Nutritional solutions to heat stress

by Cristina Molero, DVM, Invesa Internacional SA, Spain.

Productivity losses associated with high temperatures, sometimes combined with high humidity, are one of the main reasons for the economical losses that affect poultry producers every year.

This article is a review of the physiology of heat stress and gives ideas about how to combat it efficiently by nutritional means.

Poultry are homeotherm animals. They can regulate their body temperature – around 41°C – by regulating metabolic heat production and heat loss. The body temperature of birds should remain within certain limits (thermoneutral zone) to safeguard welfare and maintain production.

Chickens remain in their thermoneutral zone when environmental temperature is between 12.5 and 24°C.

Heat stress starts when birds are not able to control their body temperature any more and it starts rising.

Affected chickens show symptoms such as panting, lost of appetite, increase in water intake, wings outstretched and prostration. If heat stress persists, it will lead to coma and death. In the flock, heat stress will increase the occurrence of metabolic disorders, digestive alterations, respiratory lesions, skeletal disorders and skin lesions. A rise in cannibalism and mortality and a drop in production will be seen.

Heat Stress Index (HSI), the sum of environmental temperature (≥27°C) and relative humidity, helps us to determine the onset of heat stress, that starts when the index is higher than 105. The most sensitive poultry to heat stress are heavy old male broilers, because they produce more endogenous heat.

Physiological changes

Physiologically, heat stress causes a thermoregulatory failure which leads to an increase in body temperature. To stop this, the bird's body activates a series of reactions, which can be counterproductive.

Blood leaves viscera to increase peripheral circulation and help dissipate excessive heat. Veldkamp et al. (2002) describe that in heat stressed animals blood flowing to the digestive system diminishes, causing a decrease in protein digestion and absorption.

Poultry that are affected by heat stress will decrease feed intake and increase water consumption.

Furthermore, feed intake is also reduced to avoid heat production from digestion process and thus growth is negatively affected.

Respiratory rate increases due to a greater oxygen demand and evaporative cooling needs. Panting causes respiratory alkalosis because blood carbon dioxide levels diminish due to hyperventilation.

Respiratory alkalosis leads to an excess of blood bicarbonate (CO_3H^-), which is eliminated through urine, pulling other ions such as Na^+, Ca^{2+}, Mg^{2+}, K^+ and water.

Dehydration, caused by losses of electrolytes and water, has negative repercussions on growth and mortality rate in broilers, and on egg size and shell quality in layers and breeders.

Stress, caused by the increase in blood corticosterone, inhibits non-essential body functions, such as the immune response, growth and reproduction. So, fertility and disease resistance are diminished.

In broilers, heat stress diminishes growth, increases FCR (feed conversion ratio) and mortality, and worsens carcase quality, resulting in important productivity losses.

In laying hens, heat stress decreases egg production, egg size and egg shell quality.

Finally, in breeders fertility is negatively affected by heat stress.

Nutritional strategies

Although technical measures, such as housing isolation, management, ventilation systems and so on, are essential methods to combat heat stress, nutritional strategies become a necessary mean when the first ones are not enough or can not be applied.

Traditionally, several nutritional products have been administered to help to combat heat stress.

Electrolytes need to be increased due to acid-base disequilibrium derived from heat stress. An extra supplement will help to restore the cellular hydro-electrolytic disequilibrium.

Vitamin C or L-ascorbic acid (AsA) is synthesised by many mammals and birds. However, it is interesting to give AsA under stressful conditions because the endogenous

Continued on page 29

Broilers affected by heat stress showing panting, wet wattle and neck.

Continued from page 27
synthesis of vitamin C do not satisfy animal requirements.

Sahin et al. (2004) reported that in heat stress supplementation of ascorbic acid (AsA) can reduce metabolic changes associated with a rise in plasmatic corticosterone. Corticosterone is the main glucocorticoid steroid hormone related to stress in chickens.

AsA can be found at high concentrations in the adrenal glands and inhibits the synthesis of corticosteroids.

Stress induces depletion of AsA in the adrenal and this is associated with corticosterone release. Heat stress can cause up to fivefold increase in plasma concentrations of corticosteroids.

Maintenance of high adrenal concentrations of AsA by dietary supplementation has been found to limit the rise in circulating corticosterone concentrations in birds under stress.

Betaine is a metabolite derived from choline (Vitamin B group) by enzymatic oxidation. It occurs naturally in animal and vegetal tissues, mainly plants subject to drought such as sugar beet. Betaine has two important properties:

- Acts as an osmolyte and helps to maintain the balance of water and ions, protecting cells and tissues against dehydration.
- Is a methyl donor.

The movement of water in and out of the cell depends on the intra- and extracellular concentration gradient in salts and solids. In heat stress, extracellular concentration of salts and solids increases because more water is lost by evaporation, urine and faeces. Intracellular water tends to leave the cell in order to restore hydric balance.

Trying to stop this water leaving, the cell activates the Na/K ion pump (ATPase) to increase intracellular electrolyte concentration and be able to retain water. This process represents a high energetic expense and an increase of intracellular ions, such as potassium, that can be dangerous.

Remus (2001) reported that the main advantage of betaine over Na/K is that less energy is required to keep betaine inside the cell than to run Na/K ATPase, so more energy is available for growing and production. Furthermore, it is safer for the cell to keep intracellularly high amounts of betaine than electrolytes, such as potassium.

Methyl groups are continuously used in essential metabolic routes (hepatic function, DNA, RNA and protein synthesis).

Vertebrates can not synthesise methyl groups, so they must be provided through the diet.

The main sources of methyl groups are choline, betaine and methionine. If feed intake is decreased, extra supply of methionine and choline must be provided.

Productively, it is advantageous to add betaine in diets to diminish the amount of methionine and choline and thus reduce costs.

Betaine can donate methyl groups to form carnitine, which is involved in the transport into the mitochondria and oxidation of fatty acids. Betaine has been used to prevent fatty liver, a common pathology seen in laying hens affected by heat stress.

Menthol is a naturally occurring compound of plant origin which gives the typical minty smell and flavour.

Menthol has been used as a decongestive because it provides a cool sensation caused by the stimulation of oral mucosa sensory cold receptors, which give a very pleasant sensation of 'freshness' and 'cleanliness'.

Laying hen production is affected in cases of heat stress.

The best strategy is to use all these nutritional measures simultaneously, to combat heat stress at several physiological levels.

However, we must be careful at mixing different products to avoid interactions.

In acute heat stress, oral solutions in drinking water are preferable to medication in feed because poultry will drink more water and thus consume more product. ■

References

- Bellés Medall, Santiago. (2005) Recursos prácticos a aplicar en las granjas de broilers contra el calor. Jornadas Profesionales de Producción de Carne, 25-27 abril. Real Escuela de Avicultura.
- Castelló José A. (2004) Efectos del calor sobre la puesta y la calidad del huevo. Selecciones Avícolas, Junio 2004 357-395.
- Ching, S. and Mahan, D.C. (2001). Ascorbic Acid Synthesis in Fetal, Nursing and Weanling Pigs. On-line bulletin of the Ohio State University. Research and Reviews: Swine. Special Circular 185-01. www.ohioline.osu.edu/sc185/sc185_5c.html
- Eccles, R. (2000) Role of cold receptors and menthol in thirst, the drive to breathe and arousal. Appetite **34** 29-35.
- McKee, J.S., Harrison, P.C. (1995) Effects of Supplemental Ascorbic Acid on the Performance of Broiler Chickens Exposed to Multiple Concurrent Stressors. Poultry Science, **74** 1772-1785.
- Nowaczewski y Kontecka. (2005) Effect of dietary vitamin C supplement on reproductive performance of aviary pheasants. Czech J. Anim. Sci., **50(5)** 208-212.
- Quiles, A., Hevia, M.L. (2005) Estrategias de manejo de gallinas en épocas de calor. Producción Animal **221** 41-51.
- Remus, Janet. (2001) Betaine for increased breast meat yield in turkey. World Poultry. Elsevier **17(2)** 14-15.
- Sahin, N., Onderci, M., Sahin, K., Gursu, M.F. and Smith, M. O. (2004) Ascorbic acid and melatonin reduce heat induced performance inhibition and oxidative stress in Japanese quails. British Poultry Science **45(1)** 116-122.
- Veldkamp, T., Kwakkel, R. P., Ferket, P. R. and Verstegen, M.W.A. (December 2002) Impact of ambient temperature and age on dietary lysine and energy in turkey production. World's Poultry Science Journal, **58** 475-491.
- Whitehead, C.C., Keller, T. (2003) An update on ascorbic acid in poultry. World's Poultry Science Journal **59** 161-184.