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Heat Stress and Processing

The impact of heat stress on processing and meat quality

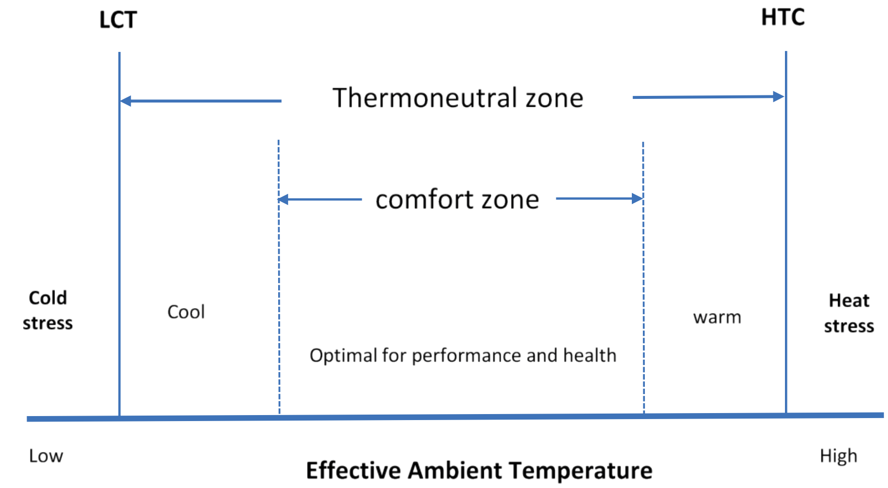
In this issue

As the average temperature on Earth increases the poultry industry will face a number of issues, one of which is heat stress and the effects on flocks. Knowing how to mitigate temperature in both hot and cold weather with careful planning will become increasingly more important, during both the growth period and processing.

In the following articles we will discuss the consequences of heat stress in the production chain and what we can do to avoid or at least limit damage on welfare, production and quality parameters. Outlining some key concepts around heat stress and practical tips to mitigate its effects on the birds.

An introduction to heat stress in poultry production

By Dr. Andre Derkx, Veterinarian, Cobb Europe



Depending on human behavior and who you listen to, it is expected that the average temperature on earth will increase 1.5 to 3 C this century with serious impacts on nature. This will also affect the global poultry industry by creating heat stress conditions. This is what we will be discussing with you in this issue of Technical Focus.

Chickens cannot sweat, we all know that. So how does the chicken lose heat? First, what is sweating? This is the active process to excrete water on the skin which will evaporate and cool that skin. Sweat glands in the skin provide the moisture necessary for this active process.
Since chickens do not have sweat glands, only a minor amount of water evaporation occurs from the skin to the environment. This form of moisture loss is not an active process and does not add much to bird cooling.

Some abbreviations for this article:

Ta	Ambient temperature
Tb	Body temperature, mostly measured as cloaca temperature
TNZ	The Temperature Neutral Zone where the bird can keep control and maintain its body temperature without panting. Within the TNZ, the comfort zone is the temperature range where *Tb* is maintained with minimum effort. The endothermal broiler over 3 weeks of age has a TNZ of 17.5 to 24 °C of the *Ta*. It must be mentioned that there is quite a variation in reported TNZ in literature.
HCT	Highest Critical Temperature. This is the upper temperature limit within the TNZ. Above this value we speak of heat stress and active evaporation through panting starts.
RH	Relative Humidity. There is an influence of the RH on the TNZ. The HCT is dependent on the RH. The higher the RH, the lower the HCT becomes. Evaporation becomes less efficient when the RH rises.
THI	Temperature Humidity Index gives you the level of heat stress the birds suffer from. There are several websites that can assist you in the calculation of the THI.
BMR	Basal Metabolic Rate. The amount of energy used at rest as Joule/kg/hour. Above the TNZ, the bird will reduce its BMR and will produce less heat.

Keeping the birds body temperature in the thermoneutral zone. How does it work?

During evolution there has been a shift from exothermy (heat exchange with the environment based on behavior-sunbathing) to endothermy (internal heat production). In most literature you will find that chickens are fully endothermic, but the embryo starts its development "ectothermic" and becomes fully endothermic around day 4 after hatch. One could argue that this is not completely true and that the thermoneutral zone for a young chicken is very narrow. So, the newly hatched chick appears to be depending only on environmental heat when really the chick is an endotherm at hatch.

The shift from exotherm to endotherm during evolution, could be established by a higher cardiovascular output and internal heat production. More oxygen and a higher aerobic metabolism gave birds the option to migrate over longer distances and inhabit varied environments. The *Tb* is constant within a narrow range and the bird has developed several mechanisms to maintain it. The *Tb* for a bird over 3 weeks of age is between 40.5 to 41.6 °C.

Within the TNZ there is a comfort zone. This is the temperature range within which the bird performs excellently and does not need any extra physical or behavioral measures to maintain body temperature.

Heat loss is controlled by:

-	Radiation	heat transfer by electromagnetic infrared waves
-	Convection	heat transfer within a solid, fluid or gas
-	Conduction	direct contact between 2 objects with a different temperature
-	Evaporation	transition of liquid to gas
-	Vasodilation	Dilating the blood vessels to increase transfer of heat from blood across skin

Heat production is controlled by:

- Body metabolism
- Feed intake

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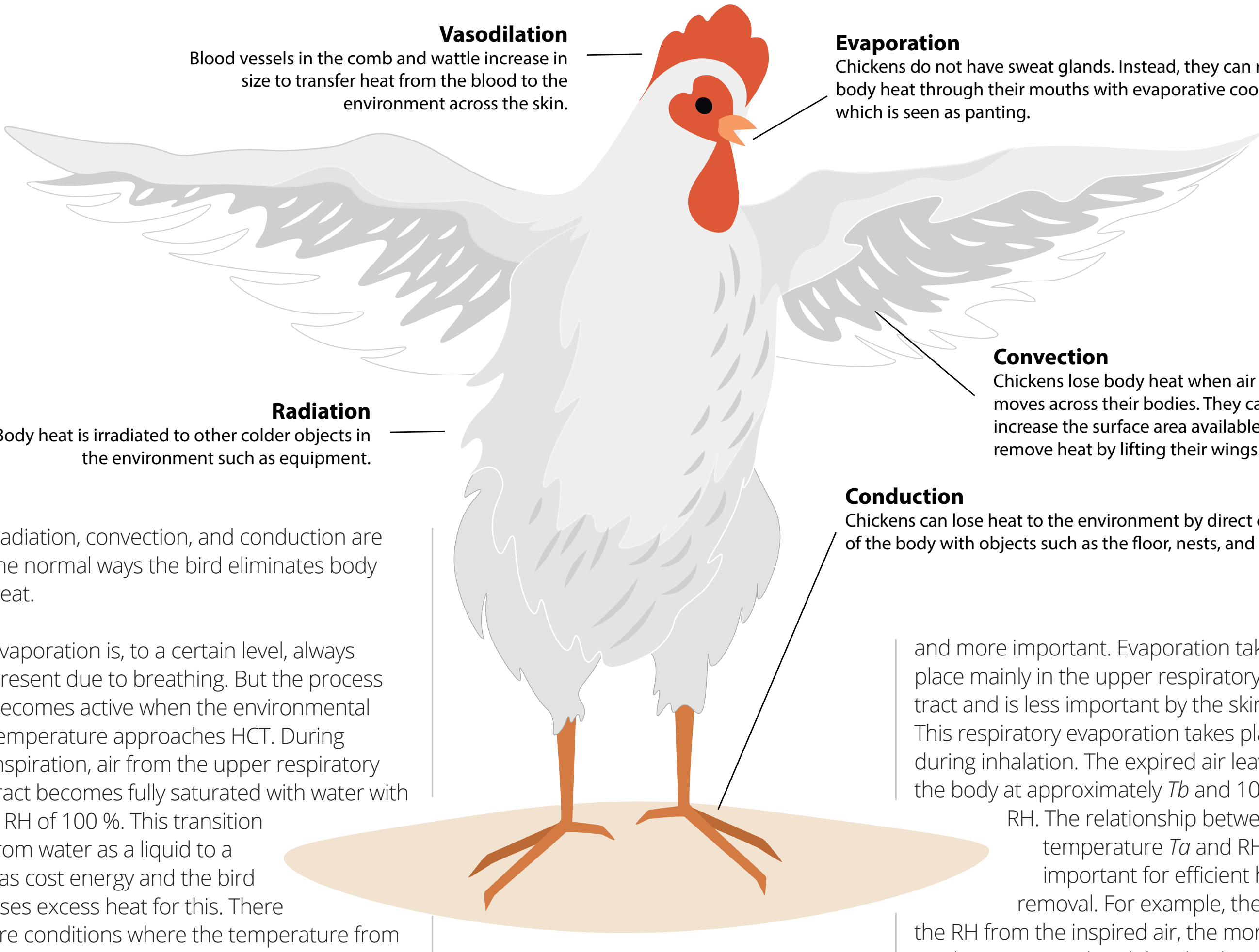

Radiation, convection, and conduction are the normal ways the bird eliminates body heat.

Evaporation is, to a certain level, always present due to breathing. But the process becomes active when the environmental temperature approaches HCT. During inspiration, air from the upper respiratory tract becomes fully saturated with water with a RH of 100 %. This transition from water as a liquid to a gas cost energy and the bird uses excess heat for this. There are conditions where the temperature from the incoming air does not exceed the tissue temperature in the upper respiratory tract and that the air does not have an RH of 100 %. With this evaporation, the bird will lose water. The panting bird will lose CO_2 which will lead to an increase in blood pH and the development of respiratory alkalosis. The bird will try to correct this with a higher HCO^-_3 excretion and H+ retention by the kidneys but the pH increase leads to a more extreme case of respiratory alkalosis which will affect welfare and performance. The Dietary Electrolyte Balance in the feed can be very helpful here increasing the blood buffer capacity for these kind of changes

$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H+ + HCO^-_3$
The formula will move to the left

Also, the bird will change the type of metabolic pathways it uses, and this can lead to an increased amount of oxidants. The resultant oxidative stress can compromise the immune system.

Chickens have a circadian temperature fluctuation. The BMR decreases in the dark period. This is sometimes used in hot weather but be aware that birds will sit and lose less heat by conduction through the legs and feet.

In the legs and head (wattles, comb) heat exchanges from arterial to venous blood. The artery and the vein are lying next to each other and exchange heat. The arterial-venous system works like a heat exchanger. Through conduction, hot arterial blood will transfer its heat to cooler venous blood. The venous blood flow in the skin, mainly in the feet and head (wattles, combs), will transfer heat to the environment and the blood will decrease in temperature. When the blood returns to the heart, this cooler venous blood will exchange heat with its environment and will rise in temperature. If we take an organ such as the liver, metabolic heat will be produced and spread within the liver by convection and to the surrounding tissues and blood by conduction.

The bird is also able to dissipate heat efficiently through the skin thanks to Arterial-Venal Anastomoses which are connections between small arteries and veins. With this system, only a portion of the blood travels through the capillaries. This ability to lose heat through the skin is a big help when trying to eliminate heat in hot conditions. A properly designed ventilation system will assist in eliminating heat through the skin to the air and from the air out of the barn. The higher the airspeed, the higher the temperature difference between skin and air. In addition, the lower the RH from the air, the more efficient the heat exchange will be.

When the body temperature comes close to the upper HCT in the thermoneutral zone, evaporation will become more and more important. Evaporation takes place mainly in the upper respiratory tract and is less important by the skin. This respiratory evaporation takes place during inhalation. The expired air leaves the body at approximately *Tb* and 100 % RH. The relationship between air temperature *Ta* and RH is very important for efficient heat removal. For example, the lower the RH from the inspired air, the more water can be evaporated and thus leading to a higher heat loss.

The bird has thermoreceptors in the skin, organs, and brain. The pre-optic-anterior hypothalamus in the brain serves as a central command. These thermoreceptors also play a role in what is called thermal conditioning. Thermal conditioning is the process of exposing the embryo or very young chicken to temperatures above the TNZ for a short period, hours. With this technique we attempt to switch on genes which make the bird more tolerant to future heat stress conditions.

In the following articles we will discuss what are the consequences of heat stress in the production chain and what we can do to avoid or at least limit damage on welfare, production, and quality parameters.

About the author:

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Managing broiler breeders during heat stress

By Paul Welten, Senior Tech Service Team Manager and Breeder Specialist, Cobb Europe

Globally, the climate is changing, and temperatures are rising. As a result, the number of days that poultry, including broiler breeders, experience heat stress is increasing. Broiler breeders show their full genetic potential when they can maintain their internal body temperature of 41 to 42 °C. How the ambient temperature (T*a*) affects chickens depends on the stage of growth or production phase. For example, adult breeders should be maintained at an environmental temperature of 18 to 22 °C. Factors that influence the degree of heat stress are temperature, relative humidity, bodyweight, feather quality and density. Body heat will mainly be lost by passive (radiation, conduction, and convection) and active means (panting). During panting, a breeder will lose a large amount of CO_2 which does not come into the bloodstream. This results in a higher pH (alkalosis) which could cause a reduction in feed intake, drop in egg production and more eggs with thinner shells. High temperatures also result in increased water intake which can lead to the excessive mineral excretion. When heat stress is not properly managed, flock mortality will increase. It is important to adapt your management during periods of high temperature to eliminate heat stress. Well managed broiler breeders are fully capable of performing well during high temperature conditions.

Symptoms and signals of heat stress

Most breeder producers monitor and record temperature daily and can tell if it is too cold or too hot. However, it is also important to look at bird behaviour and observe how they perceive the temperature. Symptoms and signals of heat stress include:

- **Panting**
- **Spreading of the wings**
- **Bird migration towards fans**
- **Higher water to feed ratio**
- **Extended feed clean up time**
- **Reduced bird activity in the house**
- **An increase in floor eggs due to lower mobility**
- **Wet neck feathers**
- **Higher floor egg ratio**
- **Reduction of eggshell quality**
- **Lower egg production**
- **Lower fertility**

Heat stress in relation to performance

Housing environment has been greatly improved over the past few decades which helps to manage heat stress conditions. However, even with improved ventilation capacity, cooling systems (pad cooling or high-water pressure nozzle systems), and faster water distribution you can still experience a loss in egg production, fertility, and hatchability. This is especially true around peak production when the broiler breeder is most sensitive to heat stress. It is at peak that the flock is experiencing high productivity and feed intake. The birds are still completely feathered which makes it harder to lose heat. When temperatures rise above the Thermoneutral Neutral Zone (TNZ), the broiler breeder is less active and has a reduced appetite. General feed clean up time starts to increase above temperatures of 27 °C. Studies have shown that extended periods of heat stress (exceeding 12 days) will result in lower body weight gain and loss of production. Heat stress also leads to elevated water consumption which can further reduce the efficiency of the gut by increasing the rate of nutrient passage and flushing of valuable vitamins and minerals through the intestines.

Panting is one of the mechanisms a chicken uses to control heat balance when the TNZ is exceeded. Unfortunately, there are consequences to excessive panting.

Panting increases the CO_2 loss from the lungs that results in an increase in the blood pH. This lowers the availability of calcium ions in the blood available for eggshell mineralization leading to poor eggshell quality and increased frequency of cracked and downgraded eggs. Maintaining the electrolyte balance by extra supplementation with potassium, sodium bicarbonate and chloride has been shown to make breeders more tolerant to heat stress. An electrolyte balance (DEB) of about 250 mEq/kg is suggested to be effective in heat stress conditions.

Fatty liver problems

The incidence of fatty liver disease increases during heat stress periods due to severe unbalance in liver metabolism. High environmental temperatures together with the lethargy produced by heat stress reduces the energy requirement of the bird. The surplus energy that the bird has consumed is transformed into fat within the liver and the accumulation can result in fatty liver disease.

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The unbalance can also occur when high producing broiler breeders, often at peak production, self-limit feed intake during hot weather. During this time, they have a shortage of energy and transition into a negative energy balance.
If there is not enough fat present, the liver will break down body fat. The liver must process this fat and at a certain point reach the maximum processing capacity. The liver stores the fat and becomes fatty. As a result, the vessels in the liver become blocked. This damages the liver and results in less vital hens with fewer eggs. Providing substances like choline, biotin, inositol, Vit B12 and betaine can help to reduce fatty liver issues.

Impact on reproduction

Exposing broiler breeders to heat stress has a negative impact on fertility due to a reduction in mating activity. There is also evidence that elevated temperatures increase the number of dead sperm, and reduce sperm production, motility, and overall semen quality. Motility is very important for sperm to reach the site of storage in the uterovaginal junction.

Some studies have also demonstrated that heat stress increases the frequency of sperm deformities. High temperatures can negatively impact hatchability. Since a fertile egg contains a developing embryo, it is important to cool the egg as soon as possible. To maximize hatchability during hot weather, collect the hatching eggs in the community nest 4 times/day and manual nest 6 times/day. Store eggs in an environment-controlled storage room so the eggs cool to physiological zero (24 °C). The goal of egg cooling is to slow embryo development until incubation. Stopping embryo development means the embryo has died.

Ventilation

To reduce chicken metabolic heat from the house, implement tunnel ventilation in combination with pad cooling. The airflow creates a wind-chill effect which reduces the effective temperature for the bird. The goal is to keep this below 30 °C. Evaporative cooling works well but the RH % increases by 4.5 % for every 1°C cooling. Pad cooling should not be used at temperatures below 28 °C and RH % should not exceed 85 to 90 %.

In milder climates where they don't have pad cooling systems, farms can install a high-water pressure nozzle system inside the house above the inlets. The objective is to create water droplets of approximately 10 mircometres. The small water droplets evaporate quickly, so a higher water pressure is required, 70 to 100 bar which can be obtained by a high-pressure pump and high-pressure pipes. It is important that the installation has good filtration, so the small nozzles don't become blocked by lime deposits or dirt. The fine mist is blown into the incoming air which can cool the air by 10 °C. Another option is to use low-pressure cooling. This cooling system is installed outside and is designed to cool the incoming air. The system has the disadvantage of using a lot of water with only a minor cool down of house temperature. It has an advantage of being relatively cheap and easy to install.

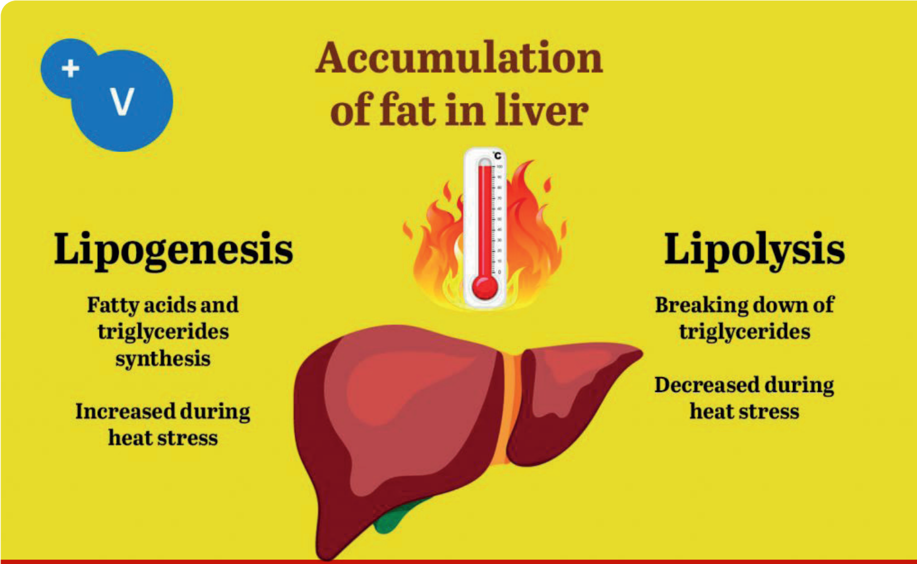
Providing extra vitamins and minerals during heat stress conditions can improve the performance in hot climates. Vitamin E is a fat-soluble vitamin which acts as an antioxidant and has shown improvements in egg production by heat stressed birds.

Studies have shown that supplemental vitamin E can improve egg weight and eggshell thickness. Vitamin C has also been shown to have many positive impacts on egg production and quality during heat stress conditions. Selenium should be used in organic form for poultry. It is easy to digest in heat stress conditions and has shown improvements in productive and reproductive performance, egg weight and eggshell quality.

To reduce heat stress many points can be considered:

- In hot climates place a bird density of 5 to 5.5 birds/m^2.
- Have feed available first thing in the morning as the lights switch on.
- Record and monitor feed clean up times. In general, clean up time should not exceed 2.5 hours. If heat stress results in an extension of clean up time beyond 3 hours consider shifting the lights on and feed period 2 hours earlier in the day.
- Ensure a good physical quality feed to encourage appetite and to increase clean up time. A pellet or crumble feed can be provided instead of mash feed.
- To ensure good eggshell quality provide oyster shells as scratch feed (1.5 grams/bird).
- Collect the eggs at least 4 times/day in community nests and 6 times/day in manual nests.
- Make sure that all eggs are collected by the end of the day.
- Close automatic nests at lights off so hens do not rest in the nest at night.
- Maintain 50 to 60 % humidity in egg storage.
- Control water intake, maximum water to feed ratio of 2.5 : 1 and 3.5 : 1 during extreme temperatures.
- Flush the nipple water lines to provide clean freshwater (below 25 °C). If bell drinkers are used, close the water for 2 hours so they become empty and new fresh clean water can be provided later.
- Make sure that the air can easily enter the house by eliminating any resistance due to dust.
- Create shadow sides by planting trees along the sides of the house. This keeps the temperature lower during the heat of the day.
- Hang temperature sensors just above bird level so they measure the temperature that the bird feels.

Heat stress not only challenges the welfare of the broiler breeder but also harms their productivity. This in turn, affects the profitability of the farms. Take the appropriate measures in time to limit the effects of heat stress.



Plusvet animal health, heat stress and fatty liver hemorrhagic syndrome in poultry.

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Thermoregulation in broilers

Keep them comfortable at all stages

By Martijn Gruyters, Senior Manager, Technical Service, Cobb Europe

The genetic progress of our modern meat type broiler has made remarkable improvements in efficiency over the past decade. To attain this genetic potential, all necessary management and nutrition steps need to be optimized to always ensure flock comfort. Be aware however, that the parameters for comfort will shift with flock age. For example, the nutritional requirements for energy will increase and the requirement for protein/digestible amino acids will decrease as the flock ages.

Figure 2: measuring body temperature with a rectal thermometer.

This article will focus on another factor which is very important to consider, and which varies with age and developmental stage: temperature.

When discussing temperature, it is important to realize that a broilers perception of temperature (effective temperature) will depend on a variety of factors:

1. Age
2. Bodyweight
3. Housing conditions
4. Feed levels and nutrition
5. Relative humidity
6. Air speed
7. Health status

Young broilers (0-3 weeks)

During incubation (embryonic stage), embryos behave as "cold blooded" (poikilothermic or exothermic). This means that the developing embryo depends on the environment to keep itself warm and comfortable. At hatch a broiler is already endothermic, but its thermoneutral zone is very narrow. Any housing conditions which are outside the comfort zone of the young broiler including low or high house temperatures, incorrect floor temperatures, or drafty conditions, will create a difficult start for the young broiler. Of the items listed above, give special attention to the floor temperature as young birds will lose or gain a lot of heat through their legs. The floor (concrete) should be between 28 to 30 ˚C and the fresh litter should be between 30 to 32 ˚C (RH 30 to 50 %) with forced air heating. When radiant heaters are used, temperatures under the heater should be 40.5 ˚C. A proven practice to check if broilers are in their comfort zone is by measuring their cloacal temperature with a digital thermometer. Start with these measurements immediately after placing the chicks to evaluate the brooding conditions. From placement to 5 days, cloacal temperature should be range from 40.0 to 41.0 ˚C. When temperatures are out of this range, action needs to be taken to get the chicks to the correct temperature by increasing or decreasing the house set temperatures in small steps (0.5 ˚C). When the cloacal temperature is out of this range, broilers will be less active, and feed and water intake will be negatively affected.

Depending on the age of the parent stock, the young broiler will slowly change from "cold blooded" to "warm blooded" by day 5. At this age, chicks can regulate their body temperature, but in suboptimal climate conditions this will require energy. Energy diverted to thermoregulation will not be available for growth and immune functions making chicks more susceptible to disease challenges and reduced weight gains.

The capacity to regulate heat can be divided in 2 different processes:

1. Physical heat regulation

2. Chemical heat regulation

Broilers will regulate internal body temperature by physical mechanisms or responses:

- Body position and huddling ➔ by increasing proximity to other chicks (huddling) birds will conserve heat
- Feather development ➔ feathers have an insulating effect so heat loss to the environment is minimized. The fluff on young, hatched broilers has very poor insulating properties (R-value of 0.075).
- Evaporation of water ➔ heat is lost through evaporation of moisture in the respiratory tract. By panting, birds can increase the amount of heat that is lost.
- Changing the blood flow through the capillaries in the skin ➔ by dilating or contracting capillaries, the amount of blood flowing through them is regulated as is the amount of heat lost or conserved.

Environmental temperature can stimulate chemical hormone production. These chemical factors can dictate bird behavior. This response is known as chemical heat regulation. In this context, the birds can:

- Increase feed intake when ambient temperatures are below the thermal neutral zone (TNZ)
- Decreased feed intake when ambient temperatures are above the TNZ

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Older broilers (>3 weeks)

As broilers age, feed intake will increase. A modern broiler will consume around 264 kcal/kg of live weight per day. To put this into perspective: this is about 5 times more when compared to human consumption. About 25 % of this consumed energy is used to power the basic functions of life (growth, development, movement, breathing). The remaining 75 % is released as metabolic heat, this needs to be removed from the house to keep the birds comfortable in their TNZ. Even in poorly insulated houses, about 85 % of the heat added to the house will be from the birds. It is important to note that while metabolic heat output is increasing, the insulative value of a broiler is increasing as well making correct management for heat disposal even more critical (Figure 3).

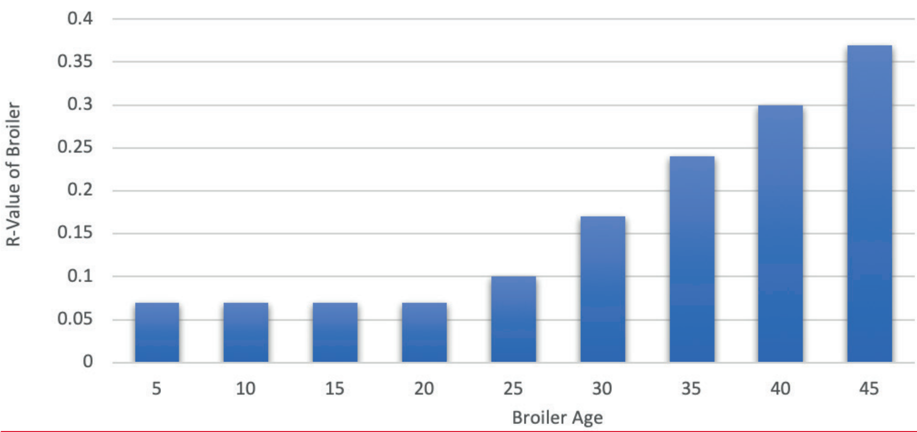

Figure 3: insulation value (R-value) of a broiler with increasing age.

Because poultry do not sweat, broilers must lose their excess heat by dissipation. This can be either through radiation, convection, conduction, or evaporation. The first 3 paths are known as sensible heat loss and work on the temperature differences between the bird and its environment. Broilers will lose heat through the shanks, wattles, and non-feathered areas like the breast and under the wings (see figure 4). The impact of sensible heat loss on bird behavior, feed intake and metabolism are minimal. Broilers partition approximately 40 % of their heat loss through the sensible component and 60 % through evaporation. When sensible heat loss can no longer keep the broiler in their TNZ, the broiler will increase its evaporative heat loss which is very clearly seen as panting. When excessive panting occurs, feed intake will decrease and water intake will increase, negatively impacting growth and litter conditions. Panting will cost a lot of energy and broilers can lose 5 to 18 grams of moisture per hour if body temperature exceeds 42 ˚C. Body temperatures over 42.5 ˚C for longer periods are potentially lethal, so all effort must be taken to manage your house environment during periods of extreme heat.

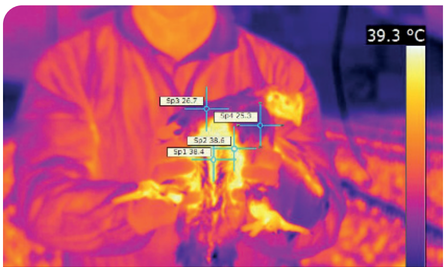

Figure 4: heat loss through head, legs and breast.

When birds get older the density in terms of kg/m^2 increases, resulting in less available floor area. When broilers are trying to dissipate excess heat, the heat output of the litter increases due to the microbial load in the litter. When microbial based heat is not removed, body temperatures can rise quickly causing the negative effects as described earlier. Often when final weights are below target, but the bird's health status and early development was good, low feed intake post 25 days is likely due to high broiler body temperature.

Good management practices encompass all necessary actions needed to remove excess heat. Focus should be on house temperature settings, ventilation rates, air speed and bird activity. Measuring body temperatures with a digital thermometer after 25 days will indicate if broilers are in the target temperature range of 41 to 42 ˚C. When temperatures are above 42 ˚C, action needs to be taken because the bird's response will be to reduce feed intake and consequently lead to a reduction weight development.

In the first 14 days post hatch, the temperature settings are the same for all different climates, houses and stocking densities, and will mainly depend on the parent stock age and house relative humidity. As temperature sensors are the main source of information for controlling the ambient temperature, the position of these sensors is very important. Birds are the main source of heat output in a broiler house so the temperature sensors should be as close as possible to the birds. Table 1 shows temperature recordings at several heights. Consider a height of 0 cm to be the sensor positioned between the birds and a height of 20 and 100 representing the distance higher than the 0 cm position. From this table, at 28kg/m^2 the difference between the sensor recording and what a broiler will experience is increasing rapidly. Heat removal will be more important than house temperature and the air exchange need to be increased.

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Height (cm)	19.4 kg/m^2	28.0 kg/m^2	40.2 kg/m^2
100	21.8	21.8	22.3
20	22.3	22.5	28.6
0	23.3	26.9	30.3

Table 1: temperatures at several heights and stocking densities.

The age when the flock reaches this point will depend on several factors such as day old chicks (DOC) per m^2, growth rate and mortality rates, all of which will vary significantly by region. To calculate when the flock will reach the stocking density, the actual density can be calculated by multiplying DOC at placements by mortality. The actual density can then be used to determine at what age the house temperature should be adjusted using the standard stocking density and extrapolating from the Cobb Supplement available here (***www.cobb-vantress.com/resource/product-supplements***)

Example:

- 20-day old chicks per m^2 at placement (DOC/m^2)
- Mortality of 1.5 % up to 25 days = 19.7 birds/m^2 at 25 days
- Growth according to the Cobb curve

→ 28 kg/m^2 ÷ 19.7 birds/ m^2= 1.421 kg so when birds will reach 1.4 kg the stocking density will be at 28 kg/m^2.

→ Extrapolate from the Cobb Supplement will show that temperature needs to be adjusted at 26 days.

At this point, house target temperatures should be decreased, and ventilation rates increased to support the heat removal trapped underneath the birds. As a general guideline, the table below can be used to design a target temperature program based on bird density (kg/m^2) for houses using perimeter inlet ventilation.

When a flock is thinned, temperature settings need to be readjusted for the weight/m^2 (after the thinning process.)

To maximize the genetic potential of the modern broiler it is important to keep them comfortable at all stages during the growing period. Maintaining broilers within their TNZ is one of the important factors for this comfort and will change with age. If birds are in their TNZ, they will be able to regulate their body temperature at minimal energy cost and can exhibit their genetic potential for feed intake and growth. A turning point for house target temperatures is around 28 kg/m2 at which bird density will make heat removal from the broilers difficult with a risk of overheating broilers and reduced feed intake. Designing a temperature program based on this bird density will make it possible to customize target temperature settings for the different regions around the world.

Density kg/m^2	Target house temperature (˚C)
28	22 to 24
30	21 to 23
32	20 to 22
34	19 to 21
36	18 to 20
38	17 to 19

About the author

Martijn Gruyters has 22 years of poultry industry experience, 15 of which have been at Cobb. He services the European region. Martijn holds bachelor's and master's degrees in animal science from the University of Wageningen.

Heat Stress – Practical Tips for Broilers

By Brendan Graaf, Broiler Specialist, Technical Service, Cobb Europe

Knowing how to mitigate the adverse effects of heat stress on broiler performance helps to maintain high production performance and ensure good welfare during periods of hot weather. In this article we will outline some key concepts around heat stress and layout some practical tips to mitigate its effects on the birds.

Careful planning is fundamental, whether you live in a hot weather region and deal with heat stress on a regular basis or live in a cold weather region and only experience seasonal acute periods of heat stress. Keeping up to date with local weather and knowing which days may be heat stress days allows you to proactively adjust management practices to keep birds alive and productive.

One proactive tip is to increase ventilation rates earlier on in the morning, keeping birds cool during this period will allow them to cope better during the peak midday heat. Secondly, birds will carry heat from the day late into the evening. So maintaining higher ventilation rates for longer and later into the evening, even after house temperatures have returned to set point, will help reduce heat stress. Interestingly the more we can cool the birds during the evening the better the birds are able to deal with heat stress the following day (Figure 1). So, if you have back-to-back hot days, it is worthwhile to lower set-point temperatures during the evening and ventilate more.

When the lights go off in the evening (dark period) we often also see a reduction in house temperatures. However, using internal bird temperature sensors it is now well known that bird body temperatures increase during the dark period (Figure 2). This creates a situation where an automatic controller set to reduce ventilation, due to a reduction in house temperatures, will cause the birds to get even hotter. We need to be aware of this danger especially during hot weather periods so we can override our controller systems to ensure sufficient ventilation longer and later into the evening. It is also important to ensure you have your temperature and RH probes set at the right heights, just above bird height where they cannot interfere with the sensors but where the sensors are best able to measure the temperature and RH the birds are experiencing. If they are raised too high above the birds it can give a false sense of environment and result in inaccurate ventilation resulting in bird heat stress.

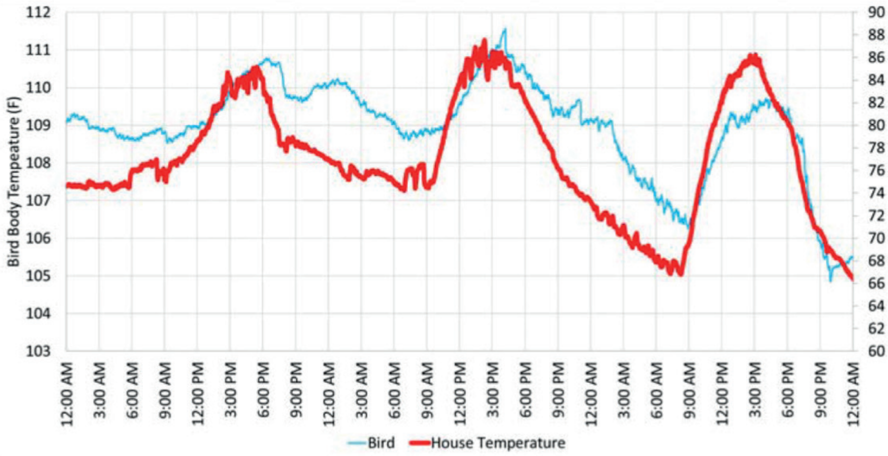

Figure 1. Reduction of internal body temperature the night before allows birds to cope better with same heat the following day (M. Czarick & B. Fairchild UGA Poultry Housing Tips Vol 30, No. 3 – Seven key tunnel ventilation management tips).

With regards to the lighting program, during hot weather periods it is better to set the light off time later into the evening. This will allow the birds more time to cool off from the hot day as well as more time to compensate on feed intake that they missed during the heat of the day. The length of the dark period is also important. Longer solid blocks of dark (6 to 8 hr) will result in more heat stressed birds. Therefore, breaking the dark period into a shorter maximum 4 hr block followed by a light period (minimum of 2 hr for birds to crop up) and then another 2 hr dark block will help reduce heat stress.

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Figure 2. Internal body temperature increases during dark period (grey blocks) while house temperatures come down (M. Czarick & B. Fairchild UGA Poultry Housing Tips Vol 30, No. 3 – Seven key tunnel ventilation management tips).

It is important to note that the light off time should be set from day 0 and not adjusted throughout the cycle, this needs to be planned and set in advance taking into consideration hot weather seasons.

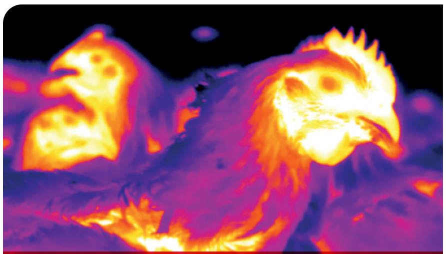

Figure 3. Thermal image of broilers glowing during heat stress – birds also seen panting.

Although outside temperature is a major factor, generally the most heat being produced in a broiler house comes from the birds themselves (Figure 3). This is the heat that our ventilation systems need to remove from the birds and from the house to keep birds alive and productive. As mentioned in article 3 bird density plays a major role, the higher the bird density the more heat being produced in the house and the harder it is to remove heat from the birds and from the house. If you know your housing system struggles to keep birds comfortable and productive during the hot weather season, then reducing stocking densities during this period can go a long way in making sure birds don't succumb to heat stress and continue to achieve excellent performance (Figure 4).

Walking the birds gently can be highly beneficial since heat stressed birds tend to lie down more and have significant heat build-up under their bodies and in the litter. Getting your birds to stand up and release this heat will be beneficial. Importantly this needs to be conducted when the house is fully ventilating and there is air movement over the birds, that can remove the built-up heat from around the birds as well as heat trapped in the litter (Figure 5). The way in which the houses should be walked

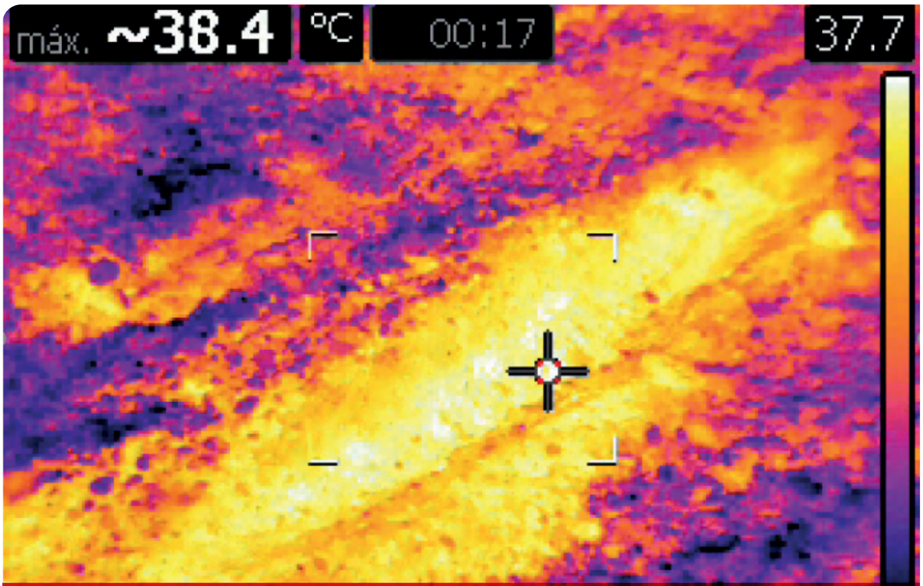

Figure 5. Thermal image of heat trapped in the litter from broilers lying down during hot weather.

is very important, this should be done in a calm steady manner as to not cause bird flightiness. This will also allow the birds around you to stand up for slightly longer before sitting back down again allowing more heat to be removed.

Water and drinker line management during hot weather is very important to reduce heat stress. During periods of panting water is lost through the respiratory tract of the birds. In response, water intake is increased to maintain thermoregulation. Therefore, ensure there is enough drinker space (10 to 12 birds/nipple) and that all drinker lines are working correctly and can supply enough water to the birds (correct flow rates/pressures). Maintaining water temperatures below 25 °C through regular flushing of drinker lines will also help alleviate heat stress. Making sure water storage/header tanks are shaded or kept indoors out of direct sun exposure will also help ensure cooler water delivery into the houses. Electrolytes and vitamins such as sodium bicarbonate, potassium chloride and vitamin C can be added to the water to help with heat stress. However, this should be monitored closely to prevent any wet litter issues as well as biofilm formation in the drinker system.

Feed formulation and quality can also play a role in alleviating heat stress. The partial replacement of energy sources from carbohydrates to lipids is a common practice to reduce the heat increment of the diet as lipids generate less heat when they are digested and metabolized compared to carbohydrates. Since heat stress negatively affects feed intake, gut health and villi function the use of lipids also has the benefit of slowing feed passage rate in the gut thus giving more time for nutrient absorption.

Since heat stressed broilers have impaired digestive function, the selection of protein sources that are high in digestible protein and amino acids, as well as switching to the use of more supplemental/synthetic sources of amino acids, can help improve digestibility and reduce heat production during digestion. There is also an added benefit of being able to dose essential amino acids such as methionine and cysteine which play a role in the body's antioxidant system.

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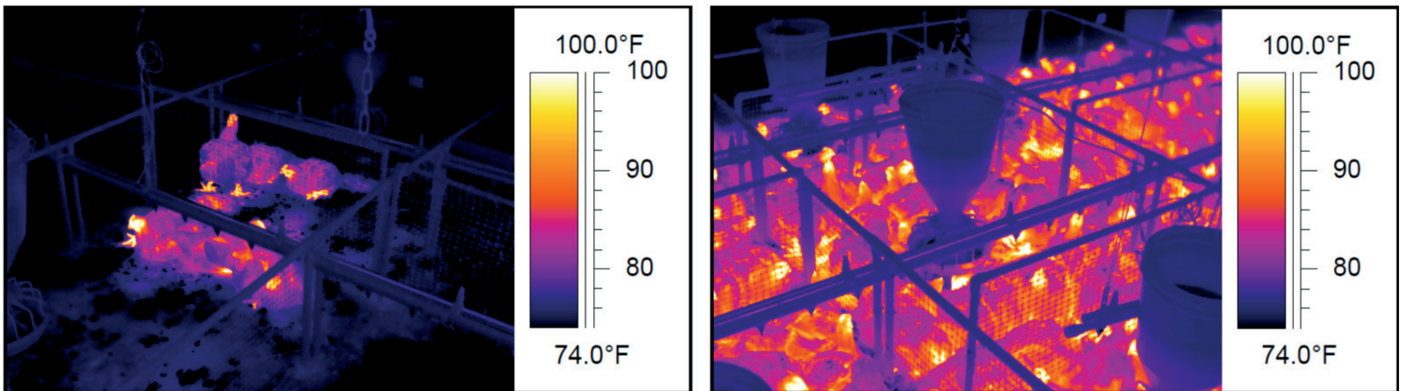

Figure 4. Thermal image of lower stocked broilers (left) compared to higher stocked broilers (right) (M. Czarick & B. Fairchild UGA Poultry Housing Tips Vol 29, No. 5 – Bird density and its influence on effective temperature).

Figure 6. Good pellet quality (left) vs poor pellet quality (right).

Broilers tend to generate more heat and use higher energy during eating when fed a mash feed compared to a pelleted feed. Good pellet quality with no more than 10 % to 15 % fines and a durability index higher than 95 % can help alleviate heat stress by reducing energy used during eating (Figure 6).

Other areas feed can assist:

Electrolyte balance is important to prevent alkalosis, the main electrolytes being Sodium (Na), Potassium (K) and Chlorine (Cl). To maintain balance, diets must maintain the correct ratio of cations (Na & K) and anions (Cl), please refer to Cobb broiler nutrition supplement (***www.CobbVantress.com***) for details on inclusion levels. The inclusion of products that assist mitochondrial ATP production such as guanidinoacetic acid have been shown to improve feed efficiency and reduce signs of heat stress. Supplementation with betaine at 1,000 to 2,000 mg/Kg feed also helps with feed intake and growth in heat-stressed birds. The gut microbiome is negatively impacted during heat stress, so the use of probiotics and prebiotics will help elevate gut health and improve growth performance. Some phytogenic compounds such as sanguinarine and curcumin, which have anti-inflammatory and antioxidant properties, have also been reported to help reduce heat stress conditions. The use of enzymes that attack non-starch polysaccharides can improve nutrient digestion and reduce metabolic heat. Make sure to thoroughly evaluate any feed additive before making it a part of your normal formulation.

When it comes to reducing bird effective temperature and alleviating heat stress, being able to achieve wind speed across the birds is huge (Figure 7). This is easily achievable if you have a well-designed tunnel ventilated house which is often used in hot weather countries. However, European style houses and older style open-sided houses do not have tunnel ventilation capability.

European style houses will however have inlets which are located slightly lower down along the side walls and when fully opened are able to direct air downwards onto the birds thus creating a wind chill effect. Open sided houses should have positive pressure circulation fans setup evenly inside the houses which will blow air directly across the birds and can be used in conjunction with fogger systems for more cooling effect (Figure 8). Although the speeds and evenness may not be as ideal as a tunnel house, some air movement at bird level is better than none. Ensuring that your house is ventilating at maximum capacity and is creating as much air movement at bird level during hot weather as possible, will significantly help alleviate the effect of heat stress on the birds. To assist further in naturally ventilated houses the feeding system can be lifted six hours before the hottest part of the day, this will help reduce body heat output of the birds due to metabolism. Feed can then be returned in the early evening hours when outside temperatures are cooler.

Managing house relative humidity (RH) during hot weather is also critical. As mentioned in article 3 (Martijns article) birds will lose heat through respiration and their ability to do so will be greatly affected by the RH of the air around them. When using evaporative cooling systems (cool pads or fogging systems) they will reduce the ambient air temperature in the house. However as a result this will increase RH and thus reduce the bird's ability to lose heat through respiration. As a rule, these systems should not be used when house RH levels are above 85 %.

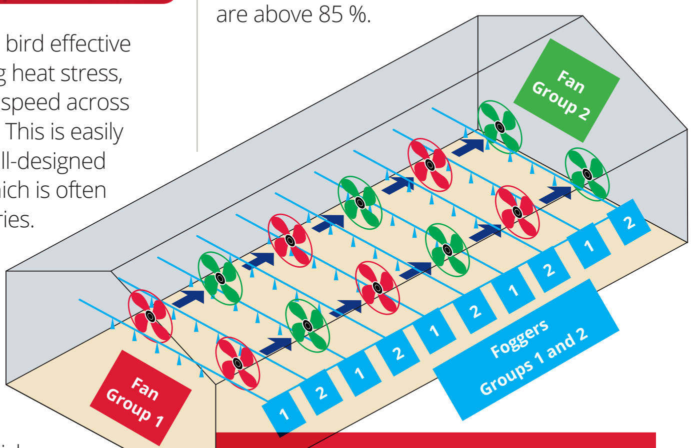

Figure 8. Configuration of positive pressure circulation fans for curtain sided house. (Cobb broiler management guide pg.84, www.cobb-vantress.com)

Managing broilers through periods of heat stress is not only about keeping birds alive but keeping them comfortable and productive. Making sure to monitor your local weather and planning is the proactive way to successfully implement many of the above tips and will go a long way in ensuring a successful broiler cycle.

About the author:

Brendan Graaf is a broiler specialist with 8 years of experience in the poultry industry. He services the EMEA region. Brendan holds a bachelor's degree in Animal Science and a master's degree in Poultry Science.

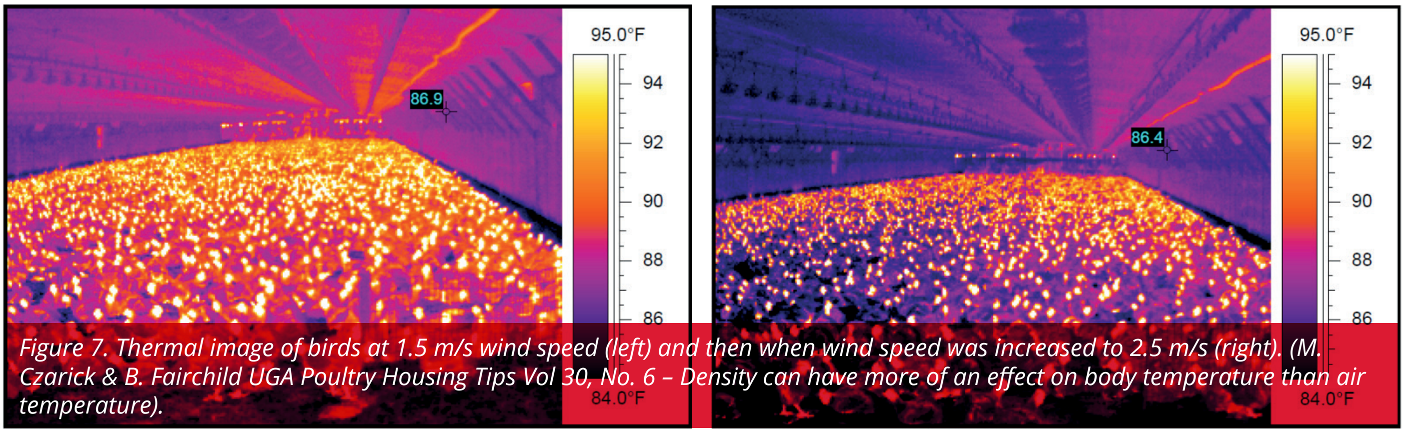

Figure 7. Thermal image of birds at 1.5 m/s wind speed (left) and then when wind speed was increased to 2.5 m/s (right). (M. Czarick & B. Fairchild UGA Poultry Housing Tips Vol 30, No. 6 – Density can have more of an effect on body temperature than air temperature).

Heat Stress and Processing

The impact of heat stress on processing and meat quality

By Dr. Andrea Pizzabiocca, Senior Manager, Technical Service Italy, Cobb Europe

When considering heat stress and processing, there are two different subjects to discuss. The first is the occurrence of heat stress in the operations which come immediately before processing (transport and holding), the second is the consequence of heat stress on the quality of processed meat.

	Ambient Temperature			
	20°C (68°F)	25°C (77°F)	30°C (86°F)	35°C (95°F)
Humidity				
50%	21°C (70°F)	28°C (82°F)	36°C (97°F)	45°C (113°F)
60%	22°C (72°F)	30°C (86°F)	38°C (100°F)	48°C (118°F)
70%	23°C (73°F)	32°C (90°F)	41°C (106°F)	51°C (124°F)
75%	24°C (75°F)	33°C (91°F)	42°C (108°F)	53°C (127°F)
80%	25°C (77°F)	33°C (91°F)	43°C (109°F)	54°C (129°F)
85%	25°C (77°F)	34°C (93°F)	44°C (111°F)	56°C (133°F)

Table 1: The "humidex" should be factored into transportation logistics. A relative humidity of 50% or above can increase the perceived temperature by 2 degrees or more (from Cobb Processing Guide, https://www.cobbvantress.com/resource/management-guides).

The impact of heat stress on live production is well known and easy to calculate especially in terms of weight loss, increased FCR and mortality. Unfortunately, not all the consequences of heat stress on processing operations are immediately obvious. For example meat quality and safety aspects may appear during processing but also on retailers shelves and on the consumers table. Integrators and processors must be aware of potential problems and monitor for any signs indicating heat stress exposure had occurred. There needs to be quick implementation of corrective measures not only on the farms they receive birds from, but also during the operations which are under their direct control such as transport and holding.

Of course heat stress is also a major concern for animal welfare. Eliminate unsatisfactory outcomes by closely monitoring all phases immediately before processing (loading, transport and holding).

Logistics are very important when planning transport from the broiler farm to the processing plant. Things to consider include the live weight of birds, the type of transport truck, the length of the travel, the time of loading and of course the season, temperature and humidity. The easiest way to minimize heat stress would be to catch and transport birds during the coolest hours of the evening/night. Unfortunately, this is not always possible due to logistics and planning. The interaction of temperature and humidity (humidex scale, Table 1) should be used as a guide to decide the best time for catching and tranport. The humidex scale shows the effective temperature perceived by the birds, and should be considered when setting the parameters for the catching and transport of the birds to the processing plant. Never transport birds under conditions that could represent a serious threat to animal welfare.

Photo 1: A typical US fan-trailer close to a trailer full of birds: it is very important that both trucks have the same length so that the fans are able to cover all birds modules without creating dead spots.

In the US it is typical to have fan trailers close to the transport trucks to cool birds during loading (photo 1). It is very important that the fans cover the length of the trailer to eliminate areas without air movement on the birds. When using water to cool birds, always use it in combination with air speed. The use of a water hose or fogging equipment on fans will improve the effeciency of evaporative cooling. The only moment when it might be advisable to directly wet the birds is right before the transport leaves the farm, so that the birds will experience the wind chill effect while the trailer is moving. Do not make any unnecessary stops during transport to the plant because every stop increases the risk of heat stress for the birds.

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Photo 2: A modern broiler transport truck with environmental control, useful both during hot and cold season to avoid any kind of stress due to temperatures.

The best option would be to use modern trucks with environmental control, which not only will be useful during the hot season but will also keep birds warm during the cold season (photo 2).

When the truck reaches the processing plant, place it into the holding area as quickly as possible to cool the birds and provide adequate shade and ventilation. Again, fans in the holding area (photo 3) must cover the entire trailer length.

Processing plant holding areas must be designed with animal welfare consideration. Holding time must be minimized to two hours or less and the area must be very well ventilated by fans or air-conditioning blowing units. Foggers, cool cell pads for evaporative cooling or air conditioning systems can be used in combination with fans to reduce the effective temperature in the holding area. As a guide, with a temperature of 16 °C all fans should be running, while foggers or cool cells should be used at or above 25 °C. Remember to provide enough space between cages, coops or modules to maximize air flow around containers and ensure adequate air distribution (photo 4).

Photo 3: A bird holding area in a processing plant. Even in the best designed areas minimize holding time to maximum 2 hours.

The first and most clear consequence of heat stress during transport and holding at the plant will be bird mortality. On a normal transport mortality is approximately 0.126 %. On average 40 % of Dead On Arrival (DOA'S) are associated with heat stress. Studies have shown that when temperatures (measured in the shade) rise to between 17 and 19.9 °C typical processing plant mortality rises by 30 %. Temperatures between 20 and 22.9 °C results in 2.6 times average transport mortality. Temperatures above 23.0 °C increase average mortality by 6.6 times (P.D.Warriss et al., 2007).

A less clear consequence of heat stress for processing plants will be in yield and meat quality. Commercial broilers exposed to constant high temperatures of 34 °C showed lower breast yield and higher deposition of abdominal and intramuscular fat (Lu et al., 2007). Another study (Zhang et al., 2012) showed how broilers exposed to high temperatures (34 to 36 °C) between 4 and 6 weeks of life had lower breast yield and higher thigh yield. The breast meat had lower protein content and higher fat content. Furthermore, meat of heat stressed birds had higher drip and cook losses, lower initial and final pH, increased production of lactate and accelerated meat glycolisis, eventually leading to poor meat quality (PSE meat, Pale – Soft – Exudative).

Heat stress not only has a negative impact on meat quality but also on food safety. Foodborne pathogens like Salmonella and Campylobacter, which represent a major public health concern, can colonize birds more easily in presence of environmental stressors like heat. This increases the risk of shedding, transmission and contamination of animal products. Hormones produced in association with stress will affect the immune system causing immunosuppression and therefore making it easier for bacteria to infect birds.

In conclusion, heat stress should be a major concern for all processing plants and integrators since it represents a major threat to animal welfare and meat yield, quality and safety. All efforts should be made to ensure that the operations leading to processing eliminate the opportunity for heat stress. Contingency plans should be in place with corrective measures to rapidly respond and eliminate any signs of heat stress from the time birds are loaded to processing.

About the author:

Dr. Andrea Pizzabiocca has 25 years of experience in the poultry industry including 12 years with Cobb. He holds a DVM with specialization in genetic improvement through selective breeding. He currently services Italy, Turkey, Egypt, and the Middle East.

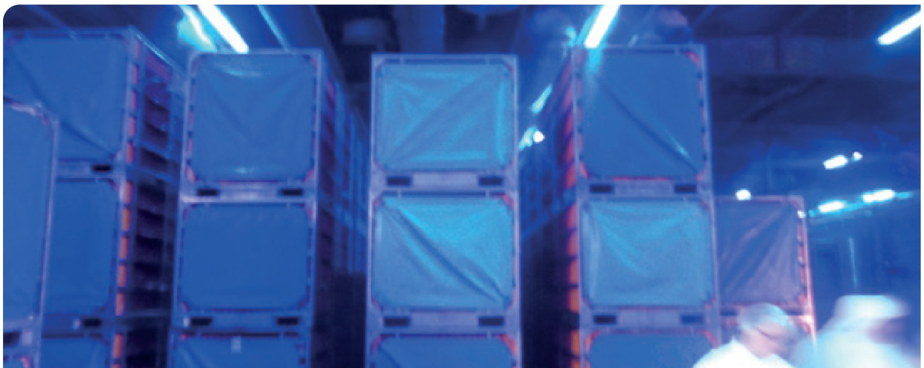

Photo 4: Provide adequate space between containers to maximize air flow and distribution.