Advances and Future Directions in Poultry Nutrition
World Animal Protein Production, 1961-2007

Source: FAO

- Pork
- Poultry
- Beef
- Farmed Fish
- Sheep and Goats
Production standards have continuously increased over this period

Male broilers capable of reaching 2 kg at 30-35 days

White-egg layers capable of producing 330 eggs in 52 weeks of lay
Body Weight

<table>
<thead>
<tr>
<th>Days of Age</th>
<th>Ross 2001 diet</th>
<th>Ross 1957 diet</th>
<th>ACRBC 2001 diet</th>
<th>ACRBC 1957 diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>743</td>
<td>176</td>
<td>539</td>
<td>1117</td>
</tr>
<tr>
<td>42</td>
<td>2672</td>
<td>21</td>
<td>3946</td>
<td>4808</td>
</tr>
<tr>
<td>56</td>
<td>3946</td>
<td>56</td>
<td>809</td>
<td>1117</td>
</tr>
<tr>
<td>70</td>
<td>4808</td>
<td>70</td>
<td>809</td>
<td>1430</td>
</tr>
<tr>
<td>84</td>
<td>5520</td>
<td>84</td>
<td>1117</td>
<td>1430</td>
</tr>
</tbody>
</table>
Cumulative Feed Conversion

Kg feed per kg BW

Days of age

Ross 2001 diet
Ross 1957 diet
ACRBC 2001 diet
ACRBC 1957 diet

<table>
<thead>
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<th>Ross 2001 diet</th>
<th>Ross 1957 diet</th>
<th>ACRBC 2001 diet</th>
<th>ACRBC 1957 diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>1.63</td>
<td>2.34</td>
<td>2.55</td>
<td>3.20</td>
</tr>
<tr>
<td>42</td>
<td>1.63</td>
<td>2.34</td>
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</tr>
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</tr>
</tbody>
</table>
Males on 2001 Ration

1957 ACRBC
Av. 591 g a

2001 Ross 308
Av. 2903 g a

42 Day Live Weight
Courtesy: NCSU
Growth of the Poultry Industry is due to:

Improvements in,

• Genetics and Breeding
• Nutrition and Feed Management
• Health Care / Disease Prevention
• Poultry Management
• Poultry Equipment and Housing
• Integration of the Industry
• Further Processing
• Fast Food Technologies
• Marketing
## 1957-Type Broiler Diets

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Starter 1 to 42 d</th>
<th>Grower 43 to 84 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>61.0</td>
<td>66.5</td>
</tr>
<tr>
<td>Soybean meal (48% CP)</td>
<td>23.8</td>
<td>13.3</td>
</tr>
<tr>
<td>Meat and Bone meal (50% CP)</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Fish meal</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Alfalfa meal (17% CP)</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Wheat middlings</td>
<td>0</td>
<td>10.0</td>
</tr>
<tr>
<td>Whey</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>Distillers dried grains</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>1957 vitamin premix</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>1957 trace mineral premix</td>
<td>----To 100%</td>
<td></td>
</tr>
</tbody>
</table>

### Nutrient Analysis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Starter</th>
<th>Grower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kcal ME/kg</td>
<td>2895</td>
<td>2930</td>
</tr>
<tr>
<td>Crude Protein, %</td>
<td>23.7</td>
<td>19.2</td>
</tr>
<tr>
<td>Lysine, %</td>
<td>1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Methionine + Cysteine</td>
<td>0.75</td>
<td>0.65</td>
</tr>
<tr>
<td>Calcium, %</td>
<td>1.35</td>
<td>1.20</td>
</tr>
<tr>
<td>Non Phytate Phosphorus, %</td>
<td>0.61</td>
<td>0.44</td>
</tr>
</tbody>
</table>

1 Starter and grower were fed as mash
The only feed additive available was antibiotics. The following were not available:
- Crystalline amino acids
- Feed enzymes
- Mycotoxin binders
- Vitamins: A, D, B\textsubscript{12}, riboflavin, Niacin, Pantothenic acid
- Trace minerals: Zn, Se
MAJOR ADVANCES

Defining nutrient requirements

Raw material evaluation

Formulation and modelling

Feed additives

Feed Processing
Defining nutrient requirements

- Breeding company recommendations closely match the requirements of modern strains
- Energy and essential AA are the critical components
- Concept of ‘ideal protein’
  - Lysine as the reference amino acid
  - Other AA set as a % of lysine requirement
<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>1-21 days</th>
<th>22-42 days</th>
<th>43-56 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Arginine</td>
<td>105</td>
<td>108</td>
<td>108</td>
</tr>
<tr>
<td>Histidine</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>67</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>Leucine</td>
<td>109</td>
<td>109</td>
<td>109</td>
</tr>
<tr>
<td>Met + Cysteine</td>
<td>72</td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td>Phe + Tyrosine</td>
<td>105</td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>Threonine</td>
<td>67</td>
<td>68.5</td>
<td>68.5</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>16</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Valine</td>
<td>77</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Digestible lysine requirement, %</td>
<td>1.07</td>
<td>0.865</td>
<td>0.745</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------</td>
<td>---------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Lysine</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Arginine</td>
<td>-</td>
<td>130</td>
<td>107</td>
</tr>
<tr>
<td>Histidine</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>79</td>
<td>86</td>
<td>79</td>
</tr>
<tr>
<td>Leucine</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Met + cysteine</td>
<td>93</td>
<td>81</td>
<td>94</td>
</tr>
<tr>
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<td>-</td>
<td>-</td>
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</tr>
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<td>66</td>
<td>73</td>
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</tr>
<tr>
<td>Tryptophan</td>
<td>19</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Valine</td>
<td>86</td>
<td>102</td>
<td>93</td>
</tr>
<tr>
<td>Digestible lysine</td>
<td>700</td>
<td>636-705</td>
<td>538</td>
</tr>
</tbody>
</table>
- Large volume of data on gross composition, including amino acids
- Rapid tests (NIRS) for gross composition are now available
- But no rapid tests for available energy and amino acids
Energy evaluation

- Fraps (1946) described the concepts of productive energy and net energy
- Hill and Anderson – 1950’s – AME system
- Sibbald (1977) – TME system (rooster assay)
  - Ethical issues
- Net energy system is again being researched
  - Costly and time consuming
  - Routine evaluation?
Protein evaluation

- Initially protein
- Then total amino acids
- Excreta-based digestible amino acids
- True digestible amino acids – Rooster assay
  - Excreta-based
  - Relevance to growing birds?
  - Ethical issues
- Ileal digestible amino acids
Nutrient requirement  =  Nutrients supplied by combination of raw materials

- Initially simple balancing of few ingredients for limited number of nutrients
- Now computer-aided linear and non-linear programmes for least cost diet formulations
- Nutrient partitioning/ growth models
Formulation package

- RM Availability
- Specification
- Sales Forecast
- Local Constraints
- Evaluations
- Declarations/Analysis
- Constraint Costs
- Product Costing
- Buying Requirements
- Production Formulae
- Matrix Review
- RM Costs
– Initially simple balancing of few ingredients for limited number of nutrients
– Now computer-aided linear and non-linear programmes for least cost diet formulations
– Nutrient partitioning/ growth models
Advent of feed additives

- In-feed antibiotics
- Feed enzymes
  - NSP enzymes
  - Phytases
  - Cocktails with amylases, proteases etc
- Crystalline amino acids
- Mycotoxin binders/deactivators
- Organic trace mineral chelates
- Emulsifiers
Feed Processing

- Simple mixing of mash diets - to pelleting or crumbling
- A major contributor to improved bird performance
  - ↓ Feed wastage
  - ↑ nutrient density
  - ↓ Selective feeding
  - ↓ energy spent in eating
  - Destruction of pathogens
Defining nutrient requirements

Raw material evaluation

Formulation and modelling

Feed additives

Feed Processing

PRECISION FEEDING
Phase Feeding

- A form of precision feeding
- Nutrient requirement changes on a daily basis as the bird grows.
- Dietary amino acid levels are steadily reduced over time to closely match the requirements
  - Excess feeding of AA is avoided
  - Lower feed cost
  - Lower N excretion
Phase Feeding

- A form of precision feeding
- Nutrient requirement changes on a daily basis as the bird grows.
- Dietary amino acid levels are steadily reduced over time to closely match the requirements
  - Excess feeding of protein/AA is avoided
  - Lower feed cost
  - Lower N excretion
Future Directions in Poultry Nutrition
Algae bloom near La Jolla
Reducing environmental emissions

- Precise nutrition
- Feed formulation techniques
- Improve feed digestibility
  - Reduce anti-nutritional factors
  - Feed enzymes
  - Gut flora stabilisers
- Good feed manufacture – particle size, pellet quality
- Maintain good litter quality
Antibiotic-free nutrition
- Competitive exclusion
- Probiotics
- Prebiotics
- Anticoccidials

- Acidifiers
- Essential oils
- Plant extracts
- Enzymes

None are currently standard inclusion in poultry diets, except enzymes. But there is increased interest in the use of ‘natural additives’
Alternatives to in-feed antibiotics

Most have shown to ‘mimic’ the working effects of antibiotics on gut flora.

None, on their own, are capable of fully replacing antibiotics.

But these may way work within combination products.

To be accepted, they must consistently improve bird performance.
Raw materials
• Demand for raw materials will continue to increase in the coming decade
• This will be the major challenge
• Test and evaluate new raw materials
• Evaluate ways of maximising nutrient extraction from raw materials
  – Feed processing, additives
• Includes INORGANIC PHOSPHATES
Inorganic Phosphate Supply
Declining and non-renewable
World rock phosphate production

Production (Mt)

year

1900 1925 1950 1975 2000 2025 2050
Cheap inorganic phosphates – a thing of the past
Phosphate Rock Commodity Price

Data: Minemakers (2008)
And we’ve used up the good stuff

Quality will decline and price will increase
Feed enzymes
• Improved enzyme products
• Thermostable enzyme
• Strategic enzyme combinations
• Combining with other additives
• Inclusion of higher enzyme doses
Improved enzymes

- http://www.wipo.int

- An ideal enzyme will have,
  - High specific catalytic activity/ unit of protein
  - High activity over wide range of pH
  - Resistance to proteolysis, especially pepsin
  - Thermostability
Crystalline amino acids
Maximising protein utilisation

– To precisely meet the ideal amino acid profile
– To formulate diets on the basis of digestible amino acids (and to increase the range and inclusion levels of alternate raw materials)
– To lower dietary crude protein levels (and reduce N excretion in manure)
– To develop phase-feeding systems
Available crystalline AA

Commonly available amino acids:
- Methionine
- Lysine
- Threonine
- Tryptophan

Recent additions/ future:
- Valine
- Isoleucine
- Arginine
End Thoughts

- Major challenges are ahead for nutritionists – especially raw material issues
- Future decisions will be shaped not only by economics and science, but also by societal issues
- Industry and nutritionists need to be ‘pro-active’ to address the public concerns