YOUNG ANIMAL NUTRITION WEBINAR SERIES

Starting Your Chicks Right: An Early Broiler Nutrition Masterclass

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Early Chick Nutrition: Its Impact on Lifetime Performance

Rick Kleyn
The Start

• First week
  • Increasing proportion of production cycle
  • Impacts on lifetime performance
  • 7 day weight – critical measure.

• Feeding the chick is a challenge
  • Nutritional & physiological
  • Management of both feed and farm
  • Practical feed formulation
7 day weight versus 28 day weight

$y = 2.4785x + 1089.9$

$R^2 = 0.2026$
The Start

In the 1st week, broiler is immature:

- The thermo-regulatory system
- Anatomy and physiological function of GIT
- Undeveloped/immature gut microbiota
- Underdeveloped skeleton and musculature
- Immune system
- Eyesight not great until 3 days of age
The Start

- Chick nutrition begins with the breeder hen.
- Egg (yolk) formation is crucial.
- Skeletal development begins during incubation.
- Need to deal with “hatch” windows.
- Chick “processing” and environment – GIT microflora.
- Farm delivery – stress free.
- Need to remember – this is a continuum.
Maternal Nutrition

• Chick nutrition begins with mother
• Require adequate diet to lay eggs
• “Nutrition” begins 9 – 10 days before oviposition
  - Amino acid
  - Essential fatty acid
  - Vitamins (Vit A,D,E & anti-oxidants. Choline, folic acid)
  - Minerals (Se, Zn and Fe)
• Little carry over - protein and energy
Micro-nutrients

• Easy to underfeed micro-nutrients (essential)
• Elevated vit and min levels - increased leukocytes at hatch
• Indicates stimulated immune system  Rebel et al (2004)
• Better able to cope with stress
### Vitamin A – Feed & Egg
(Hill 1961)

<table>
<thead>
<tr>
<th>Dietary Vit A (IU/kg feed)</th>
<th>Yolk Vit A (IU/g yolk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800</td>
<td>1</td>
</tr>
<tr>
<td>2700</td>
<td>4</td>
</tr>
<tr>
<td>11000</td>
<td>13</td>
</tr>
<tr>
<td>20000</td>
<td>16.5</td>
</tr>
</tbody>
</table>
Minerals

• Uptake of minerals can be trans and/or paracellular
• Generally – fairly difficult to boost levels
• Broadly – uptake mechanisms are overcome
• Mineral’s chelated with a ligand (organic)
Minerals

- Offer alternative uptake pathways.
  - AA/peptide pathways.
- No – inorganic, lower organic enhanced breeder & chick performance (Araujo et al., 2019)
- Best performance 50:50 Inorganic/Organic (Wang et al., 2019)
Iron
(Ebbing et al., 2019)

• Breeder hens fed the Fe-AA (40ppm)
• More eggs - higher fertility.
• Vieira (2020) PSA:
  • Hatch improved 1.3% in commercial flock
Minerals – Zinc
(De Grande et al., 2020)

• Organic zinc (ZnAA complexes):
  • Enhances Zn uptake by 12%
  • Improved oxidative status in starter phase.
  • Increased villus length
  • Modified gut micro flora (fewer Proteobacteria)
  • Enhanced broiler performance in early life.
Skeletal Integrity

• Deal with normal skeletal development.
• Primary breeders – reduced abnormalities.
• Examine interaction Ca, P, Vitamin D & phytase
Vitamin E and Se
(Urso et al., 2015)

• **Combination of Vit E (120 IU/kg) and organic Se (Availa Se 1,000,)**
  - Improved hatchling Se status of embryo.
  - Heavier hatchlings (< 33 weeks).
  - Mature breeders - heavier eggs & albumen.
  - Improved hatchability.
  - Boosts chick immunocompetence (Surai, 1999)
Skeletal Development

- Bone formation begins with incubation - plateaus at 19d.
- Adequate Ca – shortfall of other minerals.
- Fast growing embryo’s – exceed mineral deposition capacity.
- Young hens – reduced egg minerals.
- Bones relatively poorly mineralised.
- Porous bone structure at hatch.
The Skeleton

• Rapid bone formation 2 to 18 days of age.
• Rapid mineralisation 2 to 11 days.
• Starter period is critical!
Rate of Bone Mineralization
(Angel, 2013)
Hatch Day

• Major change in nutrient supply:
  • Yolk → corn, soybean meal
  • Yolk = fat + lipoproteins
  • Corn-soy = carbohydrate + protein (peptides)

• Time taken to begin feeding critical

• Residual yolk
  • Questionable if really important if chick is feeding
  • Important component of immune system

• Early access to feed critical
Development of the GIT

• Feed intake stimulates development of:
  • The intestine
  • Endogenous enzyme systems.
Small intestine weight
(Sklan, 2001)

Fed (triangles) - held chicks (circles)
Fasting and Villi Development
(Viola et al., 2003)
Protein

• Both GIT and microflora - high demands.
• Gut responds to high protein starter diets.
• Yet – surplus has severe consequences.
  • Negative effect of gut health
  • Direct impact on environment.
## Digestible AA and the Intestine
(Ivanovich et al., 2017)

### Digestive System at 10d

<table>
<thead>
<tr>
<th>Dig Lysine (g/kg)</th>
<th>Pancreas (g)</th>
<th>Protease secretion (mg/g min)</th>
<th>Intestine Length (cm)</th>
<th>Small Intestine Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.9*</td>
<td>0.97&lt;sup&gt;b&lt;/sup&gt;</td>
<td>139&lt;sup&gt;b&lt;/sup&gt;</td>
<td>106&lt;sup&gt;b&lt;/sup&gt;</td>
<td>101&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>12.8</td>
<td>1.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>147&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>107&lt;sup&gt;b&lt;/sup&gt;</td>
<td>103&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>13.7</td>
<td>1.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>160&lt;sup&gt;a&lt;/sup&gt;</td>
<td>112&lt;sup&gt;a&lt;/sup&gt;</td>
<td>107&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

- Primary breeder recommendation
- Energy had no impact on any parameter
## Carry over from Starter to End
(Ivanovich et al., 2017)

<table>
<thead>
<tr>
<th>Dig Lysine (g/kg)</th>
<th>Body Weight 10 d (g)</th>
<th>Body Weight 39 d (g)</th>
<th>FCR 39 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.9*</td>
<td>157&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1956&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.80</td>
</tr>
<tr>
<td>12.8</td>
<td>169&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1985&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.79</td>
</tr>
<tr>
<td>13.7</td>
<td>190&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2094&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.74</td>
</tr>
</tbody>
</table>
Enzyme System

• Enzyme secretion low at hatch
• Secretion triggered by feed intake
• Pancreatic amylase increase 3 fold
• Bile secretion retarded – reduced deconjugation & reabsorption in lower GIT
Duodenal Secretion of Enzymes
(Sklan and Noy, 2003)

These are data from turkey poult. However, similar results were found in broilers in an earlier publication,
Musculature
Musculature

• Number of myofibres - defined at hatch
• Post-hatch muscle growth - hypertrophy of existing fibres
• Satellite cells – differentiate, fuse and donate nuclei to muscle fibres
  • Satellite - maximally active in first week
  • Susceptible to feed/nutrient restriction
• Increased lifetime capacity for protein synthesis
• Process – triggered by access to balanced protein
The Microbiota
The Microbiota

• Bird begins life with limited microbiota.
• Vertically transmitted – breeder hen.
• Horizontal transmission - environment.
• Seek to populate gut with “beneficial’s”.
• Almost more importantly – avoid “harmfull’s”
• Early population sets stage for lifetime.
The Microbiota

- 1000 spp. bacteria colonise GIT.
- Viewed as another organ. (Van Immerseel et al., 2017)
- Taxonomic profiles differ widely (geography; flock; individuals)
- Diversity low when compared to mammals (Rehberger, 2017; Clavijo et al., 2018)
The Microbiota
(Kiarie et al., 2014)

• Population influenced by:
  • Initial exposure (good or harmful).
  • Chemical & physical composition of digesta (nutrients, pH, viscosity, osmolality).
  • Rate of passage (gizzard health).
  • Other management factors (geography)
  • Feed additives
Additives Alter Gut Microbiota
(Gao et al., 2017)
The “Hatch Window”

• Biggest and strongest hatch first (19 d).
• Early hatch chicks – accelerated muscle growth
• No feed or water for 24 to 48 h.
• Dust filled environment.
• Processing stress.
• Transport stress.
Commercial Practice

• Chicks “held” in overnight hatchery
• Lose weight – yolk reabsorbed as energy source
• Dehydrate
• Poor chick performance
Hatching broilers on the farm

- After 18 d incubation – in ovo accinated.
- Delivered to farm.
- Hatchability improved 2-3%
Within the NestBorn-concept, a special machine places the 18-day incubated eggs on a 5 to 6 cm thick and 2 m wide litter bed inside the poultry house. Several eggs are then connected to the so-called Ovoscans. Photo: Van Assendelft Fotografie
<table>
<thead>
<tr>
<th>Management</th>
<th>Direct</th>
<th>Delayed</th>
<th>Starter</th>
<th>Pre Start</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 d weight (g)</td>
<td>191.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>173.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>172.4&lt;sup&gt;y&lt;/sup&gt;</td>
<td>192.6&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td>0-7 d Feed (g)</td>
<td>142.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>127.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>130.9</td>
<td>138.95</td>
</tr>
<tr>
<td>0-7 d F:G</td>
<td>0.978</td>
<td>0.984</td>
<td>1.023</td>
<td>0.939</td>
</tr>
<tr>
<td>34 d weight (g)</td>
<td>2246.3</td>
<td>2217</td>
<td>2194.8</td>
<td>2268.5</td>
</tr>
<tr>
<td>34 d F:G</td>
<td>1.1585</td>
<td>1.1645</td>
<td>1.169</td>
<td>1.154</td>
</tr>
</tbody>
</table>

Directly on feed and Pre Starter 201.6g
Deliver to the farm

• Our goal is to deliver:
  • Uniform chicks of good weight.
  • Well calcified skeleton.
  • Adequate reserves of vitamins and minerals.
  • Well modulated immune system.
  • Gut micro-flora – free of pathogens.
  • Chicks that are well hydrated.
Starting your chicks right:
“An early broiler nutrition masterclass”

Peter Chrystal
01 July 2021
This is not a new concept!

• In 1997, early broiler nutrition was at the forefront of global Provimi research *but*, also at Novus:
  
  • Presentations from Mario Penz Jr, Rick Kleyn & Ian Mackinson
  
  • First 7 days focus
    • In 1997, a 2.0 kg liveweight achieved in 38 days
    • In 2021, this is achieved in 29 days (Ross 308 FF broiler)
  
  • Excellent work by Y. Noy & Sklan (1995) and J. Dibner (1998)
Make sure sheds are set up correctly!
Practical Early Nutrition

• Make sure there are SUFFICIENT Feeders and Drinkers – Especially when part house Brooding
Importance of Pellet Quality

• Pay particular attention to Crumbles
• or Mini-pellets
Outline of presentation

Genetic advancement, Yolk sac, In-ovo feeding & Growth of digestive tract

Compromised digestion & Gut physiology

Strategies (Breeder nutrition), - In ovo feeding - Early access to feed, - Pre-starter diet

Take home message
## Annual Gains in the USA 2001-2019

<table>
<thead>
<tr>
<th>Trait</th>
<th>Annual rate of Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to reach 2.25 kg</td>
<td>- 0.90 days</td>
</tr>
<tr>
<td>F.C.R. at 2.25 kg</td>
<td>- 0.024</td>
</tr>
<tr>
<td>Eviscerated yield</td>
<td>+ 0.32 %</td>
</tr>
<tr>
<td>Breast meat yield</td>
<td>+ 0.53 %</td>
</tr>
<tr>
<td>Broiler liveability</td>
<td>+ 0.15 %</td>
</tr>
<tr>
<td>Plant condemnations</td>
<td>- 0.11 %</td>
</tr>
<tr>
<td>Broiler chicks (64 weeks)</td>
<td>0.5 Chicks</td>
</tr>
</tbody>
</table>

Burnham, 2006, Aviagen 2019
### Improvements in Broiler Performance

<table>
<thead>
<tr>
<th>Year</th>
<th>Weight</th>
<th>Age</th>
<th>FCR</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1925</td>
<td>1.0 kg</td>
<td>16 Weeks</td>
<td>4.7</td>
<td>18%</td>
</tr>
<tr>
<td>1945</td>
<td>1.4 kg</td>
<td>12 Weeks</td>
<td>4.0</td>
<td>10%</td>
</tr>
<tr>
<td>1965</td>
<td>1.6 kg</td>
<td>9 Weeks</td>
<td>2.4</td>
<td>6%</td>
</tr>
<tr>
<td>1985</td>
<td>2.0 kg</td>
<td>7 Weeks</td>
<td>2.0</td>
<td>5%</td>
</tr>
<tr>
<td>2005</td>
<td>2.4 kg</td>
<td>6 Weeks</td>
<td>1.7</td>
<td>4%</td>
</tr>
<tr>
<td>2021</td>
<td>2.7 kg</td>
<td>5 Weeks</td>
<td>1.5</td>
<td>4%</td>
</tr>
</tbody>
</table>

Source: USDA/EFG Model
Ross 308 Growth Curve 2006 - 2019

Ross 308 Body Mass to 98 days

Kilograms

Age (days)

- Females
- Males
- AH Ross 308 FF, 2019

Adapted from Burnham, 2006
Genetic advancement on the importance of the first 7 Days
Days to 2.0kg - Importance of 1st 7 days

Adapted from Bilgili, 2005
First week of life is the most critical period in broilers

Digestive and immune systems are still immature
- Nutrition, good housing, brooding management
Major challenges to the hatchling

- Start of thermal regulation
- From yolk (lipids) to oral (carbohydrate) nutrition
- Switch to aerial breathing
- Rapid development of digestive organs, skeletal system and immunity

Ravindran, 2019
The yolk sac is taken into the chick’s body at hatch

- 10% of the body weight
- Important role in the nutritional adaptation of the chick

Ravindran, 2019
The yolk sac delivers its contents to the chick intestinal lumen and blood stream over the first 4 days of life
In-ovo feeding
In-ovo feeding

• Administration of highly digestible nutrients (dextrin, maltose, sucrose, amino acids, salt, Zn-met, vitamins) into the amnion of late term embryos

• Benefits:
  • Advanced gut development
  • Increased glycogen reserves
  • Advanced muscle development
  • Better humeral and innate immunity
  • Improved chick quality
  • Increased growth performance

Courtesy: Peter Ferket, NC State University

Control  

IOF

Oliveira et al., 2008
Evidence indicates,

- Growth benefits during week 1 and early stages
- BUT growth over the whole grow-out period may not be different (compensatory growth?)

- Influence on feed efficiency?
- Negative impact on hatchability?
- Slow adoption – difficult to implement in practise
Growth of the digestive tract
# Weight of Body & Visceral Organs (g/100g body weight)

<table>
<thead>
<tr>
<th></th>
<th>Day 1</th>
<th>Day 7</th>
<th>Day 14</th>
<th>Day 21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live weight (g)</td>
<td>49.5</td>
<td>153</td>
<td>399</td>
<td>709</td>
</tr>
<tr>
<td>Small intestine</td>
<td>4.1</td>
<td>7.2</td>
<td>5.0</td>
<td>3.7</td>
</tr>
<tr>
<td>Gizzard</td>
<td>5.6</td>
<td>4.7</td>
<td>3.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Yolk sac</td>
<td>8.1</td>
<td>0.07</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Liver</td>
<td>4.1</td>
<td>4.4</td>
<td>4.6</td>
<td>3.2</td>
</tr>
<tr>
<td>Pancreas</td>
<td>1.1</td>
<td>0.6</td>
<td>0.4</td>
<td>0.3</td>
</tr>
</tbody>
</table>

BW increases by **14%** during the first 24 hrs & Peaks at **22%** per day on day 11

Iji, P. 1998
Growth of digestive organs

**Small intestine**

![Graph showing growth of small intestine](image)

**Pancreas**

![Graph showing growth of pancreas](image)

**Liver**

![Graph showing growth of liver](image)

Ravindran et al., 2006
Cross-section of small intestine – day 1

The replicating cells have been stained &

The cells start their migration from the base of the villi

Ravindran, 2019
Proliferating villus cells - day 3

Note that the stained cells are half-way up the villus.

Ravindran, 2019
Skeletal system

- Bones are poorly mineralised at hatch
- Rapid mineralisation and growth during the first two weeks (when adequate Ca and P diets are fed), regardless of growth potential
- Tibia ash increases from day 2, when there is sufficient Ca and P

- Skeletal system carries considerable weight even at week 1
Influence of broiler age on fat-free tibia ash (%)

\[ y = -1.0357x^2 + 10.464x + 26.571 \]

\[ R^2 = 0.9553 \]

David et al., 2019
Age effect on Ca digestibility in limestone

The ileal calcium digestibility coefficient decreases with age. The relationship can be described by the equation:

\[ y = -0.0448x + 0.558 \]

with a coefficient of determination \( R^2 = 0.6942 \).

David et al., 2019
Digestion is compromised in the neonatal chick -
Or is it?
Total tract starch digestibility – corn/soy diet

Not limiting in the young chick

Thomas & Ravindran, 2008
Ileal protein digestibility – corn/soy diet

Potential inefficiencies – enzyme secretion?, absorption?, transport?

Ravindran, unpublished data
Pancreatic Enzyme Activity in Small Intestine (0-7 days)

Lipase

Amylase

Trypsin

Units, $10^{-3}$/small intestine

Fed

Held

Noy, Y. 2005
Secretion of digestive enzymes

- Low at hatch, but increases (both in the amount and activity) with feed ingestion
- Rate of increase differs for different enzymes
  - 6 to 10-fold increases during the first 10 days
- Does enzyme availability limit early performance?
  - Contradictory evidence, but appears not limiting

Ravindran, 2019
Points to Note

• Enzyme production in the GI tract is substrate dependent.
• It is therefore important to get feed to the birds as soon as possible to stimulate production of enzymes.
• Consider using exogenous enzymes:
  • Protease, NSPases and Phytase.
## Effects of fat type and broiler age on fat digestibility

<table>
<thead>
<tr>
<th>Fat type</th>
<th>Age (weeks)</th>
<th>Fat type x age, P &lt; 0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Tallow</td>
<td>0.37</td>
<td>0.65</td>
</tr>
<tr>
<td>Soy oil</td>
<td>0.59</td>
<td>0.89</td>
</tr>
<tr>
<td>Tallow : Soy oil</td>
<td>0.50</td>
<td>0.83</td>
</tr>
<tr>
<td>Poultry fat</td>
<td>0.60</td>
<td>0.85</td>
</tr>
<tr>
<td>Palm oil</td>
<td>0.60</td>
<td>0.83</td>
</tr>
</tbody>
</table>

Lipase not limiting. But insufficient bile secretion (emulsification)

Tancharoenrat et al., 2014
Fat retention influenced by age of bird
(average of five fat sources)

<table>
<thead>
<tr>
<th>Week</th>
<th>Digestibility Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>0.532b</td>
</tr>
<tr>
<td>Week 2</td>
<td>0.807a</td>
</tr>
<tr>
<td>Week 3</td>
<td>0.859a</td>
</tr>
<tr>
<td>Week 5</td>
<td>0.857a</td>
</tr>
</tbody>
</table>

Week 2 is significantly higher than Week 1 (P < 0.01)

+52% difference
Fat retention influenced by age of bird (tallow)

![Graph showing the digestibility coefficient for fat retention over different weeks. The graph indicates a significant increase in digestibility coefficient from Week 1 to Week 2, with a +77% increase. The values for each week are as follows: Week 1: 0.368 b, Week 2: 0.653 a, Week 3: 0.736 a, Week 5: 0.726 a. The P value is less than 0.01.](image)
## Percentage Retention of Nutrients

<table>
<thead>
<tr>
<th>Component</th>
<th>0-7 days</th>
<th>8-14 days</th>
<th>15-21 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter</td>
<td>76.9</td>
<td>76.8</td>
<td>78.6</td>
</tr>
<tr>
<td>Methionine</td>
<td>71.1</td>
<td>74.2</td>
<td>76.9</td>
</tr>
<tr>
<td>Lysine</td>
<td>72.9</td>
<td>89.9</td>
<td>89.1</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>47.8</td>
<td>69.3</td>
<td>74.1</td>
</tr>
<tr>
<td>Threonine</td>
<td>60.1</td>
<td>65.8</td>
<td>71.1</td>
</tr>
<tr>
<td>Alanine</td>
<td>64.8</td>
<td>67.6</td>
<td>73.0</td>
</tr>
<tr>
<td>Fat</td>
<td>37.4</td>
<td>50.4</td>
<td>57.9</td>
</tr>
<tr>
<td>Linoleic acid</td>
<td>53.8</td>
<td>64.4</td>
<td>71.6</td>
</tr>
<tr>
<td>Calcium</td>
<td>18.6</td>
<td>27.0</td>
<td>6.1</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>4.6</td>
<td>19.2</td>
<td>9.6</td>
</tr>
</tbody>
</table>
Early access to feed
data sheet

Product Description
OASIS hatching supplement is a hydrated nutritional formulation specially designed for the first days of life for hatching poultry. OASIS is used during transport from the hatchery to farms or as a top dress application on starter feed during the first two days after placement. OASIS can also serve as a delivery system for other oral supplements such as vitamins, minerals, vaccines and immune stimulants.

Feeding Instructions
Feed OASIS at a rate of 2.0-2.5 g/hatching/day. This feeding rate equals roughly 63.5 lb/100 birds/day (or a volume measure of approximately 405 mL or about 1 1/4 cups/100 hatching birds/day).

Nutrient Values
- Moisture: Minimum 29%
- Crude Protein: Minimum 20%
- Crude Fat: Minimum 0.8%
- Crude Fiber: Maximum 3%

Product Characteristics
- Appearance: Green pellets
- Packaging: 1 box contains two 10 kg (22 lb) bags
- Shelf Life: 18 months

Storage Instructions
Store in a tightly sealed container in a cool dry place.

Overview
OASIS hatching supplement is a hydrated nutritional formulation specially designed for the first days of life for hatching poultry. OASIS is used during transport from the hatchery to farms or as a top dress application on starter feed during the first two days after placement. OASIS can also serve as a delivery system for other oral supplements such as vitamins, minerals, vaccines and immune stimulants.
Intestinal villi of Fasted (left) and Fed (right) chicks 24 hours after hatch

Dibner, J. 1998
Early feeding increases villus length

Both groups on ad lib feeding from day 3

Ravindran, 2019
Fed birds utilize nutrients in the residual yolk more efficiently

Ravindran, 2019
Delayed access increases mortality during week 1

Body Weight & mortality (kg & %)

Post Hatch Holding Period (hr)

- 0-6
- 24
- 48

Body Weight
Cum Mortality

Pinchasov & Noy, 1993
Effect of Early Feeding on Small Intestine Weight as a Percent of Body Weight

Both groups on *ad libitum* feeding from day 3

Ravindran, 2019
Early Feeding Effect on Bursa Weight

Adapted from Dibner, J. 1998
Development of Mucosal Immunity

IgA (ELISA OD)

Age, Days  Fed  Held

Adapted from Dibner, J. 1998
Effect of Delayed Access to Feed and Water on Liver Glycogen in Chicks

Delayed access to dietary nutrients for 48 hours after hatch can result in higher mortality rates and stunted growth of broilers that persists until market age.
Feed intake is most important during the first 10 days of life

• Check crop fill:
  • 80% at 8 hours after delivery &
  • 95% within 24 hours of delivery
The Physiological Importance of the Gut
The Physiological Importance of the Gut

• The intestine is a multi-cellular organ

  • Absorptive enterocytes
  • Goblet cells – mucin production
  • Immune Cells
  • Intrinsic neural system

• The intestine is the “first line of defense against”

  • Dietary toxins
  • Enteric pathogen invasion
There is a Metabolic Price for these Physiological Benefits

The intestinal tissues contribute disproportionately to:

- Whole body energy expenditure (10-20% of total)
- Protein turnover (35-50% of total)
- Essential amino acid requirements: (Possibly 40% of maintenance)
Nutrient requirements & strategy for pre-starter feeds
# Nutrient requirements – first 10 days

**Pre-starter crumble 350 g**

<table>
<thead>
<tr>
<th>Day of age</th>
<th>% male</th>
<th>Feed name</th>
<th>Live Weight (g)</th>
<th>Weight gain (g/d)</th>
<th>Food in cum (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50</td>
<td>Broiler Starter Crumble</td>
<td>44</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>49.98</td>
<td>Broiler Starter Crumble</td>
<td>63</td>
<td>19.3</td>
<td>12</td>
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<tr>
<td>2</td>
<td>49.96</td>
<td>Broiler Starter Crumble</td>
<td>77</td>
<td>13.6</td>
<td>27</td>
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<tr>
<td>3</td>
<td>49.95</td>
<td>Broiler Starter Crumble</td>
<td>93</td>
<td>15.8</td>
<td>44</td>
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<tr>
<td>4</td>
<td>49.94</td>
<td>Broiler Starter Crumble</td>
<td>111</td>
<td>18.5</td>
<td>65</td>
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<tr>
<td>5</td>
<td>49.93</td>
<td>Broiler Starter Crumble</td>
<td>133</td>
<td>21.5</td>
<td>89</td>
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<tr>
<td>6</td>
<td>49.92</td>
<td>Broiler Starter Crumble</td>
<td>158</td>
<td>24.9</td>
<td>118</td>
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<tr>
<td>7</td>
<td>49.91</td>
<td>Broiler Starter Crumble</td>
<td>186</td>
<td>28.5</td>
<td>151</td>
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<tr>
<td>8</td>
<td>49.91</td>
<td>Broiler Starter Crumble</td>
<td>219</td>
<td>32.4</td>
<td>190</td>
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<tr>
<td>9</td>
<td>49.9</td>
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<td>36.5</td>
<td>235</td>
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<tr>
<td>10</td>
<td>49.9</td>
<td>Broiler Starter Crumble</td>
<td>296</td>
<td>40.7</td>
<td>286</td>
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<tr>
<td>11</td>
<td>49.89</td>
<td>Broiler Starter Crumble</td>
<td>341</td>
<td>45.2</td>
<td>343</td>
</tr>
</tbody>
</table>

EFG: Ross 308 FF, 2019 genetics
Energy Levels

\[ y = -0.0895x^2 + 9.0866x + 3000.7 \]

\[ R^2 = 0.8917 \]

Burnham, 2006
Age effect on AME

AME, MJ/KG DM

Wheat-soy
Corn-soy

Thomas & Ravindran, 2008
Results

**Wheat**

- Age: $P < 0.001$
- Linear: $P = 0.004$
- Quadratic: $P = 0.002$

**Sorghum**

- Age: $P < 0.001$
- Linear: $P < 0.001$
- Quadratic: $P = 0.072$

Khalil et al., 2021
Results

Barley

- Age: P < 0.001
- Linear: P < 0.001
- Quadratic: P < 0.001

Maize

- Age: P < 0.001
- Linear: P = 0.455
- Quadratic: P = 0.043

Khalil et al., 2021
Age of broiler has substantial influence on AME/AMEn values of individual cereal grains

The highest AMEn value at week 1 for all cereal grains

Application of a single value of AME or AMEn for broilers at different ages can under- or over-estimate the dietary energy content

Age-dependent AME/AMEn should be used when formulating broiler diets

Khalil et al., 2021
Nutrient requirements – first 10 days
(Pre-starter crumble 350 g)

Feed Conversion Ratio

Age (days)

FCR (g food/g l.wt. (bird)) cum.  FCR (g food/g l.wt. (bird)) daily

EFG: Ross 308 FF, 2019 genetics
# Sodium Level on Water & Feed Intake

Maiorka et al., 2003

<table>
<thead>
<tr>
<th>Sodium (%)</th>
<th>Water Intake (ml)</th>
<th>Feed Intake (g)</th>
<th>Weight gain (g)</th>
<th>FCR (g/g)</th>
<th>Litter Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>213</td>
<td>124</td>
<td>67</td>
<td>1.85</td>
<td>68.3</td>
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<tr>
<td>0.22</td>
<td>282</td>
<td>139</td>
<td>104</td>
<td>1.34</td>
<td>69.7</td>
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<tr>
<td>0.34</td>
<td>303</td>
<td>148</td>
<td>116</td>
<td>1.28</td>
<td>70.9</td>
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<tr>
<td>0.46</td>
<td>322</td>
<td>147</td>
<td>119</td>
<td>1.24</td>
<td>71.0</td>
</tr>
</tbody>
</table>
Nutrient requirements – first 10 days
Pre-starter crumble 350 g

Approximately a ~ 3-fold increase in requirements
Nutrient requirements – first 10 days
Pre-starter crumble 350 g

However, as a concentration, quite stable
So, feed intake is all important!
\[ y = -4 \times 10^{-6} x^3 + 0.0006 x^2 - 0.0352 x + 1.58 \]

\[ R^2 = 0.9996 \]

**Digestible Lysine Level**

- **Dig Lysine Theoretical**
- **Preferred**
- **Aviagen Guide**

Burnham, 2006
Body Protein and the Amino Acid Requirements for Growth

Burnham, 2006
Relative intestinal utilization of different amino acids

Intestinal utilization (Percent of intake)

- Cys
- Glut
- Asp
- Thr
- Gln
- Lys
- Leu
- Phe
- Met
- Val
- Arg
- Pro
- Tyr
- Ala

Reeds, 2001
Clearly the pattern of amino acids directly available to the body is NOT the same as that removed from the lumen

- 0% of the cysteine and glutamine
- < 10% of the glutamate and aspartate
- < 60% of the threonine
  
  but
- > 85% of the arginine, proline and tyrosine
- > 200% of the alanine

appear in the portal vein

There is therefore simultaneous utilization and synthesis of amino acids
Principal contributors to intestinal energy supply

It appears that under “normal” conditions the gut derives more than 60% of its energy from amino acid oxidation.
Principal contributors to intestinal energy supply

- Lysine 2%
- Phenylalanine 5%
- Aspartate 9%
- Glutamine 11%
- Leucine 12%
- Glutamate 30%
- Glucose 32%

Van der Schoor, 2001
Intestinal Nutrients Summary

- Clearly the gut cannot only modify the amino acid pattern available to the rest of the body but apparently satisfies its needs in “competition” with other tissues
  - Threonine (mucin secretion),
  - Glutamate (energy, arginine and GSH synthesis)
  - and possibly Cysteine (GSH and mucin synthesis)
- play critical roles in gut health
**Are the “ideal protein” relevant?**

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Age (days)</td>
<td>0-21</td>
<td>0-21</td>
<td>21-42</td>
<td>0-10</td>
<td>11-20</td>
</tr>
<tr>
<td>Digestible?</td>
<td>True</td>
<td>True</td>
<td>True</td>
<td>True</td>
<td>True</td>
</tr>
<tr>
<td>Met</td>
<td>36</td>
<td>37</td>
<td>40</td>
<td>41</td>
<td>38</td>
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<tr>
<td>TSAA</td>
<td>76</td>
<td>72</td>
<td>75</td>
<td>74</td>
<td>76</td>
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<tr>
<td>Thr</td>
<td>68</td>
<td>67</td>
<td>70</td>
<td>67</td>
<td>68</td>
</tr>
<tr>
<td>Arg</td>
<td>105</td>
<td>105</td>
<td>108</td>
<td>107</td>
<td>107</td>
</tr>
<tr>
<td>Ile</td>
<td>68</td>
<td>67</td>
<td>69</td>
<td>67</td>
<td>68</td>
</tr>
<tr>
<td>Val</td>
<td>78</td>
<td>77</td>
<td>80</td>
<td>75</td>
<td>76</td>
</tr>
<tr>
<td>Leu</td>
<td>109</td>
<td>109</td>
<td>110</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>Trp</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Phe+Tyr</td>
<td>105</td>
<td>105</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>His</td>
<td>35</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Special diets

- During the first 48 hours,
  - Solution of highly digestible sugars and protein (amino acids); no fat; organic acids (pH 3.5-4.0); enzymes & probiotics

- Pre-starter diets during week 1 – two options
  - Higher nutrient levels (amino acids, minerals)
  - Highly digestible, quality nutrients
Nutrient requirements during week 1 – a major knowledge gap

• Requirements are higher during week 1

• High levels of amino acids, P and Ca are needed

• Some evidence
  • Glycine + serine
  • Sodium

• Ideal protein balance?
Take home messages

• Make sure shed is set up correctly & is preheated
• Early access to feed (& water) is critical
• Ensure enough drinkers and feeders are accessible
• Good crumble or mini-pellet quality is vitally important
• Use highly digestible feed ingredients
• Use exogenous enzymes (protease, phytase and NSP-ase)
• Most importantly: ensure adequate feed intake (crop fill)
Starting strong is good.
Finishing strong is epic.
Robin Sharma

The first seven ten days is the magic number
Early Chick Nutrition: Practical

Rick Kleyn
Introduction

• Reminder – feed intake is the key.
• First step – need to decide on feeding program.
  • Pre-Starter - 3 to 4 days
  • Starter – 10 days
• Second step – decide on feed form.
• Third step – decide on energy and nutrient levels
• Fourth step – what additives to add (enzymes & probiotics)
Pre Starter

• During the first 48 hours:
  • Solution of highly digestible sugars and protein
  • Highly digestible, quality nutrients (avoid indigestible components)
  • Excellent feed form and texture (no fines)
Pre Starter

• Higher AA levels than starter diet
• Higher nutrient levels (amino acids, vitamins, minerals)
• Avoid fat, particularly saturated fats
• Fish oil – may be beneficial.
• Feed additives to assist digestion (emulsifiers, proteases)
• Increase Na - promote intake and nutrient absorption
# Typical Specifications

<table>
<thead>
<tr>
<th></th>
<th>Pre Starter</th>
<th>Starter</th>
<th>Starter Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>1 - 4</td>
<td>4-10</td>
<td>1-10</td>
</tr>
<tr>
<td>AME (Kcal/kg)</td>
<td>2850</td>
<td>2900</td>
<td>2875</td>
</tr>
<tr>
<td>Crude Protein (g/kg)</td>
<td>21.5</td>
<td>20.5</td>
<td>21.0</td>
</tr>
<tr>
<td>SID Lys (g/kg)*</td>
<td>13.2 – 13.5</td>
<td>12.0</td>
<td>12.5 – 12.8</td>
</tr>
<tr>
<td>Ca (g/kg)</td>
<td>9.0</td>
<td>8.0</td>
<td>9</td>
</tr>
<tr>
<td>Avl P (g/kg)</td>
<td>4.8</td>
<td>4.3</td>
<td>4.6</td>
</tr>
<tr>
<td>Na (g/kg)</td>
<td>2.5</td>
<td>2.2</td>
<td>2.2</td>
</tr>
</tbody>
</table>

*Use: TSAA 76, Thr 67, Val 78
Feed ingredients
Feed Ingredients

- Correct ingredients – more important than specifications
- Digestible - not palatable
- Avoid poor-quality ingredients
- Promote gizzard development (feed particle size, fibre)
- Gut flora enhancers from day (probiotics, phytogenic products)
Ingredients and Consistency

• Feed quality – should be excellent
  • High biological quality (taste, smell, moisture)
  • Highly digestible - low in fibre and ash.
  • Properly processed protein sources
  • Free of broken kernels, moulds/mycotoxins
  • Correct texture (particle not too fine)
  • Minimize anti-nutritional factors (phytate, TI, β-mannan)

• However good you think you are – you must try harder!
Standard ingredients

• Grain:
  • Maize superior to wheat (more digestible, less NSP)
  • Starch is highly digestible in all grain (90% plus)
  • Maize – adequate essential fatty acids
  • Regardless – must not be ground too fine
Grain source (3-5 DAYS)
(Ravindran et al., 2005)

<table>
<thead>
<tr>
<th>Grain Source</th>
<th>Gain (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>56.9</td>
</tr>
<tr>
<td>Barley</td>
<td>41.9</td>
</tr>
<tr>
<td>Sorghum</td>
<td>55.8</td>
</tr>
<tr>
<td>Maize</td>
<td>52.0</td>
</tr>
</tbody>
</table>
Standard ingredients

• Soybeans:
  • Reasonable digestibility (83 to 87%)
  • But undigested material – food source for microbiota
  • Antigenic proteins (Glycinin and β-conglycinin)
  • Hull generally indigestible – select hi-pro SBM
  • FFS – high in hull. Ascribed energy – may be too high?
  • Require excellent processing (urease around to 0.1 mark).
  • Try not to exceed 30% of diet
Soybean Quality – Performance (21 days)  
(Ribeiro et al., 2005)
Standard ingredients

• Sunflower:
  • Good, digestible protein source
  • No know ANF
  • But high in fiber – fiber good for gizzard

• Rapeseed products:
  • Lower in protein, high in fibre

• Prime gluten:
  • Highly digestible – but Lys deficient
Standard ingredients

• Fish Meal:
  • High BV – but may be over processed, and/or high in ash
  • Becoming expensive – less of an option

• Other animal products:
  • Variable digestibility – may be high in ash and/or fat
  • May represent of biosecurity risk (Salmonella)
Novel ingredients

- Fermented soybeans
- Spray dried blood plasma
- Insect meal?
Fermented Soybeans

- Soybeans - antigenic proteins
- Not deactivated by heating
- Indigestible pentose sugars (Raffinose, Stachyose)
- Microbial fermentation - alters native composition
- 6 x increase lactate content
- Glycinin reduced by half
- ME increased by about 10%
Spray dried blood plasma (SDP)

• Highly digestible (95%)
• Produced under controlled conditions
• Rich in functional proteins (albumen, globulins, transferrin, growth factors)
• Support biological functions (growth, tissue repair, immunity)
• Benefits extend for lifetime of broilers
Take Home!

• Must achieve feed intake
• Protein quantity and quality all important
• Energy less critical – avoid fat
• Avoid high fiber and ash levels
Take Home!

• Chick is not a “small” adult
• “A good start” essential
• Impacts on lifetime performance and profitability
• Much still to discover – but much is already known
• Implement some simple ideas – increase returns