“Managing the stress – Key to successful poultry production”

Dr. Saravanan Sankaran
16.02.18
Modern commercial poultry

Objectives:
- Better Feed Conversion
- Higher livability
- Higher meat yield
- Higher quantity and quality eggs
Broiler FCR developments

If we consider year average, FCR will be more than 1.8

Ref: Industry trend
Broiler mortality

More challenge period, mortality goes up to 20% also

Ref: Industry trend
Breeder productivity - Egg production

Ref: Industry trend
Breeder productivity - Depletion

Depletion % vs Age in weeks

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Courtesy: Dr. DC (Senior Consultant)
The reason for gap…

One of the major reason for the gap- “STRESS”

Categories of stress in poultry

- Climatic stress
  - Extreme heat, cold or humidity

- Environmental stress
  - Bright light, wet litter, poor ventilation

- Nutritional stress
  - Deficiency, less feed intake

- Physiological stress
  - Fast growth, sexual maturity, peak production

- Physical stress
  - Injections, catching, grading, transport

- Immunological stress
  - Disease causing organisms

- Social stress
  - Overcrowding, poor uniformity

Ref: A G Rosales, 1994
Stress in poultry operation...

**Stress**
Detrimental effects of variety of situations on the health and performance of the poultry

**Stressors**
Factors causing stress

- Chicken encounter stressors every day of life..
- The adverse effect of stressors are additive !!
- Chicken under stress- extreme functional, structural and behavioral adjustments to cope with adverse effects of its environment
- **Heat stress** is the major stressor in summer months
- The interrelationship between stress, immunity and nutrition is critical !!
Physiology of stress

What is happening in the system during stress??

Phase 1 - Flight or Fight
- Rapid release of glucose
- Try to avoid stressor

Phase 2 - Adaptive
- Mobilization of glucose from reserves
- Immuno-suppression

Phase 3 - Exhaustion
- Fatigue and death

Ref: A G Rosales, 1994
Physiology of stress

Phase 2: General Adaptation Syndrome

- Chicken under stress need adaptation to survive which requires ‘Energy’
- The adaptation energy yields from carbohydrates, lipids and protein
- These nutrients are available from both feed and body reserves
- The nutrients in feed are not digested and absorbed efficiently during stress conditions
- Hence chicken rely on body reserves for adaptation energy or survive !!
- The vital organ functions like heart, lung, liver, etc will not compromised during stress
- The less important functions like egg production, reproduction, growth and immunity are highly compromised
Physiology of stress

Phase 2: General Adaptation Syndrome

- Continuous stressors
- Depletion of body reserves
- Inadequate stress hormone

Phase 3: Exhaustion

- Fatigue and Death

Ref: G D Butcher and R D Miles, 2011
Heat stress in broilers

Ref: Defra, 2005
Heat stress in broilers

- Reduced feed consumption
- Less weight gain
- High FCR
- Dehydration
- Immuno-deficiency
- Disease outbreaks
- Increase in energy demands
- Increased culls
- High mortality
Heat stress in breeders and layers

Calcium tetany

Muscle weakness or paralysis, caused by inadequate levels of Calcium in blood especially young flocks in breeders and layers
Heat stress in breeders and layers

Calcium tetany

Heat stress → Panting → Blood CO2 ↓ → Blood pH ↑ → Calcium tetany → Interruption of nerve impulses → Blood Calcium ↓

Ref: B J Turner, 2009

2005
Heat stress in breeders and layers

Reduction in production

20% reduction in feed intake

Increased levels of stress hormone

Respiratory alkalosis / Panting

Affecting the reproductive organs

Reduction in egg production
Heat stress in breeders and layers

Reduction in HE selection/ hatchability

Heat Stress

Stress hormone

Cessation of cuticle formation

Reduced feed intake

Reduced absorption of essential minerals

Pale colored eggs

Egg abnormalities

↓ Hatching eggs

Ref: G D Butcher and R D Miles, 1994
Heat stress in breeders and layers

Reduction in HE selection/hatchability

- Heat Stress
  - Poor HE quality
  - Poor semen quality
  - Reduction in hatchability
  - Poor chick quality

Ref: J.O. Ayo et al, 2011
Heat stress in breeders and layers

Poor egg shell quality in layers

Lungs

$\uparrow \text{CO}_2 + \text{H}_2\text{O}$

Blood

$\text{H}_2\text{CO}_3 \rightarrow \text{HCO}_3^- + \text{H}^+$

Shell gland

$\text{CO}_3^- + \text{H}^+$

Protein-bound Non-diffusible calcium

Ionized diffusible calcium

Hyperventilation causes increased loss of CO$_2$ gas from the lungs

Blood pH increases as a result, producing a respiratory alkalosis; this reduces the activity of carbonic anhydrase (an enzyme critical to form eggshell)

Reduced secretion of calcium and carbonate by the shell gland results in thin, weak eggshells

Ref: Hy-Line technical update, 2015
Heat stress on immunity / immunological stress

- Immunological challenge is accompanied with reduced feed intake during heat stress.

- Increased levels of stress hormone causes reduction in size of immune organs and antibody production.

- Increased susceptibility to coccidiosis / oocyst production.

- Reduced levels of biologically active molecules like lymphokines, cytokines, etc.

- Reduction in mounting of innate immune response- reduction in phagocytic activity by macrophages and natural killer cells.

- The stress in brooding period can result in poor immunity and future performance.

- The panting impairs the filtering mechanism of nasal passage and allows the respiratory pathogen bypassing and entering the system.

Highest challenge in stress conditions- immunosuppression.
Heat stress on immunity / immunological stress

Stress hormone

- Cells unresponsive to insulin
- Reduced weight of bursa and thymus
- Reduced feed intake
- Deposition of stress hormone in HE

Hyperglycemia

- Lack of energy
- Susceptible to viral infections
- Reduced antibody production
- Reduction in progeny performance

Reduction in antibody titres

- Reduced levels of protein, Zinc, Methionine
- Reduction in growth rate of progeny

Reduction in antibody production

- Reduced feed intake
- Reduced weight of bursa and thymus

Deposition of stress hormone in HE

- Reduced feed intake
- Reduced weight of bursa and thymus

Ref: Farnell M.B. 2001
Heat stress on immunity / immunological stress

**Figure 2.** Effects of heat stress (31 ± 1 and 36 ± 1°C) for 10 h per day from experimental d 35 to 42 on the relative weights of lymphoid organs. Data are presented as the means ± SEM (n = 10/group). *P < 0.05 and ***P < 0.001 compared with the control group (1-way ANOVA followed by Dunnett’s test).

**Figure 3.** Effects of heat stress (31 ± 1 or 36 ± 1°C) for 10 h per day from experimental d 35 to 42 on the corticosterone serum levels (ng/mL). Data are presented as the means ± SEM (n = 10/group). ***P < 0.001 compared with the control group (Kruskal-Wallis test followed by Dunn’s test).

Ref: W.M. Quinteiro-Filho. *et al*, 2010
Immunosuppressive interaction in broilers

Environmental stresses (ammonia, temperature), exposure to Marek’s disease, chicken anemia and enteric viruses

Permanent immunosuppression

Decline of maternal immunity and infection by IBD and CIA, sequentially or in combination

Transient immunosuppression

IB, Influenza, ND, ILT, Pneumovirus, GD

Coccidiosis, E coli

Influence on Cost, Livability, FCR and condemnations

Ref: K A Schat and M A Skinner, 2014
Immunosuppressive interaction in breeders/layers

Body weight vs. Age in weeks

- Vaccination, Grading, IBD, ND
- Coccidiosis, MD, CIA, Stress

- Vaccination, production stress, MD, IB, ND, Mycoplasmosis, Pnuemovirus, ILT, AE, Respiratory complications, REO, Adeno virus infections, Influenza, Insemination

- Hatch, transport stresses, vaccination reactions
Heat stress on gut health

- Alteration in gut microbial population
- More of Clostridium and Coliform bacteria
- Intestinal lesions
- Increased villi tips sloughing rate
- Loss of microvilli

Damaged intestinal lining

- Less nutrient absorption and absorption of endotoxins
- Endotoxins go to different organs in the birds
- Leads to multi organ dysfunction, poor growth and mortality

Ref: Lambert et al. 2002, Hall et al. 2001
Heat stress on gut health

Intestinal villi morphology in 25°C and 39°C (heat stress for 4 days - 24 to 27 days of age)

Ref: R R Santos et al. 2015
Heat stress on gut health

Intestinal villi morphology in 25°C and 39°C (heat stress for 4 days)

Ref: R R Santos et al. 2015
The effects of heat stress in poultry...

- Reduction in egg production
- Hatching egg selection
- Egg shell quality
- Immunosuppression
- Higher FCR
- Higher mortality
- Overall poor performance

But ....

Ref: G D Butcher and R D Miles, 2011
Stress Management

In nature, *Stress is the rule not the exception*
Complete freedom from stress
*Mortality !!*

Management of stress is the key to successful poultry production
Heat Stress Management

Three combined approaches

Nutrition → Gut health → Environment

All the three factors are interlinked

Nutritional management of immunity during stress period is important!!
Heat Stress Management

Environmental management
Heat Stress Management

Environment management

Includes poultry house preparation, water, biosecurity and hygiene

Poor management is one of the greatest stress to poultry
Heat Stress Management

Nutritional management
Heat Stress Management

Nutritional Management

Nutritional management during heat stress is very important

Energy

- Optimizing the nutrient composition is the key for nutritional management of heat stress
- Low dietary intake associated with heat stress warrants high density diet
- Optimizing the energy levels through fat is major approach to meet the demands
- During heat stress, the intestinal passage time will be increased, in turn non availability of nutrients
- Increase in fat content in the diet will reduce the passage time and increase the availability of nutrients
- Also high energy efficiency of fat compared to carbohydrates and protein with less heat increment
- Fat addition as energy source highly suggested for reducing the heat stress

Ref: Ghazalah et al 2008, Mujahid, 2011
Heat Stress Management

Nutritional Management

**Protein**

- The protein requirement during heat stress is not clear and different school of thoughts !!
- Increasing protein content during heat stress will increase the heat load by break down
- Supplementing good quality protein with improved amino acid balances is critical
- During heat stress, outflow of amino acid increases due to poor digestibility
- Deficiency of arginine, lysine increases the heat load
- **Improved balance of amino acids- reduction wastage, heat load due to nitrogen excretion and improved digestibility**

Heat Stress Management

Nutritional Management

Vitamins

- Supplementation of **Vitamin C** is beneficial in stressful conditions - **Anti-Stress Vitamin**
- Kidney used to synthesize Vitamin C and the ability varies with age, environment, management, disease and stress
- Vitamin C plays major role in regulation of release of corticosterone form adrenal
- **Vitamin E** and **Vitamin C** are important during disease stress or infection
- **Vitamin A** is required for maintaining cellularity of lymphoid organs and immunity
- In heat stressed conditions, it is advisable to increase all the vitamin levels by 20% since the need and excretion also high

Ref: G D Butcher and R D Miles, 2011
Heat Stress Management

Nutritional Management

Trace Minerals

- Plasma **Zinc** will be redistributed to vital organs like lungs, liver for synthesis of acute phase proteins
- **Copper** is protective antioxidant in acute phase response
- **Manganese** need will be increased in GI tract and other tissues for immune response
- **Selenium** is essential for immune response

Ref: Klasing et al, 1991
Heat Stress Management

Nutritional Management

Trace Minerals

- Interesting defence mechanism - **Removal of circulating Iron** - Nutrient for bacteria

- The injectable or increased supplementation of Iron will increase the mortality / morbidity during immunological stress

- The increase levels of trace minerals recommended during heat stress conditions (15-20%)

- **For Calcium tetany** - Calcium can be supplemented as 2-5g shell grit for consecutive 3 days followed by 3 days rest

- The trace mineral deficiency during heat stress in breeder, not only affects the hen, also affects the progeny chick performance and immunity

Also should be readily available organic form to meet the demand!!
Heat Stress Management

Nutritional Management

**Trace Minerals**

Recently the role of Chromium is well defined in development of good immunity and reducing the effect of stress

- Chromium is an integral part of GTF which potentiates insulin action
- Improves the immune function in stress condition and in disease challenge conditions
- Reduces the stress hormone levels and nullify the effect of stress
Heat Stress Management

Nutritional Management

Trace Minerals

Organic Chromium propionate in cell mediated immunity

Ref: Rajalekshmi et al, 2014

y = 0.054x + 0.3293
R² = 0.8816
Heat Stress Management

Nutritional Management

Trace Minerals

Organic Chromium propionate in humoral immunity

Ref: Rajalekshmi et al, 2014

$y = 708.77x + 5690.5$

$R^2 = 0.8819$
Heat Stress Management

Nutritional Management

Trace Minerals

Eggs shell weight and thickness in layers

Egg shell weight (g)

Egg shell thickness (mm)

Ref: Rajalekshmi et al., Kemin ID-2008
Heat Stress Management

Nutritional Management

Trace Minerals

Chromium Propionate and Vitamin C synergism

- Stimulates Insulin Release

GTF

- Acts as an Antioxidant
- Reduces synthesis and secretion of Corticosteroids
- Improves absorption of Cr

Vit.C

Insulin

- Improves blood glucose utilization
- Improves Ascorbic acid transport in RBC

Combats Heat Stress
# Heat Stress Management

## Nutritional Management

### Trace Minerals

Chromium propionate and Vitamin C synergism

In heat stress conditions

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>Cr</th>
<th>Vit C</th>
<th>Cr + Vit C</th>
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</thead>
<tbody>
<tr>
<td>T3, ng/ml</td>
<td>2.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.18&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.95&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>T4, ng/ml</td>
<td>7.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.09&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.84&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>Insulin, U/L</td>
<td>29.23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>31.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>31.53&lt;sup&gt;b&lt;/sup&gt;</td>
<td>33.62&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Corticosterone, mol/L</td>
<td>1.95&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.62&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.44&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>Glucose, mg/dl</td>
<td>215&lt;sup&gt;a&lt;/sup&gt;</td>
<td>198&lt;sup&gt;b&lt;/sup&gt;</td>
<td>182&lt;sup&gt;b&lt;/sup&gt;</td>
<td>168&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cholesterol, mg/dl</td>
<td>258&lt;sup&gt;a&lt;/sup&gt;</td>
<td>249&lt;sup&gt;b&lt;/sup&gt;</td>
<td>235&lt;sup&gt;b&lt;/sup&gt;</td>
<td>220&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total protein, g/dl</td>
<td>4.30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.45&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.54&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.66&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Ref: Sahin *et al*, 2003
Heat Stress Management

Nutritional Management

Trace Minerals

Chromium propionate and Vitamin C synergism
In heat stress conditions

Vitamin C strongly needs Chromium* for a better performance
Vitamin C and Chromium* Compliment each other

Ref: Sahin et al, 2003
Heat Stress Management

Chromium propionate

Chromium propionate is an integral part in stress conditions. It is highly bioavailable organic chromium, ensuring immunity, performance, meat yield and production efficiency.
Heat Stress Management

Gut health management
Heat Stress Management

Gut health Management

Supplementation of *Bacillus subtilis* PB6 improving the gut health in heat stress conditions

Birds were heat stressed from 21 to 35 days @ 35°C - Broiler performance

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Thermoneutral</th>
<th>Heat stress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basel diet</td>
<td>B. subtilis</td>
</tr>
<tr>
<td>Initial body weight (g)</td>
<td>870</td>
<td>870</td>
</tr>
<tr>
<td>Final body weight (g)</td>
<td>2030&lt;sup&gt;xy&lt;/sup&gt;</td>
<td>2067&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td>Average daily feed intake (g/day)</td>
<td>152.6&lt;sup&gt;x&lt;/sup&gt;</td>
<td>151.3&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td>Average daily gain (g/day)</td>
<td>87.9&lt;sup&gt;xy&lt;/sup&gt;</td>
<td>90.5&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td>Feed conversion (kg/kg)</td>
<td>1.73&lt;sup&gt;x&lt;/sup&gt;</td>
<td>1.66&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>Rectal temperature (°C)</td>
<td>41.3&lt;sup&gt;y&lt;/sup&gt;</td>
<td>41.2&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>Rate of increase in rectal temperature (°C/h)</td>
<td>0.11&lt;sup&gt;y&lt;/sup&gt;</td>
<td>0.08&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mortality (%)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0&lt;sup&gt;x&lt;/sup&gt;</td>
<td>0.0&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Ref: A.R.Al-Fataftah and Anas Abdelqader, 2014
Heat stress management

Gut health Management

Supplementation of *Bacillus subtilis* PB6 improving the gut health in heat stress conditions

Birds were heat stressed from 21 to 35 days @ 35°C - Intestinal microflora

Effect of *B. subtilis* PB6 on the intestinal microflora of broilers (log$_{10}$ CFU/g of fresh digesta).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Thermoneutral</th>
<th>Heat stress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basel diet $B. subtilis$</td>
<td>Basel diet $B. subtilis$</td>
</tr>
<tr>
<td><em>Lactobacillus</em></td>
<td>9.04$^y$</td>
<td>7.06$^z$</td>
</tr>
<tr>
<td><em>Bifidobacterium</em></td>
<td>7.22$^y$</td>
<td>6.14$^z$</td>
</tr>
<tr>
<td><em>Clostridium</em></td>
<td>4.11$^{yz}$</td>
<td>5.78$^x$</td>
</tr>
<tr>
<td><em>Coliforms</em></td>
<td>5.72$^y$</td>
<td>6.88$^x$</td>
</tr>
</tbody>
</table>

*Bacillus Subtilis* PB6 improves counts of commensals and reduces pathogenic bacteria in both normal and heat stress conditions.

Please note the increase in the *Clostridium* spp. and *Coliforms* counts in the heat stressed birds compared to normal birds.

Ref: A.R.Al-Fataftah and Anas Abdelqader, 2014
Heat stress management

Gut health Management

Supplementation of *Bacillus subtilis* PB6 improving the gut health in heat stress conditions

Birds were heat stressed from 21 to 35 days @ 35°C - Intestinal villi morphometry

### Effect of *B. subtilis* PB6 on the morphology of duodenum and ileum of broilers.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Thermoneutral</th>
<th>Heat stress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basel diet</td>
<td><em>B. subtilis</em></td>
</tr>
<tr>
<td>Villus height (µm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duodenum</td>
<td>1552.8&lt;sup&gt;y&lt;/sup&gt;</td>
<td>1823.4&lt;sup&gt;w&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ileum</td>
<td>523.0&lt;sup&gt;y&lt;/sup&gt;</td>
<td>658.6&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td>Crypt depth (µm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duodenum</td>
<td>315.9&lt;sup&gt;x&lt;/sup&gt;</td>
<td>304.5&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ileum</td>
<td>122.1&lt;sup&gt;x&lt;/sup&gt;</td>
<td>108.2&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>Villus surface area (µm²)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duodenum</td>
<td>382.6&lt;sup&gt;y&lt;/sup&gt;</td>
<td>482.1&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ileum</td>
<td>110.4&lt;sup&gt;y&lt;/sup&gt;</td>
<td>186.3&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td>Absorptive epithelial cell area (µm²)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duodenum</td>
<td>220.5&lt;sup&gt;y&lt;/sup&gt;</td>
<td>248.4&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ileum</td>
<td>162.4&lt;sup&gt;y&lt;/sup&gt;</td>
<td>198.2&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Ref: A.R.Al-Fataftah and Anas Abdelqader, 2014

Increase in Villi health by *B Subtilis* PB6
Heat Stress Management

*Bacillus subtilis* PB6

- Improves counts of commensals and reduces pathogenic bacteria in both normal and heat stress conditions.
- Improved Villi health
- Better Intestinal Health Management and Intestinal integrity during heat stress
- Better Performance of Birds
In conclusion…

Heat stress management

Environment
- Farm preparation
- Biosecurity
- Hygiene
- Feed form
- Feeding time

Nutrition
- Energy
- Amino acids
- Vitamins
- Minerals
- DEB
- Chromium propionate

Gut health
- Hygiene
- Raw material quality
- Bacillus subtilis PB6
In conclusion…

In nature, **Stress is the rule not the exception**

Management of stress is the key to successful poultry production

Thank you !!