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CARIBBEAN POULTRY INDUSTRY INTEGRATED IMPROVEMENT PROGRAM

BROILER FARM PRODUCTION MANUAL

December 2004

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CARIBBEAN POULTRY ASSOCAITION
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Foreword

As CARICOM moves towards increased trade liberalization under the Caribbean Single Market and Economy (CSME) and the Free Trade Areas of the Americas (FTAA), Caribbean Poultry Association members will need the need to address the challenge of improving competitiveness more aggressively. While the region already faces the threat of injury from US leg-quarters which are sold onto the world market below the cost of production, the FTAA will bring new competition from low cost producers in South America such as Brazil and from value added producers such as Panama and Costa Rica.

In response to this CARICOM has been advocating for sensitive treatment of the poultry industry to afford our producers more time to improve competitiveness and to secure our food, nutrition and rural livelihood security. CPA members must make use of this time to embrace cutting-edge marketing and production technology, adopt industry best management practices in order to be competitive and maintain profitability.

Already several of our members have shown that it is possible for us to achieve international competitiveness in areas which are not scale dependant. Two of these, Jamaica Broilers and Chickmont Foods, who subscribe to Agristats, the largest international poultry industry benchmarking service, are able to achieve farm performances (FCR, mortality, live weight gains), which frequently ranks them in the top 10% of the database through the use of modern technology and management in their broiler operations.

This manual is intended to help more Caribbean broiler farmers to meet these standards. It is meant to provide producers with a core of modern production practices, around which national and company specific programs can be developed. It is designed as a living manual, which needs to be updated periodically by additions by producers from sources such as the internet sites provided in the manual. For these purposes, it is therefore recommended that it be reproduced and distributed in binder format to facilitate easy modification and addition.

We wish to thank some of the leading Caribbean integrators - Best Dressed Chicken, Pinnacle Feeds, Arawak & Co., and the international breeders - Cobb-Vantress Inc, and the Lohmann Group them making their reference guides available as the basis for this manual.

We wish to acknowledge the support of the Canadian International Development Agency – Caribbean Program for Economic Competitiveness (CIDA-CPEC) Program who provided the funding for the development and review of this developing this manual.

We encourage our member associations to distribute this manual to all our producers and to encourage them to participate the in the national poultry production seminars and annual regional CPA Poultry Production Schools where the best practices in this manuals can be taught and updated.

Robin Phillips
President, Caribbean Poultry Association, December 2004

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Abbreviations

FCR	Feed Conversion Ratio
ADG	Average Daily Gain

GENERAL MANAGEMENT

CHICK QUALITY

Good quality chicks are uniform in size and have navels which have healed. They are active immediately on release from the boxes and will spread out evenly in a well prepared environment.

Broiler performance and profitability are dependent on attention to detail throughout the entire breeding and production processes. Top quality broiler chicks will result when parent stock has been managed correctly, attention has been paid to good hatchery practice and chicks have been delivered carefully. Broiler chick quality is influenced at each of these earlier stages.

Placement of broiler chicks should be planned to ensure that at the parent stage:

• Differences in age and/or immune status of parent flocks are minimised. One parent flock per broiler flock is the ideal. For large farm complexes, one production house could be considered to be one “flock”.

• Vaccination of parent stock maximizes maternal antibody protection in the offspring against immunosuppressive diseases (e.g. Infectious Bursal Disease (IBD), Chick Anemia Virus, Reovirus).

• Time at which eggs are set is adjusted according to differences in parent flock age. This minimizes time between hatching and delivery of chicks.

The hatchery and transport systems should provide optimum conditions for chicks as illustrated in Table 1.

CHICK PLACEMENT

Before Arrival:

• Ideally, all sites should be single age (i.e. all in-all out).

• Houses, the surrounding areas and all equipment should be thoroughly cleaned and disinfected.

TABLE 1: SUMMARY OF OPTIMUM CONDITIONS - CHICK HOLDING AND TRANSPORT

Chick holding conditions	24°C Ambient Temperature 50% Relative Humidity (RH) 1.42m³/min per 1000 chicks Air Exchange
Transport conditions	24°C Ambient Temperature 50% Relative Humidity (RH) 1.42m³/min 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.

• Expected delivery time of chicks should be confirmed so that there is no possibility of delay in unloading boxes. The longer the chicks remain in transport boxes, the greater the degree of dehydration. This may result in early mortality and reduced growth potential.

• All equipment must be checked to see that it is in good working order.

• Litter material should be spread evenly to a depth of 3-10cm and then leveled and compacted in the brooding area.

• The rodenticide program should be in operation prior to chick arrival.

• Equipment must be assembled in the appropriate configuration:

– Configuration will depend on the brooding system and on other equipment being used.

– Feeders, drinkers, brooders and fans should be arranged to allow chicks to maintain body temperature without dehydration and to find feed and water easily.

– Supplementary feeders and drinkers should be placed in close proximity to the main systems.

• Houses should be pre-heated to achieve target house and litter temperatures, 24 hours prior to arrival of chicks. See Table 2. Temperature should be monitored regularly to ensure that a uniform environment exists throughout the whole brooding area.

• Drinker lines should be flushed and sanitized prior to bird arrival. Water should be within the correct temperature range (i.e. 10-12ºC).

• Feeders should be filled and checked to ensure good delivery.

• Supplemental feeders should be filled and placed in the brooding area in a proper ratio (e.g. with box lids – 12/1000 chicks).

• Supplementary drinkers, such as mini-drinkers or “Easy Fills”, should also be available at 12/1000 chicks. They should be placed evenly throughout the house so that no chick will be more than 2m from water.

• Light intensity and duration should be set at 20 lux and 23 hours respectively.

After Arrival:

• Chicks should be grouped by parent age wherever possible.

• Chick boxes should be carefully unloaded and distributed evenly throughout the house. They should not be stacked.

• Chicks must be tipped quickly, gently and evenly over the brooding area. The empty boxes should be removed from the house as soon as possible.

• All chicks must be able to eat and drink immediately on placement in the house.

• During the early brooding period, feed should be provided in crumble form on supplemental feeders (12/1000 chicks) so that chicks have easy access.

• Chicks should be left to settle for 1-2 hours to become accustomed to their new environment.

• After 1-2 hours, a check should be made to see that all chicks have easy access to feed and water and that they are active and spreading uniformly throughout the house. Adjustments should be made to equipment and temperatures where necessary.

• Checks should be made every 4-6 hours, throughout the first 24 hours, paying particular attention to ventilation, temperature, feeding and drinking equipment. Chick behaviour is an indicator of whether or not problems exist.
• From 2-3 days of age, permanent feeders and drinkers should be repositioned and adjusted and additional ones introduced as the illuminated area is increased.
• On day 7, one third to one half of the supplemental drinkers should be removed and the balance should be removed at 10 days of age.
• On each of days 8, 9 and 10, one third of the supplemental feeders should be removed. Chicks should be gradually trained to the main feeding system within the first 10 days of placement.

EVALUATION OF GROWTH DURING BROODING

Genetic gains in growth rate mean that broilers are achieving market weights at an earlier age and as a result, the brooding period occupies a greater proportion of the life of the flock. It is now accepted that liveweight at 7 days is highly correlated to liveweight at market age. It is strongly recommended that a sample of each flock be weighed at 7 days to evaluate growth performance and that this be compared with targets for the product. Weighing scales, which are capable of weighing in increments of 1g, should be used. Minimum sample size should be 50-60 birds. Samples should be taken from at least 3 separate areas of the house. See L.I.R. Broiler Production Targets. A general guide would be a 7-day target weight of 4 x day old chick weight. Average weights below 140g indicate a problem and should prompt immediate investigation.

BROODER MANAGEMENT

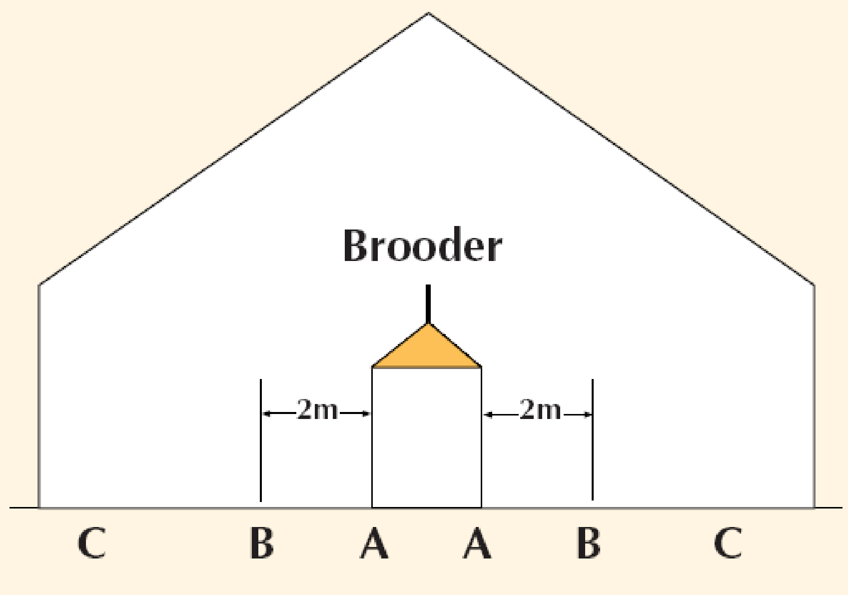
Chick behaviour is an obvious and immediate indicator of correct brooder temperature.
There are 2 systems of brooding broiler chickens:
–Spot Brooding
–Whole House Brooding

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%.*

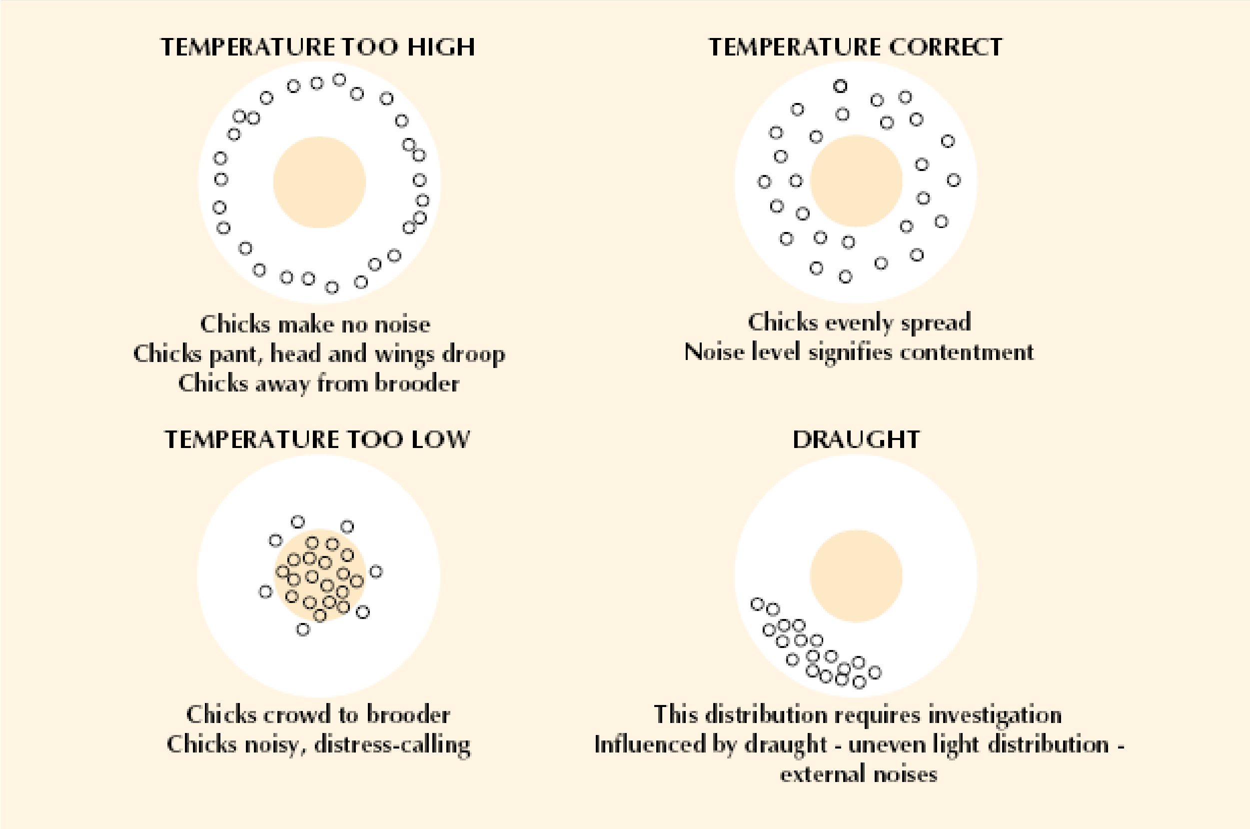
DIAGRAM 2: SPOT BROODING - AREAS OF TEMPERATURE GRADIENTS



Spot Brooding is where heat is provided by conventional canopy brooders with heat lamps. For maximum effectiveness, brooder surrounds should be used to confine birds to the desired area of heat, feed and water. Correct temperature is indicated by chicks being evenly spread throughout the brooding area.

See Diagram 3.

DIAGRAM 3: BIRD DISTRIBUTION UNDER BROODERS



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 4 illustrates the typical layout of whole house broodingsystems.

As with spot brooding, chick behaviour is a good indicator of correct temperature. Diagram 5 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 drinking and feeding by the birds. As with spot brooding, chick noise is an excellent indicator of comfort level.

DIAGRAM 4: TYPICAL LAYOUT OF A WHOLE HOUSE BROODING SYSTEM

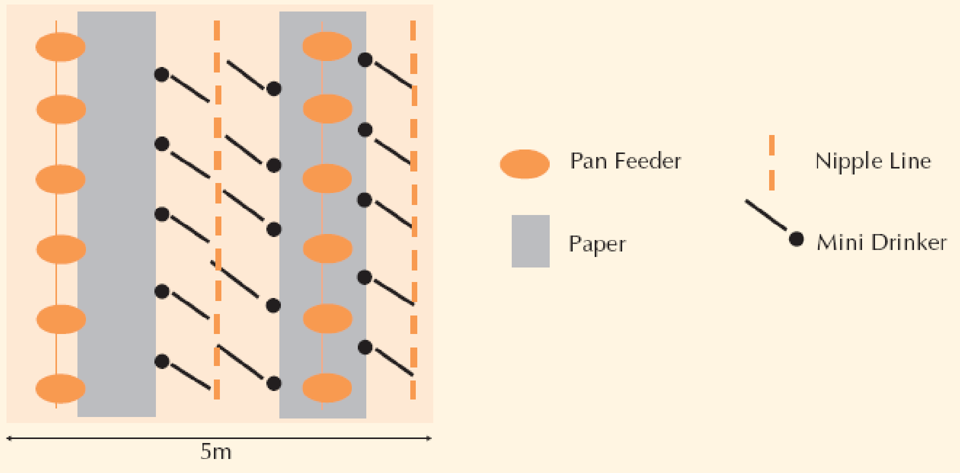
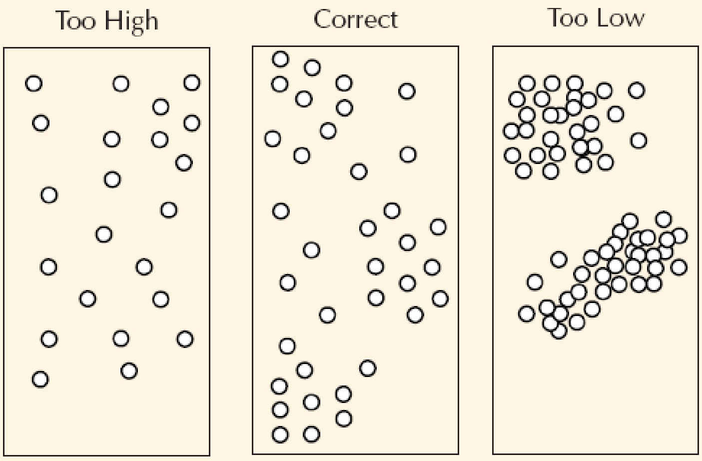


DIAGRAM 5: TYPICAL BEHAVIOUR OF CHICKS IN WHOLE HOUSE BROODING AT DIFFERENT TEMPERATURES



LITTER MANAGEMENT

Litter material, when laid in sufficient depth, provides a layer of insulation between the chicks and the cold concrete of the house floor. Litter is important for the well-being of young chicks because it creates a comfortable environment at chick level.

Litter absorbs moisture from the droppings and from spillage around drinking systems. If this is excessive, however,wet litter can result. This increases downgrading at processing through breast blisters, hock burns and ammonia burns on the skin. Increased concentrations of ammonia in the house caused by wet litter can impair the immune system of the birds.

Advantages and Disadvantages of Various Litter Materials

Shavings

Shavings from softwoods, which include only small amounts of sawdust make good litter. Shavings generally have a high water absorption capacity. Residues from chemical treatments can sometimes be harmful to birds or cause skin discolouration.

Paper

The only form of shredded paper suitable for litter is that with a high water absorption capacity. Wet litter from paper is difficult to manage. Brightly coloured paper should not be used as residues from printing colours may be harmful to the birds.

Sand

Sand has little or no capacity for insulation from the cold of the floor. Sand should therefore only be used as litter material when the floor is warm, (i.e. in warm climates). Loose sand can make movement around the house difficult for the birds.

Rice Hulls

The water absorption capacity of rice hulls is poor. It is therefore necessary to replenish them frequently, to avoid a build up of wet litter.

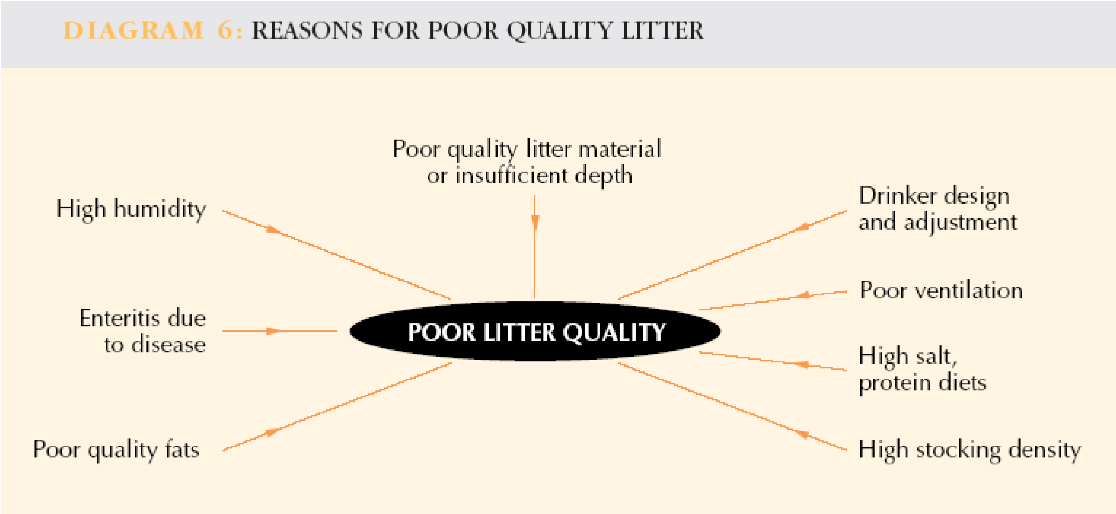
Factors Affecting Litter Quality

There are various factors which can affect the quality of litter and therefore influence the health,well-being and productivity of broiler chickens.

Litter Moisture: Litter moisture is affected by drinker design, air change rate, litter material and its depth, stocking density, diet and flock health.

Nipple or cup drinker systems can reduce litter moisture by up to 7%, provided that they are at the correct height.

Nutritional factors known to influence litter moisture are amounts of sodium and chloride in the diet. Potassium, which is derived from the feed ingredients molasses, manioc and soyabean meal, is also important, as are excess protein and amino acid imbalances.



Greasy Capped Litter: Excess fat and/or fat of poor quality in the feed can increase the fat content of the litter. This reduces its water absorption capacity. A cap forms on the litter,which can cause bruising and lesions on the birds' pressure points. At the first indication of greasy capped litter, remedial action should be taken and litter should be replenished.
Nitrogen in the Litter: Increases in the levels of nitrogen in the litter are frequently associated with high moisture content. Levels of crude protein in the diet, which are above optimum and amino acid imbalances may result in litter which has a high nitrogen content.
Litter Height:The amount of litter required to provide adequate height depends upon the water absorption capacity of the material being used. A general guideline is that the litter height should be in the range of 5-10cm. Where litter material is of low absorption capacity, or where there is water spillage, a litter height of up to 20cm may be necessary to avoid problems of wet litter.

STOCKING DENSITY

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. Bird welfare is compromised and this will reduce ultimate profitability. Quality of housing and especially environmental control will influence the stocking density which is applied. If stocking density is increased, an appropriate increase in feeding space and drinker availability must be made. In such circumstances, care must be taken to maintain air quality by careful ventilation.

The area of floor space needed for each broiler will depend on:
– Target liveweights and/or age at slaughter

– Climate and season
– Type and/or system of housing and equipment

TABLE 3: 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

HEAT STRESS

Heat stress is likely to have detrimental effects upon growth rate and bird welfare and can result in increased mortality. It can be minimised by altering the environment to reduce the temperature experienced by the bird and/or allowing the bird to control its temperature by behaviour, (e.g. panting, stretching its wings to increase the area available for loss of heat).

Actions to Reduce Heat Stress

• 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.

• Lowering the stocking density reduces house temperatures and therefore reduces heat stress experienced by the birds.

• Birds loose heat by evaporation of moisture during panting and at such times, require increased amounts of drinking water. Adequate fresh water should be available at all times. Insulation of storage tanks and water pipes will help to reduce heat stress by making drinking water more palatable.

• Digestion generates heat; therefore feeding during the hottest part of the day should be avoided. This is most important in open-sided houses.

• A significant amount of heat is lost by convection. At high humidity, convective heat loss becomes more important. Increasing the air flow over the birds promotes heat loss by convection. An air flow of at least 2.5m/sec, measured just above bird level, provides optimum heat loss by convection. In open-sided houses, this can be achieved by using extra, 91cm fans, placed at angles of 32º, every 10m across the house. Fans should be set to move air in the same direction as the prevailing wind.

- High humidity reduces the effectiveness of evaporative heat loss which occurs when birds pant. The litter is a significant source of moisture in the broiler house, so litter condition should be managed carefully to avoid heat stress.
- 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.
- The installation of tunnel ventilation and evaporative cooling systems will assist in the prevention of heat stress.

Minimum and maximum ventilation rate recommendations vary with bird weight and are illustrated in Table 6, page 18.

HOUSING & ENVIRONMENT

One of the most important considerations in the choice of housing design is local climate. Environmental conditions affect the well-being and performance of the broiler chickens. Housing and ventilation equipment should allow control of the environment so that the commercial and welfare objectives can be fulfilled.

AIR QUALITY

The supply of fresh air to broiler chickens is essential for good performance, health and bird welfare. 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 be capable of removing these waste gases from the house and of delivering air which is of good quality.
The main air contaminants within the broiler house environment are dust, ammonia, carbon dioxide, carbon monoxide and excess water vapour. When in excess, these can damage the bird’s respiratory tract, decreasing the efficiency of respiration and reducing performance. Continued exposure of birds to contaminated air may trigger outbreaks of respiratory diseases and Ascites. Excess water vapour in the house environment affects temperature regulation and contributes to poor litter quality. Table 4 shows the major effects of each contaminant and the levels at which problems are likely to occur.

TABLE 4:	EFFECTS OF COMMON BROILER HOUSE AIR CONTAMINANTS
Ammonia	May be detected by smell at 15ppm or above. >10ppm will damage the lung surface. >20ppm will increase susceptibility to respiratory diseases. Prolonged exposure may increase susceptibility to blindness. >50ppm will reduce growth rate.
Carbon Dioxide	>0.35% causes Ascites. Fatal at high levels.
Carbon Monoxide	100ppm reduces oxygen binding. Fatal at high levels.
Dust	Damage to respiratory tract lining. Increased susceptibility to disease.
Humidity	Effects vary with temperature. At >29°C and >70%RH, growth will be affected.

Good air quality is best achieved by maintaining ventilation rates at or above the minimum defined in Table 6, page 19, especially during the brooding stage. Chemical additives are available for use as litter treatments to reduce the production of ammonia.

HOUSING

Local, geographical and ambient climatic conditions must be taken into account when deciding on housing design.

There are two main types of housing system:

– Environmentally controlled

– Open-sided

Open-sided housing is becoming less popular due to the production advantages of a controlled environment (e.g. increased stocking density, improved livability, better growth rate, improved feed conversion).

Environmentally Controlled Housing

Characteristics of modern environmentally controlled houses include:

- “Air tight” construction.
- Efficient side-wall and ceiling insulation. Side-wall insulation with an R-value of 12-14. Ceiling insulation with an R-value of 20.
- Complete control of lighting both duration and intensity.
- Temperature and ventilation equipment capable of providing and maintaining optimum environmental conditions.
- Back-up power supply.
- Alarms for monitoring systems.

Open-sided Housing

Characteristics of well designed open-sided houses include:

• Construction on well-drained land with unrestricted air movement.
• House orientation having the long axis lying east to west,which prevents direct sunlight from falling on sidewalls during hottest part of day.
• Roof construction designed to insulate against extremes of temperature, (“open ceiling” R-value of 9;“drop ceiling” R-value of 20).
• Exterior roof surface treated to reflect solar heat.
• Side wall height of 6-9m.
• Curtain opening covered with 2.5cm wire mesh.
• Incorporation of an adjustable, reinforced plastic curtain to assist in temperature control.
• Temperature and ventilation equipment capable of moderating ambient conditions within the house

DIAGRAM 7: EXAMPLE OF PAD COOLING COMBINED WITH TUNNEL VENTILATION

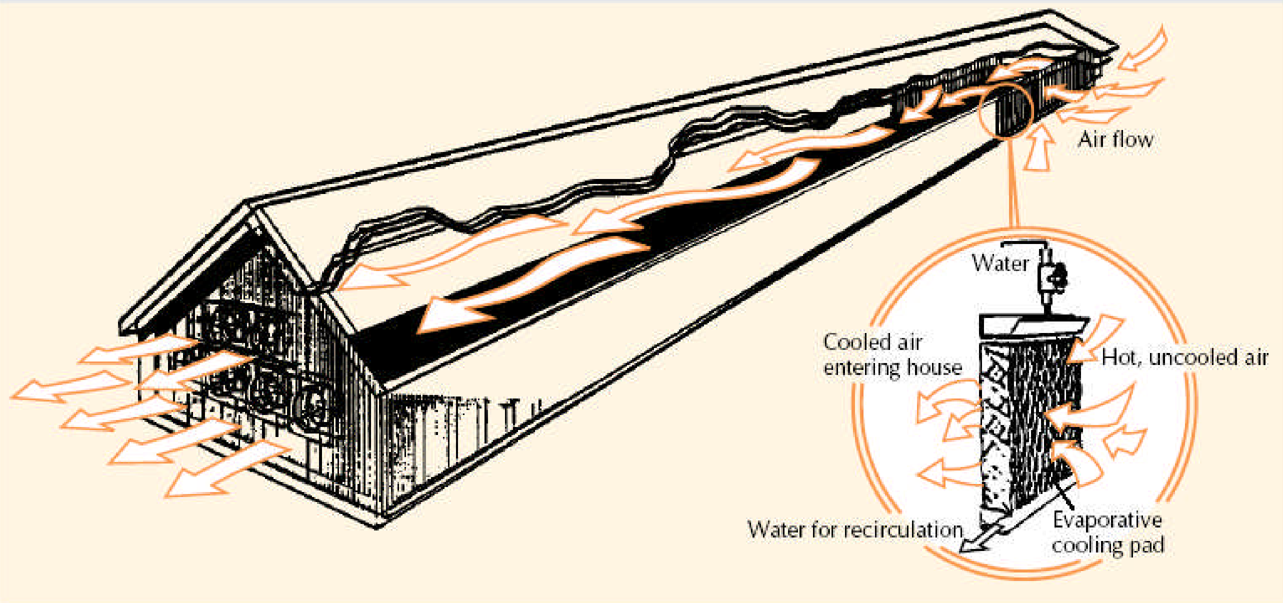
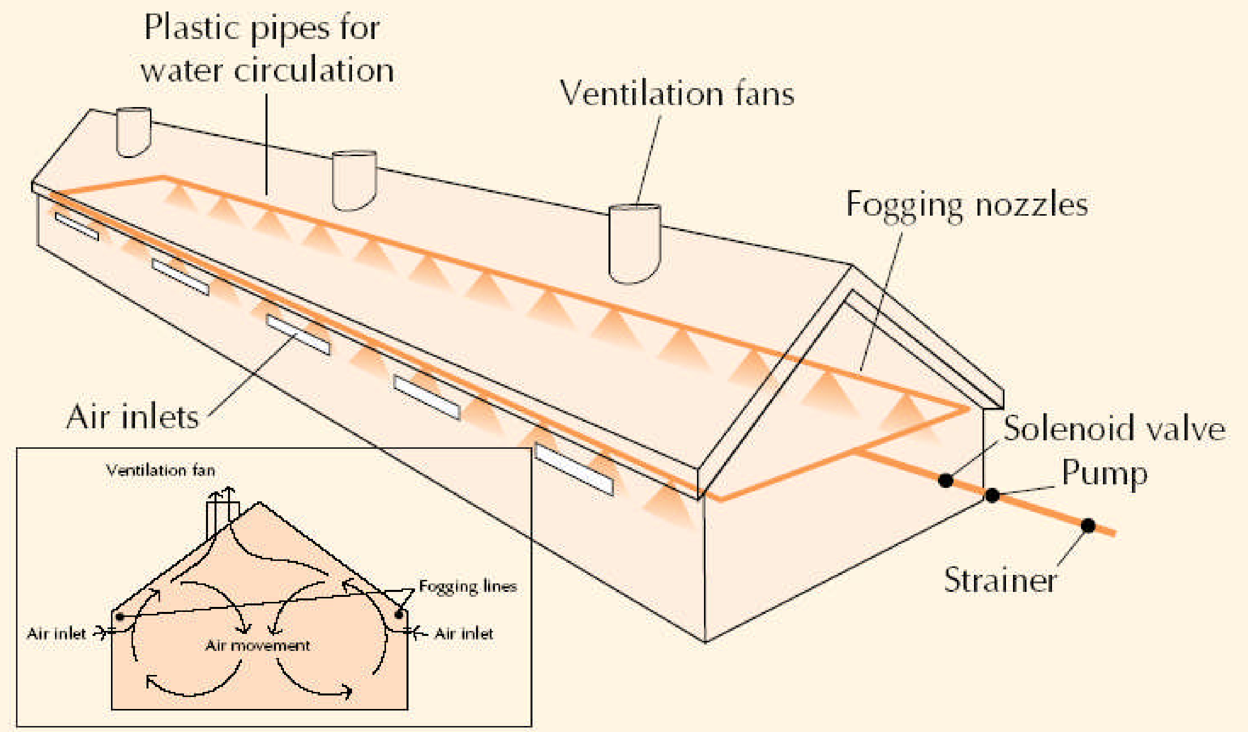
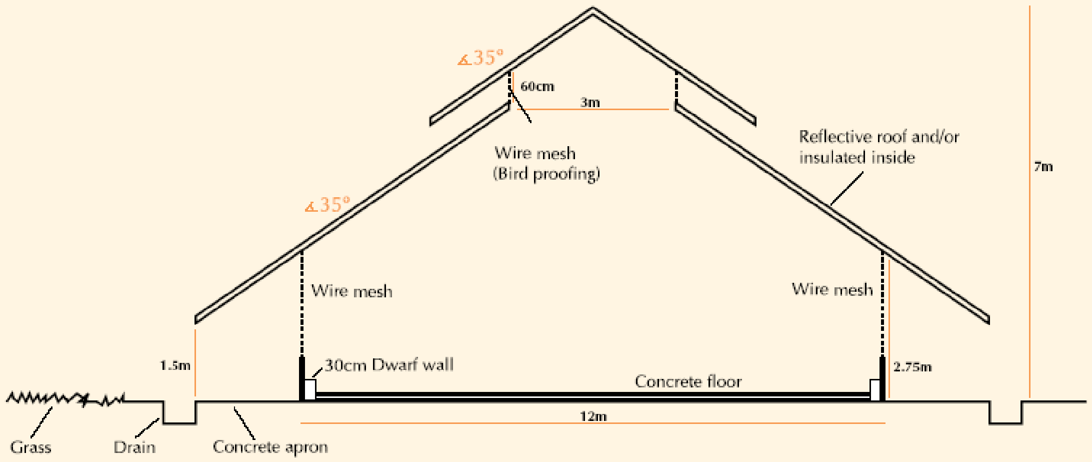


DIAGRAM 8: ULTRA HIGH PRESSURE FOGGING/AIR FLOW



CROSS SECTION OF HOUSE SHOWING AIR FLOW

DIAGRAM 9: EXAMPLE OF OPEN HOUSE BASIC DESIGN



INTERACTION BETWEEN TEMPERATURE AND HUMIDITY
Chickens lose heat to the environment by evaporation of moisture, mainly from the respiratory tract, by panting. At high relative humidity (RH), evaporative loss is restricted and so the bird's apparent temperature increases. The temperature experienced by the bird is dependent on the dry bulb temperature and on RH. High RH increases the apparent temperature at a particular dry bulb temperature, whereas low RH decreases apparent temperature.
Table 5 shows the predicted dry bulb temperature required to achieve the target temperature profile over a range of RH. The information in Table 5 can be used in situations where RH varies from the target.

TABLE 5: DRY BULB TEMPERATURES REQUIRED TO ACHIEVE TARGET, APPARENT EQUIVALENT TEMPERATURES AT VARYING RELATIVE HUMIDITIES

Age (days)	Temperature °C at RH%			
		Ideal		
	50	60	70	80
0	33.0	30.5	28.6	27.0
3	32.0	29.5	27.6	26.0
6	31.0	28.5	26.6	25.0
9	29.7	27.5	25.6	24.0
12	27.2	25.0	23.8	22.5
15	26.2	24.0	22.5	21.0
18	25.0	23.0	21.5	20.0
21	24.0	22.0	20.5	19.0
24	23.0	21.0	19.5	18.0
27	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 5. 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.

VENTILATION
Good ventilation is crucial to health, growth, welfare and productivity of broiler chickens. The ventilation system must be designed to deliver fresh air evenly throughout the broiler house and to remove waste gases and air contaminants. It is essential to make sure that the minimum requirements for air quality are met at all times.

The design and construction of any ventilation system should be carried out by companies, which specialize in this type of work.

TABLE 6: MINIMUM & MAXIMUM VENTILATION RATES AT VARYING LIVEWEIGHTS

Liveweight (g)	Ventilation Rate (m^3/hour)		Liveweight (g)	Ventilation Rate (m^3/hour)	
	minimum	maximum		minimum	maximum
50	0.07	0.76	1800	1.09	11.19
100	0.12	1.28	1900	1.14	11.65
150	0.17	1.73	2000	1.18	12.11
200	0.21	2.15	2100	1.22	12.56
250	0.25	2.55	2200	1.27	13.01
300	0.28	2.92	2300	1.31	13.45
350	0.32	3.28	2400	1.35	13.88
400	0.35	3.62	2500	1.40	14.31
450	0.39	3.95	2600	1.44	14.74
500	0.42	4.28	2700	1.48	15.16
550	0.45	4.60	2800	1.52	15.58
600	0.48	4.91	2900	1.56	16.00
650	0.51	5.21	3000	1.60	16.41
700	0.54	5.51	3100	1.64	16.82
750	0.57	5.80	3200	1.68	17.23
800	0.59	6.09	3300	1.72	17.63
850	0.62	6.37	3400	1.76	18.03
900	0.65	6.65	3500	1.80	18.42
950	0.68	6.93	3600	1.83	18.82
1000	0.70	7.20	3700	1.87	19.21
			3800	1.91	19.60
1100	0.75	7.73	3900	1.95	19.98
1200	0.80	8.25	4000	1.99	20.36
1300	0.86	8.77	4100	2.02	20.74
1400	0.90	9.27	4200	2.06	21.12
1500	0.95	9.76	4300	2.10	21.50
1600	1.00	10.24	4400	2.13	21.87
1700	1.04	10.72	4500	2.17	22.24

Source: UK Agricultural Development and Advisory Service.

LIGHTING

The most popular lighting program for broiler chickens is the provision of a long period of continuous light followed by a short period of darkness (e.g. 0.5-1 hour). This regime allows birds to achieve maximum daily weight gain, whilst ensuring that they become accustomed to darkness in the event of a power failure.

Recently, various lighting programmes have been devised to modify broiler growth, minimize Feed Conversion Ratio (FCR) and help to reduce mortality. These new systems have involved increasing the periods of darkness.

All lighting programmes should provide a long day length (e.g. 23 hours light) of adequate intensity for the first 7 days, to stimulate feed intake in the early stages of the chicks' development.

Light intensity at placement should be 20-25 lux at the feeder level. It should then be reduced gradually, so that by 28 days, it is approximately 3-5 lux. Light intensity should be uniform throughout the house.

FEEDING SYSTEMS

There are several different systems available for delivery and distribution of feed to broilers. Since feed constitutes the major share of total production cost, wastage should be an important consideration in the choice of system. There are three major systems available:

- Automatic pan feeders: 1 pan per 65 birds; 33cm pan diameter.
- Chain feeders: 2.5cm per bird; 80 birds per metre of track.
- Round, hanging tube feeders: 65 birds per tube; 38cm diameter base.

Automatic pan feeding systems have become the industry standard due to advantages of low feed wastage, ease of height adjustment, preservation of pellet quality, and reliability. As a number of different pan feeder designs are available, feeder heights should be set according to manufacturers' recommendations.

Distance between the feeder lines should be not more than 2.5metres. This ensures that all birds have adequate access to feed.

Level of feed within the feeder should be adjusted to a height that minimizes wastage. If possible, the feed supply system should be allowed to empty at least once a day. This eliminates the presence of stale food and therefore reduces the risk of contamination and the growth of micro-organisms.

DRINKING SYSTEMS

It is essential that fresh water is available to the broiler flock at all times and that it is free of contamination. The drinking systems chosen must be capable of delivering the water efficiently to all birds with the minimum of spillage. To ensure that the flock is receiving sufficient water, each day, the ratio of water to feed consumed should be monitored. 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), only then can it be assumed that the birds are consuming sufficient water.
Table 7 shows water consumption achieved 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 as temperature exceeds 21ºC. Water consumption will vary with feed consumption.

TABLE 7: TYPICAL WATER CONSUMPTION BY BROILERS AT 21°C 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

Nipple Drinkers
Nipple systems provide water with lower levels of bacterial contamination than conventional open systems. They have become the standard in modern broiler production.
General recommendations for the management of nipple systems are:

• 12 birds per nipple. This should be reduced to 9-10 per nipple for birds weighing 2.75kg or more.
• Nipple height should be monitored daily and adjusted as appropriate. At day old, nipples should be placed at chick eye level. From day 2 onward, while drinking, the back of the chick should form an angle of 45º with the floor.
• Litter, under and around the drinker lines, should be level to allow all birds to have equal access to water.
• Drinker lines should be level to a avoid spillage.
• Individual nipples should be checked regularly to confirm that access is available to birds through 360º (i.e. from all directions). Faulty nipples will reduce birds' access to drinking water. Nipples should be activated and checked by hand before placement to ensure all nipples are working.
• Water pressure should be set according to manufacturers' specifications.
• Nipple lines should be flushed and sanitized weekly. See WATER QUALITY page 33.

Bell Drinkers

- When whole house brooding is practiced, a minimum of 6 bell drinkers should be provided per 1000 chicks.
- Drinkers should be distributed evenly throughout the house so that no broiler is more than 2m from water.
- As a guide to level, water should be 0.6cm below the top of the drinker until 7-10 days and there should be 0.6cm of water in the base of the drinker from 10 days onwards.
- The height at which the bell drinkers are suspended should be checked and adjusted daily, so that the lip of the bell is level with the broilers' backs from 7 days onwards.

HYGIENE & HEALTH

GENERAL RECOMMENDATIONS

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

Where possible, sites should be built in isolated locations and access should be restricted. Movement of people, feed, equipment or animals on to broiler sites should be controlled to prevent the introduction of pathogens. There should be barriers to prevent unauthorized entry.

Anything brought on to the farm, which is essential to the life of the flock, (e.g. people, feed, litter or equipment), represents a biosecurity risk; therefore an understanding of hygiene and its implications for biosecurity cannot be overemphasized.

Single-age sites are preferred, so that recycling of pathogens is kept to a minimum.

Broiler chicks should be produced from parent stock which have a good health status. Parent stock should have a high and uniform level of maternal antibody against those diseases that reduce broiler performance.

HYGIENE

Hygiene practices should be clearly defined for the information of staff and essential visitors. Notices should be posted indicating requirements. Staff and visitors should be provided with, and should wear, appropriate, clean protective clothing and foot coverings on each site. Disposable boots and coveralls are recommended. If more than one farm visit has to be made in one day, the youngest birds should be visited first.

Empty Farm Cleaning Schedule

The following points are important in preparation of an efficient farm cleaning schedule.

1. Incorporate features in the construction of the house which allow it to be easily cleaned. A concrete surround or plinth of sufficient size to permit cleaning and storage of removable items is recommended.

2. Dismantle and remove equipment from the house. Drain the drinking system and header tanks.
3. Pre-soak all surfaces with a detergent solution, ensuring that surface dust is removed and heavy soil is thoroughly moistened.
4. Remove litter for disposal to a distance of at least 1.5km from the house, where it should be buried, burned or stacked and composted for at least one month, prior to being spread on agricultural land. Local regulations on disposal of litter should be followed.
5. Using a pressure washer and detergent solution, wash the house thoroughly. Ensure that all debris is removed from the air inlets and outlets, fan housings, ledges and all pipe runs.
6. Always follow local health and safety guidelines when using disinfectants or fumigants.
7. Clean the water storage tank, removing sludge and accumulated debris. Flush and clean flexible hoses, line filters and filter housings. Refill the header tank and drinker lines with an appropriate concentration of an approved water disinfectant. This must be drained, and the system rinsed and refilled with potable water prior to arrival of chicks.
8. Only when the house is absolutely clean, should a disinfectant be applied to all surfaces at the recommended concentration.
9. Carry out repairs as soon as possible in the period when the farm is empty.
10.Formaldehyde fumigation of the house may be beneficial where disease has occurred in the previous flock. Manufacturers recommendations must be followed.
11.Wash and disinfect the outside of the house.
12.Establish and follow a monitoring procedure to ensure effective cleaning.

HEALTH

Pressure from governments and consumers may restrict the range of medicines available for use in poultry production. This emphasizes the need for good husbandry and hygiene practices to prevent the introduction of pathogens and to minimize the effects of disease.

Vaccinations

The vaccination program must be designed in consultation with a reputable local veterinarian and be appropriate to the particular circumstances of the farm.

Only healthy flocks should be vaccinated. It is very important to check the expiry date of vaccine. Vaccine must not be used after this date. Accurate records of all vaccinations and vaccine serial numbers should be kept. Provision of extra vitamins in the first 2-3 days after vaccination can help to reduce stress and prevent undesirable reactions. The usefulness of such action will depend on the specific situation on each farm.

Various methods are available for vaccination of broiler chickens:

Individual vaccination. Vaccination of individual birds by injection or eyedrop is very effective and generally well tolerated, but is very labour intensive.

Spray vaccination. Vaccination by spray is not as labour intensive and is highly effective, but may occasionally have side effects. Where spray vaccination is chosen, it is essential that, for chicks up to the age of 3 weeks, a coarse spray only should be used.

Drinking water vaccination. Whilst not labour intensive, this form of vaccination must be carried out with the greatest care if it is to be effective. The water used for preparing the vaccination solution must not contain any disinfectants. During the growing period, water should be withheld from the birds for approximately 2 hours prior to vaccination. During hot weather this time should be reduced accordingly. The amount of vaccine solution to be administered should be calculated so that it will be completely consumed within 2 – 4 hours. When vaccinating with live vaccines, 2g of milk powder per liter of water should be included in order to protect the virus titer.

NUTRITION

GENERAL INFORMATION

Feed is the 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.

Stocking density, climate and health status can affect weight gain and feed conversion, leading to altered nutrient requirements.

Local market structure, product value and variations in feed ingredient price and supply must all be considered in ration specification. This will ensure that economic and nutritional requirements are satisfied.

RAW MATERIALS

It is important that the ingredients used in the manufacture of feeds for broilers are of high quality and are fresh. See Table 8. When poor quality ingredients are consumed, non-utilizable constituents must be broken down and excreted by the birds. This wastes energy and causes metabolic stress. 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.

The feed formulation matrix of ingredients should be appropriate to the geographical area. The matrix should be updated regularly with the support of routine chemical analyses and examination for contamination (e.g. mycotoxins). Table 9 lists the nutrient composition of ingredients which are frequently incorporated in broiler feeds. Table 10 lists the limits of inclusion recommended for some of the commonly used ingredients for broiler feeds.

VITAMIN AND MINERAL PREMIXES

General recommendations are given in Tables 11, 12 and 13 for the supplementation of broiler feeds with vitamins and trace minerals.

TABLE 8: QUALITY FEATURES FOR FEED INGREDIENTS

Ingredient	Quality Feature	Notes
CEREALS	Mycotoxins	
	Contaminants, weed seeds	
Maize	Mycotoxins	
Wheat	Viscosity (soluble NSP*)	Modified by enzymes
	Ergot contamination	
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	Ensure proper processing
	Trypsin inhibitors	
	Fat digestibility	
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	Proper processing is essential
	Amino acid availability	
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		

**NSP: non-starch polysaccharides.*

TABLE 9: NUTRIENT COMPOSITION OF SOME COMMONLY USED FEED

	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

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 10: 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 11: FEED SPECIFICATIONS FOR AS-HATCHED OR FEMALE BROILERS GROWN TO 1.6-1.8KG 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

TABLE 11: FEED SPECIFICATIONS FOR AS-HATCHED OR FEMALE BROILERS GROWN TO 1.6-1.8KG 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*

These feed specifications should be used as a guide.

TABLE 13: FEED SPECIFICATIONS FOR MALE BROILERS GROWN TO APPROXIMATELY 3KG 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.

FAT SOURCES

Fat, of either animal or vegetable origin, may be added to rations as an important source of energy. Animal fats, such as tallow, contain more saturated fatty acids, which are less digestible, especially in the immature digestive system of the young 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. Fat blends used in finisher rations should have a higher percentage of saturated fats than starter rations to avoid the production of greasy carcasses which also do not store well.

SUPPLY OF NUTRIENTS

Energy

The conventional method of expressing the energy content of the feed is as apparent metabolizable energy level corrected to zero nitrogen retention (AMEn). Data on energy contents expressed in this way are available from many sources.

Some typical energy levels for broiler feeds are indicated in Tables 11, 12 and 13. This information is a practical guide and does not represent the absolute 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.

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 to 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.

Protein and Amino Acids

The level of protein in the feed must be sufficient to ensure that the broilers' requirements for all essential and non-essential amino acids are met.

It is preferable to use high quality protein sources wherever possible, especially for broilers under heat stress. Poor quality protein or protein imbalances in the diet can create metabolic stress. When excess protein is broken down within the gut, there is an energy cost associated with the resultant nitrogen excretion. Wet litter may also result.

Broiler feeds should be formulated using available or digestible amino acid levels. The levels of protein proposed in this program should be used as guidelines only and not as definitive statements.

In formulating broiler rations, amino acid levels should be considered together with energy levels. Higher ratios of digestible amino acids to energy have been shown to improve profitability by increasing broiler and processing performance.

Major Minerals

Calcium: Calcium level in broiler diets influences growth and feed efficiency, bone development and leg health as well as the immune system. The widespread change to all-vegetable broiler feeds in many countries means 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.

Phosphorus: Care should be taken to use consistent data on available phosphorus content of feed ingredients and bird requirements for phosphorus.

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

Sodium, potassium and chloride: Control of sodium and chloride levels in broiler diets is important. 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. lysine hydrochloride and choline chloride).

Control of potassium and chloride levels is especially important during hot weather.

FEED PROCESSING AND FEED FORM

Broiler growth and Feed Conversion Ratio (FCR) will be improved if the starter feed is crumbled and the grower and finisher feeds are pelleted.

WATER QUALITY

Unrestricted access to good quality water, delivered at an appropriate temperature (10-12ºC) is essential.

The water supply should be tested regularly for bacteriological and mineral contaminants, and the necessary corrective action taken.

In hot weather, drinker lines should be flushed regularly to ensure water is as cool as possible.

Drinking water should be treated with an approved sanitizer on a routine basis. Chlorine could be used at a rate of concentration of 1-3ppm when tested at the furthest point from the source.

Table 14 shows drinking water quality standards for broiler chicken.

TABLE 14: 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

Table 15: 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		

Appendices

PROBLEM SOLVING

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	• Readjust brooders
	Disease	• Post mortems on dead chicks, consult with a veterinarian
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)
		• Consult with a veterinarian regarding medication and vaccination
	Leg problems	• Check calcium, phosphorus and vitamin D_3 levels in diet
		• Use lighting programs to increase bird activity
Poor early growth	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 lighting program
		• Check air quality – CO_2, dust, minimum ventilation rate
	Appetite	• Check for indications of reduced appetite (e.g. low "crop fill")
Poor late growth	Low nutrient intake	• Check feed quality and formulation
		• Check feed intake and accessibility
		• Excessive early restriction
		• Lighting program 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
		• Humidity too high
		• Stocking density too high
		• Insufficient ventilation
	Infectious disease	• Causing enteritis, consult with a veterinarian

Continued...

PROBLEM SOLVING

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 temperatures
	Infectious disease	• See high mortality
	Nutrition	• Check feed formulation and quality
Poor feather cover	Environment	• House temperatures too high
	Nutrition	• Check ration for methionine and cystine content and balance
		• Check dietary sodium level
Processing plant downgrades and condemnations	Ascites	• See high mortality
	Blisters and burns (i.e., breast blisters)	• Check stocking density
		• Check litter quality
		• Increase bird activity (e.g. feeding or lighting programs)
	Bruises and breaks	• Check handling procedures at weighing and catching
	Scratches	• Excessive light stimulation
		• Check handling procedures at weighing and catching
		• Check access to feed and water
		• Check stocking density
	Green Muscle Disease (Deep Pectoral Myopathy)	• Birds excessively disturbed during growth, e.g. at partial depletion (thinning), weighing, etc. Poor feed distribution
	Oily Bird Syndrome	• Check nutritional balance of diet

Management of Large Broiler Farms

In the early days of the broiler industry, a flock of a few hundred birds was considered large. Today, improvements in management, equipment, vaccines and medication allow larger numbers of birds to be grown on the site. Recently, the industry has moved toward bigger broiler farms with flocks of between 50, 000 and 100,000 birds becoming fairly common. Advantages to large farms include reduced fixed costs and labor requirements. Also, growers increase their profits by handling more birds. Although advantages to large farms are significant, there are also inherent disadvantages.

Labor problems, disease, equipment maintenance and waste disposal magnify as farm size increases. Recently, some broiler companies have experienced such serious production problems with large farms that they have limited farm size to six or fewer houses. Large broiler farms can overcome these problems with proper management and equipment.

Labor Requirements

Labor is the most serious problem associated with large farms. With today's automated equipment, it is estimated one worker can care for 25,000 birds. Every aspect of the operation – from equipment to environment – must be checked continually throughout the day, every day. There are early morning, late nights and no holidays. As a result, finding reliable, competent workers is difficult. Training hired help is essential. Universities and poultry trade organizations sponsor educational seminars and provide publications that are excellent training tools. Some large farm operators encourage employees by profit sharing. Job satisfaction increases when workers can contribute ideas toward operation improvement. As a result, employees believe their hard work is rewarded and that are part of a team working toward the same goal. For more information on these programs and publications, contact the Livestock and Livestock Products Board.

Broiler Health

Each breeder flock has distinctive health and immunity profiles, so chicks from different breeders do not respond to vaccines and diseases equally. Broiler companies try to fill a farm with chicks from a single breeder flock, but some broiler farms have gotten so large, their capacity exceeds the hatchery's production. Therefore chicks from different breeder flocks must be mixed. This presents a considerable challenge to large broiler farm operators. Rolling vaccine reactions as well as field exposure to diseases are unavoidable. This makes diseases frequent and difficult to eliminate. Minimize diseases by following strict sanitation and biosecurity measures. Never allow unnecessary visitors onto the farm. Keep all animals, including wild birds, pets and rodents, away from the broiler houses. Keep foot baths filled with fresh disinfectant at each broiler house entrance. Prevent diseases through frequent clean-out and disinfection. This improves health and feed conversion and decreases the change of condemnation at processing.

A minimum of 10 to 14 days between flocks also minimizes disease by reducing the change of new chicks being infected by disease organisms surviving from the previous flock. For more information on biosecurity and sanitation, contact your agricultural extension officer.

Feeding Birds

Feeding chicks their first week of life is time consuming. Alternative methods eliminate the hand labor of filling feeder lids several times a day. The most popular method used is the feeder ditch system Approximately 7 days of feed is deposited into a paper-lined trough constructed underneath the regular feeding system. Feed is delivered into the trough through closable holes cut into the feed line or by tractor-powered feed auger. When the chicks have consumed this, they are large enough to use the pan feeders. The paper breaks up as the birds become heavier and completely disintegrates by the end of the growing cycle.

Waste is inevitable using the feeder ditch system. Constructing the ditch carefully and putting out just enough feed minimizes waste. Certain growers and companies prefer using feeder lids because less feed is wasted. Attachments are made for feeding systems that mechanically fill the feeder lids and reduce the labor involved. Paired or dual feed bins are a necessity. Keeping track of feed inventories is demanding, and mistakes are unavoidable. Use two feed bins per house or pair the bins of adjacent houses. This decreases the chance of broilers going without feed for extended periods of time. Two bins allow you to keep starter, grower and finisher feeds separate, give you easy access to medicated feed, and make it easier for bin clean-out.
As mentioned before, feed inventories are difficult to keep up with. Make sure that feed arrives on time and is placed in the correct bins. Label bins clearly to reduce the chance of mistakes.

Watering Birds

The time and labor involved in cleaning open-type waterers makes them impractical for large broiler farms. An enclosed watering system that needs little or no cleaning is preferred. Although enclosed waterers minimize labor, they require as much or more management as open waterers. Their height is critical and must be adjusted daily. Pressure regulators also require frequent monitoring and adjustment. An effective filtering system is essential when using enclosed systems. Inspect filter cartridges weekly and replace as needed. Perform routine flushing and preventive maintenance after every flock. Water meters are useful and are recommended for large farms. Monitor and compare water consumption between houses and flocks to identify disease and production problems quickly. An alarm system that alerts the grower when water pressure drops in a house is also a worthwhile safety feature.

Preventive Maintenance

While automated equipment enables growers to care for more birds with less labor, serious problems occur when equipment malfunctions. Today’s large farms have so much equipment, something always needs repairing. As a result, birds are frequently neglected.
Minimize time spent working on equipment with a preventive maintenance program. Between flocks, inspect and tighten all fan belts, clean dust and debris off fan motors and shutters, flush

out the entire watering system, and completely clean out the feeding system. Keep an inventory of spare parts (including fan and feeder motors, belts, water nipples, fogger nozzles, pumps for fogging systems, PVC pipe, water filter cartridges and light bulbs) on hand at all times. Develop a
maintenance checklist based on the recommendations of equipment manufacturers. Include scheduled maintenance dates and check them off as maintenance is performed.

Another way to minimize maintenance is to use energy efficient equipment. Using fluorescent bulbs saves time and money. Fluorescent bulbs last much longer than incandescent bulbs (10,000 hours compared to 1,000 hours) and use considerably less electricity. Increase fan motor life by cleaning the motor housing, fans and shutters frequently.

Environment

Growers managing large farms do not have time to fine-tune ventilation systems. Set times and thermostats so houses are slightly over-ventilated. A fan staging system with adequate backups maintains proper broiler house temperature and air quality and conserves fuel.
Computerized monitoring systems regulate the broiler house environment and are becoming more practical and affordable. Analyzing the data from these is invaluable in discovering and correcting problems. Alarms are essential in detecting power outages and temperature extremes inside broiler houses. New alarm systems call programmed telephone number to alert personnel of broiler house problems. Check all alarm and emergency systems monthly to ensure proper performance.

Automatic standby generators are extremely expensive but can be worth the investment for the peace of mind they provide at night and when the farm is unattended. The losses incurred during a single power failure more than pay for the generator. Be sure to test generators once a month.

Litter Disposal

Broiler manure is a big problem on large farms. Litter disposal is a sensitive issue as more land is taken out of agricultural production and as concern over pollution of streams and rivers grows. One broiler house (20,000 birds per flock, 5 flocks per year) produces
approximately 150 tons of manure per year. If this manure is used as fertilizer at a rate of 3 to 6 tons per acre, 30 to 60 acres of land will be needed for litter disposal. A practical, economical and environmentally sound waste disposal plan is essential for a large farm.

Litter cannot always be disposed of immediately. If it must remain on the farm, store it as far away from broiler houses as possible. Cover litter with plastic if it is stored outside for more than a few days. Composting is an excellent way of reducing the volume of litter as well as minimizing insects, pathogens, weed seeds and odors. Contact your agricultural extension officer for information concerning composting and litter use on crops and pasture. Prevent litter storage or disposal from contributing to surface or ground water pollution.

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LARGE FARMS require conscientious management to avoid disasters. Develop detailed management and maintenance plans to prevent problems. If you react to problems after the fact, you have no time to care for the birds. Disease ruins many large broiler farms. Biosecurity and strict sanitation are important. It is difficult to eliminate a disease once it is established – prevention is essential.

Automated equipment saves time and labor but also requires skill and understanding to operate. Train personnel thoroughly to have an efficient, productive large farm.

Hot Weather Management of Poultry

Hot weather can have a severe impact on poultry performance. Production efficiency can be affected long before the temperature reaches a level at which survival becomes a concern. Table 1 is a general guide to the reaction of adult poultry to various temperatures. Heat stress begins when the ambient temperature climbs above 80oF and is readily apparent above 85oF. When a bird begins to pant, physiological changes have already started within its body to dissipate excess heat. Even before the bird reaches this point, anything that you do to help birds remain comfortable will help maintain optimum growth rates, hatchability, egg size, egg shell quality, and egg production.

Table 1. Heat Stress & Ambient Temperature

55o to 75oF	Thermal neutral zone. The temperature range in which the bird does not need to alter its basic metabolic rate or behavior to maintain its body temperature.
65o to 75oF	Ideal temperature range.
75o to 85oF	A slight reduction in feed consumption can be expected, but if nutrient intake is adequate, production efficiency is good. Egg size may be reduced and shell quality may suffer as temperatures reach the top of this range.
85o to 90oF	Feed consumption falls further. Weight gains are lower. Egg size and shell quality deteriorate. Egg production usually suffers. Cooling procedures should be started before this temperature range is reached.
90o to 95oF	Feed consumption continues to drop. There is some danger of heat prostration among layers, especially the heavier birds and those in full production. At these temperatures, cooling procedures must be carried out.
95o to 100oF	Heat prostration is probable. Emergency measures may be needed. Egg production and feed consumption are severely reduced. Water consumption is very high.
Over 100oF	Emergency measures are needed to cool birds. Survival is the concern at these temperatures.

Methods of Heat Loss

During the summer months, when daily temperatures regularly reach the mid- to upper 90s, it becomes critical for the birds to dissipate body heat to the surrounding environment. Poultry do not sweat and therefore must dissipate heat in other ways to maintain their body temperature at approximately 105oF. Body heat is dissipated to the surrounding environment through radiation, conduction, convection, and evaporation (Table 2). The first three avenues are known as sensible heat loss; these methods are effective when the environmental temperature is below or within the thermal neutral zone of the bird (55o to 75oF) (Figure 1). The proportion of heat lost through radiation, conduction, and convection depends upon the temperature difference between the bird and its environment. The bird loses heat from surfaces such as wattles, shanks, and unfeathered areas under wings. To maintain body temperature by sensible heat loss, the bird does not need to drastically alter its normal behavioral patterns, feed intake, or metabolism. The purpose of poultry house ventilation is to maintain a high enough air velocity or a low enough temperature in the house that the birds can maintain body temperature by sensible heat loss.

Table 2. Methods of Sensible and Latent Body Heat Loss

Heat Loss Method / Definition	Direction of Heat Flow
Sensible Heat Loss Methods	
Radiation	
Flow of thermal energy without the aid of a material medium between two surfaces	All surfaces radiate heat and receive radiation back; the net radiation heat flow is from higher to lower temperature surfaces.
Conduction	
Thermal energy flow through a medium or between objects in physical contact.	Direction of energy transfer depends on a temperature gradient; heat moves from areas of higher to lower temperature.
Convection	
Heat flow through a fluid medium such as air; thermal energy moves by	Energy transfer to the air depends on temperature and movement of air across the skin surface; heat is transferred to air moving across the skin surface if the air

conduction between a solid surface and the layer of air next to the surface, and the thermal energy is carried away by the flow of air over the surface.

is at a lower temperature than the skin.

Latent Heat Loss Method

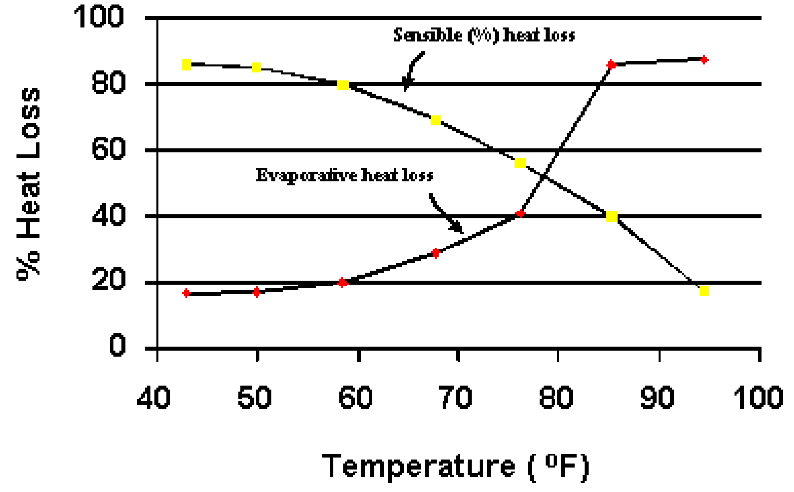
Evaporation

The transfer of heat when a liquid is converted to a gas; when water is converted from a liquid to a vapor, heat is utilized.

Energy transfer is influenced by the relative humidity, temperature, and air movement; heat is transferred from the animal's body to water, turning it to water vapor.

Once the environmental temperature reaches approximately 77oF, the method of heat loss begins shifting from sensible to evaporative heat loss, as shown in Figure 1. Dissipation of body heat by the evaporative process requires the bird to expend energy by panting (hyperventilation), which begins to occur at about 80oF.

Figure 1. Method of heat loss from birds as temperature changes.



Physiological Effects of Panting

Panting removes heat by the evaporation of water from the moist lining of the respiratory tract. However, panting itself generates body heat, and it causes poultry to eliminate water from the body. It can induce respiratory alkalosis, which occurs because the bird "blows off" excessive carbon dioxide (CO2) when it pants. As a result, body fluids become more alkaline, causing the kidneys to excrete excessive amounts of several electrolytes.
As the shift in body fluid pH occurs, feed intake is increasingly depressed, adversely affecting growth, production, and overall performance of the bird. During the hot summer months, evaporative heat loss typically becomes the primary method by which birds regulate their body temperature unless proper ventilation is provided and other steps are taken to reduce heat stress.

Feed and Feeder Management

Any management technique that increases nutrient intake during heat stress will minimize the drop in production efficiency. Three easy ways to increase nutrient consumption are to increase nutrient density, take advantage of natural increases in feed consumption at certain times of the day, and adjust ventilation fans to provide more cooling during the evening.
A very direct way to ensure optimum nutrient intake despite decreases in feed consumption is to increase the nutrient density of the ration. Recent research indicates that low phosphorus consumption can contribute to increased heat prostration losses.
A second alternative is to feed the birds at the time of day when feed consumption is highest. The light-to-dark cycle results in a U-shaped feed consumption curve. Shortly after lights come on, feed consumption is high. It gradually declines during midday and then increases about 1 hour before lights are turned off. If birds are fed during the cool part of the day, feed consumption will be higher. Birds should not be fed during the afternoon in periods of hot weather since this will increase the amount of body heat that

they must dissipate and thus increase the potential for heat prostration. Abrupt changes in feeding times should be avoided.

A third technique is to cool the birds as much as possible during the evening hours. Hens or meat birds tend to build up body heat during extended periods of hot weather. If their body temperature can be reduced during the evening, the birds will be able to consume more feed in the early morning. The house can bee cooled in the evening by setting the fan thermostats so that the fans will continue to run until the internal house temperature reaches 75oF (65oF for mature birds).

Building Construction

The building site, orientation, insulation, roof overhang, and equipment design all affect the temperature inside the poultry house.

The broiler and turkey industry has shifted from pole-construction curtain houses having very little insulation to houses with well-insulated walls and ceilings. The latter type is easier to ventilate if certain procedures are followed. Air movement is particularly important in houses that are ventilated by natural air currents. All poultry houses, but particularly curtain-sided houses, should be positioned so that the roofline runs from east to west. This orientation will keep direct summer sunlight from coming through the sidewall and causing heat to build up within the house. Adequate insulation in the ceiling and sidewalls will pay dividends by reducing the amount of the sun's radiant heat energy that reaches the interior. Installing insulation to the end of a 24-inch roof overhang will prevent solar radiation from penetration the sidewalls. Insulation also reduces heating costs during winter months.

The trend for the layer industry is toward light-tight houses with mechanical ventilation. The new houses are of tighter construction and allow for greater bird density, requiring closer attention to building details. Insulation with an R-value of 18 is recommended for the ceilings of all poultry houses in North Carolina. If the building has an attic, vents must be provided to reduce heat and moisture buildup above the insulation. The inside surface of the ceiling and sidewalls should be covered with a heavy plastic vapor barrier to keep moisture away from the fiber insulation. During cool months, the vapor barrier will prevent condensation from forming inside the insulation. Condensation reduces the resistance to heat transfer and can eventually destroy the insulation.

Techniques for Managing Heat Stress

A grass cover on the grounds surrounding the poultry house will reduce the reflection of sunlight into the house. Vegetation should be kept trimmed to avoid blocking air movement and to help reduce rodent problems. Shade trees should be located where they do not restrict air movement.

Fans should be routinely maintained. Maintenance should include cleaning the fan and keeping pulleys and belts in good condition and properly adjusted. Poultry netting on sidewalls or air inlets often will pick up enough dust to restrict air movement and should be cleaned regularly.

Keeping a reliable, clean, cool source of water available to poultry is essential to help the birds cope with high temperatures. Because the birds excrete electrolytes during periods of heat stress, electrolytes can be added to the drinking water to replace those that are lost and to stimulate water consumption. Avoid placing water pipes near the ceiling where the water will gain extra heat. Line in which the water has become warm can be drained to allow cooler water to reach the waterers. A second well or access to an emergency source of water should be available in case the primary water source fails.

Another factor that affects heat gain of a house is the condition of the roof. A shiny surface can reflect twice as much solar radiation as a rusty or dark metal roof. Roofs should be kept free of dust and rust. Roof reflectivity can be increased by cleaning and painting the surface with a metallic zinc paint or by installing an aluminum roof. These practices are particularly effective for buildings that are under insulated.

Equipment and Ventilation Techniques for Reducing Heat Stress

During the summer when the temperature and humidity are high, proper poultry house ventilation is vital to ensure the necessary removal of heat and the continued productivity of the flock. Poultry house ventilation systems have a number of components. These include curtains, fans, fogging nozzles, evaporative cooling pads, timers, static pressure controllers, and thermostats.

Most ventilation systems can provide an adequate indoor environment when properly managed. If the design and management of the ventilation system fails to satisfy the flock's ventilation needs, stale, contaminated air can build up in the poultry house. Stale air and contaminants, including ammonia, moisture carbon dioxide, carbon monoxide, and dust, can cause stress and lead to depressed performance. Stress may impair the immune system and increase susceptibility to disease. To reduce problems with stale air and contaminants, air temperature, air speed, and relative humidity must be controlled by careful management of the ventilation system.

Natural Ventilation

Curtain-sided houses rely extensively on natural air movement. These houses work best when they are located away from obstructions such as other buildings or trees that can block natural air currents. To avoid total reliance on natural air movement, most producers have added circulation fans in curtain houses to increase air movement and promote the loss of body heat from the birds. These fans should be spaced and positioned to maintain air movement between fans and to direct their flow in a way that will increase the turbulent air movement around the birds. Spacing of the fans depends somewhat on their size, but they are generally spaced about 25 to 30 feet apart in curtain layer houses and 40 to 50 feet apart in broiler houses.

Circulation fans should be controlled by thermostats set at about 85 o F (or lower in hot weather). To save energy, the fans should shut off when the temperature drops below 85 o F except during periods of extended hot weather. At those times, it is advantageous to leave the circulation fans running through the cool evening hours by turning the thermostats down to 75 o F or even lower. This practice will lower the inside temperature faster, providing the birds with a cooler environment in which to dissipate stored body heat.

Foggers reduce air temperature in the house on hot days (90 o to 95 o F) when humidity is low, especially during midday when humidity levels are lowest and temperature is highest. The foggers inject fine water particles into the warm inside air. As the water vaporizes, heat is absorbed from the air, lowering its effective temperature. When foggers are used, they should be operated intermittently or designed to avoid excessive water flow into the environment. If too much water flows through the foggers, humidity levels may increase to the point where birds can no longer cool themselves by evaporation. In addition, litter made wet by excessive fogging can lead to performance and health problems. The appropriate water flow rate and timer settings depend on the method of ventilation, ventilation rate, bird size, and outdoor conditions. Fogging systems in naturally ventilated house are typically designed for a water flow rate of 50 to 100 gallons per hour.

Forced Ventilation

In forced ventilation systems, all air movement is produced by fans in the building walls. Houses that use this type of ventilation are also referred to as controlled environment systems. Power ventilation houses can provide good, uniform airflow patterns under hot summer conditions if correct static pressure is maintained and airflow obstructions are avoided. It is very important to determine how much air should be moved through the building. This can be accomplished in two ways. Approximate values for the minimum volume of air required per pound of poultry body weight are given in Table 3. These values can be used to determine the total fan capacity required for the house. Keep in mind, however, that the rates shown are minimum estimates, and it is best to plan for the worst possible case. For example, the efficiency of fans is greatly reduced if they are allowed to become excessively dirty, reducing the airflow through the building.

Table 3. Recommended Minimum Ventilation Rates Based on Body Weight

Body Weight (pounds)	Airflow Per Pound of Body Weight (cubic feet per minute)
1 to 6	1.0
6 to 15	0.8
15 to 30	0.7

A second method for determining airflow rate is to plan for a summer ventilation rate of one complete air exchange per minute. The necessary airflow volume per minute is equal to the interior volume of the house, which can be calculated from building measurements.

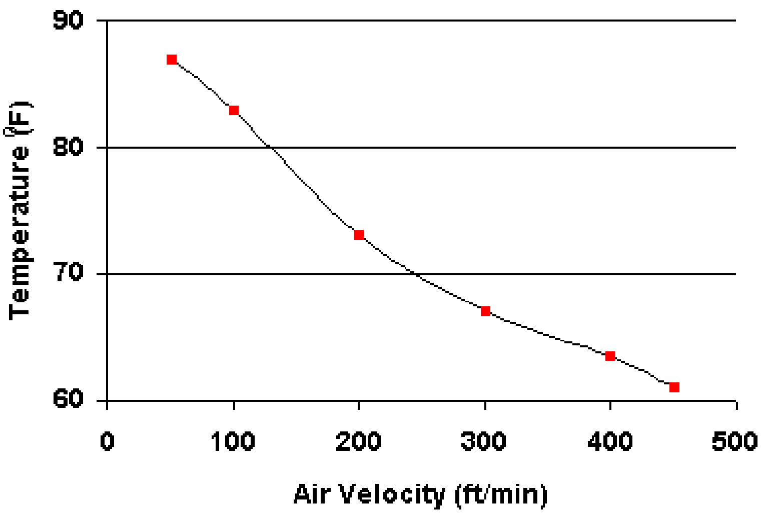
Negative pressure systems use exhaust fans to provide air movement. Stale air is expelled from the house by fans at a slightly higher rate than air is allowed to enter through the vents. This creates a partial vacuum, causing the air to enter the house at a high velocity. The increased velocity creates more turbulent air movement. Negative pressure systems are designed to operate best with a static pressure drop of 0.03 to 0.08 inch of water. This pressure difference induces the air to travel from inlets along the ceiling until it meets a stream from inlets on the opposite side of the house. As the two streams meet in the center of the house, the air drops, creating turbulence. The air then travels toward the exhaust. If the pressure difference is too low, the velocity of the air is reduced as it enters the building. In that case, the resulting air drops to floor level and travels directly toward the exhaust fan. Conversely, if the static pressure is greater than 0.08 inch of water, the velocity of the inlet air is increased, but the volume of air is restricted and fan efficiency is reduced because of back pressure on the fan blades. This condition can result in pockets of stale air where there is little or no air movement, which is detrimental under summer conditions. Dead air zones must be avoided by proper inlet placement and system management. The location and orientation of the inlets is the single most important factor influencing the airflow pattern inside the building.

Positive pressure systems use fans to blow fresh air into the building, creating a slightly higher pressure inside the house. Stale air is allowed to escape through strategically placed exhaust vents. Air movement is controlled by automatic environmental control mechanisms.

Tunnel Ventilation

A new arrangement for ventilating poultry houses in the summer is tunnel ventilation. Simply put, this method involves moving air along the building axis from inlets to exhaust fans, providing high airflow velocities. This rapid air movement increases convective heat loss, reducing the effective temperature experienced by the birds. Most of the benefits of tunnel ventilation occur at an air velocity of 350 feet per minute. This velocity should be considered the minimum for most house designs. Tunnel ventilation systems do not operate on a static pressure difference. In fact, they work best when there is no pressure difference between the inlets and the fans.

Figure 2. Effective Temperature



Source: Timmons, 1989.

Evaporative Cooling with Power Ventilation

Fogging nozzles and evaporative cooling pads are options that can be used in combination with power ventilation systems and especially with tunnel ventilation. Evaporative cooling used heat from the air to vaporize water, increasing humidity but lowering air temperatures. Evaporative cooling can be effective in North Carolina during the hottest part of most days because that is when humidity is lowest. On rare occasions the humidity remains high the entire day or immediately before or after a storm; evaporative cooling is ineffective under such conditions and should not be used. Evaporative cooling pads operate on the same cooling principle as foggers, except that the air is cooled when it passes through the wet pads as it enters the house. This method avoids the problem of wet litter sometimes encountered with foggers, allowing evaporative cooling pads to be used on a continuous basis. Aspen fiber and corrugated cellulose are two materials widely used as cooling pads. Regular maintenance is necessary to ensure long life of the pads. First, the pads must be allowed to dry out once each day. First, the pads must be allowed to dry out once each day. They can be dried by turning off the water supply but allowing the fans to continue running. The best time to dry the pads is in the early morning hours when the outside temperature is relatively low. Drying allows the adhesive that holds the pad together to maintain its integrity and also helps reduce the buildup of algae. To further reduce the growth of algae, and algaecide can be used in the water supplied to the cooling pads. Calcium hypochlorite, ethylene dichloride, or ammonium chloride can be administered at a rate of 6 ounces per thousand gallons of water, applied once each week. In addition, the pads should be washed monthly to remove dust and sediment. The entire system should be flushed monthly to remove the mineral salts and dirt that accumulate in the pipes and reservoir.

Evaporative pads constructed of aspen or cellulose ranging in thickness from 2 to 6 inches are being used in the industry in conjunction with power ventilation systems. On a hot, dry day these pads evaporate water at a rate up to 100 gallons per minute per hundred square feet of pad surface area. Using tunnel ventilation, they can evaporate up to 200 gallons per minute per hundred square feet of pad on a hot, dry day.

Fogging systems have also been used successfully in environmentally controlled poultry houses. Fogging systems that provide a reliable fine mist and that have water filters (to keep nozzles from clogging) and also have a positive shutoff to prevent dripping can provide successful cooling without causing wet litter. The water pressure should be at least 100 pounds per square inch (psi) to achieve a fine mist; a pressure 200 psi is preferred. The volume of water that goes through the fogging system and the number and placement of the nozzles are critical design considerations. A total flow rate of up to 1 gallon per hour per thousand cubic feet per minute (cfm) of ventilation can be used in tunnel-ventilated houses.

The design of the fogging system is critical for tunnel-ventilated houses. Cross lines of nozzles that provide a "curtain" of fog across the house at various intervals are fairly effective. Nozzles or lines of nozzles should be located close together near the air inlets, then spaced farther apart along the house, ending 60 feet from the exhaust fans. Tunnel-ventilated houses can use substantially more fogging capacity (50 to 100 percent more) than naturally ventilated houses because the forced air movement is able to carry the mist.

The value of a summer ventilation system should not be underestimated. If the system is operating properly, it can improve litter quality, reduce dust levels, and improve the flock's rate of gain or production level. The key to operating any ventilation system is understanding how it works. In addition, a good maintenance program of cleaning, adjusting, and monitoring controls for the curtains or inlets will maintain system efficiency. Fans in any ventilation system should be cleaned and lubricated frequently, and fan belts should be adjusted periodically, especially during times of heaviest use. If foggers are used, they should be serviced periodically to ensure that they produce a uniform, fine fog. If questions arise concerning the operation of your ventilation system, consult your flock supervisor.

Heat Stress

High ambient temperatures can be devastating to commercial broilers; coupled with high humidity they can have an even more harmful effect. Heat stress interferes with the broilers comfort and suppresses productive efficiency. During periods of heat stress the broiler has to make major thermo-regulatory adaptions in order to prevent death from heat exhaustion. The result is that the full genetic potential of the broiler is often not achieved.

What is the broilers natural physiological response to heat stress?

Broilers subject to high environmental temperatures exhibit many behavioral changes which allow them to re-establish heat balance with their surroundings. Broilers rest more during periods of heat stress. Some birds will stand quietly while others simply crouch near walls or waterers. Usually, their wings are spread away from the body to promote cooling by reducing body insulation. Within the bird, blood flow is diverted from certain internal body organs such as the liver, kidneys and intestines to dilated blood vessels of the peripheral tissue (skin) in order to facilitate heat loss.

Hyperventilation or "panting" increases during periods of high environmental temperature. Heat loss through evaporative cooling allows the broiler to dissipate the heat it is generating.

However, panting requires increased muscle activity and this results in an increased energy requirement which is associated with heat stress. Therefore, decreased energy efficiency also accompanies hot weather. Panting would normally be expected to occur when the ambient temperature is near or above 30C. Relative humidity influences evaporative heat loss through panting. Broilers, as well as other domestic poultry, cannot tolerate high temperature coupled with high relative humidity.

Death due to heat exhaustion will occur very quickly, especially in heavier birds, if both temperature and humidity are high. In normal birds, panting will remove approximately 540 calories per gram of water lost by the lungs.

How will panting influence pH or
acid-base balance in the broiler?
Normally, blood pH is controlled by the lungs and kidneys along with the various buffer systems which prevent rapid changes in the pH. However, as the respiratory rate increases in heat stressed broilers, there is a corresponding decrease in the levels of blood carbon dioxide. Respiratory alkalosis (elevated blood pH) results. Heat stress also depletes potassium and other minerals in the body, altering the delicate electrolyte balance in the body.

Should a decrease in feed intake be
expected during heat stress?
Yes. Broilers maintained in hot environments reduce their feed consumption. This is a part of their physiological adaptation to heat stress. The reduction in feed intake results in a decrease in the daily intake of nutrients responsible for growth. However, fewer nutrients to metabolize means less heat produced by the body. Thus, even though growth is slowed, the broiler can now more easily cope with the heat because of the lessened need for heat dissipation.
Research data clearly shows that the survival rate of broilers decreases as feed intake increases during heatstress, especially during the hottest part of the day.

Why is fasting beneficial during heat
stress?
In addition to heat-stress mortality, economic losses associated with broiler heat stress also occur as a result of lowered growth rate and decreased feed efficiency. Therefore, it is natural for producers to want to stimulate feed consumption in hot weather. However, any management technique which promotes feed consumption or increased activity during the peak hot periods may be counterproductive. The extra feed consumed will increase the bird's heat load and probably result in additional mortality. Fasting the broiler prior to or during peak hot periods of the day lessens the heat load and enhances survival.

Fasting reduces the heat production from digestion, absorption and metabolism of nutrients. Fasting also has a calming effect. Movement in animals occurs through muscle contraction, which generates heat. In hot environments this heat production only adds to the heat load. Therefore, to lessen the heat load, broilers should be kept as calm as possible. This is especially important during the hottest parts of the day. Once the hottest periods are over and ambient temperature starts to fall, the broilers will usually begin consuming feed again.

What alleviates heat stress in broilers?

In hot/humid environments with open-style houses adequate air movement and water consumption are essential. Ventilation should be maximized. Air movement facilitates removal of build-up ammonia, carbon dioxide and moisture. Panting is accompanied by an increase in water loss by the lungs. Therefore, more water has to be consumed by broilers during hot weather in order to prevent dehydration. Cool drinking water stimulates both feed and water intake.

Reducing the body temperature of heat stressed broilers is beneficial. When the temperature of drinking water is lower than body temperature it will absorb body heat. Therefore, providing adequate and cool drinking water is extremely important to heat stressed broilers. Usually, anything that results in increased water consumption during heat stress will benefit the survival rate. In fact, some researchers have attributed the increased survival rates of heat stressed broilers receiving supplemental salts such as potassium bicarbonate, potassium chloride, sodium chloride and ammonium chloride to the increased water consumption which results, not to the salts.

Can dietary adjustments promote better performance of broilers under heat stress?
Yes. Heat stress causes broilers to decrease feed intake and consequently nutrient intake. Therefore, the dietary nutrient concentrations should be increased. Simply increasing the protein concentration is the wrong approach. The energy content of the diet, along with other nutrients, should be increased. Increasing fat calories should be considered. Dietary vitamin and mineral concentrations should be re-evaluated.

The use of vitamin C, as an anti-stress agent, is often considered during periods of heat stress. Choosing the correct coccidiostat is very important as well as the use of antioxidants and mold inhibitors in stored feed. Protein contributes more to metabolic heat production than do carbohydrate and fat. Therefore, feeding imbalanced diets with regards to amino acids will result in increased metabolic heat production. Amino acid balance in the diet is especially important. Efforts should be made to formulate diets with slightly lower protein levels and to utilize synthetic amino acids, especially methionine and lysine.

Summary

Broilers under heat stress have to make critical life sustaining physiological adjustments. Feed intake is depressed and water intake is increased. Dietary adjustments can help reduce metabolic heat production and maintain nutrient intake. Energy intake and amino acid balance is of extreme importance in heat stress. Providing adequate ventilation and stimulating water consumption is essential. Minimizing bird activity during the hottest parts of the day lessens the heat burden. Controlled fasting is beneficial and usually increases survival rate of broilers during heat stress.

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