Improving broiler chick performance before they hatch

Optimal trace mineral nutrition, such as zinc, is essential for the ideal performance of the progeny of broiler breeders.

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reports on a study that evaluated the effect of different zinc trace mineral supplementation sources in the diet of broiler breeders on the epigenetics-related markers of their offspring.

Weeks before it hatches, the very composition of every new chick is assembled and encased in an eggshell. During incubation every cell, bone, strand of connective tissue, immature organ, layer of skin, section of gut, meter of veins and capillaries are laid down in perfectly synchronised order. Also during this time, we see development of an immature but powerful immune system and the first cascade of hormones and enzyme activity. Each component must be present in the albumin and yolk of the egg at point of lay to ensure a healthy, vigorous young chicken. The code for this development lies in the DNA. But more about that later.

Role of trace minerals in development and performance

It has long been known that essential trace minerals play significant roles in development and performance, particularly in high performing animal models such as the modern broiler. These essential trace minerals act as co-factors, the ignition key if you like, to hundreds of metallo-enzymes and other proteins including structural proteins. Examples are the role of zinc in testosterone, a familiar hormone or in carbonic anhydrase which carries spent carbon dioxide back to the lungs for expulsion. Copper driven lysil oxidase enzymes help build and maintain elastic tissue by cross-linking collagen and elastin. Of significant importance are the roles of antioxidant enzymes such as superoxide dismutase ensuring the birds can effectively address oxygen free radicals and the associated oxidative stress. Manganese, zinc and copper are all important co-factors in this cycle. Studies conducted by Novus International, Inc., and in independent peer reviewed articles have shown consistent benefits to feeding chelated minerals in the form of metal methionine hydroxy analogue chelate (MMHAC, Novus's Mintrex chelated trace minerals) to broilers as well as breeding hens and roosters.

Novus mineral programmes have shown, due to their high bio-availability that a significantly lower volume of MMHAC chelated zinc, copper and manganese can be used in this form for improved performance. This so called 'reduce and replace' strategy has shown increased hatchability, liveability and performance not only for the breeding stock, but of the resulting progeny. Over time it became apparent that chick liveability, vigour and performance far exceeded expectation of simply meeting mineral requirements. Breeder nutrition has largely been formulated using performance parameters such as mortality, persistence and chicks per hen housed. Although it is acknowledged that healthy breeders beget healthy chicks, in the chase for optimal performance, the subsequent chick development is not regularly attributed to breeder management and it is not until recently that key epigenetic pathways have been more clearly understood. Dietary manipulation of these pathways are shown to have profound effects on the survival and vigor of the chick,

Table 1: Trial design.

2 Weeks	6 Weeks	6 Weeks
Pre-experiment	Breeder trial	Broiler (progeny) trial
	Hen treatments	Chick treatments
Hens fed Zn deficient diet (0 ppm added)	1. 0 ppm $ZnSO_4$	Low Zn: 20 ppm $ZnSO_4$
	2. 50 ppm MMHAC Zn	Normal Zn: 70 ppm $ZnSO_4$
	3. 300 ppm MMHAC Zn	
	4. 50 ppm $ZnSO_4$	
	5. 300 ppm $ZnSO_4$	

affecting lifetime performance. Novus found that the superior performance of broiler chicks was not simply due to the eggshell characteristics, hatching ease or initial nutritional benefit, but through genetic switches being turned in the breeding hens resulting in superior health and development.

Epigenetics

Epigenetics is the study of heritable phenotype changes that do not involve alterations in the DNA sequence. Epigenetics or 'maternal programming' effectively prepares progeny for the environment they can expect to enter by changing the frequency of DNA expression. The DNA remains unchanged.

Across species we can see examples of epigenetics such as in cattle where muscle mass and fat deposition are being investigated via manipulation of maternal nutrition, sheep, where changes in key sulfur amino acids fed to a ewe at certain time-point in pregnancy can change the frequency of wool follicles in her offspring. Or using

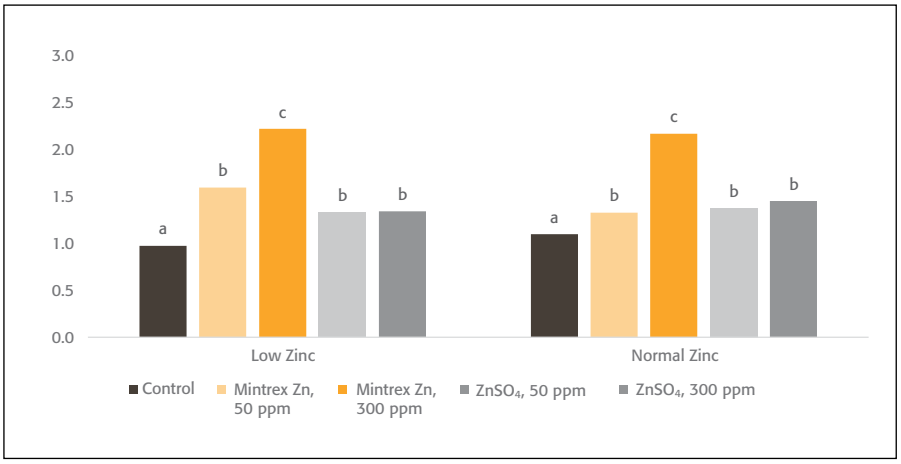
a very human example, the Dutch famine or 'hunger winter' of 1944-45 significantly affected gene frequency in children of famine survivors, with epigenetic effects still appearing three generations after the event.

Some well documented examples of dietary manipulation affecting broiler breeder progeny include examples where source, rate and quality of energy source can improve carcass yield. The combination of quality energy and protein at elevated percentages is shown to significantly increase growth performance of progeny. Using lipid sources containing higher amounts of linoleic and linoleic acid compared to animal sourced fats reduce mortality in progeny, increasing both performance and carcass yield. Carnitine supplementation alone has been shown to improve carcass and performance in broiler progeny (especially males). But are these strictly epigenetic effects or simple nutritional intervention?

When looking at vitamins and minerals, although minimum calcium and phosphorous levels must be met, further supplementation appears to serve no useful purpose to progeny. Maternal supplementation of 25 hydroxy vitamin D_3, however has been shown to improve eggshell calcification, chick hatchability and humoral immunity. Supplementation with Selenium and vitamin E, known for their direct antioxidant support can result in higher levels in the egg, protecting sensitive fatty acids in the yolk. Supplementation of zinc in the hen has been shown to improve humoral and cellular immunity, improving response to pathogenic challenges. These results show that vitamins and minerals fed to breeding hens may have a profound effect on subsequent progeny when it comes to chick immunity and vigor.

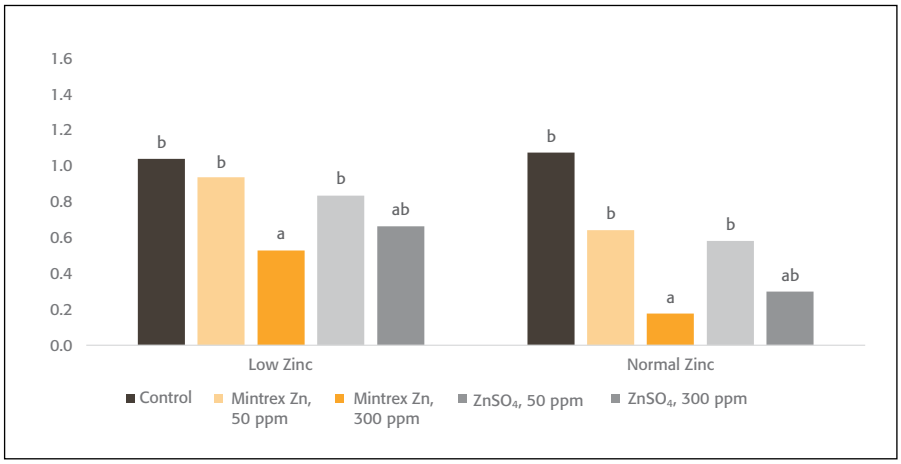
If we look at a very simplified action of epigenetic function, the physical manifestation is either the presentation or suppression of genes. Consider that DNA strands in each and every cell could stretch out well over a metre in length if laid in a straight continuous line. As such, DNA must be bundled tightly in the cell nucleus around histone proteins (think fishing reel). When the cell is required to produce a specific protein (think hormone, enzyme etc.) the

Figure 1: Zn supplementation in broiler breeder hens and offspring birds increased A20 gene expression in jejunum of offspring birds at 35 day of age.



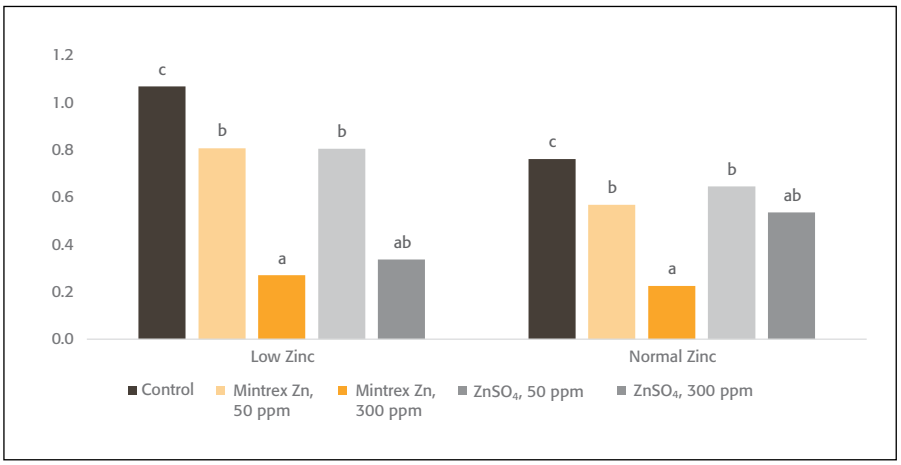
Maternal: *p*=0.001

Figure 2: Zn supplementation in broiler breeder hens and offspring birds reduced IL6 gene expression in jejunum of offspring birds at 35 day of age.



Maternal: *p*=0.022 Offspring: *p*=0.001

Figure 3: Zn supplementation in broiler breeder hens and offspring birds reduced NF-κB of offspring birds at 35 day of age.



Maternal: *p*=0.028 Offspring: *p*=0.034

spool of DNA presents the relevant section of the chain to be copied by RNA (the copier) which then assembles the required amino acids in sequence to build the necessary protein. Epigenetics changes the frequency that particular sequences allow themselves to be exposed for 'copying'. The key areas of research in this field study DNA methylation, Histone modification, chromatin re-modelling and regulation of gene expression by non-coding RNA's. To be accepted as a true epigenetic effect, sections of the DNA must be transcribed in either greater or lesser frequency giving a phenotypic effect without any change to the DNA itself.

Broiler breeder trial

Trial design

In a study conducted by Drs. Mercedes Vazquez-Anon and Juxing Chen at Novus, in an attempt to reveal the pathways leading to the superior broiler chick performance, breeding hens were fed escalating levels of zinc from either inorganic (sulfate based) salts or Mintrex Zn (chelated trace mineral in the form of Zn-MHAC). The chick progeny were subsequently fed either low or breed target levels of zinc for their 35 day grow out. Markers that are of critical importance to inflammation and immunomodulation at the gut were then measured in the birds at the small intestine, alongside the direct transcription rate of key proteins.

Results – epigenetics markers

Whether the resulting chicks were subsequently fed low or target rates of zinc during growth, those chicks from hens fed the highest dose of Zn-MHAC maintained a significant upregulation of a zinc finger protein (A20) (Figure 1). A20 can block phosphorylation of two key inflammatory responders, Interleukin 6 (IL6) (Figure 2) and NF-kB (nuclear factor kappa B) (Figure 3). Running unchecked, both IL6 and NF-kB can result in inflammatory cascades that negatively affect gut barrier function and immune competency. Frequency regulation of this activity was discovered as the direct decrease in methylation and increasing acetylation of the DNA at specific promotor regions for the A20 protein. It should be no surprise then, that those chicks from the hens fed the highest rate of zinc as MMHAC showed improved gut barrier function, tight junction integrity, mucosal immunity and reduced gut inflammation. This increase in intestinal integrity results in greater absorption of all nutrients.

Conclusion

It seems then that we have unearthed at least some of the story behind the performance benefits of progeny from breeding hens fed chelated trace minerals in the form of MMHAC. Further research is being conducted across species, with supporting data already emerging from swine studies and ruminant work soon to be published.

As maternal programming becomes more clearly understood, it stands to be a cost effective and potent tool in supporting development, vigour and performance of your growing broiler flocks. *Ap*

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