Nutritional and metabolic disorders and role in epidemiology of poultry diseases.

By

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- A nutritional deficiency occurs when the body doesn't absorb or get from food the necessary amount of a nutrient.

- Deficiencies can lead to a variety of health problems. These can include digestion problems, skin disorders, stunted or defective bone growth, and even dementia.

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Determination of nutrient requirements

- Criteria used to determine the requirement for a nutrient include growth, feed efficiency, egg production, prevention of deficiency symptoms, and quality of poultry product.
- These requirements assume the nutrients are in a highly bioavailable form.
- Adjustments should be made based on bioavailability of nutrients in various feedstuffs.
- A margin of safety should be added based on the length of storage time before diet feeding, changes in rates of feed intake due to environmental temperature or dietary energy content, genetic strain, husbandry conditions (the level of sanitation), and presence of stressors (as diseases or mycotoxins).

1-Water

- Water is an essential nutrient.
- Many factors influence water intake, including environmental temperature, relative humidity, salt and protein levels of the diet, birds' productivity (rate of growth or egg production), and the individual bird's ability to resorb water in the kidney. As a result, precise water requirements are highly variable.
- Water deprivation for ≥12 hr has an adverse effect on growth of young poultry and egg production of layers; water deprivation for ≥36 hr results in a marked increase in mortality of both young and mature poultry.
- Cool, clean water, uncontaminated by high levels of minerals or other potential toxic substances, must be available at all times.

The energy requirements of poultry

- The energy requirements of poultry and the energy content of feedstuffs are expressed in kilocalories (1 kcal equals 4.1868 kilojoules).
- Two different measures of the bioavailable energy in feedstuffs are in use, metabolizable energy (AMEn) and the true metabolizable energy (TMEn). AMEn is the gross energy of the feed minus the gross energy of the excreta after a correction for the nitrogen retained in the body.
- Calculations of TMEn make an additional correction to account for endogenous losses of energy that are not directly attributable to the feedstuff and are usually a more useful measure.
- AMEn and TMEn are similar for many ingredients. However, the two values differ substantially for some ingredients such as feather meal, rice, wheat middlings, and corn distiller's grains with solubles.

Amino Acid Requirements

- Poultry, like all animals, synthesize proteins that contain 20 L-amino acids. Birds are unable to synthesize 9 of these amino acids because of the lack of specific enzymes: arginine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. Histidine, glycine, and proline can be synthesized by birds, but the rate is usually insufficient to meet metabolic needs and a dietary source is required.
- These 12 amino acids are referred to as the essential amino acids. Tyrosine and cysteine can be synthesized from phenylalanine and methionine, respectively, and are referred to as conditionally essential because they must be in the diet if phenylalanine or methionine levels are inadequate.
- The diet must supply sufficient amounts of nitrogen to allow the synthesis of nonessential amino acids.
- Essential amino acids are often added to the diet in purified form (eg, DL-methionine and L-lysine) to minimize the total protein level as well as the cost of the diet. This has the added advantage of minimizing nitrogen excretion.

Vitamins

- Requirements for vitamins A, D, and E are expressed in IU. For chickens, 1 IU of vitamin A activity is equivalent to 0.3 mcg of pure retinol, 0.344 mcg of retinyl acetate, or 0.6 mcg of β-carotene. However, young chicks use β-carotene less efficiently.
- One IU of vitamin D is equal to 0.025 mcg of cholecalciferol (vitamin D_3). Ergocalciferol (vitamin D_2) is used with an efficiency of <10% of vitamin D_3 in poultry.
- One IU of vitamin E is equivalent to 1 mg of synthetic dl-α-tocopherol acetate. Vitamin E requirements vary with type and level of fat in the diet, the levels of selenium and trace minerals, and the presence or absence of other antioxidants. When diets high in long-chain highly polyunsaturated fatty acids are fed, vitamin E levels should be increased considerably.

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- Choline is required as an integral part of the body phospholipid, as a part of acetylcholine, and as a source of methyl groups. Growing chickens can also use betaine as a methylating agent.

- All vitamins are subject to degradation over time, and this process is accelerated by moisture, oxygen, trace minerals, heat, and light.

- Stabilized vitamin preparations and generous margins of safety are often applied to account for these losses.

- This is especially true if diets are pelleted, extruded, or stored for long periods.

Minerals:

- Much of the phosphorus in feedstuffs of plant origin is complexed by phytate and is not absorbed efficiently by poultry.
- It is critical that only the available phosphorus and not the total phosphorus levels be considered.
- Appropriate calcium nutrition depends on both the level of calcium and its ratio to that of available phosphorus.
- For growing poultry, this ratio should not deviate substantially from 2:1.
- The calcium requirement of laying hens is very high and increases with the rate of egg production and age of the hen.

Other Nutrients and Additives

- The chick has requirements for 38 nutrients, together with an adequate level of metabolizable energy and water. Some additional nutrients may be necessary for growth and development under certain conditions. These include vitamin C, pyrroloquinoline quinone, and several heavy metals.
- Non-nutrient antioxidants, such as ethoxyquin, are usually added to poultry diets to protect vitamins and unsaturated fatty acids from oxidation. Antibiotics at low levels (5–25 mg/kg of feed, depending on the antibiotic) and surfeit copper (150 ppm) are sometimes included to improve growth rate and feed efficiency.
- Enzymes that increase the bioavailability of dietary phosphorus, energy, and protein are often used in poultry diets. Phytase enzymes are used to decrease the amount of phosphorus in the excreta to meet environmental regulations.

Rickets

- Rickets is caused by a deficiency or imbalance of circulating calcium, vitamin D3 or phosphorus.
- The disease occurs when there is an imbalance of these nutrients or if the diet is deficient in any of them.
- Some medications and mould toxins may also cause rickets.
- The condition results in soft bones, which will often become bowed, thereby restricting the birds' ability to stand and walk.

Prevention of Rickets

- Rickets can be prevented or treated if the condition is caught early. In order for normal bone calcification to occur, calcium and phosphorus must be supplied in adequate amounts and they also need to be supplied in the correct ratio to each other (2:1).
- Mycotoxin induced rickets can be treated by replacing toxin-contaminated feed and supplementing vitamin D3 to three- or four-fold the usual levels.

Caged layer fatigue (CLF)

CLF was first observed in the mid-20th century, shortly after layer producers began to laying hens in cages. Although diets for laying hens are specifically formulated to be nutritionally complete, CLF is described as a nutritional disease and is a major cause of death in laying hens in cages.

The condition occurs in birds around peak egg production and may also be associated with osteoporosis, a condition that causes brittle bones. The primary cause of CLF is thought to be the depletion of the body stores of calcium, usually as a result of a delay in feeding with high calcium feeds during high production.

The condition can occur from a metabolic malfunction that impairs calcium absorption or bone calcification during the production.

Birds suffering from CLF will lose control of their legs and lie on their side, no loss in egg production nor is shell quality or interior egg quality reduced.

Some bones may be fractured and some will break when the birds are

Prevention and/ or treatment of CLF

- Because the condition is more prevalent in caged layers than floor pen birds, exercise can play a role in preventing or treating the condition.
- Hens will recover if they are removed from the cages and allowed to walk normally on the floors.
- It has been observed that CLF is more prevalent in single-hen cages rather than multiple-hen cages because multiple birds in a cage will get more exercise when competing for feed and water.
- Feeding the hens a diet with the right proportions of calcium in a timely manner will prevent the depletion of calcium from the medullary bones.

Fatty liver syndrome (FLS)

- FLS is one of the most important metabolic disorders observed during high production periods in laying hens.
- It was first described in the 1950s as excessive fat in the liver associated with varying degrees of hemorrhage.
- The actual cause of the disease is still unclear and the first sign is often an increase in mortality in the flock. Several factors can cause increased deposition of fat in the cells of the liver including high egg production, toxins, nutritional imbalances, excessive consumption of high energy diets, deficiency of nutrients that mobilise fat from the liver (lipotropic agents), endocrine imbalances and genetic components.
- FLS occurs when birds are in a positive energy balance (i.e. an over-supply of energy)
- FLS in chickens is a result of excessive accumulation of fats when lipoprotein transport is disrupted.

Necropsy FLS

- The liver is the main site of lipid synthesis in the avian species which is very active in adult females that are producing eggs.
- Dead hens with FLS reveals enlarged and pale livers (the pale yellow color of the liver can result of dietary xanthophylls).
- Affected birds have pale combs.
- The liver cells are distended with fat vacuoles and different size haemorrhages.
- Bird’s abdominal cavity contains large amounts of fats.
- FLS without excessive fat is associated with mycotoxins in feeds.

Prevention of FLS

- The best way to prevent FLS is to prevent excessive positive energy balance in older birds.
- Body weight can be monitored when potential problems are seen.
- When increased body weight is observed, action should be taken to limit energy intake by feeding lower energy diets and or a change in feed management.

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Feed quality and availability:

- **Dietary characteristics can modulate a bird's susceptibility to infectious challenges.**
- **Adequate nutrition is critical to the development of the immune system in the embryo and the posthatch period during the seeding of lymphoid organs.**
- **A reduction in the time that feed is freely available to young broiler chickens results in atrophy of the bursa and thymus.**
- **The nutritional requirements for normal lymphoid organ development may not be sufficient for the immune responses required by infectious disease challenge. In this situation, nutrients formulated and intended for maintenance and growth are used instead for immune response, inflammation, and repair.**

Fatty acids and vitamins:

- Fatty acids and vitamins A, D, and E have direct regulatory roles on leukocytes and are essential for maintaining an adequate immune response to disease challenges.
- Rancid fats produce free radicals that are broadly damaging to gut epithelium, liver, and lymphoid tissues.
- VitA is protecting epithelium and mucus integrity, in the body, Aso, is known as an anti-inflammation vitamin because of its role in enhancing immune function.
- Vit E is protective of free-radical formation and is integral to immunoreactive cellular functions; subclinical deficiencies are insidiously damaging to immune functions.

Mycotoxins:

Group of biotoxins produced as fungal metabolites. Many mycotoxins target components of innate and acquired immunity.

Aflatoxin is broadly immunosuppressive in chickens, turkeys, and ducks, as shown by increased severity of concurrent diseases, vaccination failures, depletion of lymphoid tissues, impaired functions of lymphocytes and macrophages, and a reduction in serum complement.

Trichothecenes: such as T-2 toxin and diacetoxyscirpenol damage protective barriers of mucosal membranes and feathers. Trichothecenes cause depletion of lymphoid organs, reduce lymphocyte mitogenic responses, and are cytotoxic to macrophages.

Impact of nutrition on the immune response

- Appropriate nutrition may aid in minimizing the incidence of diseases by enhancing immunity and productivity.
- Dietary bioactive food components that interact with the immune response have considerable potential to reduce susceptibility to infectious diseases.
- Major classes of macronutrients provide numerous examples, including amino acids such as arginine or threonine , lipids such as the n-3 polyunsaturated fatty acids, or novel carbohydrates such as various sources of β-glucans .
- Vitamins such as D and E are commonly used as antioxidants, whereas zinc and selenium are minerals with a wide spectrum of effects on the immune system.
- There is accumulating evidence for prevention of infectious diseases by probiotics and prebiotics, and these may also affect the immune response .

Effect of The nature and type of feed ingredients on the integrity of the GIT of birds.

- The GIT functions not only as a site for digestion and absorption of nutrients but also acts as a metabolic and immunological organ.
- It serves as a barrier against abnormal presentation of luminal constituents, caused by dysfunctional intestinal epithelial barrier, to the mucosal immune system.
- Invasion by pathogens in the case of disease or stress or a massive influx of commensal bacteria overcomes the defensive mechanisms, resulting in the full activation of local dendritic cells and the expression of co-stimulatory molecules and pro-inflammatory cytokines.
- The nature and type of feed ingredients play some roles on the integrity of the GIT of birds. Because dietary intake or nutritional status and nutrient requirements may be altered as a result of disease or stress, this may alter the gut microflora and intestinal mucosal integrity, resulting in a compromised barrier of the intestinal epithelium.

- The weakening of the intestinal integrity could result in an increase in bacterial adherence to the mucosa, bacterial translocation, susceptibility to opportunistic bacterial infection, and mis-appropriation of nutrients.
- Infectious agents such as bacteria (*Escherichia coli*, *Salmonella typhimurium*, *Clostridium perfringens*, *Campylobacter* etc.), intestinal parasites such as protozoan (e.g., *Eimeria species*) and worms (e.g., *Ascaridia galli*), as well as stress arising from poor management (lack of adequate diets and/or water as well as sub-optimal barn or cage temperature) could compromise the integrity of the GIT.
- Toxins from mycotoxins found in feed ingredients have also been shown to be capable of negatively impacting intestinal integrity, reduce performance, and in some cases lead to high mortality.

Feed additives and gut health

A synergistic effect of different feed additives as part of gut health strategy to support broiler health for reducing or removing antibiotics by:

- 1: **Special blends of organic acids** can reduce the pH in the crop and proventriculus to levels where many pathogenic bacteria struggle to survive, while also supporting digestion.

Bactericidal effects of dietary organic acids have been observed for pathogenic bacteria and even for beneficial bacteria to some extent.

Dietary organic acids can improve dry matter and protein utilization, but the extent of improvement in nutrient utilization is smaller than has been anticipated.

Growth performance is likely improved.

2: **Specially-developed feed additives** can strengthen the gut barrier function and balance the microbiota. Probiotics, Feed acidifier, Natural extract, Herb oil, Enzymes...etc.

Exogenous enzymes increase nutrient availability as a consequence of the hydrolysis of dietary proteins and cell wall polysaccharides, the break down anti-nutritional factors such as phytic acid and solubilize insoluble non starch polysaccharides resulting in an overall improved energy utilization.

- 3: **Specific ingredients** can help immunemodulation, directly and by contributing to a healthier gastrointestinal tract as gut microbiota and their metabolic products. Indirectly improve nutrient digestion, absorption, metabolism, and overall health and growth performance of poultry.

Thank

you