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Short Communication

Monogastric Nutrition and Ration Formulation

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The diverse nation of poultry nutrition

Poultry production and nutrition is an extremely diverse area within monogastric nutrition due to the ever changing markets and varying production types throughout the globe. Within poultry supply chains the production systems will differ as well, meaning the birds natural requirements will also vary. The core nutritional requirements will similar in terms of nutrient profile due to the species internal requirements however dependant on the production objectives varying levels of certain nutrients will be used.

The constant drive for improved efficiencies within poultry production has led the poultry industries output to increase through improved management practices (husbandry, environmental stress management etc.) [1], these management practices have shown the importance of the bird's nutritional requirements to ensure the birds health, welfare and productive abilities [2]. The nutritional requirements of birds is also a fluid science with the genetic companies constantly breeding for higher output from the birds the nutritional requirements alter in accordance [3].

Avian digestive system

The avian digestive system is a monogastric system. The oxford English dictionary [4] defines monogastric digestive systems on an animal as having a singular stomach or digestive cavity. The avian digestive systems anatomy is believed to have a marked influence on the way feed is utilised within the bird with regards to both digestion and absorption [5]. The knowledge and understanding of avian digestive anatomy and their primary functions is important in nutrition as it allows the nutritionist to understand the birds ability to digest and absorb nutrients important to both the birds maintenance and production requirements [3]. Functionality of the digestive tract or gastrointestinal tract are vital for the bird's ability to efficiently undergo production. The following (figures 1 and 2) show the components of the digestive system as well as their locations.

Figure 1: Digestive track of a female chicken [6].

Figure 2: Location of the digestive tract within a female chicken [6].

The primary functions of the main organs for digestion and absorption are as follows:

The crop is known for its function of storage if the birds do not undergo ad. Lib feeding the crop can hold feed for later digestion, very little digestion occurs within the crop [7]. The oesophagus continues through the crop into the proventriculus or what is the avian form of the glandular stomach. Hydrochloric acid amongst other enzymes such as pepsins are secreted in this organ to stimulate chemical digestion of the feed. This chemical digestive reactions occurring in the proventriculus are a lot more active than the enzymatic reactions occurring from the salivary glands secretion. The gizzard is the organ which primary function is mechanical breakdown of feed through muscular contractions of smooth muscle tissue fibres [8,9]. This allows for an increase surface area of the feed particulate which in turn aids the chemical digestions. This small intestines comprise of the duodenum, ilium and jejunum. The primary function of the duodenum is to aid in final digestion of the feed before absorption occurs within the ilium and jejunum. Within the duodenum other organs secrete fluids to aid in digestion such as bicarbonate to counteract the hydrochloric acid secreted by the proventriculus as well as bile and other secretions from the pancreas and liver. The main digestive function of the duodenum is protein digestion [6]. The ceca and large intestine are primarily responsible for water absorption [6]. The final organ is the cloaca whereby digestive waste mixes with the urinary system for excretion.

Ideal amino acid profile

The ideal amino acid profile is a crucial concept within nutrition which illustrates the need for the correct amino acid composition within protein sources opposed to a purely crude protein value in feed [10]. The ideal amino acid profile is a vital concept within poultry nutrition to maximise production due to lysine being the first limiting amino acid within poultry diets [11]. This profile requirement will vary between bird production types in level rather than substrate.

The concept is illustrated very well by the Liebig law of minimum [12]. This states the animal utilisation of protein is not determined by the availability of protein but rather by the scarcest of amino acid resource. The water illustrates the available protein levels to the animal. The first limiting amino acid thus limits the utilisation of other amino acids within poultry. This concept is vital when formulating diets for the differing types of production due to the varying levels of required proteins [13]. Or more adequately explained with stating the utilization of feed protein is determined by the amino acid profile compared to the bird's physiological requirements.

This accompanied with the knowledge of the feed intake of the bird allows for formulation which will ensure the correct amount of nutrients are available in the correct proportion. Feed intake is influenced by several factors namely – genetics, pellet size, energy levels within the diet, age of the bird, environmental stresses and the production type [13,14].

Broilers

The broiler market is a highly developed market from both a management as well as a nutritional stand point. The primary purpose behind broiler production is lean meat creation i.e. muscle synthesis for conversion to meat at slaughter. The conventional bird, has also undergone several decades of selective breeding in order to fully maximise growth and dependant on the strain muscle deposition profile will differ [13,14]. This form of production demands a high nutritional plane to achieve the production outputs required. This means the nutrient availability in the diet must match the bird's ever increasing requirement for maintenance as well as also for the bird to maximise genetic growth potential. Gut development and health in broilers is also of utmost importance nutritionally and as such the feed ingested throughout its lifetime but especially during the younger phases of growth the feed and thus formulation, pellet chemical and physical properties must enhance gut health and microvilli development whilst encourage the proliferation of a healthy gut microbiome [6]. Broiler is also focused on the physiological aspects required during the growth cycles of the birds (neural, skeletal, muscular and fat deposition) due to the nature of differential tissue proliferation at differing ages of the bird's life [15]. This means the ration will have diminishing protein levels as the bird matures in its diet due to the decrease rate of muscle deposition however it should contain increase energy levels as the bird's maintence requirement increases proportionately to its body size [6].

A genetic fault in broilers which has led to nutritional correction in fast growing birds is calcium deposition in the femur causing legs issues such as femoral head necrosis amongst others [16]. This has led studies into nutritional correctional approaches in order to stimulate bone calcification through ensuring correct calcium phosphorous levels as well as vitamin supplementation of cholecalciferol (Vitamin D3) to promote calcium deposition in the long bone of the birds legs. The previous 20 years of studies has led nutritionists to understand the requirement for this nutrient are much higher than previously believe in the commercial broilers due to the genetic pressure to ensure maximum growth [16].

In western Europe however the consumer trend for higher welfare birds has led to generation of a slower growing bird market in order to better allow the bird to undergo growth at a rate which eliminates some of the pressure physically on the birds to achieve a higher growth rate (reference benefits of slower growing broilers) this has meant the nutritional profile of requirements has changed through the birds life and the emphasis on importance of required nutrients has changed. The same profiles of nutrients are required but not in the proportions of commercial broiler productions with more emphases placed on nutrition to ensure bone formation and body weight maintence rather than exploitation of genetic potential due to the market requirement of a bird of the same weight dynamics however with a significantly increased lifespan. This new movement also allows nutritionist to feed for further fat development and deposition to increase the organoleptic facets of the final carcass [17]. This diet will follow the same principles as a commercial diet of decreasing protein through the phases of feeding with increased energy however with a lesser initial requirement by the bird for the rate of muscle deposition – this means a lower plane of nutrition is required to meet the birds needs due to the increasing feed intake as the bird ages and the increased length of time the bird in the production system. The figure below illustrates the growth impetus differential between the two types of production and as such illustrates the differential in nutritional planes required between the production types (commercial broilers vs the slower growing birds).

Figure 3: Higher nutritional plans vs low plane to depict the nutritional requirements of commercials broilers vs slow growing broilers (Albere, 2001).

Layers

The production objectives of layer birds is significantly different to the objectives of broilers and this thus means they are given rations which are designed for a differing purpose and differing nutritional requirements by the birds. Layer hen's diets can be broken down into rearing diets as laying diets each with their own phases feeding systems in them [6].

The main nutritional goals with birds during their rearing phase is to ensure maturation of the birds with a focus primarily of ensuring maturation and functionality of the reproductive organs of the hen. These birds are typically a lot older when they head into egg production compared to broilers (both conventional and slower growing) meaning the birds maintence energy requirement will remain constant once maturation is completed (prior to lay).

One of the primary nutritional objectives with creation of a rearing diet for layer birds in the stimulation of calcium deposition within the femur in order to ensure sufficient calcium deposits are available to the bird at a later stage in its production – this is due to the increased calcium demand for egg formation to ensure egg shell quality which has commercial ramifications. Studies have shown additives such as calcium pidolate stimulate and aid in calcium absorption during bone formation [18]. This has both production and welfare implications as this substrate has been shown to improve bone formation and as such bird mobility throughout production.

The primary objective of birds during their laying production stage is to ensure egg output and egg size throughout the production cycle. Due to the facts hens in lay have reach body maturation feed intake becomes constant (typically 110 -150 grams per bird per day) [19] allowing for rations to be fed with are on a similar nutritional plane throughout lay opposed to the decreasing nutritional plane seen with birds undergoing maturation in rear. Maintence of body mass in layer birds is of importance as if the birds begin increase in size they will supersede their ideal body weight for reproductive efficiency and thus rations may need altering throughout the birds lay period however these alterations are usually minute as the maintence requirements of birds at this stage of their production cycle remain constant [6].

Lysine requirements throughout the layer hen's lifecycle are also a marked difference. The decreased need to deposit muscle tissue due to it not being the primary objective for layer birds means the lysine values in layer diets are usually lower compared to broiler diets as can be seen in the comparison of the ideal amino acid profile of a commercial broiler vs a laying hen in production [13,19].

However, due to the demand for calcium during egg formation layer diets will generally contain much higher values of calcium within the formulation in order to adequately supply the bird with the correct calcium levels to ensure egg shell formation – typically calcium will sit circa the 3.5-4% level within a layer hen diet [19]. The commercial significance of egg shell quality is driving by the market with eggs with shell defects generally deemed inadequate for sale as whole eggs and as such go into subsidiary markets at a lower price – mayonnaise production, bakeries etc.

Layer hens have another facet to incorporate during ration formulation and diet preparation. Behavioural studies on layers has shown increased fiber in the diet to reduce negative behavioural aspects such as pecking [19].

Water

Water levels of calcium, potassium, phosphates etc. will differ between water sources and will have an effect on the nutrient requirements of the birds. A common nutritional error in poultry management which will affect the nutritional requirement of the birds is hygiene and bio-security [6]. Inadequate water hygiene may lead to digestive stresses on the digestive tract due to bacterial counts in the water, incorrect pH effecting the gastrointestinal tract or even the minerals within the natural water having interactions with nutrients within the feed – antagonistic effects are often seen. This illustrates the need for ration formulation to incorporate all facets of the bird's environment and production objectives rather than just the immediate nutritional needs to ensure maintence with increased production.

Poultry nutrition and ration formulation is complex due to the economic pressures to ensure the highest level of efficiency. Throughout poultry ration formulation the nutrient requirements will differ between production types and in most cases between farms. Nutrient requirements are often dictated by the breeder company under ideal production circumstances. This is rarely the case on farm during production with all the varying husbandry and environment management differences between farms and production units have a large effect on the stresses the bird undergoes and thus its nutritional requirements to produce efficiently within those circumstances. This is evidence to a thought process within poultry production of encompassing all aspects into the ration formulation including the bird's genetics and production systems.

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