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Early post hatch feeding in chicks and practical constrains-A review

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ABSTRACT

At present, broilers reach slaughter weight at a physiologically younger age and the embryonic developmental period as well as the first week after hatching represents a larger proportion (45%) of the whole life span. Thus, pre-hatch as well as the transitional post-hatch period must be achieved efficiently. It is known that body weight is increased three to four fold during the first week and considerable changes in gut, and muscle weight and morphology are observed. The post-hatch period is critical for the digestive tract because the system is switching itself from off to on. The first day after hatch is critical for the development of body systems in the chicken and certain types of manipulation must occur during the first days after hatch in order to achieve long-term effects. Meat-type broilers are capable of achieving 70 g/day until 40 days. This achievement requires emphasis on early phase nutrition (i.e. pre-starter diets). The use of pre-starter diets assumes that starter diets are somewhat inefficient in providing balanced nutrients. Early nutritional strategies offer the promise of sustaining progress in production efficiency and welfare of commercial poultry. In order to achieve broiler potential several unconventional changes must be made: supplying nutrients to the developing embryo before hatch, supplying feed within hatchery, developing highly digestible pre-starter diets. Integrate all of the above to create a continuous feeding process from several days prior to hatch, during hatch and till farm placement where first feed is provided.

Key words: Broilers, Hatch, Pre-starter, Starter diets, Slaughter.

The second half of the twentieth century has seen an enormous expansion in poultry production. The dramatic increase in production volume and production efficiency per bird is attributable largely to the ongoing developments in chicken genetics and nutrition. The progress in chicken nutrition during the last 50 years is attributable to a number of factors, including the use of synthetic vitamins and enzymes; the move from total protein to available amino acids; the development of a greater number of feeding programs to meet the special requirements during the production cycle and of new genetic lines; the addition of micro- and macro-elements to diets; the energy: protein ratio; the progress in feed meal technology and the use of true metabolizable energy (TME) evaluation to assess the energy available to poultry in various raw materials. At the end of the twentieth century it is natural and useful to ask whether or not, and how, the progress in productivity and feed efficiency will continue in the next century. There are two new approaches. One is the approach of early nutrition, or more broadly, manipulation during the post-hatch period. The second approach is an understanding of processes in the small intestine.

Birds are precocial and will forage for feed immediately and begin to grow, where as holding those without feed results in body weight loss for some 24 hours after poultry are fed (Henderson *et al*., 2008). Under commercial practice, eggs within a single tray will hatch over a 24 to 36 hour window, during which time the birds which have pipped are left without access to feed. The early hatching chicks are therefore at a disadvantage because of the prolonged fasting period and potential dehydration it causes (Tweed, 2005). Logistics within the hatchery as well as treatments such as sex determination, sorting, vaccinations, beak trimming, comb dubbing and transport to the farm involve a further holding period. During this time chicks' decrease in weight at an approximate rate of 4 g per 24 hours, due in part to moisture loss as well as yolk and pectoral muscle utilization (Careghi *et al.,* 2005). Thus, birds are often held for 48 hours or more before initial access to feed and water which can have lasting negative effects (Juul-Madsen *et al.,* 2004). Delaying access to feed and water makes hatchlings more susceptible to pathogens (Dibner *et al.*, 1996), increased weight loss (Noy and Sklan, 1999) and the development of critical tissues is restricted (Moore *et al.*, 2005). All of this leads to irreversible damage to muscle development and retarded growth through to marketing. These effects are more pronounced in the modern strains of meat–type poultry which are characterized by elevated metabolic rate compared to the older strains (Tona *et al.*, 2004).

Relevance of early feeding strategies for today's poultry:
+developmental period as well as the first week after hatching represents a larger proportion (45%) of the whole life span

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(Bigot *et al.*, 2003). Thus, pre-hatch as well as the transitional post-hatch period must be achieved efficiently. It is known that body weight is increased three to four fold during the first week and considerable changes in gut, and muscle weight and morphology are observed (Jin *et al.*, 1998). Meat-type broilers are capable of achieving 70 g/day until 40 days. This achievement requires emphasis on early phase nutrition (i.e. pre-starter diets). The use of pre-starter diets assumes that starter diets are somewhat inefficient in providing balanced nutrients.

Consequently, modern broiler strains require re-evaluation of nutrient provisions. Each gram of additional weight at 7 days of age translates to 5 g of extra body weight at day 49 (Leeson and Summers, 2001). Therefore, delayed feeding in the first few days of life reduces final bodyweight (Noy and Sklan, 1999; Kidd *et al.*, 2007) and it probably affects immunological capacities (Dibner *et al*., 1998). Early post hatching feeding is therefore recommended to reduce these effects. In order to develop efficient early feeding techniques it is necessary to understand the physiological and metabolic changes which occur in the pre- to post-hatch period.

Physiological changes occurring during the pre- to post-hatch period: The pre-hatch period (last phase of incubation) is characterized by oral consumption of the amnion by the embryo, accumulation of glycogen reserves in muscle and liver tissues and glycogenolysis, initiation of pulmonary respiration, abdominal internalization of remaining yolk, shell pipping, and emergence (Moran, 2007). During this time frame, dramatic physiological and metabolic changes occur, and any disturbances at this stage may markedly affect embryonic survival and its' subsequent performance (Leksrisompong *et al.*, 2007). Some of the important metabolic pathways prior to hatch are described in a recent review (De Oliveira *et al.*, 2008) which emphasises the liver, pectoral muscle, hatching muscle and intestine, as most affected by changes toward hatching.

One of the major physiological processes during pre-natal development is the maintenance of glucose homeostasis. The glycogen reserves are withdrawn as embryos go through the hatching process. Researchers have suggested that insufficient glycogen and albumen forces the embryo to mobilise more muscle protein for gluconeogenesis thereby reducing early growth and development (Vieira and Moran, 1999a; 1999b). Glycogen reserves begin to be replenished when the newly hatched chick has full access to feed (Moran, 2007).

Another significant physiological process occurs in the intestine. Exploration of this process shows that, towards the end of incubation, the gastrointestinal tract undergoes extensive morphological, cellular and molecular changes. Research in broiler embryos has shown that, during the last days of incubation, intestinal weight relative to embryonic weight increases from 1.4% at 17E to 3.4% at hatch (Uni *et al*., 2003). Activity and RNA expression of brush-border enzymes which digest disaccharides (sucrase-isomaltase), small peptides (aminopeptidase) and major transporters (sodium-glucose transporter and ATPase) begin to increase a few days before hatch and this process continues on the day of hatch and thereafter (Uni *et al*., 2003; Gilbert *et al.*, 2007).

In the newly hatched chick the small intestinal mucosa appears to be immature. This is reflected in the organization and establishment of the crypt region, several-fold increase in villus height and area, and the maturation of enterocytes and goblet cells (Uni, 2006).

The immediate post-hatch period is critical for intestinal morphological development in order to digest feed and assimilate nutrients. Intestinal growth occurs in delayed fed chicks but to a significantly lesser extent than in early fed birds (Bigot *et al*., 2003). This indicates a preferential intestinal growth immediately post-hatch. Decreased intestinal development in chicks fasted for 36 to 48 hours post-hatch was reflected in the decreased enterocyte number, crypt size, the number of crypts per villus, crypt proliferation, villus area, rate of enterocyte migration, goblet-cell size and mucin dynamics (Uni *et al.*, 2002).

Therefore, the sooner the gastrointestinal tract achieves functional capacity, the more quickly the chick can utilise dietary nutrients and replenish its depleted energy status efficiently thus achieving genetic growth potential, while resisting infectious and metabolic diseases.

Current industry practices that impact early nutrition: A common practice in the poultry industry is delayed access to feed and water for the first 12-24 hours post-hatch. This is due to necessity in many situations as newly hatched poults and chicks must be processed at the hatchery prior to delivery to the farm. Another industry application that can impact early nutrition is beak trimming. This typically occurs at the hatchery or during the first week of life and has been found to cause little stress to poultry during and immediately following the procedure. Beak trimming is helpful in reducing mortality and stress as the chicken or turkey matures and is generally recognized as a beneficial practice of proper bird management.

Importance of first day feed in chicks life: The post-hatch period is critical for the digestive tract because the system is switching itself from off to on. The first day after hatch is critical for the development of body systems in the chicken and certain types of manipulation must occur during the first days after hatch in order to achieve long-term effects. The GIT which is sterile at the time of birth undergoes exposure to different antigens through the passage of feed. The earlier the food passes through the tract the sooner the proliferating stem cells will meet an environmental antigen, which helps to create a wider antibody repertoire. At the time of hatching

bursal ducts also open. Transport of environmental antigens into bursal lumen and further into the lymphoid follicles begins with unique and sucking movements. Intestine is the primary nutrient supply organ, the sooner it develops its functional capacity, the faster the young chick can utilize dietary nutrients and grows to its genetic potential and resist infectious and metabolic diseases. Early access to feed and water is desirable in order to encourage better growth and performance. A good start can help to ensure higher body weight, and there is a positive relationship between first week weight and final body weight.

Delaying access to feed and water: Noy and skylan (2001) reported that the delay access of feed and water that can cause reduced body weight gain and that negatively impact on breast muscle yield. Bhanja *et al.* (2010) reported that feed and water provision delay means its leads to slow down the gastro intestinal system and immune system. Uni and ferket (2004) reported that 5% reduced body weight due to the delay accessing feed and water. Dibner *et al.* (1999) reported that susceptibility of pathogen very quickly for immature immune system due to late provision of water and feed. Kidd *et al.* (2007) reported that delayed feeding in the first few days of life reduces the final body weight.

Problems: Many problems exist within this early period in poultry due to the delayed feeding and watering. These includes

- Starve- outs in turkey poult
- Intestinal challenges leads to
- Necrotic enteritis
- Malabsorption
- Decreased performance
- Mortality

Role of residual yolk: The unabsorbed yolk in the hatchling is called as residual yolk. During hatchling the yolk comprises about 20% of the chick body weight .towards the end of the incubation remaining yolk is internalised in to the abdominal cavity. Thus newly hatched chick provide immediate post-hatch energy and protein for growth and maintenance the residual yolk sufficient to keep chicks alive for first 2- 3 days without feed but it will not support the development of gastrointestinal tract development and immune system, the protein contains valuable bio molecules such as maternal antibodies that are better used for passive immunity than as a source of amino acids. Lipid fraction of yolk contains triglycerides, phospholipids with small amount of cholesterol nor free fatty acids. In hatching chicks the yolk utilized either endocytosis of yolk contents in to the circulation or by transport through yolk stalk in to small intestine. Anti-peristaltic movements transfer the yolk to the proximal small intestine where acyl-lipids are digested by pancreatic- lipase and absorbed.

Effect of fasting:

Fasting causes

- Secretion of corticosteroids
- Reduce growth & surface area of GIT (cells / crypt or
- Reduce Villi height (2/3) & width crypts / villi)
- Inhibit yolk utilization
- Delayed maturation of enzyme system
- Poor breast muscle development

Fasting inhibits:

- Development of gut associated lymphoid tissue (GALT)
- Bursa of Fabricius
- Caecal tonsils
- Meckel's diverticulum
- Payer's patches
- Intra - epithelial lymphocytes

Geyra *et al.*, (2001) uni *et al.*, (2002) reported that decreased intestinal development in chicks fasted for 36-48 hours post-hatch was reflected in the decreased enterocyte number, crypt size, number of crypts per villus, crypts proliferation, villus area, rate of enterocyte migration, goblet-cell size, and mucin dynamics. (Seto, 1981; Mast and Godderris., 1999) reported that the Chicken lacks adequate immune-response in first two weeks of post-hatch. Vieira and Moran., (1999 a,b) reported that fasting contribute reduced growth and increased early mortality.

- More disease susceptibility, e.g. colibacillosis.
- One day fasting = one day delay in marketing.

Early feeding: In nature the yolk would maintain the hatching birds during the initial post hatch period until stable feeding was available. However, today, with our intensive growing system, we are losing potential growth if we do not make feed available immediately after hatch. A broad spectrum of knowledge has shown that chicks are capable of utilising nutrients prior to hatch, during the hatching process and in transport boxes. Our proposed concept is to set aside the 'traditional feeding model' of starter, grower finisher on-farm feeding and provide a 'nutrient link' between the embryonic and on-farm growth phases. The 'nutrient link' may include nutrient solutions injected into the fertile egg, feed and/or water in the hatcher and during transport as well as specially designed pre starter feeds.

- Feed the birds as soon as possible.
- Don't ''rely'' on the yolk sac.
- Early feeding will contribute to earlier development of the immune response.
- There is a biological limit to the gastrointestinal (GIT) function.
- Start "operating" the digestive tract as soon as possible after hatch.
- New technology should be developed for early feeders and early diets (which will be suitable for hatcheries or even *in ovo).*

Early nutrition: Access or administration of nutrient immediately post-hatch is called as "Early nutrition".

Necessity of early nutrition:
1. Muscle development
2. Intestinal development
3. Immunity development

Effect of Early Nutrition on
1. Yolk and it's utilization
2. Growth performance
3. Development of Gastrointestinal tract (GIT)
4. Intestinal and pancreatic enzymes secretion and nutrient utilization.
5. Immuno competence and disease susceptibility.

Yolk and its utilization: The residual yolk is usually used within four days of hatching Early feeding utilize residual yolk faster than those fasted for 48 hours. The remaining yolk weight at the time of hatching was 6.5g which was reduced to 0.4g within 96 hours in those chicks were fed immediately after hatch. However the remaining yolk weight was 0.7 g and 1.5g after 96 hours in chicks are fasted for 24 or 48 hours. This is because of anti- peristaltic movement that transfer the yolk from yolk stalk to the duodenum appears to be stimulated by the presence of feed in the gut. Dibner *et al*. (1998) reported that in hatchling large fraction of egg protein consists of maternal antibodies these maternal antibodies are non digestible during incubation. Immunoglobulin intact and fully functional at the time of hatch. Amitav *et al.,* (2007) reported that the yolk is utilized for passive immunity of the chicks' immune system, not a source of amino acids.

Growth performance: Juul-Madsen *et al*. (2004) and Vasanthi *et al.* (2009) reported provide early nutrition in initial post- hatch period have that better viability and faster growth rate. Increased body weight by 7.8% compared to fasted chicks (Noy and Sklan, 2001). Young chick must makes the transition from metabolic dependence on endogenous lipid rich yolk to exogenous CHO and protein rich feed (Uni *et al.,* 1998). Feed availability is essential to enhance body and muscle weight.

Development of gastrointestinal tract (git): Uni *et al*. (1998) and Geyra *et al,* (2001) reported that the initial post hatch feeding that stimulates development of GIT which can be delayed under fasting condition. Fast GIT development & secretion of various enzymes for digestion & absorption of nutrients (Maiorka, *et al*., 2003).
1. Rapid growth of small intestine and maximized in first 6-10 days of age.
2. Stimulates intestinal villus growth and enterocyte differentiation.

Effect on intestinal and pancreatic enzymes secretion and nutrient utilization:
1. Increases total intestinal trypsin, amylase and lipase activities that are correlated with intestinal weight and bodyweight.
2. Stimulates the growth of pancreas and intestine with digestive & absorptive capacity of the intestine. (Jin *et al*.,1998).
3. Triggers the production and secretion of pancreatic enzymes at relatively constant amount per feed intake as chick grows. (Sklan and Noy.,2000).

Immuno competence and disease susceptibility:
1. Lacks adequate immune responsiveness at immediate post-hatch.
2. Development of immune system begins in the embryo and continues for few weeks after hatch.

In first week
1. Rapid expansion of leukocyte population.
2. Seeding and maturation of lymphoid organs.

Immune system of hatchling:

A. Mucosal immune system
Fasting & stress
1. Secretion of corticosteroids.
2. Inhibition of growth of immune cells.
3. Immunosuppresion.
4. Feed provides nutrients which essential for growth and development of all secondary lymphoid organs.
5. Consists biliary IgA bearing lymphocytes which are found in GALT.
6. Critical for disease resistance in the GIT & respiratory system.
7. Birds that received hatchling supplement shows significantly higher levels of biliary IgA.
8. Biliary IgA & germinal centers appears earlier.
9. Improves resistance to disease challenge.

B. Humoral immune system:
1. Active immune system.
Consist of only IgM bearing lymphocytes which are primarily found in bursa.
2. Passive immune system
Consist of Yolk proteins i.e. Maternal antibodies(Dibner *et al*. 1998) reported that Lymphocytes must be exposed to foreign antigen to produce antibodies.

Three ways:
(a) Nutrients provide substrates for cell proliferation & differentiation.
(b) Certain nutrients have immune modulation effect.
(c) Oral intake of nutrients provides many of the antigens that drives both the development of isotopes & generation of Ig diversity in bursa.

Early feeding to earlier development of the immune response: Many antigens encountered by the immune system enter the body through mucosal surfaces lining the respiratory, digestive and genitourinary tracts. As a result a unique and complex im
mune apparatus has developed the mucosa associated lymphoid tissue (MALT), which provides the first line of defense against these antigens. A major component of MALT is the gut-associated lymphoid tissue—

GALT. In chickens, GALT is responsible for inducing immune responses against bacterial, viral and parasitic enteral (i.e. introduced via the digestive tract) antigens as well as responses to innocuous antigens. The avian GALT contains unique lymphoid structures such as the bursa of Fabricius, caecal tonsils (CT) and Meckel's diverticulum as well as Peyer's patches (PP), intraepithelial lymphocytes (IEL) and scattered immune cells residing in the intestinal lamina propria. As chickens do not have other peripheral encapsulated lymph nodes, GALT lymphoid structures serve as major secondary lymphoid organs emphasizing the importance of the avian GALT in protection of birds. The information describing the normal development and immunological function the avian GALT in the immediate post-hatch period. This appears to be critical for the chick's survival immediately after hatch, for concomitant with foraging it is exposed to adult type microflora. It is not known whether the chick GALT is functionally mature at this time and able to provide enteral protection in the absence of maternal oral antibodies as is observed in mammals. The immune cell activation as expressed by cytokine gene expression is initiated as early as 4 days post-hatch that indicates the ability of GALT to respond to gut born antigens at an early age(Shira. *et al*., 2003).

It is known that the bursa of Fabricius plays a major role in creating antibody diversity. It is also known that the bursa has already completed its function in creating antibody diversity at Day 4 after hatching. At the time of hatching the bursal duct opens. Simultaneously, transport of environmental antigens into the bursal lumen and further into the lymphoid follicles begins with unique and sucking movements. Conceivably the peripheral function of the bursa in exposing the dynamically proliferating stem cells to environmental antigens could serve in the creation of an antibody repertoire necessary for the host survival in a given environment.

The passage through the GIT of food, which is not sterile and contains many antigens, will expose the bursa to a variety of antigens. The earlier the food passes through the GIT, the sooner the proliferating stem cells will meet environmental antigens, which will help to create a wider antibody repertoire. However, the finding that early feeding leads to a higher rate of development of the bursa follicles needs to be followed up by research that will screen the antibody repertoire and examine the maturation of antibody response.

The digestive tract: The immediate post-hatch period is critical for the digestive tract because the system is switching itself from "off" to "on." This period is the ideal one for manipulations. Examples of recent research dealing with the digestive tract include publications by our research group (Uni, Noy, and Sklan) that have shown the effect of feeding from the moment of hatch on the small intestine's development, and Dibner's work that has shown the effect of feeding from moment of hatch on bursa development. Israeli researchers have been studying other systems as well. Yahav (1996), in his work with broilers is conducting temperature conditioning as early as 3 days post-hatch. He has shown that conditioning at an early age improves thermo-tolerance and increases productivity. Rozenboim *et al.* (2004), studied the effect of green light on chicks during the post-hatch period. They found that until Day 5 post-hatching, light affects muscle development, and green light increases proliferation of muscle satellite cells. Research in early manipulation has led to the conclusion that the first days after hatch are critical for the development of all systems in the chicken and those certain types of manipulation must occur during the first days after hatch in order to achieve long-term effects. There is great commercial potential in manipulation at a young age, including manipulation of nutrition, the immune system, heat tolerance, and muscle growth. Another promising way to increase feed efficiency and productivity is by adopting a research plan which will be focused on the "black box" of the small intestine. Our knowledge about processes in the small intestine is limited: we know the energy and protein levels entering in food and leaving in droppings, and we know the percentage of each amino acid, and the fat, vitamins, and mineral content. We can calculate digestibility for amino acids, fats, and carbohydrates, but we know very little about luminal digestion, brush-border membrane digestion, and the mechanism of absorption.

The work of Croom *et al.* (1999) and Lilburn (1998), has provided much information on the physiology of poultry small intestine. Pancreatic enzymes digest proteins to large and small peptides and even to free amino acids. Researchers have reported that pancreatic enzymes are not a limiting factor. This information is almost the sum of our knowledge on protein digestion.

Uni, (1998), in their work has focused on the chicken intestinal brush-border enzymes (BBE) on two major enzymes: sucrase-isomaltase, which is active in the final digestion of disaccharides, and peptidase, which is active in the digestion of short peptides. They isolated partial cDNA of two BBE. First isolated partial cDNA of sucrase-isomaltase and second, the partial cDNA of intestinal aminopeptidase. They are now using these cDNA fragments as a probe to study BBE RNA expression and activity with increasing age and under different nutritional or management conditions.There results suggested that vitamin A deficiency reduces amino-peptidase activity in the RNA level, which reduces BBE chemical activity. This reduction in digestibility of peptides retards chicken growth and development. Another process in the small intestine that needs to be better understood is the proliferation and maturation of enterocytes in the small intestine epithelium. By proliferating cell nuclear antigen (PCNA) staining, there lab recently found that 55% of the cells in the chick crypt are proliferating. In addition

they found proliferating enterocytes along the villi and even on the tips of the villi. There results indicated that unlike in mammals, enterocyte proliferation in chickens is not limited to the crypt region but also occurs along the villus. Studying the final stage of digestion at both the cellular and molecular levels will ultimately give us a tool for understanding small intestine functionality, including the changes it undergoes with age and in different nutritional manipulations. Such knowledge can be applied in the development of poultry diets, where it will introduce a new dimension to poultry nutrition. This and the concept of early nutrition, or more generally, manipulation during the post-hatch period, will provide breakthroughs for greater feed efficiency per bud in the coming century.

Feeding the embryo (In ovo feeding): In order to overcome the described hysiological limitations and to improve the intestinal functionality and nutritional status of hatchlings, a methodology for feeding the embryo (in ovo feeding) was developed. A method of inserting nutrient solutions into the embryonic amniotic fluid was created for poultry and patented (Uni and Ferket, 2003). This method makes use of the knowledge that neonatal birds naturally consume the amniotic fluids towards hatch (Romanoff, 1960). Therefore, addition of a nutrient solution to the embryonic amniotic fluid delivers essential nutrients into the embryo intestine.

Many potential nutrient supplements can be included in the in ovo feeding solution. Carbohydrates can be used as a source for glucose, which is crucial for the hatching process and hatchling development (Moran, 1985). Sodium and chloride ions (Na^+, Cl^-) play a major role in the activity of apical and basolateral transporters and in the absorption of glucose and amino acids. β-hydroxy-β-methylbutyrate (HMB); a leucine metabolite which affects muscle satellite cells and increases carcass yield (Kornasio *et al*., 2009), is a good candidate for the in ovo feeding solution, as are minerals and vitamins which support the development of skeletal, immune and digestive systems in chickens.

Studies have shown that the administration of 1 ml of in ovo feeding solution including dextrin (as a source of carbohydrates), Na^+, Cl^-, zinc-methionine and HMB leads to increased total liver glycogen in the pre-hatch period (by 75% on the day before hatch, and by 47% on the day of hatch) and markedly enhances enteric development (Smirnov *et al*., 2006). Morphological evaluation of enteric sections from embryos and hatchlings revealed a significant acceleration of development 48 hours after in ovo feeding relative to non-injected controls. The in ovo fed birds exhibited increased pancreatic capacity for carbohydrate digestion, increased villus dimensions, higher levels of mRNA expression and activity of brush-border digestive enzymes and transporters (leucine-aminopeptidase, sucrase-isomaltase, sodium-glucose co-transporter, Na^+K^+-ATPase, zinc transporter).

It can be concluded that, at the time of hatch, the small intestine of in ovo fed birds is at a functional stage similar to that in conventionally fed 2 day old chicks. Several experiments with offspring from young maternal flocks demonstrated that in ovo feeding increases hatching weights by 5% over controls and elevates relative breast muscle size (calculated as % of body weight) by 6%. These weight advantages were sustained throughout the experiments (25 days). Commercial practice can be adapted to use in ovo feeding methodology by using existing automated systems for in ovo vaccination. Adaptation of injection machines to inject 0.6 ml to broiler and turkey embryos at 18E and 24E respectively was done by Embrex-Pfizer and in ovo feeding solutions were formulated and tested.

In ovo feeding is expected to yield several advantages, among them reduced post-hatch mortality and morbidity, greater efficiency of feed-nutrient utilisation at an early age, improved immune response to enteric antigens, reduced incidence of developmental skeletal disorders, and increased muscle development and breast meat yield.

Immediate post-hatch feed: (Feed and/or Water in Hatcher and in Transport) A series of studies provided chicks at hatching (within one hour of clearing the shell) with nutrients and examined the effect on body weight until marketing day, as compared to chicks held for 48 hours. One such study addressed the effect of the form of the feed presented comparing solid feed, a liquid nutrient supplement or water to birds held for 48 hours on the body weight of chicks through to marketing (Noy and Sklan, 1997). Provision of caloric nutrients in solid or liquid form produced a considerable increase in body weight which was maximal between 4 and 8 days and then decreased. Supplying water alone also resulted in an increase in body weight, but this effect was smaller than that of feed and was no longer apparent after 8 days. Recent research by Fairchild *et al.* (2006) concurs that providing chicks with water during holding increases placement weight but does not influence broiler performance after first 2 weeks of grow out. At marketing, all birds with early access to nutrient or nutrient solutions were 8 to 10% heavier than those held for 48 hours or watered birds. The cumulative feed efficiency through to marketing was not changed by early nutrition, whereas the percentage of breast meat was increased by 7 to 9% in all fed birds (Noy and Sklan, 1999b).

Since provision of nutrients enhanced growth, the effect of applying specific materials by gavaging birds at hatch was examined using glucose, starch, protein, fat or mixtures at hatch and then returning the birds to the incubation trays. Gavaging with all nutrients enhanced body weight post-hatch, although glucose produced the lowest and most transient response (Noy and Sklan, 1997). In an additional trial, the effect of administering a single immediate post hatch intubation of nutrients to offspring of either mature

(65 weeks) breeder flock or young maternal flock (28 weeks) was compared to held birds. Intubation significantly improved body weight performance especially in offspring from young maternal flocks (Noy and Pinchasov, 1993).

Additional techniques to reduce the adverse effects of delayed feeding have recently been researched. These include the usage of supplements known as 'early feeding supplements', whose aim is to provide the neonate with additional nutrient sources prior to full access to feed and water. Various commercial methods of immediate feeding have been investigated. Use of Earlybird™ showed that significant increases in body weight (2.7%) can be seen at 21 and 42 days of age (Henderson *et al.*, 2008).

Oasis™ decreased body weight loss in the 48 hour post-hatch period and treated chicks maintained this advantage through 21 days and 39 days of age with a higher breast yield (Noy and Sklan, 1997). Additional research involved usage of Oasis™ on female broiler breeders and indicated increased initial body weight growth (Boersma *et al.*, 2003). Thus providing an early feeding supplement may help decrease negative effect of delayed feeding.

Specifically designed 'pre-starter feeds': On the farm, feed is provided for the newly arrived chicks. However, optimal nutrition during this period must take into account the contribution of the yolk nutrients, and the ability and necessity to effectively utilise exogenous feed by the immature developing intestine. Thus, formulating pre-starter diets for quick growing meat type broilers requires use of 'highly digestible' ingredients. The aim of the pre-starter diet is to pre-condition the chick such that it can digest complex substrates or provide more digestible substrate until enzyme development matures. Chicks provided with highly digestible ingredients have achieved a 7 day body weight of 200 g, as compared with 160 to 170 g with conventional corn-soybean diets. This increase in body weight is maintained through to marketing (Leeson, 2008).

CONCLUSION

'Early' access to feed stimulates body weight growth and maintains this advantage through to marketing. Early nutritional strategies offer the promise of sustaining progress in production efficiency and welfare of commercial poultry. A better understanding of the transition period from embryo to chick will further develop this nutrient link.

In order to achieve broiler potential several unconventional changes must be made :

- Supplying nutrients to the developing embryo before hatch.
- Supplying feed within hatchery.
- Developing highly digestible prestarter diets.
- Integrate all of the above to create a continuous feeding process from several days
- prior to hatch, during hatch and till farm placement where first feed is provided.

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