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Nutrition of the newly hatched chick – physiological limitations and potential

The first week post-hatch is associated with rapid growth of the digestive tract and is the most critical period in the life of a broiler chicken. Professor RAVI RAVINDRAN* discusses the sooner a chick starts eating, the quicker the gut develops and emphasises the nutritional requirements of the chick and options to address these needs.

Introduction

When the chick emerges from the egg, its digestive and immune systems are still immature and the hatchling is not prepared to face the challenges confronting them. First, there is the transition from yolk to oral nutrition. Associated with this are the substantial physical and functional development of the digestive tract and organs and the development of active immunity. The capacity to digest, absorb and transport nutrients is limited during the early life of broilers. To achieve their genetic potential, the neonate must quickly adapt to efficiently digesting and utilising nutrients from complex exogenous dietary sources in which energy is supplied predominantly by carbohydrates. As the growing period of modern broilers continues to shorten, the early nutritional management of the chick becomes increasingly important to success.

Yolk sac

The residual yolk sac (Figure 1), which is the source of nutrients to the embryo, plays a crucial role in early nutrition. If the chick has no access to feed, the yolk can supply nutrients until they become available. However, this will be a waste, as specific nutrients in the residual yolk are much more functionally valuable - maternal antibodies for passive immunity and, phospholipids, choline and triglycerides for cell membrane development.

The yolk sac is taken into the chick's body at hatch accounts for 10% of the chick's bodyweight. It delivers its contents to the chick intestinal lumen and blood stream over the first 4 days of life.

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So it does appear that providing the newly hatched chick with feed as early as possible is the best option as it allows the yolk to be used for its intended purposes. For example, the phosphorous, triglycerides and cholesterol are needed for cell membrane development, Protein can be broken down and used as a source of amino acids and the maternal antibodies for passive immunity.

Growth of digestive organs

The daily relative growth rate is high during first 10 days of life. Bodyweight increases by 14% during the first 24 hours, and peaks at 22% per day on day 11. Associated with this are:

- rapid growth of digestive tract
- normal development of intestinal refluxes
- increased secretion of digestive enzymes
- increased intestinal surface area for absorption
- development of immune system

The chick places a high priority on early intestinal growth to ensure the development of nutrient supply functions, which are necessary for subsequent growth of demand tissues, such as the muscles. The early development of the small intestine is stimulated by early access of feed. Feed intake of chicks during week 1, however, is limited due the size of intestinal tract and by ▷

Figure 1: The yolk sac has an important role in the nutritional adaptation of the chick.

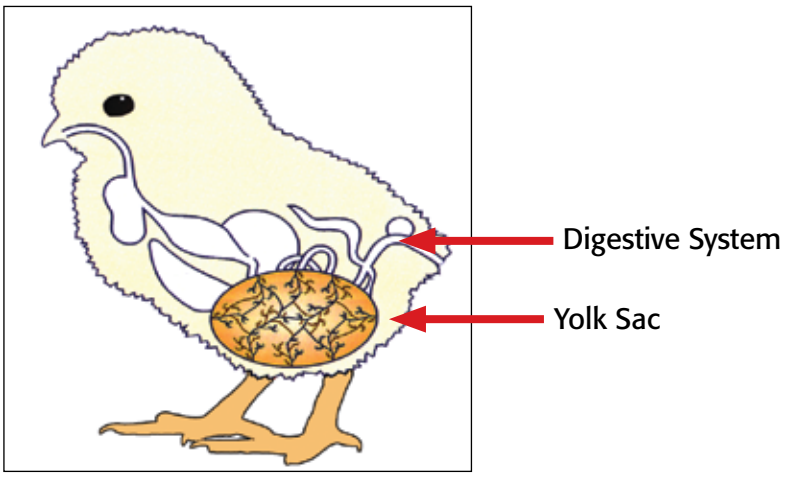


Figure 2: Fed birds more efficiently use nutrients in the residual yolk.

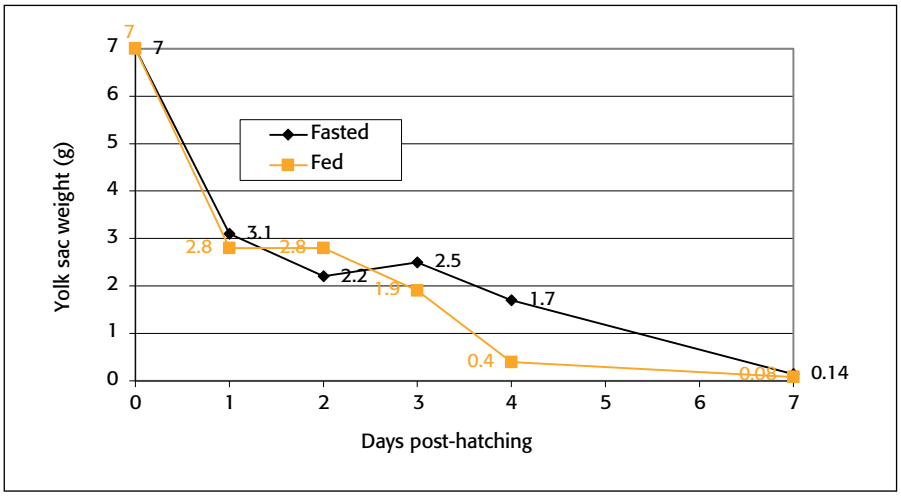
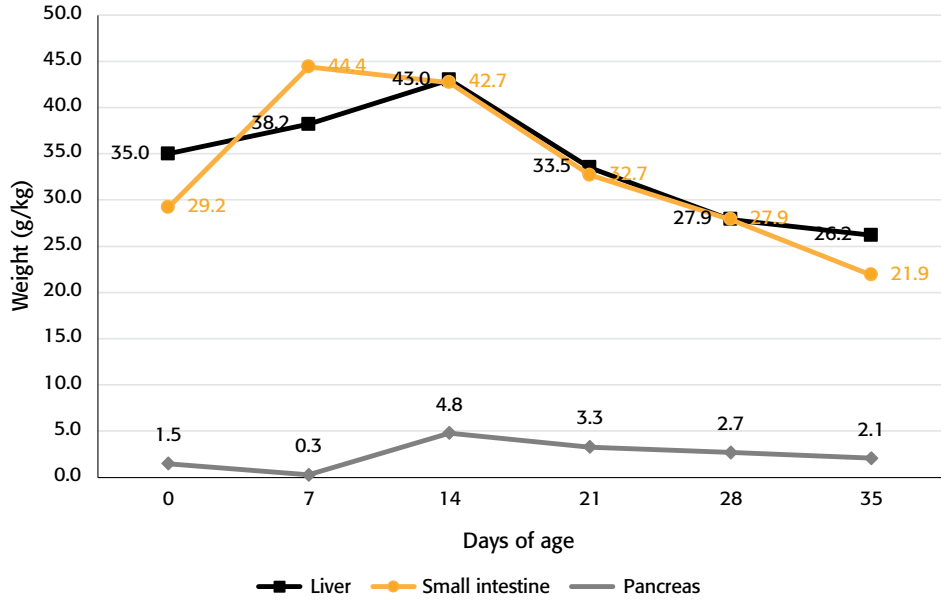


Figure 3: Growth of the Digestive system.



Ravindran *et al.*, 2006

◁ limitations in feed passage rate. Feed intake increases many-fold during week 1, paralleling the changes occurring in the intestine.

Gut morphology drives gut function

Phenomenal growth occurs in the gut mucosa (villi, crypt and goblet cells) during the first week when the chicks have access to feed. Gut morphology is directly linked to digestion and absorption, and this determines available nutrients for growth.

The functionality of the intestine is related strictly to its microscopic structure. The growth of intestinal villi and mucosa after hatch is phenomenal and these dramatic increases in the weight and length of small intestine are minor relative to the growth of gut mucosa. The digestive organs are functionally immature at hatch, but undergoes rapid maturation thereafter. The secretion of digestive enzymes by pancreas and the brush border of the small intestine are low at the time of hatch, but increase after hatch although the rates of increase are different for different enzymes. It is, however, unclear whether the availability of enzymes limits early growth.

The replicating cells have been stained. The cells start their migration from the base of the villi. Note that the stained cells are half way up the villus by day 3 (Figure 4).

Digestion during week one

It is generally accepted that digestibility of fat and protein, and metabolisable energy are compromised during the first week of life and increase with advancing age. Digestibility of both unsaturated and saturated fats is low in young chicks, but fats with high proportions of saturated fatty acids (such as tallow and palm oil) are more poorly digested than those with unsaturated fatty acids, such as soybean oil (Table 1). The implication is that saturated fats must be avoided in diets fed during week 1.

On the other hand, starch digestion appears not limiting in young chicks and digestibility of starch in maize-soy diets is over 95% by 4-10 days of age (Figure 5). Recent data indicate that calcium

Figure 4: Cross-section of the small intestine – day 1 (left) and proliferating villus cells day 3 (right).

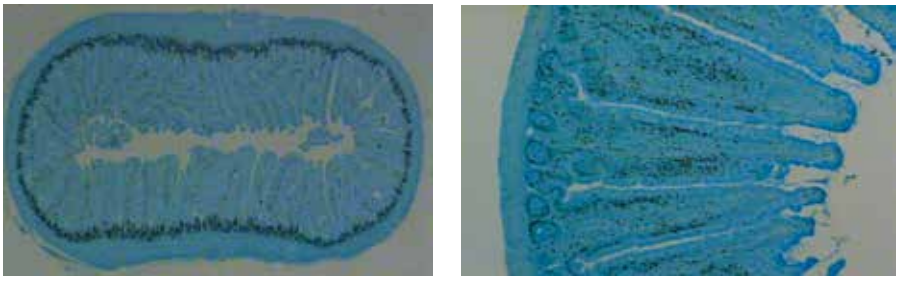
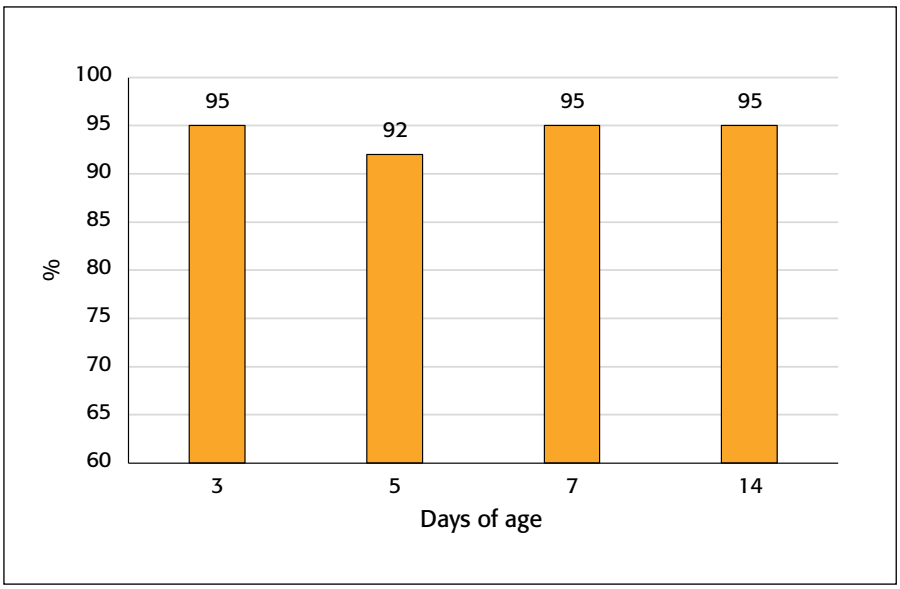


Table 1: Effect of fat type and broiler age on fat digestibility.

Fat type	Age (weeks)			
	1	2	3	4
Tallow	0.37	0.65	0.74	0.73
Tallow:soy oil	0.59	0.89	0.95	0.95
Poultry fat	0.50	0.83	0.83	0.85
Palm oil	0.60	0.83	0.85	0.85

Tancharoenrat *et al*., 2014

Figure 5: Total tract starch digestibility – corn/soy diet.



Thomas and Ravindran 2008

absorption is another exception, being higher during week 1 and decreasing with advancing age.

Overall, evidence suggest that intestinal growth and function of newly hatched chicks may not be adequate to support efficient growth. Thus potential exists for the realisation of the modern bird's genetic potential though nutritional manipulation of digestive capacity during the critical first few days after the hatch. Even an enhancement of early intestinal growth by a day or two will go a long way towards improving the efficiency of the bird over its grow-out period. Several strategies are available to assist the newly hatched chick

Breeder nutrition

It may be possible to enhance intestinal growth in the embryo through breeder nutrition. It is well known that the egg nutrient composition could be easily manipulated by breeder nutrition, but its effect on post-hatch growth is not clear. Another approach would be *in ovo* administration of highly digestible nutrients (dextrin, maltose, sucrose, amino acids, salt, minerals, vitamins) into the amnion of late-term embryos. Studies have shown that the intestine of *in ovo* fed chick at hatch is at a similar stage of development as a 2-day old chick. There are growth benefits during week 1 and early stages. However, this early benefit is not always carried over the whole grow-out period. Any advantage in early growth is often lost as the bird grows, which this may be a reflection of compensatory growth phenomenon.

Immediate access to feed

The easiest and the practical way to ensure the optimal intestinal development of the chick is through ensuring feed access immediately after hatch. The benefits of this practice well accepted in the industry and its role in stimulating intestinal growth, digestive function, immune development and muscle growth are now recognised.

Pre-starter diets

Feeding special, highly digestible pre-starter diets during week 1 is suggested and, the development of these diets must take into account of the intestinal and nutritional limitations of the chick. There are two options. First, a solution of highly digestible sugars and protein (amino acids); no fat; B-vitamins and organic acids (pH 3.5-4.0) could be offered during the first 48 hours – especially when the chicks are under stress conditions. Second, specialised pre-starter diets, based on highly digestible, quality ingredients, could be used and recommended. In such diets, the following principles must be followed. (i) high quality and highly digestible protein, (ii) minimal indigestible components and antinutrients, (iii) higher amino acid density than the starter diet, (iv) no saturated fats, (v) use only good quality raw materials, (vi) optimal feed particle size, (vii) additives that promote good gut flora and increase sodium level (to promote intake and nutrient absorption). Other special considerations may include specific amino acids (e.g. glycine + serine) and high trace minerals (e.g. zinc). These diets will be expensive, but practical because of the low feed intake during week 1.

Summary

The first week of life is the most critical period in broilers – the digestive and immune systems are still immature. Considering the long-term beneficial effects on broiler growth, the use of pre-starter diets must not be considered as a cost, but as an investment. AP

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