The key aspects of chick management – part one

by Antônio Mário Penz Junior, Universidade Federal Do Rio Grande Do Sul, Departamento De Zootecnia, Porto Alegre, Rs, Brazil.

The genetic progress of broilers, since the beginning of the industrial poultry industry, has been indicated as one of the most impressive evolutions of animal production.

To justify such changes, Sluis (1999) exemplified how much the broilers' performance increased since 1978 and what are the predictions for 2008. As an example, in this period he demonstrated an improvement of 44% feed conversion in poultry.

That means that every year the broilers eat less to get the same weight. So, any time that the broilers do not get the right amount of nutrient this can represent a restriction on their performance.

In this context, the feeding of broilers during the first days of life determines the success of their potential growth.

This is true as the anatomy and the physiology of their digestive tract is different from older broilers; their nutritional needs are quite limiting as they have problems in digesting and absorbing certain nutrients.

They have potential for rapid development in the first days of life but they are being selected for less feed consumption; they have problems surviving in cold environments and also, with all these challenges, their immune system must be protected to respond any time that it is needed.

Therefore, losses in the early development of the broilers is more of a problem now than it was in the past.

Anatomical changes

The anatomical changes of the digestive tract in broilers during the first days of life are remarkable.

Broilers achieve maximum relative weight of digestive organs when they are between 3-8 days of age.

Noy and Sklan (1997) showed that the highest increase in the volume of villi of the duodenum occurs when the broilers are four days old, and in the jejunum and ileum, when they are 10 days old, whereas the highest crypt depth in the duodenum and jejunum occurs at 10-12 days of age. The age hardly affects this parameter in the ileum.

Parameters	Age (days)						
	0	3	6	8	11	17	23
Velocity of gain (%/day)		12.0	18.5	15.0	16.1	16.0	9.5
Yolk sac weight (g/100BW)	10.3	1.9	0.2	0.2	0.1	0.02	0.01

Table 1. Velocity of weight gain and relative weight of the yolk sac. Adapted from Nir et al. (1988).

The authors found that the number of enterocytes per villus also increases with the age of the broilers. Geyra et al. (2001) observed that the enterocytes' migration from the crypt to the villus, before extrusion, takes 72 hours in broilers at four days of age and 96 hours in older broilers.

According to Moran (1985), the primary function of the intestinal mucosa cells, developed during the embryo stage, is the absorption of immunoglobulins. They determine the development of villi and the emergence of more enterocytes in the crypts.

These enterocytes in the crypts allow the synthesis of different enzymes. The passage of feed through the digestive tract of newly hatched chicks also promotes the development of crypt enterocytes, which gradually replace intestinal enterocytes of the embryo stage.

When this replacement is complete, the chicks reach their maturity in digestion and absorption of nutrients.

Nir, Nitsan and Mahagna (1993) also observed that the weight of the pancreas and the liver of broilers increases four and twofold as compared to the body weight during the first week of age.

These fast changes in the digestive tract allow an increase in feed intake and modify nutrient digestibility.

Physiological changes

1Digestion and absorption of carbohydrates.

Moran (1985) asserted that the secretion of α-amylase is substrate dependent, being influenced by the amount of starch in the diet. Dautlick and Stritmatter (1970) said that maltase and saccharase enzymes reach maximum activity when chicks are four days of age.

Marchaim and Kulka (1967) indicated that the activity of α-amylase is 500 times higher at hatch than on the thirteenth day of incubation.

Holdsworth and Wilson (1967) noticed that the peak of glucose active transport is reached when chicks are three days old.

Moreover, at the same time that the maximum capacity of sugar absorption occurs, intestinal area increases the most.

Shehata et al. (1981) observed that during the first days of life, glucose absorption becomes predominantly aerobic and sodium dependent, which does not happen during the embryo stage.

During this short time after hatch, maltase V_{max} significantly increases, while the enzyme K_m remains fairly constant.

Placement	Weight gain 1-21 days (g)	Weight gain 1-49 days (g)	% Mortality 1-21 days	% Mortality 1-49 days
	P<0.001	P<0.01	NS	NS
Immediate	647	2654	2.0	6.3
24 hour delay	598	2568	1.5	10.5

Table 2. Performance of broilers given feed and water immediately after hatching compared with those with a 24 hour delay.

1Digestion and absorption of lipids.

Katongole and March (1980) showed that the concentration of fatty acids binding protein is low in the intestine of newly hatched chicks and it increases until the birds reach five weeks of age.

However, the secretion of bile salts is the first limitation in the processes of lipid digestion and absorption.

Serafin and Nesheim (1970) suggested that newly hatched chicks are not able to increase the secretion of bile salts not even when it is necessary.

Krogdahl (1985) showed that the secretion of lipase is influenced by the presence of lipids in the diet and found a 10-fold increase in the levels of this enzyme from two to 56 days of age, when broilers where fed a diet with high oil levels. This was not observed when the diet had low levels of oil.

The enterohepatic circulation is also immature in newly hatched chicks. Jeanson and Kellog (1992) believed that this enterohepatic circulation inefficiency is genetic and does not depend on the presence of substrate.

Renner and Hill (1960) showed that the ability to absorb tallow and its metabolisable energy increased in 2-8 week old broilers. However, this did not occur when lard was used.

Carew et al. (1972) identified an increase in absorption between 2-15 days of age when tallow and corn oil were fed.

Sell et al. (1986) observed that the digestibilities of tallow and vegetable oil mixtures were 66.4 and 83.7% in two week old turkeys, and 90.8 and 96.5% in eight week old broilers.

1Digestion and absorption of proteins.

Hudson and Levin (1968) and Pratt and Terner (1971) showed that embryos have the ability to absorb amino acids through the intestine even before hatch. This ability may justify why newly hatched chicks have no problems absorbing amino acids.

Nitsan et al. (1991) showed that chicks hatch with some enzymatic reserve in the pancreas. This reserve tends to decrease in the first days after hatch and the enzyme synthesis, during this stage, is slower than the bird's

Continued on page 9

Continued from page 7
need of enzymes in order to achieve full protein digestion.

These authors found that trypsin and chymotrypsin specific activity decreased until 5-6 days after hatch, and then rapidly increased, reaching maximum levels at 10 days of age.

These observations were confirmed by Nir et al. (1993). Tarvid (1992) found that, on the day of hatch, chicks already had procarboxypeptidase A and active dipeptidases in the intestinal lumen.

This author suggested that the presence of active enzymes is dependent not only on the chicks' age but also on the start of the process of eating solid diets.

This was previously observed by Austic (1985), who verified that trypsin and chymotrypsin concentrations increased when chicks were fed diets with protein levels above those currently used. When the chicks were fed a diet with no protein, there was a decrease in the activity of those enzymes.

However, another aspect that can impair the digestion of lipids and protein is the presence of soluble non-starch polysaccharides (pentosans, β-glucans and pectins) in the diet. The younger the chicks the worse are the effects of these polysaccharides.

These substances promote an increase in intestinal viscosity, slowing down the velocity of diffusion of substrates and enzymes, compromising their interaction with the enterocytes.

These substances also increase the presence of micro-organisms in the small intestine. So, first week diets should preferably not contain wheat, rye, barley or oats, as these ingredients are high in soluble non-starch polysaccharides.

Development of the immune system.

The development of the immune system starts during the embryo stage and continues during the first week post-hatch and Casteel et al. (1994) mentioned that the delay in water and feed consumption promotes a depression in immune response.

According to Klasing (1998), the chronic deficiency of micronutrients can be more significant than the deficiency of energy and proteins. Friedeman and Sklan (1997) demonstrated that broilers fed vitamin A deficient diets are less resistant to infectious challenges and the immunocompetence of young chicks is maximised when the level of vitamin A is 10-20 times higher than the level suggested for maximum growth.

Dibner et al. (1998a) suggested that the nutrients available in the yolk sac must not be considered as a primary energy source for chicks. Part of the protein consists of maternal antibodies, which are important for the passive immunity of the chicks. The lipids, besides their structural function as components of cell membranes, also favour the broilers' immune responses.

Li et al. (1998) demonstrated that the IgG in the yolk sac is continuously absorbed by the embryo during incubation up to two days after hatch. In general, the larger the yolk, the greater is the amount of IgG available for the chicks.

Dibner et al. (1998b) evaluated the effect of a post-hatch diet on bursa of Fabricius development. Broilers fasted for one or two days had less bursa weight and less bursa:body weight ratio.

This lower weight of the bursa is related to a lower proliferation of lymphocytes. The fasting stimulates the secretion of corticosteroids, which inhibits the proliferation of immune cells.

Parameters	Fasting period (days)			
	Normal	0-2	2-4	4-6
Body weight at eight days	100[a]	78.4[c]	79.3[c]	82.8[b]
Body weight at 41 days	100[a]	92.7[c]	94.0[bc]	97.8[ab]
Breast muscle at 41 days	100[a]	88.6[b]	91.3[b]	100.9[a]

Table 3. Effect of fasting on relative body weight and muscle development of the chicks. Adapted from Havely et al. (2000).

The use of the yolk sac

At hatch, part of the yolk is still being absorbed. All substances which constitute the yolk are retained in the yolk sac, located in the proximal portion of the small intestine.

According to Krogdahl (1985), the substances contained in the yolk sac are directly absorbed by the yolk sac membrane, and this absorption occurs by non-specific phagocytosis.

Also, it can be absorbed by the yolk sac epithelium or by the intestinal mucosa, which is the least important of the three. The yolk sac weighs approximately 8g and 25% of the yolk consists of lipids.

However, Noy and Sklan (1997) suggested that the percentage of lipids at hatch is 50%. All substances present in the yolk sac are readily used in the first 3-5 days of the chicken's life, and they are more important in the first two days after hatch.

Nir et al. (1988) suggested that on the third day after hatch, the contribution of the yolk sac nutrients is irrelevant, and that it does not compensate the limitation of any nutrient that should be provided by the feed (Table 1).

Placement	Weight gain 1-49 days (g)	Feed conversion 1-49 days	% Mortality 1-49 days
Breeder age			
62 weeks	2692	1.93	9.0
27 weeks	2595	1.90	14.8
Propionic acid			
0%	2664	1.93	12.3
3%	2623	1.89	11.5

Table 4. Performance of broilers receiving 3% propionic acid in the first week's feed. Adapted from Vieira and Moran (1999).

However, Murakami et al. (1988) showed that on the first three days of life the yolk sac is responsible for 29% of the energy and 45% of the lipids of the chicken's requirement.

Nitsan et al. (1991) showed that broilers of genetic lines selected for faster weight gain have a heavier yolk sac at hatch than broiler lines selected for slower weight gain. This demonstrates the importance of this structure in early post-embryonic life of broilers.

Edwards et al. (1962) found that when the yolk sac of one day old broilers was removed, their weight gain was lower as compared with broilers which remained with the yolk sac.

Although the yolk sac provides most nutrients in the first hours of the broilers' life, it is the stimulation of solid feed intake that will promote the main changes in the physical structure of the digestive system and its secretions, essential for the digestion of nutrients in this period.

It is extremely important that the broilers start to eat solid feed immediately after hatch, stimulating changes in the intestinal structures and secretions.

Noy and Sklan (1997) found that the yolk sac is used faster by chicks being fed than those fasting. Thus, leaving chicks without feed in early life prevents the early stimulation of the nutrients on the digestive system and reduces the use of available nutrients in the yolk sac, which are essential for the early development of chicks.

Proposed nutritional criteria

The embryonic stage is very different from the post-embryonic stage in relation to nutrient utilisation. During the embryonic stage, nutrients are provided by the dam and are usually perfectly available.

Therefore, a fully active digestive system is, at least, partially non-essential at this stage. In embryos, the main sources of energy are lipids, while for post-hatched broilers, are carbohydrates. The use of proteins is not a big problem either before or after hatch.

This shift from lipids to carbohydrates is so important that the blood level of sugars start to increase even before hatch. This is concurrent to the beginning of the pulmonary respiratory system activity of embryos.

Glycogen reserves in the liver, stored during the embryonic stage, are obtained by glyconeogenesis from albumin protein.

These reserves are only sufficient for the first day of the chick's life. After hatch, glycogen level in the liver only increases if the chicks are ingesting carbohydrates.

Feed intake.

Under practical conditions, chicks may arrive at the farm 24 to 36 hours after hatch. This period is spent in sexing procedures, vaccination, and transport. During this period of time, chicks lose weight due to the use of yolk sac nutrients, digestive and kidney excretions and dehydration.

Noy and Sklan (1999a) showed that chicks fed immediately after hatch, had a feed intake of 6.5g, a weight gain of 3.5g and 60% decrease in yolk sac weight during the first 48 hours of life, whereas the fasted chicks lost 3.5g in weight and had a lower decrease in yolk sac weight.

However, even during fasting, their intestine increased 80%.

Continued on page 11

Continued from page 9

Therefore, early feeding may lead to early development. The benefits of early feeding are more noticeable in 7-10 day old chicks and this advantage is maintained up to market age.

Vieira and Moran (1999) verified that broilers with the placement delayed for 24 hours had a reduced weight that remained through marketing.

These authors also demonstrated that a higher mortality for birds under delayed placement than for those with no placement delay (Table 2).

Noy (1993) found that the main detrimental effect of delaying the beginning of feed intake is the reduction of the growth of different structures of the digestive system.

Havely et al. (2000) demonstrated that feed withdrawal at the beginning of the life of the chicks is more detrimental than when it happens later in their lives.

They fasted the chicks from 0-2, 2-4 and 4-6 days of age. Table 3 shows that fasting the chicks just after hatch compromises the weight and muscular development of most of them and this is due to the changes in the satellite cells proliferation.

Therefore, an important aspect of the first day of life of chicks is to place them as soon as possible in contact with feed, and to identify a diet which will make them eat as much as possible.

The enzymes which regulate digestion are dependent on substrate. So, the faster and the higher the feed intake, the faster the chicks will be ready to digest and to absorb nutrients.

Besides, if the chicks' placement is delayed, dehydration and stimulation of ketosis can occur. The addition of glucose in the diet may alleviate this situation, but only if the birds receive water and feed as soon as possible.

Age (days)	Young breeder YES	Young breeder NO	Old breeder YES	Old breeder NO	Y/N	Main effects Breeder age	Interaction
0	40.8	40.0	49.6	50.0	NS	***	NS
40	1,855	1,753	1,890	1,800	**	*	NS

**P<.05 **P<.01 ***P<.001 YES = use of nutritive solution NO = no use of nutritive solution*

Table 5. Effect of the use of nutritive solution on weight gain of broilers (40 days) from breeders with different ages. Adapted from Noy and Pinchasov, 1993.

Vieira and Moran (1999) added propionic acid to the first week's feed diet of the chicks as an attempt to improve gluconeogenesis and early performance (Table 4). The supplementation with 3% of propionic acid caused losses in weight gain but led to an improvement in feed conversion and alleviated overall mortality when chicks originated from young breeders.

Noy and Pinchasov (1993) demonstrated that feeding an oral solution of glucose:starch:oil (1:1:1 vol/vol/vol) improved chick performance from 13 days of age.

This effect was more noticeable in chicks that were kept for 24 hours after hatch with no feed and water.

These authors also studied the effect of the use of the same nutritive solution in chicks from young female breeders (28 weeks of age) and old female breeders (70 weeks of age). The use of the nutritive solution improved the performance of 40 day old broilers from both origins.

However, broilers from young breeders which were fed the nutritive solution, had higher weight than those from old breeders which were not fed the nutritive solution (Table 5).

The use of the nutritive solution probably stimulated the digestive system, making the chicks which were fed the solution independent from nutrients of the yolk sac faster and more dependent on external sources of nutrients.

Noy and Sklan (1999b) compared the weight gain of chicks fasted for 36 hours post-hatch to the weight gain of chicks receiving feed, feed and water, or only water, 40 minutes post-hatch.

At four days of age, the chicks which received feed and water, or just feed, were already heavier than those fasted for 36 hours post-hatch. This difference was maintained until the end of the experiment, when chicks were 21 days of age.

In another experiment, the authors verified that broilers fed immediately after hatch had a 10% increment in breast yield.

Araújo (2003), in a review on post-hatch nutrition, concluded that any impairment in chick development at the beginning of their lives will affect meat production.

The need for an immediate feeding after hatch is becoming so important that researchers start challenging the use of prehatch nutrition.

Uni and Ferket (2001) hypothesised that the in ovo nutrition promotes an acceleration of the enteric development and this will cause an improvement of the digestion and absorption of the nutrients offered to the post hatch chicks. Also, this can improve health status and the resistance to stress that happens after hatch.

There are several theories which suggest regulation mechanisms of feed intake in animals. Among them, are the glucostatic, thermostatic, lipostatic, aminostatic and ionostatic theories.

According to a review on this subject in the NRC (1987), it is still not clear which theories best apply to birds and which brain structures interpret differences in ingested nutrients.

Although at the moment there are several discussions on this subject, the hypothesis which sustains that broilers eat in order to satisfy their energetic needs cannot be totally rejected.

However, Maiorka et al. (1997) showed that this effective regulation of feed consumption by the energy of the diet only happens after the chicks get to three weeks of age.

They hypothesised that this should be due to their ability to efficiently digest lipids, essential energy source in high energy level diets. n