to Ascites and SDS.
Sex	Males have increased incidence of Ascites and SDS due to faster growth.	Separate the sexes to allow different management of males and females.
Temperature	High temp. >25°(C (77°F) Low temp. <15°(C (59°F) and/or large diurnal variation.	Control environmental temperature.
Growth rate	High growth rate is associated with increased incidence of Ascites and SDS.	Use growth modification programmes.
Pelleted feed	Increases metabolic rate which is associated with increased incidence of Ascites and SDS.	Balance improved broiler performance against increased mortality.
High energy diets	Increased metabolic rate is associated with increased incidence of Ascites and SDS.	Balance improved broiler performance against increased mortality.
Salt	Excess may cause increased incidence of Ascites.	Check sodium, potassium, calcium and chloride levels in diets.
Vitamin E and selenium status	Low levels are associated with increased incidence of Ascites. Vitamin A, Vitamin C and dietary fat quality may also have an effect.	Check vitamin and mineral levels in diet. Check dietary fat quality.
Fishmeal	High levels (>200ppm) of histamine increase incidence of Ascites.	Control of fishmeal in diet.
Phosphorus deficiency	Marginal phosphorus levels may increase incidence of Ascites. Rickets and/or lameness will usually be observed.	Control levels of dietary phosphorus.

FACTOR	COMMENT	ADVICE
Chemical contamination	A number of chemicals are known to cause Ascites: Monensin Some mycotoxins (e.g. aflatoxin) Phenolics Coal tar derivatives Chlorinated hydrocarbons Furazolidone Pentachlorophenols Cobalt Chloride	If elevated incidence of Ascites is observed then analyse diets for contaminants.
Liver disease	e.g. Cholangiohepatitis - associated with Necrotic Enteritis and other liver diseases can cause an increase in the incidence of Ascites.	Control Necrotic Enteritis.
Viral Myocarditis	e.g. Adenovirus infection will cause Ascites.	
Bacterial Endocarditis	Contamination at hatchery, farm or vaccination equipment.	Improve hatchery and farm hygiene.
Plant poisoning	A number of plants can contaminate dietary raw materials which can increase the incidence of Ascites if consumed: Mexican Poppy *(Argemone sp)* Pyrrolizidine alkaloids Rape seed oil	Check raw materials for contaminants.

SDS[1] - Sudden Death Syndrome
IB[2] - Infectious Bronchitis
ART[3] - Avian Rhinotracheitis

Genetic selection by Aviagen has resulted in improved leg health. The most frequent problems in leg health are likely to be Tibial Dyschrondroplasia (TD) and FHN. Nutrition, stocking density, viral and bacterial disease will all influence leg health. Growth modification programmes are useful when problems with leg health persist over consecutive flocks.

Investigation of health problems

When health problems are suspected in broiler flocks, veterinary advice should always be sought at the earliest possible opportunity.

Investigation of health problems may involve serological sampling. Care must be taken when interpreting serology from young broilers because of insufficient time for development of immune responses and/or other factors in serum samples from young chicks.

In investigating the cause of disease, care must be taken in associating a bacterium or virus isolated from the infected flock as the cause of the disease. Many innocuous bacteria or viruses e.g. *E. coli*, Reovirus, Adenovirus etc. may be isolated from healthy broilers.

Immunosuppression caused by a variety of pathogens in parent stock or broilers is a significant cause of broiler morbidity. Management of the causes of immunosuppression (i.e. infections, poor nutrition, toxins etc.) in broiler flocks is an important part of the health programme. Efficiency of the management of immune status can be monitored by examination of a combination of parameters including bursal size or weight, thymus appearance, response to therapies, performance etc.

Mycotoxins

Poor handling and storage of raw materials or finished feed carry a high risk of mycotoxin contamination, which can have serious implications for broiler health. (See Nutrition, Non-nutritive Feed Additives, Section 4, page 43).

Health Monitoring

Continuous improvement of broiler health within a broiler operation requires that records be kept throughout the lives of the broiler flocks and across the whole process of production. (See Appendix 1, page 94).

Section six

Housing and Environment

Objectives

To provide an environment that permits the bird to achieve optimum performance in growth rate, uniformity, feed efficiency and meat yield and to ensure that the health and welfare of the bird are not compromised.

page contents

HOUSING AND ENVIRONMENT

Principles

The housing and ventilation systems used will depend upon climate. The housing and equipment should allow responsive control of the environment so that the commercial and bird welfare objectives can be fulfilled.

CONTROL OF ENVIRONMENT

Local climate is one of the most important factors in the design of housing systems. The different types of production system in use throughout the world can be categorised by the three main climates for which they have been designed:

- Temperate climates (usually controlled environment)
- Hot, dry climates (usually controlled environment with cooling systems)
- Hot, humid climates (often open-sided housing)

Strategies for dealing with high temperatures are also discussed later in this section. (Heat Stress pages 75-79)

TEMPERATE CLIMATES - CONTROLLED ENVIRONMENT

Controlled environment housing should provide:

- Effective insulation with a U value of 0.4W/m²/°C (i.e. R value 12-14). This is equivalent to 10cm (4in) of glass fibre. In extremely cold climates, extra insulation may be required.
- Effective light-proofing, especially when lighting programmes are in use. (See Chick Management, Lighting, Section 1, page 20). The maximum light intensity within a darkened house should not exceed 0.4 lux (0.04 foot candles). The artificial lighting system must provide uniform light distribution throughout the house and light intensity for which the control is infinitely variable, up to a maximum of 25 lux.
- Effective, draught-free ventilation, which is capable of providing and maintaining an adequate and controlled flow of uniformly good quality air at bird level.
- Floors, which should contain a vapour seal and which should be of a smooth, finished concrete, for ease of cleaning.

Baffles should be fitted to fan housings to prevent draughts and light seepage.

DANGER

HOT CLIMATE WITH LOW RH% - CONTROLLED ENVIRONMENT WITH COOLING SYSTEM

Birds will become stressed and performance will suffer if environmental control is inadequate in extremes of temperature.

DANGER

Insulation, light-proofing and ventilation requirements are similar to those for controlled environment housing in temperate climates. Because of the higher ambient temperature, a greater ventilation capacity will be necessary together with cooling systems.

In hot conditions i.e. temperatures >27°C (81°F), evaporative cooling of the air is used to maintain the acclimatised bird at operating temperatures within the range 25-32°C (77-90°F). Relative humidity (RH) influences the effectiveness of evaporative cooling as follows:

- at 20% RH, reduction in temperature can be within the range 15-20°C (27-36°F).
- at 60-70% RH, reduction in temperature is in the range 4-8°C (7-14°F).
- at RH above 70%, temperature reduction becomes limited and the bird is progressively stressed as cooling by panting becomes less effective.

In addition to evaporative cooling of the air, convective cooling may be exploited by directing air over the birds. As RH rises, convection becomes an increasingly significant part of the cooling process. Table 18 shows the estimated effect of different air velocities (wind chill) on the perceived temperature.

TABLE 18: WIND CHILL EFFECT AT DIFFERENT AIR TEMPERATURES

Air Velocity m per sec.	Estimated Wind Chill Effect Air Temp <32°C	Estimated Wind Chill Effect Air Temp >32°C
1.0	-2.0	-0.5
1.5	-4.0	-2.0
2.0	-5.5	-2.5
2.5	-6.0	-3.0

(Source ADAS)

An air speed of 2-3m/sec (394-591ft/min) at bird level will reduce perceived temperature by 6°C (10.8°F). In extreme conditions, an air speed of 3m/sec can be used to maximise heat loss by convection. Air speeds greater than 4m/sec will cause distress. The cooling effect will be greater before birds are fully feathered. Air flow can be increased by reversing existing fans, so that there is a direct flow over the birds.

e.g. in an ambient temperature of 36°C (97°F), with an RH of 50%, evaporative cooling will cause house temperature to fall to 28°C (82°F). An air speed of 2m/sec would give a further temperature drop of 6°C (10.8°F), leading to a perceived temperature at bird level of 22°C (72°F).

The addition of supplementary fans inside the house can boost air flow.

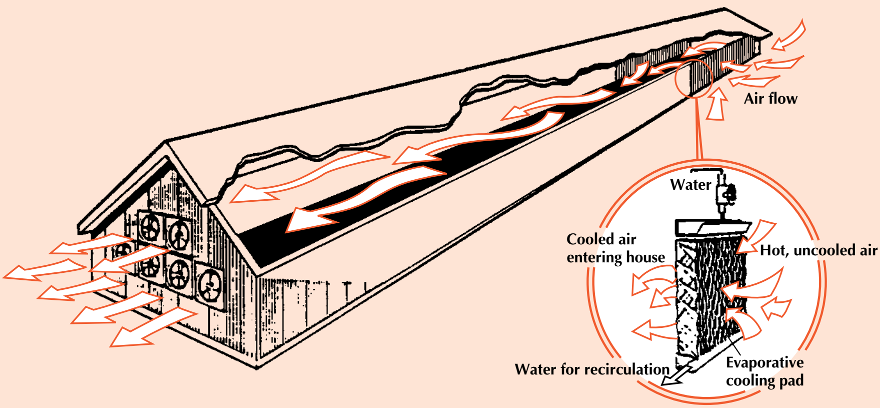
The most commonly used evaporative cooling systems are those incorporating pad cooling with tunnel ventilation and/or fogging. (See Table 19, Diagrams 12 and 13, pages 72 and 73).

TABLE 19: EVAPORATIVE COOLING SYSTEMS IN COMMON USE	
COOLING SYSTEM	**DESCRIPTION**
Low pressure fogging	100-200psi (7-14bar), droplet sizes > 30 microns may cause wet litter at high humidity.
High pressure fogging	400-600psi (28-41bar), droplet sizes of 10 -15 microns minimise residual moisture giving extended humidity range
Cooling pads	air is drawn through a water-soaked filter by tunnel ventilation. See Diagram 12

Pad Cooling with Tunnel Ventilation

Pad cooling systems in which air is cooled by drawing it through water contained within mineral or cellulose pads are relatively simple, reliable and easy to maintain (see Diagram 12). The cooled air is moved through the house by tunnel ventilation. The dual effect of pad cooling and air speed allows control of environment when house temperatures are very high i.e.> 30°C (86°F).

DIAGRAM 12: EXAMPLE OF PAD COOLING COMBINED WITH TUNNEL VENTILATION

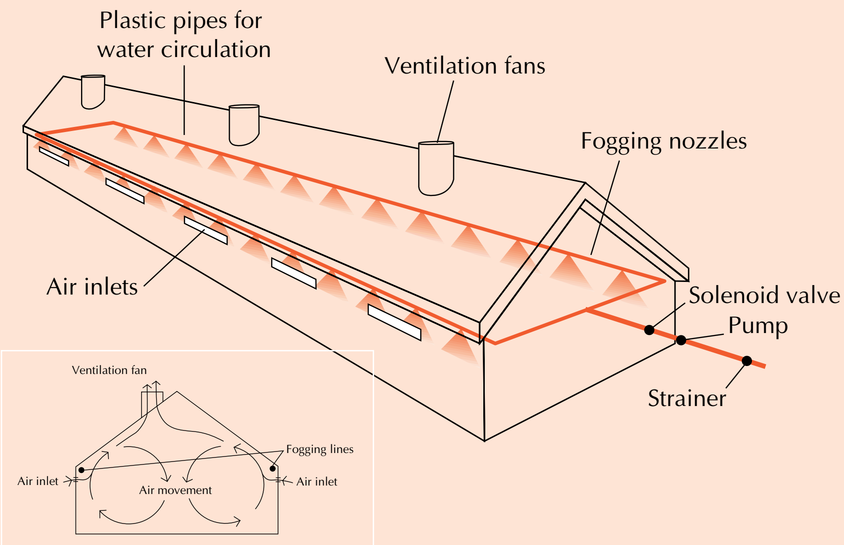


Fogging

In this system, incoming air is cooled by evaporation of droplets of water created by pumping water through hoses and nozzles. Two types of fogging system are in common use: high and low pressure. High pressure fogging systems i.e. 400-600psi (28-41bar), producing droplets of 10-15microns (which are more effectively evaporated), minimise the residual moisture within the house. They also extend the range of humidity within which some benefit may be achieved

up to 80% RH.
Fogging lines must be placed near the air inlets to maximise the speed of evaporation.

DIAGRAM 13: ULTRA HIGH PRESSURE FOGGING/AIR FLOW



CROSS SECTION OF HOUSE
SHOWING AIR FLOW

Avoid wet litter by adjusting droplet size.

DANGER

The long term effectiveness of evaporative cooling systems is reduced where water contains a high proportion of dissolved minerals and/or particles.

DANGER

Additional lines in the centre of the house may be required.
Open-sided houses should be located on well-drained land and where there is plenty of natural air movement. They should be built so that direct sunlight does not fall on to the side walls during the hottest part of the day. House orientation should be such that the long axis of the house lies east to west. The roof should be insulated (0.4W/m2/°C) with a surface finish that reflects solar heat. A high roof pitch (i.e. 30-40°) assists natural ventilation by increasing movement of air by convection and reduces radiant heat from the underside of the roof at bird level.

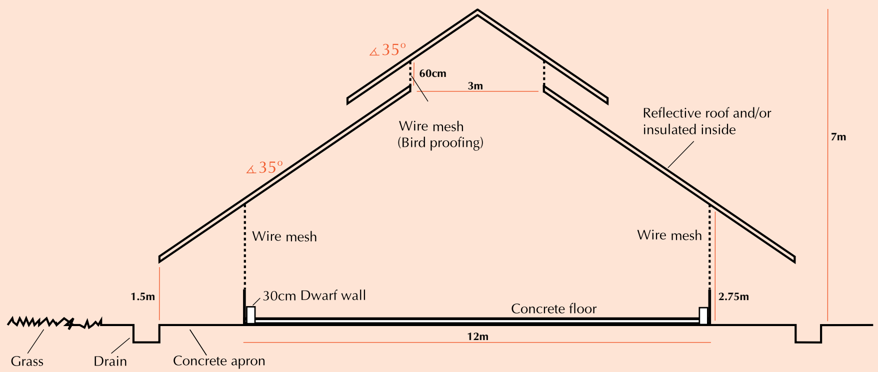
An effective design of an open-sided house is 12m (40ft) wide, 2.75m (9ft) to the eaves and the roof should overhang the walls by 1.25m (4.1ft) to limit the heating effect of direct sunlight. (See Diagram 14). Vegetation covering the ground around the house will reduce the amount of reflected heat entering the house. In addition shade, provided by trees, is beneficial as long as air circulation is not inhibited.

The side walls of open-sided broiler houses should be constructed of dwarf walls, 25-30cm (10-12in) in height with wire mesh (mesh diameter 25mm) to the eaves. End walls can either be of a similar construction, or solid, depending on climate. Side walls should also incorporate an adjustable, reinforced plastic curtain to assist in temperature control (e.g. during brooding, cold or hot weather and at night). Houses must be secure from entry by vermin and wild birds.

In regions with severe climatic variation, dwarf walls can be increased to a height of 60-80cm (24-30in) and the wire mesh area can be covered with either reinforced curtains or louvered shutters.

Open-sided housing is becoming less popular as producers become more aware of the production advantages of a controlled environment. These advantages will vary depending on climatic conditions. They are more significant where conditions are extreme, but cover all aspects of production i.e. increased stocking density, improved liveability, better growth rate,

DIAGRAM 14: EXAMPLE OF OPEN HOUSE BASIC DESIGN



In hot climates, ideal environmental temperatures cannot be maintained unless open-sided houses are modified to permit cooling.

DANGER

Key Points

- ✓ **Design and construct housing and ventilation systems to incorporate requirements for biosecurity, environmental control and responsive management.**
- ✓ **Locate and position broiler houses to minimise heat absorption from the environment.**
- ✓ **Ensure that insulation is adequate for effective temperature control.**
- ✓ **Use reflective or white surfaces to reflect radiant heat.**
- ✓ **Install cooling systems where air temperature exceeds 20°C (68°F) for significant periods.**
- ✓ **Ensure that tunnel-ventilated houses are completely sealed to maximise air flow through the cooling pads and to ensure constant air speed through the house.**
- ✓ **Monitor water quality for mineral content, droplet size and bacterial contamination when using fogging systems.**

HEAT STRESS

In tropical regions and during summer in temperate regions, heat stress and its effects upon growth rate and mortality, may become a problem. The effects of heat stress can be minimised by altering the environment to reduce the temperature experienced by the bird and/or allowing the bird to control it's temperature by physiology or behaviour.

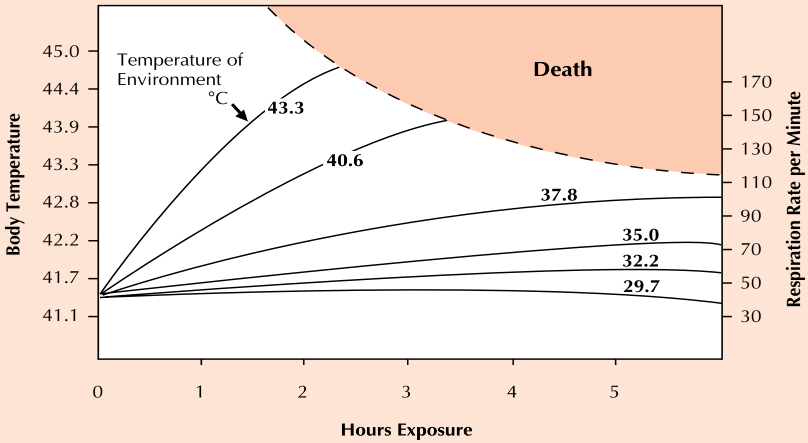
CONTROL OF HEAT STRESS

The normal body temperature of a broiler chicken is 41°C (106°F). When the environmental temperature exceeds 35°C (95°F), the broiler is likely to experience heat stress. The longer the exposure to high temperatures, the greater the stress and its effects. (See Diagram 15, page 76).

Prolonged exposure to high temperature will reduce performance and may increase mortality rates.

DANGER

DIAGRAM 15: RELATIONSHIP BETWEEN ENVIRONMENTAL TEMPERATURE, EXPOSURE TIME AND BODY TEMPERATURE



Broilers regulate their body temperature by two methods, sensible and insensible heat loss. Within the temperature range 13-25°C (55-77°F), heat loss is mainly accomplished through physical radiation and convection to the cooler environment (i.e. sensible heat loss). As the temperature rises above 30°C (86°F) the majority of heat loss is accomplished by evaporative cooling and panting, and increased respiration rate (i.e. insensible heat loss). The relationship between the two types of heat loss and environmental temperature is illustrated in Table 20.

TABLE 20: HEAT LOSS IN BROILERS

ENVIRONMENTAL TEMPERATURE	HEAT LOSS % SENSIBLE (Radiation and Convection)	INSENSIBLE (Evaporation)
25°C (77°F)	77	23
30°C (86°F)	74	26
35°C (95°F)	10	90

Panting allows the bird to control body temperature by evaporation of water from the respiratory surfaces and air sacs. The process uses energy. In conditions of high humidity, panting is less effective. Where high temperatures are maintained for long periods, or humidity is very high, panting may be insufficient to control body temperature and the bird may experience heat stress. As the bird passes into a condition of heat stress, rectal temperature rises, heart rate and metabolic rate increase and oxygenation of the blood decreases. The physiological stress induced by these reactions can be fatal.

If more than 20% of the flock are observed to be panting, the house temperature may be too high.

Immediate / Short Term Actions

Lowering of the stocking density will reduce the temperature experienced by the bird.

Birds lose heat by evaporation of moisture during panting and therefore require increased amounts of drinking water. Adequate fresh cool water should be available at all times. Insulation of the storage tanks and water pipes will help in reducing heat stress as will the addition of ice to the header tank.

Digestion generates heat within the bird, therefore feeding during the hottest part of the day should be avoided. This could be accomplished by the use of an intermittent feeding programme. Intermittent feeding or lighting programmes will have the effect of dissipating heat by disturbing birds regularly from a resting position. (See Growth Management, Intermittent Lighting Programmes, Section 2, page 31).

A significant amount of heat is lost by convection and at high humidity, convective heat loss becomes more important. Increasing the air flow over the bird promotes heat loss by convection. An air flow of 2-3m/sec, measured just above bird level, provides optimum heat loss by convection. This may be achieved by using free-standing, 91cm (36in) fans, placed at an angle of 32°, every 10 metres (33ft) across the house. Fans should be set to move air in the same direction as the prevailing wind.

High humidity reduces the capacity of birds to lose heat. DANGER

High humidity reduces the effectiveness of evaporative heat loss. The litter is a significant source of moisture in the chicken house, so litter condition should be managed carefully. Wet litter will increase relative humidity.

Radiant heat from the sun will increase house temperature, particularly if roof insulation is inadequate. Water sprinklers on the roof ridge will reduce this source of heat.

In open-sided houses, plastic netting hung from the eaves to cover 30% of the open area may be used as a screen against radiant heat.

A method of reducing heat stress by supplementing the drinking water with 1g of vitamin C plus 0.3g of salicylic acid (i.e. aspirin) per litre has been reported.

Long Term Actions

Susceptibility to and effects of heat stress increase with age and liveweight. Males are more vulnerable to heat stress than females. Increased stocking density will increase the likelihood and severity of heat stress. In the long term, placing sexes separately at lower stocking densities, when hot weather is anticipated can reduce effects of heat stress.

High stocking density increases the risk of heat stress. DANGER

A period of high temperature in the first week of life may condition the birds and may reduce the effects of high temperature later in the growing period. Acclimatisation may be achieved by subjecting birds of 5 days of age to temperatures of 36-38°C (97-100°F) for 24 hours.

Key Points

- ✓ **Reduce stocking density.**
- ✓ **Ensure fresh drinking water is available at all times.**
- ✓ **Feed during the coolest part of the day.**
- ✓ **Increase air flow over the bird to 2-3m/sec using fans.**
- ✓ **Minimise the effects of radiant heat from the sun.**
- ✓ **Reduce effects of excessive temperatures by placing sexes separately at lower stocking densities during hot weather.**

NUTRITION AND HEAT STRESS

Under conditions of high temperature, special attention should be paid to feed quality. Risks of spoilage due to mould growth and/or vitamin loss are increased at high temperatures.

The two main changes which can be made to diet composition are adjustment of nutrient levels to take account of lower feed intake and reduction of heat increment of the feed. Manipulation of the diet may itself also have a direct effect on heat stress.

> **Heat stress lowers feed intake and reduces performance.**
>
> DANGER

Increasing the nutrient density of the feed will be effective in reducing heat stress providing that the birds have the capacity to respond by increased growth. The effectiveness of this treatment will depend on the temperature and the amount of stress experienced by the birds. As an approximate guide, feed intake is reduced by 5% per degree temperature rise between 32 and 38°C (90 and 100°F) compared with 1-1.5% between 20 and 30°C (68 and 86°F). If feed intake is down by 5 or 10%, then the nutrient concentration should be increased in proportion. It is particularly important to adjust the protein, vitamin and mineral fractions of the feed. Intakes of coccidiostats and prophylactic drugs must also be maintained.

Although energy intake may limit performance in conditions of heat stress, increasing the energy content of the feed may not necessarily be of benefit. However the inclusion of fat as a source of energy, at the expense of carbohydrate, will be advantageous and may also stimulate a higher feed intake.

An increase in protein and amino acid levels may be beneficial if feed intake is reduced but should not be considered in conditions where the birds cannot respond. Excess protein is broken down and eliminated from the bird by deamination and excretion, processes which have a high heat increment. Under all circumstances of heat stress, amino acid requirements should be met at the lowest possible total protein content. Sources of high quality protein and synthetic amino acids will help to achieve this aim.

In addition to minimising protein excess, the heat increment of the feed may be reduced by substituting fat for carbohydrate. In this context, advantage should be taken of good quality fats and/or the appropriate use of feed processing technology. Fat inclusion may also stimulate intake and, under some circumstances, give a beneficial boost to energy intake. Higher levels of the amino acid arginine relative to lysine, in the diet (i.e. ratio>1.3) may have beneficial effects in heat-stressed birds.

Birds suffering heat stress exhibit reduced levels of plasma carbon dioxide and bicarbonate. Panting induces respiratory alkalosis, which may be corrected by a variety of supplements to either the feed or the water. There is also a loss of potassium by birds suffering heat stress, which may be corrected by administration of potassium chloride.

Key Points

✓ **Increase nutrient concentration to compensate for reductions in feed intake.**

✓ **Increase fat and reduce carbohydrate levels to stimulate appetite.**

✓ **Use high quality raw materials to maximise digestibility and availability of amino acids.**

✓ **Consider using bicarbonate in the drinking water to reduce alkalosis.**

✓ **Ensure vitamins C and E are provided at recommended levels.**

STOCKING DENSITY

improved feed conversion, etc.

Stocking density has a significant influence on broiler performance and final product in terms of uniformity and quality. Overstocking increases the environmental pressures on the broiler, which compromise bird welfare and will ultimately reduce profitability. Quality of housing and especially environmental control, will influence the stocking density applied. If stocking density is increased, an appropriate increase in feeding space and drinker availability must be made

Overstocking will reduce growth, liveability, litter quality and leg health. DANGER

Overstocking will increase carcase downgrading due to breast blisters, Hockburn, bruising and scratching. DANGER

The area of floor space needed for each broiler will depend on:

- target liveweight and/or age at slaughter
- climate and season
- type and/or system of housing and equipment, particularly ventilation

In the UK, the Codes of Recommendations for the Welfare of Livestock quote stocking densities at differing liveweights to obtain a biomass of 34.22 kg/m² (7lb/ft²) and these are given in Table 21. In other countries different standards may apply.

TABLE 21: STOCKING DENSITIES AT DIFFERING LIVEWEIGHTS*

Liveweight (kg)	Birds/m²
1.0	34.2
1.4	24.4
1.8	19.0
2.0	17.1
2.2	15.6
2.6	13.2
3.0	11.4
3.4	10.0
3.8	9.0

**As recommended in The Code of Recommendations for the Welfare of Livestock, Meat Chickens and Breeding Chickens, Department of the Environment, Food and Rural Affairs (DEFRA), UK.*

Stocking Density in Hot Climates

In hot climates, the stocking density applied will depend on the temperature, humidity and capacity of the ventilation system.

In houses with controlled environment, in hot climates, stocking density should be reduced to a maximum of 30kg/m² at slaughter.

In open-sided houses, stocking density should be 20-25kg/m² at slaughter. At the hottest times of the year, or at liveweights above 3kg, stocking density may have to be reduced to 16-18kg/m².

Key Points

✓ **Adjust stocking density to allow for the age and weight at which the flock is to be slaughtered.**

✓ **Reduce stocking density if target house temperatures cannot be achieved due to hot climate or season.**

✓ **Adjust ventilation and feeder and drinker space/bird when stocking density is increased.**

VENTILATION AND AIR QUALITY

Ventilation

It is essential to deliver a constant and uniform supply of good quality air to bird level. Fresh air is required at all stages of growth to allow the bird to remain in good health and achieve full potential.

The minimum ventilation rate for growing broilers is defined as the smallest air change needed to maintain air quality at a given biomass.

Minimum Ventilation Rate: 0.702m^3/hour/$kg^{0.75}$ liveweight*

**Source: UK Agricultural Development and Advisory Service. Other figures may be obtained from local advisory sources.*

The minimum ventilation rate can be used to calculate the rate of air exchange required by broilers of different liveweight. Table 39 (Appendix 4, page 106) gives the minimum ventilation rate in m^3/hour for broilers of varying liveweights. These figures can be used to calculate the minimum required settings for the ventilation systems of individual broiler sheds as the age of the flock increases. The ventilation system should be designed to allow ventilation rate to be infinitely adjustable between the maximum and minimum settings. Minimum ventilation rates may be achieved by running fans intermittently.

A maximum ventilation rate for growing broilers in controlled environment sheds in temperate climates has been defined as the quantity of air required to dissipate heat, such that the temperature within the house rises no more than 3°C (5.4°F) above outside air temperature.

Maximum Ventilation Rate: 7.20m^3/hour/$kg^{0.75}$ liveweight*

**Source: UK Agricultural Development and Advisory Service. Other figures may be obtained from local advisory sources.*

Table 39 (Appendix 4, page 106) gives the maximum ventilation rate in m^3/hour for broilers of varying liveweights.

When evaporative cooling is used, the maximum ventilation rate should maintain temperatures within 3°C (5.4°F) of the intake temperature. To achieve this the system must be capable of cooling air at the maximum ventilation rate. If the capacity of the cooling system is exceeded, or no evaporative cooling is used, then the birds should be cooled by convective heat loss using tunnel ventilation or supplementary fans as described on page 71. When tunnel ventilation is being used to cool birds by convective heat loss the maximum ventilation rate will be exceeded.

Air Quality

As broilers grow they consume oxygen and produce waste gases. Combustion by brooders contributes to waste gases in the broiler house. The ventilation system must remove these waste gases from the house and deliver good air quality.

The main contaminants of air within the house environment are dust, ammonia, carbon dioxide, carbon monoxide and excess water vapour. When in excess, they damage the respiratory tract, decreasing the efficiency of respiration and reducing bird performance. Continued exposure to contaminated air may trigger Ascites and Chronic Respiratory Disease. Excess water vapour may affect temperature regulation and contribute to poor litter quality.

The incidence of high levels of Ascites and Chronic Respiratory Disease may indicate air quality problems due to inadequate ventilation.

DANGER

Table 22 shows the major effects of each contaminant and the levels at which problems are likely to occur.

TABLE 22: EFFECTS OF COMMON BROILER HOUSE AIR CONTAMINANTS

Ammonia	Can be detected by smell at 20ppm or above. >10ppm will damage the lung surface. >20ppm will increase susceptibility to respiratory diseases. >50ppm will reduce growth rate.
Carbon Dioxide	>0.35% causes Ascites. Fatal at high levels.
Carbon Monoxide	100ppm reduce oxygen binding. Fatal at high levels.
Dust	Damage to respiratory tract lining. Increased susceptibility to disease.
Humidity	Effects vary with temperature. At >29°C (84°F) and >70% relative humidity, growth will be affected.

Inadequate ventilation causes wet litter which leads to increased incidence of hockburn and carcase downgrading.

DANGER

Good air quality is best achieved by maintaining ventilation rates at or above the minimum defined in Appendix 4, Table 39, page 106, especially during the brooding stage.

Chemical additives are available for use in feed or litter to reduce ammonia production.

Sensors which monitor ammonia, carbon dioxide, relative humidity and temperature are available commercially and can be used in conjunction with automated ventilation systems.

Key Points

- ✓ **Use a ventilation system which is capable of achieving the requirements for good air quality (i.e. minimum ventilation rate) and temperature control (i.e. maximum ventilation rate).**
- ✓ **Maintain ventilation rate at or above the minimum at all times.**
- ✓ **Monitor temperature and air quality to determine the appropriate adjustment of ventilation rate.**

Litter material should be spread evenly to a depth of 3-10cm (1-4in), depending on quality of housing and insulation. A variety of materials may be used, if they satisfy the requirements of good moisture absorption, biodegradability, comfort and cleanliness, low dust level, freedom from taint and are consistently available from a biosecure source. (See Table 23). Earth floors are impossible to clean and disinfect adequately. Concrete floors are preferable since they are washable and allow more effective litter management.

> **Poor air quality will limit flock performance, and increase susceptibility to disease.**

LITTER AND LITTER MANAGEMENT

TABLE 23: CHARACTERISTICS OF COMMON LITTER MATERIALS

MATERIAL	CHARACTERISTICS
New White Wood Shavings	Good absorption and breakdown. Possible contamination by insecticides, which can be toxic and chloramisoles which can cause a musty taint.
Chopped Straw	Wheat straw is best. Possible contamination by agrochemicals, fungi and mycotoxins. Slow to break down, best used mixed 50/50 with white wood shavings.
Shredded Paper	Can be difficult to manage in humid conditions. Glossy paper is unsuitable.
Chaff and Hulls	Not very absorbent. Best mixed with other materials. May be ingested.
Sawdust	Not suitable. Dusty and may be ingested.
Chemically Treated Straw Pellets	Use as recommended by the supplier.
Sand	Commonly used in arid/desert areas on concrete floors. Can work well, but birds have difficulty moving about if spread deeply.

> **Contamination of litter materials with mycotoxins and /or fungi may depress broiler performance.**
>
> DANGER

> **Earth floors are a biosecurity hazard because they cannot be cleaned and disinfected effectively.**
>
> DANGER

If wild birds or rodents have access to the source of litter material, there is a risk of introducing salmonellae or other pathogens on to the site. Litter storage facilities should be protected from the weather and secure from access by vermin.

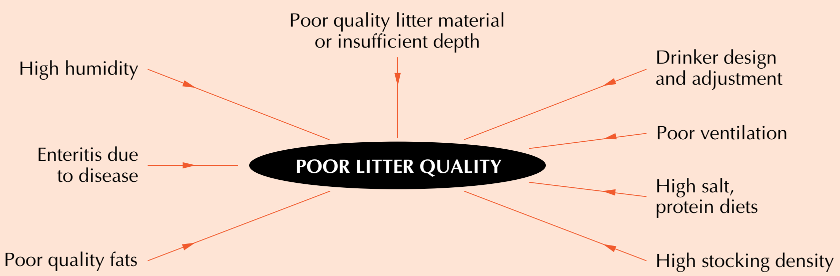
> **Avoid introducing salmonellae or other pathogens by careful attention to the source and storage of the material both before and after delivery to the farm.**
>
> DANGER

It is important that litter is kept in a dry and friable condition throughout the life of the flock. If the litter becomes caked or too wet (i.e. >50% moisture) the incidence of Hockburn and breast blisters will increase substantially. Every effort should be made to keep litter in good condition to minimise carcase downgrading.

> **Wet litter leads to increased incidence of Hockburn and carcase downgrading.**
>
> DANGER

Diagram 16 shows the likely causes of poor litter quality, any of which may be the reason for Hockburn or breast blisters. Certain feed ingredients may also be associated with Hockburn, as may deficiencies of the vitamin biotin and the trace element molybdenum.

DIAGRAM 16: REASONS FOR POOR QUALITY LITTER



Key Points

✓ **Protect broilers from damage and provide a dry, warm covering to the floor by using a good quality litter material.**

✓ **Choose litter material that is absorbent, non-dusty and clean. Litter should be readily available at a low cost from a reliable source.**

✓ **Use fresh litter for each crop, to prevent reinfection by pathogens.**

DRINKING SYSTEMS

It is essential that water is available to broilers at all times (i.e. 24 hours/day). Inadequate water supply, either in volume or in the number of drinking points, will result in reduced growth rate. To ensure that the flock is receiving sufficient water, the ratio of water to feed consumed each day should be monitored. The birds are consuming sufficient water when the ratio of water volume (ml or l) to feed weight (g or kg) remains close to 1.8:1 (1.6:1 for nipple drinkers). Water consumption can be measured using water meters installed at the point where the water supply enters the house.

Table 24 shows the typical water consumption with different drinking systems for broilers at increasing ages.

Birds will drink more water at high ambient temperatures. Water requirement increases by approximately 6.5% per degree Centigrade over 21°C (70°F). In tropical areas prolonged high temperatures will double daily water consumption.

TABLE 24: TYPICAL WATER CONSUMPTION BY BROILERS AT 21°C (70°F)* IN LITRES/1000 BIRDS/DAY

	Nipple Drinkers -without cups			Nipple Drinkers -with cups			'Bell' Drinkers		
Water Intake	**1.6litres/kg Feed**			**1.7litres/kg Feed**			**1.8litres/kg Feed**		
Age (days)	**Male**	**Female**	**As-hatched**	**Male**	**Female**	**As-hatched**	**Male**	**Female**	**As-hatched**
7	64	60	62	68	64	66	72	67	69
14	113	106	109	120	112	116	128	119	123
21	177	160	169	189	170	180	200	180	190
28	242	211	227	258	224	241	273	237	255
35	293	246	270	311	261	286	330	277	303
42	339	274	307	360	291	326	381	308	345
49	369	287	330	392	305	350	415	323	371
56	381	282	333	405	300	354	428	318	375

**Water requirement increases by 6.5% per degree C over 21°C (70°F).*
Note: Water consumption will vary with feed consumption. The figures in the table are based on daily feed consumption defined in the Performance Objectives for Ross 308.

Sudden increases or decreases in demand and/or deviation of ratio of water to feed from 1.8:1 (1.6:1 for nipples) are early indicators of stress, disease or suspect feed quality.

The two drinking systems used most commonly are:

- 'bell' drinkers
- nipple drinkers

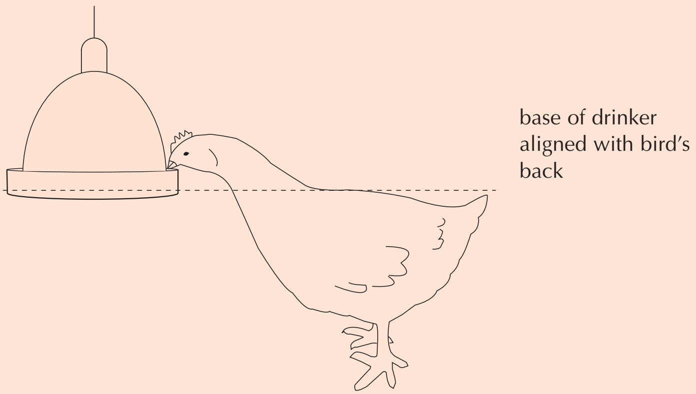
Bell Drinkers

At day old, a minimum of 6 'bell' drinkers (40cm/16in diameter) should be provided per 1000 chicks; additional sources of water in the form of 6 mini-drinkers or plastic trays per 1000 chicks should also be available. As the broilers become older, and the area of the house in use is expanded, a minimum of 8 'bell' (40cm/16in diameter) drinkers must be provided per 1000 chicks. (See Table 25, page 88). These should be placed evenly throughout the house so that no broiler is more than 2m (6.5ft) from water. Additional mini drinkers and trays used at day old should be removed gradually so that by 3-4 days all chicks are drinking from the automatic drinkers.

As a guide to level, water should be 0.6cm (0.25in) below the top of the drinker until 7-10 days and there should be 0.6cm (0.25in) of water in the base of the drinker from 10 days onwards.

Drinkers should be checked for height on a daily basis, and adjusted so that the base of each drinker is level with the broiler's back from 18 days onwards. (See Diagram 17). This minimises faecal contamination of the water. Nipple drinker height is adjusted centrally by winch, whereas 'bell' drinkers require individual adjustment. Water level in the drinkers should be adjusted to prevent spillage and subsequent problems with wet litter.

DIAGRAM 17: HEIGHT OF BELL TYPE DRINKERS



Nipple Drinkers

Nipple drinkers installed at 12 birds per nipple (9-10 for heavy broilers) may be preferred to 'bell' drinkers because they are less likely to cause spillage and wet litter. (See Table 25, page 88). Nipple systems offer drinking water with lower levels of bacterial contamination than conventional open systems. Apparent advantages of nipple systems to management of water supply may be undermined by possible reductions in carcase yield.

High pressure, nipple drinker systems (which do not need drip cups) can further reduce bacterial contamination of drinking water.

The height adjustment of nipple systems must be monitored very closely and on a daily basis. In the initial stages of brooding, the nipple lines should be placed at a height at which the bird is able to drink. The back of the chick should form an angle of 35-45° with the floor whilst drinking is in progress. As the bird grows, the nipples should be raised so that the back of the bird forms an angle of approximately 75-85° with the floor and so that the birds are stretching slightly for the water. (See Diagram 18).

Water pressure should be adjusted so that there is a flow rate of at least 60ml/min available from each nipple.

Litter under the drinker system should be level to allow all birds equal access to water and to prevent spillage.

DIAGRAM 18: NIPPLE DRINKER HEIGHT ADJUSTMENT

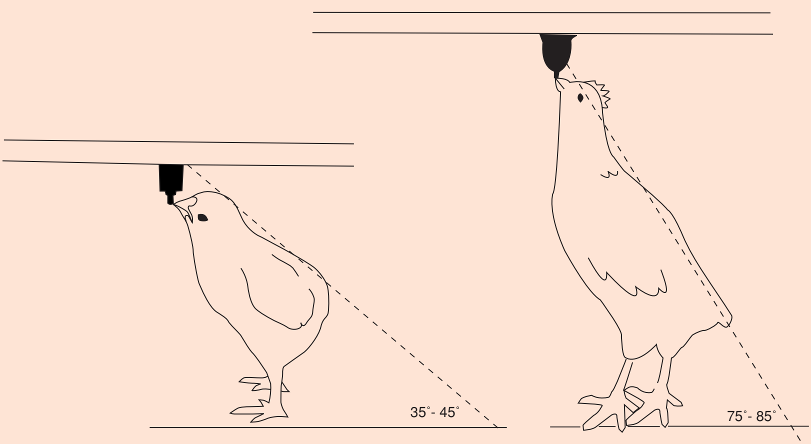


TABLE 25: MINIMUM DRINKER REQUIREMENTS/1000 BIRDS POST-BROODING

DRINKER TYPE	DRINKER REQUIREMENTS
'Bell' drinkers	8 drinkers (40cm diameter)/1000 birds
Nipples	83 nipples/1000 birds (12 birds/nipple) 9-10 birds/nipple for heavy broilers)

Adequate water storage must be provided, on the farm, in case of failure of the mains supply. Ideally, sufficient storage to provide 24 hours water at maximum consumption is required. The emergency water supply should form part of the daily water system to ensure a clean, non-stagnant and uncontaminated supply at all times.

Key Points

- ✓ **Make drinking water available to the birds for 24 hours a day.**
- ✓ **Provide supplementary drinkers for the first 4 days of the flocks' life.**
- ✓ **Monitor the ratio of water to feed consumption daily, to check that the birds are drinking sufficient water.**
- ✓ **Make allowance for an increase in water intake at high temperatures i.e. by 6.5% per degree C over 21°C (70°F).**
- ✓ **Adjust drinker heights daily.**
- ✓ **Provide adequate drinker space, and ensure that the drinkers are easily accessible to the entire flock.**

WATER QUALITY

Depending on the source, water supplied to broilers may contain excessive amounts of various minerals, or be contaminated with bacteria. Although water supplied as fit for human consumption will also be suitable for broilers, water from bore holes, open water reservoirs or poor quality, public supplies can cause problems.

The water supply should be tested to check the level of calcium salts (i.e. hardness), salinity and nitrates. At cleaning out and prior to delivery, water should be sampled for bacterial contamination at source, from storage tanks and drinkers.

Drinking water can be a reservoir of those bacteria responsible for food poisoning.

DANGER

Table 26 shows maximum acceptable concentration of minerals and organic matter in the water supply. These are unlikely to be exceeded if water is taken from a mains supply. Water from wells or bore holes, however, may have excessive nitrate levels and often has high bacterial counts due to 'run-off' from fertilised fields. Where bacterial counts are high, the cause should be established, and rectified if possible. Chlorination to give between 1 and 3ppm at drinker level will reduce the count, especially where drinker systems with open water surfaces are in use. UV irradiation is effective in controlling bacterial contamination.

If the water contains high levels of calcium salts (i.e. is hard), or a high level of iron (>3mg/l), drinker valves and pipes may become blocked. Sediment will also block water pipes and, where this is a problem, it is advisable to filter the supply using a filter which has a mesh of 40-50 microns.

Very cold or very warm water will reduce water intake and therefore growth in broilers. In hot weather, it is good practice to flush the drinker lines at regular intervals to ensure that the water is as cool as possible.

When water is very cold or very warm birds will drink less and growth will be reduced.

DANGER

TABLE 26: MAXIMUM ACCEPTABLE LEVELS OF MINERALS AND BACTERIA IN DRINKING WATER

MINERALS/BACTERIA	ACCEPTABLE CONCENTRATION
Total Dissolved Solids	300-500ppm
Chloride[1]	200 mg/l
pH[2]	6 - 8
Nitrates	45 ppm
Sulphates[3]	200 ppm
Iron	1 mg/l
Calcium	75 mg/l
Copper[4]	0.05 mg/l
Magnesium[3]	30 mg/l
Manganese	0.05 mg/l
Zinc	5 mg/l
Lead	0.05 mg/l
Faecal Coliforms	0

Notes:

1. *Levels of 14mg/l can impair performance if sodium levels are also high (50mg/l).*
2. *Acid (<pH6) drinking water can affect digestion, corrode drinking equipment, and be incompatible with medicines and vaccines.*
3. *High sulphate levels will cause wet droppings. The effect is exacerbated if sodium or magnesium levels are >50mg/l.*
4. *Excess copper can impart a bitter taste to the water, and cause liver damage.*

Source: World Health Organisation.

Excess levels of some mineral salts will reduce water intake, and this will also restrict growth.

DANGER

If water hygiene is suspect, then treatment by ultra-violet (UV) light or chlorination at the point of water entry to the house will reduce bacterial contamination.

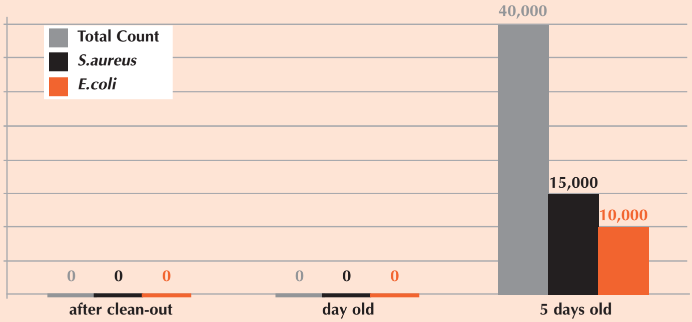
Research has demonstrated that a high bacterial load in the drinking water supplied to the young chicken will increase leg problems, especially Femoral Head Necrosis (FHN) and associated *Staphylococcus aureus* infections. This bacterial contamination can often increase downgrading at the factory due to septicaemia.

Birds offered water with a high bacterial content will experience an increased incidence of leg problems and increased downgrading at the processing plant.

DANGER

Water that is clean at the point of entry to the broiler house (e.g. good quality mains water) can become contaminated quickly by exposure to bacteria within the house environment. (See Diagram 19).

DIAGRAM 19: INCREASE IN BACTERIAL COUNT IN DRINKERS WHERE WATER IS EXPOSED TO THE BROILER HOUSE ATMOSPHERE



To ensure that the water is clean at the points of consumption, drinkers should be kept clean. In drinkers with open water surfaces (i.e. 'bell' drinkers or nipples with drip cups) chlorination of the water supply should be considered.

Key Points

✓ **Provide unrestricted access to good quality water at an appropriate delivery temperature i.e. 10-12°C (50-54° F).**

✓ **Test the water supply regularly for bacteriological and mineral contaminants, and take the necessary corrective action.**

✓ **Flush drinker lines in hot weather to ensure that the water is as cool as possible.**

✓ **Use fresh, clean drinking water to maintain leg health and reduce carcase downgrading at the processing point.**

FEEDING SYSTEMS

Feed should be provided in the form of sieved crumbs over the first 2-3 days of life. It should be placed in flat trays or on paper sheeting so that it is readily accessible to the chicks. At least 25% of the floor should be covered with paper. The change to the main feeding system should be made gradually over the first 2-3 days as chicks begin to show interest in the main system. (See Chick Management, Preparation for Chick Arrival, Section 1, page 11). The main feeding system should provide sufficient feeding space to allow the birds to achieve their optimum growth. (See Table 27, page 93). Where growth modification programmes are used, particular attention should be paid to feeding space, to allow for the extra competition created.

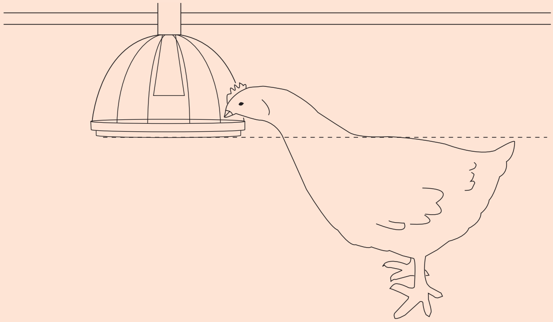
> **Insufficient feeding space will reduce growth rates and cause poor uniformity.**
>
> DANGER

The main automated feeding systems available for broilers are:

- flat chain/auger
- pan feeders
- tube feeders

All types of feeder should be adjusted to ensure minimum spillage and optimum access for the birds i.e. the base of the trough or pans should be level with the birds' backs. (See Diagram 20). Height of chain feeders is adjustable by winch, whereas height of pan and tube feeders may have to be adjusted individually.

DIAGRAM 20: HEIGHT OF FEEDERS



Incorrect feeder adjustment can increase feed spillage. When this happens, feed conversion will suffer, and the spilled feed, when eaten, is likely to carry a higher risk of bacterial contamination.

DANGER

With all feeding systems it is good practice to allow the birds to clear the feeders (i.e. consume all the feed available in the tracks or pans) 3 to 4 times per day. This will stimulate appetite and reduce feed wastage which results in improved FCR (See Section 2, Growth Management, page 26).

Adjustment of feed depth is easier with chain feeder systems, as a single adjustment to the hopper only is required. Pan and tube feeder systems, however, require adjustments to be made to each individual feeder. Careful maintenance of chain feeders will minimise incidence of leg damage.

Pan and tube feeders (if filled automatically) have the advantage that all are filled simultaneously, making feed available to the birds immediately. When chain feeders are used, however, feed distribution takes longer to accomplish and feed is not immediately available to all the birds.

Uneven distribution of feed can result in lowered performance and increased scratching damage associated with competition at feeders.

DANGER

TABLE 27: NUMBER OF BROILERS PER FEEDER

TYPE OF FEEDER	NUMBER OF BIRDS PER FEEDER
Pan Feeders	1 pan feeder for 65 birds. Diameter 33cm (13in)
Tube Feeders	1 tube for 70 birds. Diameter 38cm (15in)
Chain Feeders	2.5cm (1in)/bird i.e. 80birds/metre of track

Key Points

- ✓ **Supplement main feeding system using paper and/or trays over the first 3 days.**
- ✓ **Supply sufficient feeders for the numbers of birds in the house.**
- ✓ **Increase feeder space per bird when using growth control programmes to allow for increased competition at the feeder.**
- ✓ **Adjust feeder height daily, so that the birds' backs are level with base of the feeder.**

Appendices

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APPENDIX 1 - RECORD KEEPING

Accurate production records are essential for the effective application of responsive management. Analysis and interpretation of production data (e.g. liveweight, FCR and mortality) are essential to the upgrading and improvement of performance. Hygiene and disease status should be monitored. Record keeping and analysis are essential to determine the effects of changes to nutrition, management, environment and health status.

It is good practice for all processes in a broiler operation to have standard operating protocols (SOP). These should include documentation of established procedures and monitoring systems. (See Table 28).

TABLE 28: RECORDS REQUIRED IN BROILER PRODUCTION

Event	**Records**	**Comments**
Chick placement	Number of day-olds Flock of origin Date and time of arrival Chick quality	i.e. liveweight, uniformity, number of dead on arrival
Mortality	Daily Weekly Cumulative	Record by sex if possible Record culls separately *Post mortem* records of excessive mortality Scoring of coccidial lesions will indicate level of coccidial challenge
Medication	Date Amount Batch number	As per veterinary instruction
Vaccination	Date of vaccination Vaccine type Batch number	Any unexpected vaccine reaction should be recorded
Liveweight	Weekly average liveweight Weekly uniformity (CV%)	More frequent measurement is required when predicting slaughter weight or where growth modification programmes are applied
Feed	Date of delivery Quantity Date of starting withdrawal feed	Accurate measurement of feed consumed is essential to measure FCR and to determine cost effectiveness of a broiler operation
Water	Daily consumption Water to feed ratio Water quality Level of chlorination	Sudden fluctuation in water consumption is an early indicator of problems Mineral and/or bacteriological – especially where bore holes or open water reservoirs are used
Environment	Temperature: daily minimum daily maximum during brooding, 4 to 5 times per day External temperature - daily Relative Humidity – daily Air quality Litter quality	Multiple locations should be monitored Automatic systems should be cross-checked manually each day Dust, CO_2, NH_3
Information from slaughter house	Carcase quality Health inspection Carcase composition	
Cleaning out	Total bacterial counts	After disinfection salmonella, staphyloccus or *E. coli* may be monitored if required

APPENDIX 2 - NUTRITION TABLES

TABLE 29: FEED SPECIFICATIONS FOR AS-HATCHED OR FEMALE BROILERS GROWN TO 1.6-1.8KG (3.5-4.0LB) LIVEWEIGHT AT APPROXIMATELY 35 DAYS

		Starter		**Grower**		**Finisher**	
Age fed	Days	0-10		11-24		25-slaughter	
Crude protein	%	22-25		21-23		19-21	
Energy per kg:	kcal	3010		3175		3225	
	MJ	12.60		13.30		13.50	
AMINO ACIDS		Tot.[1]	Digest[2]	Tot.	Digest	Tot.	Digest
Arginine	%	1.48	1.33	1.31	1.18	1.11	1.00
iso-Leucine	%	0.95	0.84	0.84	0.74	0.71	0.63
Lysine	%	1.44	1.27	1.25	1.10	1.05	0.92
Methionine	%	0.51	0.47	0.45	0.42	0.39	0.36
Methionine + Cystine	%	1.09	0.94	0.97	0.84	0.83	0.72
Threonine	%	0.93	0.80	0.82	0.70	0.71	0.61
Tryptophan	%	0.25	0.22	0.22	0.19	0.19	0.17
Valine	%	1.09	0.94	0.96	0.83	0.81	0.70
MINERALS							
Calcium	%	1.00		0.90		0.85	
Available Phosphorus	%	0.50		0.45		0.42	
Magnesium	%	0.05-0.5		0.05-0.5		0.05-0.5	
Sodium	%	0.16		0.16		0.16	
Chloride	%	0.16-0.22		0.16-0.22		0.16-0.22	
Potassium	%	0.40-0.90		0.40-0.90		0.40-0.90	
ADDED TRACE MINERALS PER KG							
Copper	mg	8		8		8	
Iodine	mg	1		1		1	
Iron	mg	80		80		80	
Manganese	mg	100		100		100	
Molybdenum	mg	1		1		1	
Selenium	mg	0.15		0.15		0.10	
Zinc	mg	80		80		60	
ADDED VITAMINS PER KG		WHEAT BASED FEED	MAIZE BASED FEED	WHEAT BASED FEED	MAIZE BASED FEED	WHEAT BASED FEED	MAIZE BASED FEED
Vitamin A	iu	15000	14000	12000	11000	12000	11000
Vitamin D3	iu	5000	5000	5000	5000	4000	4000
Vitamin E	iu	75	75	50	50	50	50
Vitamin K	mg	4	4	3	3	2	2
Thiamin (B1)	mg	3	3	2	2	2	2
Riboflavin (B2)	mg	8	8	6	6	5	5
Nicotinic Acid	mg	60	70	60	70	35	40
Pantothenic Acid	mg	18	20	18	20	18	20
Pyridoxine (B6)	mg	5	4	4	3	3	2
Biotin	mg	0.20	0.15	0.20	0.15	0.05	0.05
Folic Acid	mg	2.00	2.00	1.75	1.75	1.50	1.50
Vitamin B12	mg	0.016	0.016	0.016	0.016	0.011	0.011
MINIMUM SPECIFICATION							
Choline per kg	mg	1800		1600		1400	
Linoleic acid	%	1.25		1.20		1.00	

Key: Tot.[1] – Total　　Digest[2] – Digestible

NOTES

These feed specifications should be used as a guide. They require adjustment for local conditions and markets. A withdrawal feed should be fed to meet local requirements for drug withdrawal times. This can be formulated to the same standards as the finisher or to a slightly lower specification.

TABLE 30: FEED SPECIFICATIONS FOR AS-HATCHED BROILERS GROWN TO 2.3-2.5KG (5.1-5.5LB) LIVEWEIGHT AT 42-45 DAYS

		Starter		Grower		Finisher	
Age fed	Days	0-10		11-28		29-slaughter	
Crude protein	%	22-25		20-22		18-20	
Energy per kg:	kcal	3010		3175		3225	
	MJ	12.60		13.30		13.50	
AMINO ACIDS		Tot.[1]	Digest.[2]	Tot.	Digest	Tot.	Digest
Arginine	%	1.48	1.33	1.28	1.16	1.07	0.96
iso-Leucine	%	0.95	0.84	0.82	0.72	0.68	0.60
Lysine	%	1.44	1.27	1.23	1.08	1.00	0.88
Methionine	%	0.51	0.47	0.45	0.41	0.37	0.34
Methionine + Cystine	%	1.09	0.94	0.95	0.82	0.80	0.69
Threonine	%	0.93	0.80	0.80	0.69	0.68	0.58
Tryptophan	%	0.25	0.22	0.21	0.18	0.18	0.16
Valine	%	1.09	0.94	0.94	0.81	0.78	0.67
MINERALS							
Calcium	%	1.00		0.90		0.85	
Available Phosphorus	%	0.50		0.45		0.42	
Magnesium	%	0.05–0.5		0.05–0.5		0.05 – 0.5	
Sodium	%	0.16		0.16		0.16	
Chloride	%	0.16-0.22		0.16-0.22		0.16-0.22	
Potassium	%	0.40–0.90		0.40–0.90		0.40–0.90	
ADDED TRACE MINERALS PER KG							
Copper	mg	8		8		8	
Iodine	mg	1		1		1	
Iron	mg	80		80		80	
Manganese	mg	100		100		100	
Molybdenum	mg	1		1		1	
Selenium	mg	0.15		0.15		0.10	
Zinc	mg	80		80		60	
ADDED VITAMINS PER KG		WHEAT BASED FEED	MAIZE BASED FEED	WHEAT BASED FEED	MAIZE BASED FEED	WHEAT BASED FEED	MAIZE BASED FEED
Vitamin A	iu	15000	14000	12000	11000	12000	11000
Vitamin D3	iu	5000	5000	5000	5000	4000	4000
Vitamin E	iu	75	75	50	50	50	50
Vitamin K	mg	4	4	3	3	2	2
Thiamin (B1)	mg	3	3	2	2	2	2
Riboflavin (B2)	mg	8	8	6	6	5	5
Nicotinic Acid	mg	60	70	60	70	35	40
Pantothenic Acid	mg	18	20	18	20	18	20
Pyridoxine (B6)	mg	5	4	4	3	3	2
Biotin	mg	0.20	0.15	0.20	0.15	0.05	0.05
Folic Acid	mg	2.00	2.00	1.75	1.75	1.50	1.50
Vitamin B12	mg	0.016	0.016	0.016	0.016	0.011	0.011
MINIMUM SPECIFICATION							
Choline per kg	mg	1800		1600		1400	
Linoleic acid	%	1.25		1.20		1.00	

Key: Tot.[1] – Total Digest.[2] – Digestible

NOTES

These feed specifications should be used as a guide. They require adjustment for local conditions and markets. A withdrawal feed should be fed to meet local requirements for drug withdrawal times. This can be formulated to the same standards as the finisher or to a slightly lower specification.

TABLE 31: FEED SPECIFICATIONS FOR MALE BROILERS GROWN TO APPROXIMATELY 3KG (APPROXIMATELY 6.6LB) LIVEWEIGHT AT 56-59 DAYS

		Starter		Grower		Finisher 1		Finisher 2	
Age fed	Days	0-10		11-28		29-42		43-slaughter	
Crude protein	%	22-25		20-22		18-20		17-19	
Energy per kg:	kcal	3010		3150		3200		3200	
	MJ	12.60		13.20		13.40		13.40	
AMINO ACIDS		Tot.[1]	Digest.[2]	Tot.	Digest.	Tot.	Digest.	Tot.[1]	Digest.[2]
Arginine	%	1.48	1.33	1.26	1.13	1.07	0.96	1.02	0.92
iso-Leucine	%	0.95	0.84	0.81	0.71	0.68	0.60	0.65	0.57
Lysine	%	1.44	1.27	1.20	1.06	1.00	0.88	0.95	0.84
Methionine	%	0.51	0.47	0.44	0.40	0.37	0.34	0.36	0.33
Methionine + Cystine	%	1.09	0.94	0.94	0.81	0.80	0.69	0.76	0.66
Threonine	%	0.93	0.80	0.79	0.68	0.68	0.58	0.64	0.55
Tryptophan	%	0.25	0.22	0.21	0.18	0.18	0.16	0.18	0.15
Valine	%	1.09	0.94	0.92	0.80	0.78	0.67	0.74	0.64
MINERALS									
Calcium	%	1.00		0.90		0.90		0.85	
Available Phosphorus	%	0.50		0.45		0.45		0.42	
Magnesium	%	0.05–0.5		0.05–0.5		0.05–0.5		0.05 – 0.5	
Sodium	%	0.16		0.16		0.16		0.16	
Chloride	%	0.16-0.22		0.16-0.22		0.16-0.22		0.16-0.22	
Potassium	%	0.40–0.90		0.40–0.90		0.40–0.90		0.40–0.90	
ADDED TRACE MINERALS PER KG									
Copper	mg	8		8		8		8	
Iodine	mg	1		1		1		1	
Iron	mg	80		80		80		80	
Manganese	mg	100		100		100		100	
Molybdenum	mg	1		1		1		1	
Selenium	mg	0.15		0.15		0.10		0.10	
Zinc	mg	80		80		80		60	
ADDED VITAMINS PER KG		WHEAT BASED FEED	MAIZE BASED FEED	WHEAT BASED FEED	MAIZE BASED FEED	WHEAT BASED FEED	MAIZE BASED FEED	WHEAT BASED FEED	MAIZE BASED FEED
Vitamin A	iu	15000	14000	12000	11000	12000	11000	12000	11000
Vitamin D3	iu	5000	5000	5000	5000	4000	4000	4000	4000
Vitamin E	iu	75	75	50	50	50	50	50	50
Vitamin K	mg	4	4	3	3	2	2	2	2
Thiamin (B1)	mg	3	3	2	2	2	2	2	2
Riboflavin (B2)	mg	8	8	6	6	5	5	5	5
Nicotinic Acid	mg	60	70	60	70	35	40	35	40
Pantothenic Acid	mg	18	20	18	20	18	20	18	20
Pyridoxine (B6)	mg	5	4	4	3	3	2	3	2
Biotin	mg	0.20	0.15	0.20	0.15	0.05	0.05	0.05	0.05
Folic Acid	mg	2.00	2.00	1.75	1.75	1.50	1.50	1.50	1.50
Vitamin B12	mg	0.016	0.016	0.016	0.016	0.011	0.011	0.011	0.011
MINIMUM SPECIFICATION									
Choline per kg	mg	1800		1600		1400		1400	
Linoleic acid	%	1.25		1.20		1.00		1.00	

Key: Tot.[1] – Total   Digest.[2] – Digestible

NOTES

These feed specifications should be used as a guide. They require adjustment for local conditions and markets. A withdrawal feed should be fed to meet local requirements for drug withdrawal times. This can be formulated to the same standards as the finisher or to a slightly lower specification. Birds may be reared using a controlled feeding and/or lighting programme to allow optimum bird performance.

TABLE 32: NUTRIENT COMPOSITION OF SOME COMMONLY

	C Prot.	Energy	AMEn	Arginine		iso-Leucine		Lysine		Methionine		Meth + Cyst	
				T*	D*	T	D	T	D	T	D	T	D
	g	MJ	kcal	g	g	g	g	g	g	g	g	g	g
BARLEY	107	11.7	2790	5.2	4.4	3.6	2.9	3.7	2.9	1.8	1.4	4.1	3.3
MAIZE	87	13.7	3275	4.0	3.6	2.9	2.6	2.6	2.1	1.9	1.7	3.7	3.4
WHEAT	119	12.7	3020	5.7	4.9	3.9	3.5	3.3	2.7	1.9	1.6	4.6	4.0
SORGHUM	101	13.5	3215	3.9	3.1	3.9	3.5	2.3	1.8	1.7	1.5	3.6	3.0
OATS	112	11.0	2620	7.1	6.7	4.0	3.5	4.4	3.8	1.8	1.6	5.0	4.3
MAIZE GLUTEN FEED	209	8.0	1915	8.8	7.7	6.0	4.9	6.3	4.9	3.5	2.9	8.0	6.0
MAIZE GLUTEN MEAL	607	14.9	3565	18.8	17.8	24.0	22.8	9.8	8.7	14.5	13.7	25.3	23.3
WHEATFEED/MIDDLINGS	156	7.6	1825	9.8	8.7	4.7	3.7	5.9	4.9	2.4	1.8	5.6	4.2
WHEAT BRAN	150	6.2	1475	9.9	8.2	4.5	3.6	5.8	4.3	2.2	1.8	5.3	4.1
RICE BRAN RAW	129	9.9	2370	9.9	8.4	4.5	3.4	5.7	4.2	2.6	2.0	5.4	3.9
RICE BRAN EXT.	147	6.8	1610	5.2	4.5	10.3	7.6	6.6	4.8	2.9	2.2	5.9	4.2
FIELD BEANS (white)	300	11.2	2665	25.9	24.1	11.8	10.2	18.5	16.3	2.1	1.6	5.9	4.4
PEAS	227	11.4	2715	19.0	17.5	9.1	8.3	16.1	14.8	2.2	1.8	5.4	4.1
SOYABEANS, HEATED	356	14.4	3450	26.0	22.6	16.0	13.9	21.6	19.0	4.9	4.2	10.5	8.7
SOYABEAN MEAL, 48	473	9.3	2230	34.0	32.6	20.9	19.4	28.0	25.5	6.4	5.9	13.4	11.8
SUNFLOWER MEAL, 39	386	6.7	1600	31.6	28.8	15.8	14.2	13.6	11.6	8.7	7.5	15.3	12.0
RAPE/CANOLA MEAL	343	7.1	1700	20.2	18.2	13.3	11.0	18.2	14.6	6.9	6.1	15.0	12.2
FISH MEAL 66	660	13.6	3250	37.8	34.8	27.0	24.9	49.5	44.0	18.3	16.8	24.3	21.2
HERRING MEAL	706	14.1	3360	40.3	37.0	29.8	27.4	54.3	48.3	20.5	18.8	26.8	23.3
MEAT & BONE MEAL**	538	12.6	3000	36.7	29.8	16.0	13.0	27.8	21.8	7.8	6.4	13.6	9.7

T = Total amino acid content; D* = Digestible amino acid content*

NOTES

These data are given as a rough guide. Local information on the composition of raw materials should ALWAYS be used in preference.

Data are based on information published by Degussa AG; CVB, Netherlands; National Research Council, USA.

***Meat and Bone Meal is a very variable product and is increasingly excluded from broiler feeds on the grounds of biosecurity. Data relate to a sample with 54% protein, 14% fat and 23% ash.*

USED FEED INGREDIENTS (PER KILOGRAM)

	Threonine T	Threonine D	Tryptophan T	Tryptophan D	Valine T	Valine D	Ca	Av.P	Na	Cl	K	Choline	Linoleic acid	Dry Matter
	g	g	g	g	g	g	g	g	g	g	g	mg	g	g
BARLEY	3.6	2.7	1.3	0.9	5.2	4.2	0.6	1.4	0.1	1.0	4.8	990	8.6	880
MAIZE	3.1	2.6	0.7	0.6	4.0	3.5	0.3	0.9	0.1	0.5	3.6	620	18.8	880
WHEAT	3.4	2.8	1.4	1.3	5.0	4.3	0.7	1.3	0.1	0.4	4.2	1000	6.8	880
SORGHUM	3.3	2.6	1.1	1.0	5.0	4.3	0.4	0.9	0.1	0.7	3.8	660	12.2	880
OATS	3.7	3.1	1.6	1.2	5.5	4.8	1.1	1.7	0.1	0.7	4.7	950	16.8	880
MAIZE GLUTEN FEED	7.5	5.6	1.4	1.2	10.0	8.3	1.2	3.7	2.4	2.1	12.6	1510	17.2	890
MAIZE GLUTEN MEAL	20.4	18.7	3.3	2.7	27.4	26.0	0.4	1.8	0.1	0.5	1.6	330	16.3	890
WHEATFEED/MIDDLINGS	4.9	3.7	2.2	1.8	7.0	5.0	1.0	2.9	0.3	0.3	13.7	1440	14.0	870
WHEAT BRAN	4.7	3.5	2.2	1.8	6.8	5.3	1.9	3.5	0.4	1.3	12.5	1230	14.0	870
RICE BRAN RAW	4.8	3.3	1.7	1.3	7.0	5.2	1.0	2.5	0.1	0.4	10.6	1130	38.5	890
RICE BRAN EXT.	5.4	3.7	1.8	1.4	7.9	5.9	1.4	2.8	0.2	0.7	12.1	1230	3.6	890
FIELD BEANS (white)	10.2	9.0	2.6	2.1	13.2	11.0	1.1	2.3	0.2	0.7	13.4	1670	5.2	870
PEAS	8.4	7.1	2.1	1.8	10.4	9.1	1.1	1.8	0.1	0.6	11.0	642	4.0	870
SOYABEANS, HEATED	14.0	11.9	4.8	3.5	17.1	14.7	2.3	2.2	0.1	0.3	17.6	2860	97.0	880
SOYABEAN MEAL, 48	18.1	16.3	6.2	5.4	22.1	20.1	2.7	2.7	0.2	0.3	22.6	2730	7.0	870
SUNFLOWER MEAL, 39	14.1	10.5	5.1	4.1	19.3	16.3	3.7	2.9	0.3	1.2	14.7	2890	6.8	900
RAPE/CANOLA MEAL	14.8	22.9	4.5	3.7	17.5	14.6	7.3	3.6	0.3	0.3	12.6	6700	3.1	880
FISH MEAL 66	27.2	24.5	7.1	6.3	32.3	29.7	34.9	17.6	10.3	15.8	10.0	3050	0.1	910
HERRING MEAL	30.1	27.1	7.7	6.8	35.6	32.8	26.4	15.5	10.3	16.2	13.9	5300	0.1	910
MEAT & BONE MEAL**	18.3	14.0	3.7	2.8	24.8	19.9	73.3	22.6	7.6	6.3	4.8	1900	8.1	940

TABLE 33: QUALITY FEATURES FOR FEED INGREDIENTS

Ingredient	Quality Feature	Notes
CEREALS	Mycotoxins Contaminants, weed seeds	
Maize	Mycotoxins	
Wheat	Viscosity (soluble NSP*) Ergot contamination	Modified by enzymes
Barley	Beta glucans	Modified by enzymes
Sorghum	Tannins	
Rice	Trypsin inhibitor	Heating effective
CEREAL BY-PRODUCTS	Freshness	
ROOT CROPS	Contamination	
Tapioca	Cyanide levels	
LEGUME SEEDS		
Peas	Tannins	Use white-flowered varieties De-hulling effective
	Protease inhibitors	Select suitable varieties Heating effective
Beans, faba	Tannins	Use white-flowered varieties De-hulling effective
Beans, phaseolus	Lectins	Heating effective
Lupin seed	Glycosides	Use 'sweet' varieties only
OIL SEEDS	Stability of oil content	
Toasted soya beans	Urease levels Trypsin inhibitors Fat digestibility	Ensure proper processing
Rape seed	Glucosinolates	Use low erucic acid, low glucosinolate varieties only
OIL SEED MEALS		
Soya bean meal	As for soya beans	Use soya 49 if possible
Rapeseed meal	Glucosinolates	Double zero varieties only
Sunflower meal	'Fibre' (hull removal)	Use decorticated meals
Cottonseed meal	Gossypol	Iron addition can be used
ANIMAL PRODUCTS	Microbial quality Amino acid availability	Proper processing is essential
Meat & bone meals	Calcium/phosphorus level Fat content	Saturated fatty acid levels
Poultry by-product meals	Pathogen control Feather content	
Feather meals	Amino acid availability	Proper processing is essential
Fish meals	Gizzerosine	Causes gizzard erosion
Fats and Oils	See Table 12, page 49	

**NSP: non-starch polysaccharides.*

TABLE 34: INCLUSION LIMITS FOR SOME COMMON FEED INGREDIENTS IN BROILER FEEDS

Ingredient	Starter		Grower	Finisher	
	Lower limit %	Upper limit %	Upper limit %	Upper limit %	Notes
CEREALS					
Maize					
Wheat	15	50	50	50	Lower limit for pellet quality
Barley		10	20	25	Use enzymes
Sorghum		50	50	50	Depends on tannin level
Rice		15	15	15	
BY-PRODUCTS AND ROOTS					
Wheat bran/middlings		10	15	15	
Rice bran		5	10	15	
Maize gluten feed		5	10	15	
Molasses		5	5	5	
Tapioca		5	10	20	
LEGUMES					
Peas		5	15	20	Suitable variety
Beans, faba		5	10	10	Suitable variety
Beans, phaseolus					
Lupin seed		5	15	20	White or yellow flowering varieties
OIL SEEDS AND MEALS					
Full fat rapeseed		2.5	5	7.5	
Full fat soya bean		15	20	20	Control total fat level
Soya bean meal	10	25	25	25	If higher levels, use different sources
Sunflower meal		5	10	15	Depends on fibre content
Cottonseed meal		0	5	10	
ANIMAL MEALS					
Meat meals		8	10	15	
Fish meals	5	10	10	5	Subject to availability/cost
Feather meal		0	5	5	
FATS AND OILS					
Tallow/lard etc.		0	3	5	Depends on age of bird
Vegetable fats	1	5	5	7	Minimum for pelleting and dustiness

TABLE 35: PERCENTAGE LOSS OF VITAMINS IN BROILER FEEDS STORED IN DIFFERENT CONDITIONS

Vitamin	Form	Type of Premix	Ideal Conditions		Premix Stored		Premix & Feed Stored	
			Mash	Pellets	Mash	Pellets	Mash	Pellets
A	Beadlet A/D[3]	V[1]	3	8	4	9	11	16
		VM[2]	4	9	8	13	15	19
		VMC[3]	5	10	12	17	19	23
D3	Beadlet A/D3	V	2	8	3	9	11	17
		VM	2	9	5	11	13	18
		VMC	3	9	9	15	17	22
E	Acetate	V	1	7	1	7	4	10
		VM	1	7	4	10	7	13
		VMC	1	7	7	13	10	16
K	MSBC[4]	V	7	35	8	36	26	49
		VM	12	39	22	46	37	56
		VMC	12	39	33	53	46	62
B1	Thiamin HCl	V	3	17	4	18	15	27
		VM	8	21	24	35	33	42
		VMC	8	39	30	40	38	47
B2	Riboflavin	V	1	10	1	10	7	16
		VM	1	10	5	14	11	19
		VMC	3	12	8	17	14	22
B6	Pyridoxine	V	3	13	3	13	9	19
		VM	4	14	8	18	14	23
		VMC	6	16	13	22	19	27
Pantothenic Acid	Calcium Pantothenate	V	1	10	1	10	6	15
		VM	1	10	1	10	6	15
		VMC	2	11	13	21	18	25
Biotin		V	3	13	3	13	10	20
		VM	4	14	7	17	14	23
		VMC	6	16	13	22	20	28
Folic Acid		V	1	11	1	11	3	13
		VM	2	12	6	16	8	16
		VMC	3	13	16	25	18	26
Niacin	Nicotinic Acid	V	4	13	4	13	12	20
		VM	6	15	10	18	18	25
		VMC	6	15	13	21	20	28
Vitamin C	Ascorbic Acid	V	11	56	14	57	39	70
		VM	16	58	37	69	55	78
		VMC	16	58	37	69	55	78
Vitamin C	Protected	V	5	27	7	29	25	42
		VM	8	30	18	37	34	49
		VMC	8	30	27	44	41	55
Choline	Choline chloride	V	-	-	-	-	-	-
		VM	-	-	-	-	-	-
		VMC	-	-	-	-	1	4
Storage Conditions:								
Vitamin storage			0 days		0 days		0 days	
Premix storage; 15°C (59°F), 60%RH			14 days		56 days		56 days	
Feed storage; 20°C, 60%RH			7 days		7 days		28 days	

Key: V[1] - Vitamins VM[2] - Vitamins and Minerals VMC[3] - Vitamins, Minerals and Choline
MSBC - Menadione Sodium Bisulphite Complex
Data are based on information published in the BASF Vitamin Stability Estimation Programme

APPENDIX 3 - CONVERSION TABLES

Length

1 metre (m)	= 3.281 feet (ft)
1 foot (ft)	= 0.305 metre (m)
1 centimetre (cm)	= 0.394 inch (in)
1 inch (in)	= 2.54 centimetres (cm)

Area

1 square metre (m^2)	= 10.76 square feet (ft^2)
1 square foot (ft^2)	= 0.093 square metre (m^2)

Volume

1 litre (l)	= 0.22 gallon (gal)
1 imperial gallon (gal)	= 4.54 litres (l)
1 imperial gallon (gal)	= 1.2 US gallons (gal US)
1 cubic metre (m^3)	= 35.31 cubic feet (ft^3)
1 cubic foot (ft^3)	= 0.028 cubic metre (m^3)

Weight

1 kilogram (kg)	= 2.205 pounds (lb)
1 pound (lb)	= 0.454 kilogram (kg)
1 gram (g)	= 0.035 ounce (oz)
1 ounce (oz)	= 28.35 grams (g)

Energy

1 calorie (cal)	= 4.184 Joules (J)
1 Joule (J)	= 0.239 calories (cal)
1 kilocalorie per kilogram (kcal/kg)	= 4.184 Megajoules per kilogram (MJ/kg)
1 Megajoule per kilogram (MJ/kg)	= 108 calories per pound (cal/lb)
1 Joule (J)	= 0.735 foot pound (ft lb)
1 foot pound (ft lb)	= 1.36 Joules (J)
1 Joule (J)	= 0.00095 British thermal unit (Btu)
1 British thermal units (Btu)	= 1055 Joules (J)

Pressure

1 pound per square inch (psi)	= 6895 Newtons per square metre (N/m^2) or Pascals (Pa)
1 pound per square inch (psi)	= 0.06895 bar
1 bar	= 14.504 pounds per square inch (psi)
1 bar	= 10^5 Newtons per square metre (N/m^2) or Pascals (Pa)
	= 100 kilopascals (kPa)
1 Newton per square metre or Pascal (N/m^2)	= 0.000145 pound per square inch (lb/in^2)

Stocking Density

1 square foot per bird (ft^2/bird)	=	10.76 birds per square metre (bird/m^2)
10 birds per square metre (bird/m^2)	=	1.08 square feet per bird (ft^2/bird)
15 birds per square metre (bird/m^2)	=	0.72 square feet per bird (ft^2/bird)
20 birds per square metre (bird/m^2)	=	0.54 square feet per bird (ft^2/bird)
1 kilogram per square metre (kg/m^2)	=	0.205 pound per square foot (lb/ft^2)
15 kilograms per square metre (kg/m^2)	=	3.08 pounds per square foot (lb/ft^2)
34.2 kilograms per square metre (kg/m^2)	=	7.01 pounds per square foot (lb/ft^2)
40 kilograms per square metre (kg/m^2)	=	8.20 pounds per square foot (lb/ft^2)

Temperature

Temperature (°C) = 5/9 (Temperature °F - 32)
Temperature (°F) = 32 + 9/5 (Temperature °C)

TABLE 36: TEMPERATURE CONVERSION CHART

°C	°F	°C	°F
0	32.0	22	71.6
2	35.6	24	75.2
4	39.2	26	78.8
6	42.8	28	82.4
8	46.4	30	86.0
10	50.0	32	89.6
12	53.6	34	93.2
14	57.2	36	96.8
16	60.8	38	100.4
18	64.4	40	104.0
20	68.0		

Operating Temperature

Operating temperature is defined as the minimum house temperature plus $^2/_3$ of the difference between minimum and maximum house temperatures. It is important where there are significant diurnal temperature fluctuations.

e.g. Minimum house temperature 16°C (61°F).
Maximum house temperature 28°C (82°F).

Operating Temperature (Centigrade) = [(28-16) x $^2/_3$] + 16 = 24°C

Operating Temperature (Fahrenheit) = [(82-61) x $^2/_3$] + 61 = 75°F

Ventilation

1 cubic foot per minute (ft^3/min) = 1.699 cubic metres per hour (m^3/hour)
1 cubic metre per hour (m^3/hour) = 0.589 cubic foot per minute (ft^3/min)

Insulation

U value measured in Watts per square metre per degree Centigrade (W/m^2/°C)

Light

1 foot candle = 10.76 lux

A simple formula to calculate the number of lamps required for a broiler house is as follows:

$$\text{*Number of Lamps} = \frac{\text{Floor area } (m^2) \times \text{max. lux required}}{\text{wattage of lamp} \times \text{K factor}}$$

K factor depends on lamp wattage as shown in Table 38:

TABLE 37: LAMP WATTAGE AND K FACTORS

POWER OF LAMP (Watts)	K FACTOR
15	3.8
25	4.2
40	4.6
60	5.0
100	6.0

** This formula is for tungsten bulbs at a height of 2 metres above bird level. Fluorescent lights provide 3 to 5 times the number of lux per Watt as tungsten bulbs.*

APPENDIX 4 - USEFUL TABLES & EFFICIENCY CALCULATIONS

TABLE 38: EUROPEAN EFFICIENCY FACTOR (EEF)

$$\frac{\text{Liveability} \times \text{Liveweight in kg}}{\text{Age in days} \times \text{FCR}} \times 100$$

e.g	Age 42 days, liveweight 2089g Mortality 4.89%, FCR 1.71	**e.g**	Age 46 days, liveweight 2360g Mortality 5.71%, FCR 1.78
	$\frac{95.11 \times 2.089}{42 \times 1.71} \times 100 = 277$		$\frac{94.29 \times 2.360}{46 \times 1.78} \times 100 = 272$

Note: *The higher the value the better the technical performance. Used extensively in certain European countries to compare flocks within an integration or country. Cannot be used to compare performances between countries.*

TABLE 39: MINIMUM & MAXIMUM VENTILATION RATES AT VARYING LIVEWEIGHTS

Liveweight (kg)	Ventilation Rate (m^3/hour)		Liveweight (kg)	Ventilation Rate (m^3/hour)	
	minimum	maximum		minimum	maximum
0.050	0.074	0.761	1.800	1.091	11.189
0.100	0.125	1.280	1.900	1.136	11.652
0.150	0.169	1.735	2.000	1.181	12.109
0.200	0.210	2.153	2.100	1.225	12.560
0.250	0.248	2.546	2.200	1.268	13.006
0.300	0.285	2.919	2.300	1.311	13.447
0.350	0.319	3.276	2.400	1.354	13.883
0.400	0.353	3.621	2.500	1.396	14.315
0.450	0.386	3.956	2.600	1.437	14.742
0.500	0.417	4.281	2.700	1.479	15.165
0.550	0.448	4.598	2.800	1.520	15.585
0.600	0.479	4.908	2.900	1.560	16.000
0.650	0.508	5.212	3.000	1.600	16.412
0.700	0.537	5.510	3.100	1.640	16.821
0.750	0.566	5.803	3.200	1.680	17.226
0.800	0.594	6.090	3.300	1.719	17.629
0.850	0.621	6.374	3.400	1.758	18.028
0.900	0.649	6.653	3.500	1.796	18.424
0.950	0.676	6.928	3.600	1.835	18.817
1.000	0.702	7.200	3.700	1.873	19.208
			3.800	1.911	19.596
1.100	0.754	7.734	3.900	1.948	19.982
1.200	0.805	8.255	4.000	1.986	20.365
1.300	0.855	8.766	4.100	2.023	20.745
1.400	0.904	9.267	4.200	2.060	21.124
1.500	0.951	9.759	4.300	2.096	21.500
1.600	0.999	10.243	4.400	2.133	21.874
1.700	1.045	10.719	4.500	2.169	22.245

Source: UK Agricultural Development and Advisory Service.

Notes:

For further explanation see Housing and Environment, Section 6, page 81.

Minimum ventilation rate is the quantity of air required per hour to supply sufficient oxygen to the birds and maintain air quality.

Minimum ventilation rate = 1.95×10^{-4} $m^3/sec/kg^{0.75}$

Maximum ventilation rate in controlled environment sheds in temperature climates is the quantity of air required per hour to remove metabolic heat such that the temperature within the building is maintained at not greater than 3°C (5.4°F) above external temperature.

Maximum ventilation rate = 2.00×10^{-3} $m^3/sec/kg^{0.75}$

Maximum ventilation rates will be exceeded when cooling birds using convective heat loss eg. tunnel ventilation.

Source: UK Agricultural Development and Advisory Service

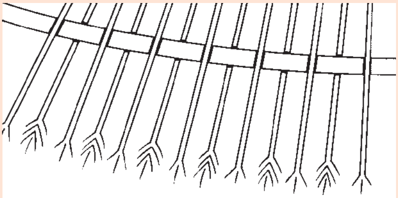
APPENDIX 5 - FEATHER SEXING

Identification of males and females at day old may be accomplished easily at the hatchery as most strains of Ross Broiler are feather sexable. In feather sexable broilers, fast feathering chicks are female, slow feathering chicks are male. The type of feathering is identified by observing the relationship between coverts (upper layer) and the primaries (lower layer) which are found on the outer half of the wing.

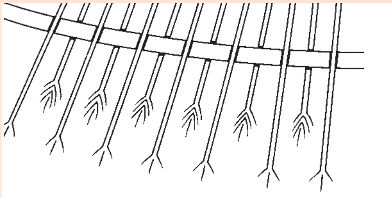
MALE CHICKS

In the slow feathering male chick the primaries are the same length or shorter than the coverts.

DIAGRAM 21: ROSS MALE BROILER CHICK WING FEATHERS



Same length primaries

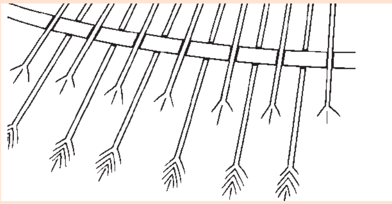


Shorter primaries

FEMALE CHICKS

In the fast feathering female chick the primaries are longer than the coverts.

DIAGRAM 22: ROSS FEMALE BROILER CHICK WING



Longer primaries

APPENDIX 6 - PROBLEM SOLVING

TABLE 40: QUICK REFERENCE

Problem	Possible causes	Action
High Early Mortality (>1% in first week)	Poor chick quality	Check hatchery practice and egg hygiene Check chick transport
	Incorrect brooding	Re-adjust brooders
	Disease	Post mortems on dead chicks, take veterinary advice
High Mortality (post 7 days)	Metabolic diseases (Ascites, Sudden Death Syndrome)	Check ventilation rates Check feed formulation Avoid excessive early growth rates Check hatchery ventilation
	Infectious diseases	Establish cause (*post mortem*) Take veterinary advice on medication and vaccination
	Leg problems	Check calcium, phosphorus and vitamin D3 levels in diet Use lighting programmes to increase bird activity
Poor Early Growth and Uniformity	Nutrition	Check starter ration - availability and quality Check water supply - availability and quality
	Chick quality	Check hatchery procedures: Egg hygiene, storage, incubation conditions hatch time, transport time and conditions
	Environmental conditions	Check temperature and humidity profiles Check daylength Check air quality - CO_2, dust, minimum ventilation rate
	Appetite	Check poor stimulation of appetite - low proportion of birds with full crops
Poor Late Growth and Uniformity	Low nutrient intake	Check feed quality and formulation Check feed intake and accessibility Excessive early restriction Lighting programme too restrictive
	Infectious disease	See **High Mortality**
	Environmental conditions	Check ventilation rates Check stocking density Check house temperatures Check water and feed availability
Poor Litter Quality	Nutrition	Poor quality fats in diet Excess salts in diet Excess protein in diet
	Environment	Insufficient litter depth at start Inappropriate litter material Drinker design and adjustment (spillage problems) Humidity too high Stocking density too high Insufficient ventilation
	Infectious disease	Causing enteritis, take veterinary advice

Problem	Possible causes	Action
Poor Feed Conversion	Poor growth	See **Poor Early Growth, Poor Late Growth**
	High mortality (esp. late mortality)	See **High Mortality**
	Feed wastage	Check settings/adjustments of feeders Allow birds to clear feeders twice daily
	Environment	Check house temperature is not too low
	Infectious disease	See **High Mortality**
	Nutrition	Check feed formulation and quality
Poor Feather Cover	Environment Nutrition	Check house temperature is not too high Check ration for methionine and cystine content and balance
Factory Downgrading	Ascites	See **High Mortality**
	Blisters and burns (e.g. Hockburn)	Check stocking density Check litter quality Increase bird activity (e.g. feeding or lighting programmes)
	Bruises and breaks	Check handling procedures at weighing and catching
	Scratching	Excessive light stimulation Check handling procedures at weighing and catching Check access to feed and water
	Oregon Disease (Deep Muscular Myopathy)	Birds excessively disturbed during growth e.g. at partial depletion (thinning), weighing etc. Poor feed distribution.
	Excessive fatness	Check nutritional balance of diet Check house temperature not too high

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