Dietary Electrolyte Balance: Implications on Heat Stressed Broilers

High temperature is a major limitation to growth and performance of birds in tropical countries. Reduced feed intake, growth rate, feed conversion, survivability, dressing yield, breast meat, total meat and increased abdominal fat are the immediate consequences of rearing broilers in a hot humid environment (Geraert, 1998).

Decreased performance and reduced profitability of broilers are aggravated when high temperature is associated with high relative humidity (Charles et al., 1978). Summer mortality and reduced performance of the flock causes enormous loses to the poultry industry every year. This situation demands an efficient means to improve the thermo-tolerance of broilers in hot and humid environment.

Excessive loss of carbon dioxide (CO2) during panting reduces the partial pressure of CO2 in blood plasma. In turn, the bicarbonate buffer system lowers the concentration of hydrogen ions and causes a rise in plasma pH and plasma bicarbonate levels, which develops a condition known as respiratory alkalosis (Linsley and Burger, 1964; Calder and Schmidt-Neilsen, 1967). The birds attempt to correct blood pH by excreting HCO3⁻ via the urine while retaining H⁺ (T. Ahmed et al, World's Poultry Science Journal, December 2006). Moreover HCO3⁻ never goes alone, this loss is always accompanied with loss of Na⁺ and K⁺.

The blood electrolyte balance is closely associated with blood pH, gas pressure and HCO3 concentration (Darreet al., 1980; Teeter, 1997a and 1997b). During respiratory alkalosis, the shift in blood pH increasingly depresses the feed intake and adversely affects the overall performance of broilers. One of the consequences of heat stress is the change in the acid-base balance with the occurrence of respiratory alkalosis.
That is why most of the other approaches fail, as the lost ions and the disturbed acid-base balance during heat stress is not taken into account.

Therefore, one of the best methods used to control heat stress is the chemical management of the acid-base balance by supplementing feed or water with a balanced electrolyte supplement. Electrolyte supplementation has been reported to maintain acid base balance and thus improve performance of broilers reared in a hot environment (Balnave and Gorman, 1993). The addition of electrolyte salts to broiler chicken diets has been recommended as a way to minimize the deleterious effects of heat stress (Borges, 1997).

Electrolytes, in different amounts and proportions, prove beneficial for birds under different heat stress regimens. Several studies have been done on electrolytes where different environmental conditions existed during the experiment. Some of those conditions were controlled while others weren’t; some were measured precisely and some left unrecorded. This lack of clarity led to the need to precisely define the proper electrolyte source, its amount and combination of different sources to have an appropriate Dietary Electrolyte Balance (DEB) for optimum broiler performance.

**Dietary electrolyte balance**

The proportion of Sodium, Potassium and Chloride in a diet determines the Dietary Electrolyte Balance.

\[
\text{DEB} = \{\text{Na}^+ + \text{K}^+ - \text{Cl}^-\} \text{ mEq/Kg}
\]

The monovalent ions (Na\(^+\), K\(^+\) and Cl\(^-\)) have a greater electrolytic potential than divalent ions (Mg\(^{2+}\), S\(^2-\), P\(^2-\) and Ca\(^{2+}\)). Mongin omitted these divalent ions from the DEB equation due to the following reasons:

a) Bivalent cations are not as rapidly absorbed as monovalent cations
b) Mg is commonly supplied in feeds.
c) Phosphate is hard to be quantified because it comes from various sources
d) Calcium absorption rate is controlled by the endocrine system and is most commonly added as calcium carbonate for skeletal development
e) Sulphate is included in small amounts as the anion for essential trace elements, or to prevent methionine breakdown.

Intestinal and renal homeostatic regulation attempt to maintain normal body content of electrolytes, and this is generally affected by higher intestinal absorption of monovalent ions than divalent ions within the electrolyte supplements (Teeter, 1997). The “strong ions” Na\(^+\), K\(^+\), and Cl\(^-\) have the greatest impact on acid-base balance or pH of blood and tissues. However, it is important to have the proper dietary ranges and ratios of these monovalent minerals without deficiency or toxicity, to meet poultry nutritional demands and achieve the best performance. Acids produced by metabolism (endogenous H\(^+\)) also contribute to the acid-base balance.
Mongin concluded in 1980 that in order to keep the acid-base homeostasis as close to normal as possible, the bird has to regulate the input and/or the output of acidity. According to Mongin the net acidity intake can be measured by the difference between fixed anion and cations (Anion-Cation) intake. Likewise the net acidity output can be measured by the balance of ions excreted in the urine (Anion-Cation) outgo. The endogenous acid production (\(H^+\)) by the metabolism of dietary components must also be considered.

\[
\text{Ingested (Anions} - \text{Cations}) + \text{Endogenous } H^+\text{− Excreted (Anions} - \text{Cations}) = \text{Zero}
\]

The above equation describes the steady state situation where the bird is in a constant acid-base balance, without either acid or base excess or deficiency. Under disturbed conditions (more acid intake or outgo) the blood base excess \([\text{base concentration in extracellular fluids (BE}_{\text{ecf}}])\) will get modified accordingly to achieve a steady state.

\[
\text{Ingested (Anions} - \text{Cations}) + \text{Endogenous } H^+\text{− Excreted (Anions} - \text{Cations}) + \text{BE}_{\text{ecf}}= \text{Zero}
\]

Diets formulated with a high anion content (Cl\(^-\)) decreases blood pH and causes acidosis. Similarly high dietary cation contents (Na\(^+\), K\(^+\)) increase blood pH and result in alkalosis. Both situations adversely affect the performance of birds. Hurwitz et al., 1973, while studying the impact of cation/anion ratio \([(\text{Na}^+ + \text{K}^+)/\text{Cl}]\) noticed that broiler growth rate was the greatest when blood pH was 7.28 and it reduced when pH values were greater than 7.30 or lower than 7.20. While adjusting the DEB for maximum bird performance, care must be taken that the total levels of Na\(^+\), K\(^+\) and Cl\(^-\) must be within the acceptable range, neither deficient nor toxic.

**Optimum DEB**

The bird’s survivability during heat stress depends on the water consumption, which depends directly on bird’s age and the EB of the diet. Birds which drink more water would be better able to reduce their high body temperature. The heat stress birds fed diets with EB of around 250mEq/kg showed better performance, well maintained blood physiological parameters (pH, HCO\(_3\), pCO\(_2\), BE\(_{\text{ecf}}\), Hb, H, L, and H:L) and blood nutrients (viz. glucose) and also retained more electrolytes (Na, K and Cl) in an attempt to maintain the disturbed acid-base and electrolyte balance (T.Ahmed et.al.).

Mongin (1981) reported that optimal chick growth performance, when fed purified diets, was achieved using DEB of around 250 mEq/kg with a relation. Weight of birds, when assessed at 42d, decreased when DEB was lower than 180 mEq/kg and higher than 300 mEq/kg (Johnson and Karunajeewa, 1985). An optimal EB was found for feeds containing from 250 to 300mEq/kg.

The DEB affects the bird’s performance and the optimal ratio is considered around 250 mEq/kg. Very high and a very low DEB can result in metabolic alkalosis and acidosis. That is why such DEB should be avoided while formulating diets.
Similarly, excess or deficiency of any particular mineral must be avoided while maintaining the DEB.

The primary role of an electrolyte supplement lies in the maintenance of the body's ionic and water balance. The requirement for strong (monovalent) ions that have characteristic effects on the body fluids homeostasis, should not be considered individually: it is the overall balance that is important. Valency of ions (mono or di), ionic balance, strength of the electrolyte supplement and its effect on DEB should always be considered while selecting a product.

Avilyte, a product from Avitech Nutrition Pvt Ltd, provides the ideal composition of electrolytes required to combat stress from extreme temperatures, handling during shifting and transportation, vaccination, de-beaking and production related stress.

To know more about Avilyte, please contact us at:

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