Developments in the Nutrient Requirement of Chicken

Introduction

- Poultry production has gained momentum during the last five decades and it has taken the shape of fully fledged industry.
- Production standards of broilers and layers:

  Live weight of 2.5 kg at 33-35 d of age and white egg layers capable of producing 330 eggs in 52 weeks of lay.
- Genetic selection brought about - 85-90%

  Advances in nutritional management - 10-15% of the changes (Havenstein et al., 2003).

Present Focus

1. To develop an understanding of nutrient metabolism and nutrient requirements,
2. To determine the supply and availability of nutrients in feed ingredients.
3. To formulate least-cost diets that brings nutrient requirements and nutrient supply together in an effective manner.

Advances in Nutrient requirement

- **Nutrient requirements are influenced by**:
- Bird-related factors (Genetics, sex and, type and stage of production)
- External factors (Thermal environment, stress, husbandry conditions).
- Precision in defining requirements involves accuracy at both these levels.

Feeding standards from different Agencies

1	**NRC 1994**
2	**CLFMA 1995**
3	**Degussa 2001**
4	**AFRC**
5	**BIS 2007**
6	**ICAR 2013**

Nutritive Requirement of Broilers (NRC, 1994)

Nutrient	Broilers		
	0-3wk	3-6 wk	6-8 wk
Metabolizable energy (kcal/kg)	3200	3200	3200
Crude protein %	23	20	18
Linoleic acid %	0.88	0.91	0.91
Lysine %	1.1	1.02	0.85
Methionine%	0.5	0.38	0.30
Calcium %	1.00	0.9	0.8
Pav %	0.45	0.35	0.30
Sodium %	0.20	0.15	0.12
Chloride %	0.20	0.15	0.12
Potassium%	0.30	0.30	0.30
Vit A, IU	1500	1500	1500
Vit D3, ICU	200	200	200
Vit E,IU	10	5	5
Vit K, mg	0.50	0.50	0.50

NUTRITIVE REQUIREMENT OF LAYERS (NRC, 1994)

Nutrient (% or kcal/kg)	Starter (0-6 wk)	Grower (6-12 wk)	Pre-layer (12-18 wk)	Layer (>18wk)
ME (Kcal/ Kg)	2850	2850	2900	2900
Crude protein %	18	16	15	17
Lysine	0.93	0.72	0.70	0.7
Methionine	0.45	0.34	0.40	0.40
Linoleic acid %	1	1	1	1
Calcium %	0.9	0.8	0.8	2.0
Pav %	0.40	0.35	0.30	0.32
Sodium	0.15	0.15	0.15	0.15
Chloride	0.15	0.15	0.15	0.15
Potassium	0.25	0.25	0.25	0.25
Vit A, IU	1500	1500	1500	1500
Vit D3, ICU	200	200	200	300
Vit E,IU	10	5	5	5
Vit K, mg	0.50	0.50	0.50	0.50

Nutrient requirement Broiler and Layer - BIS 2007

	Broiler			Layer			
	Pre starter	Starter	Finisher	Chick	Grower	Layer phase 1	Layer phase 2
Moisture (max)	11.0	11.0	11.0	11.0	11.0	11.0	11.0
CP (Min)	23	22	20	20	16	18	16
ME (Kcal/Kg)	3000	3100	3200	2800	2500	2600	2400
EE (Min)	3.0	3.5	4.0	2.0	2.0	2.0	2.0
CF (Max)	5.0	5.0	5.0	7.0	9.0	9.0	10.0
AIA (Max)	2.5	2.5	2.5	4.0	4.0	4.0	4.5
Salt (Max)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Ca (Min)	1.0	1.0	1.0	1.0	1.0	3.0	3.5
P (Min)	0.7	0.7	0.7	0.7	0.65	0.65	0.65
Pav (Min)	0.45	0.45	0.45	0.45	0.40	0.40	0.40
Lysine (Min)	1.3	1.2	1.0	1.0	0.7	0.7	0.65
Meth (Min)	0.5	0.5	0.45	0.40	0.35	0.35	0.30

Nutrient requirement Broiler - ICAR 2013

Nutrient	White			Coloured	
	0-14 d	14-21 d	21-42d	0-21d	21-42d
ME (kcal/kg)	3000	3050	3100	2950	3050
CP %	22	21.5	19.5	21.6	20
Lysine %	1.2	1.07	0.94	1.07	0.98
Meth %	0.52	0.48	0.41	0,48	0.4
Ca	1.0	0.95	0.85	1.0	0.85

Advances in Essential Nutrients requirement:

1. Amino acids
2. Energy.

Defining the requirements for the ten essential amino acids poses considerable degree of difficulty, but has been made easier by the acceptance of ideal protein concept.

Ideal Protein Concept

Amino acid	1 to 21 days	22 to 42 days	43 to 56 days
Lysine[1]	100	100	100
Arginine	105	108	108
Histidine	35	35	35
Isoleucine	67	69	69
Leucine	109	109	109
Methionine + cysteine	72	72	72
Phenylalanine + tyrosine	105	105	105
Threonine	67	68.5	68.5
Tryptophan	16	17	17
Valine	77	80	80

[1]Recommended digestible lysine requirements for meat chicken during 1 to 21 days, 22 to 42 days and 43 to 56 days are 1.070 0.865 and 0.745%, respectively (Baker, 1996).

Advances in feed nutrient composition and quality estimation

The principal role of feed ingredients is to provide the nutrients that can be digested and utilized for productive functions by the bird.

Variability in nutrient composition is hurdle in precision nutrition.

Rapid tests for Nutrient composition

Near Infrared Reflectance (NIR) analysis.

In the case of amino acids, a recent development had been the wider use of digestible amino acid concentrations, rather than total amino acid concentrations, in feed formulations. (Bryden et al., 2009).

Advantages of using digestible amino acids based formulation:

1. Makes it possible to increase the range and inclusion levels of alternative ingredients in poultry diets.
2. Improves the precision of formulation,
3. Lower feed cost.
4. Ensures more predictable bird performance.

Crystalline Amino Acids

- To more precisely meet the ideal amino acid profile.
- To use digestible amino acids, rather than total amino acids, as the basis of feed formulations (Lemme et al., 2004).
- To reduce dietary crude proteins levels.
- To develop phase-feeding programmes.

Energy System

- Despite its limitations ME has been the system of choice of describing available energy.
- Net energy (NE) system, which is a refinement of the ME concept, has received attention from time to time.
- However, no real progress has been made in determining the NE of raw materials for poultry.

Advances in Feed Formulation:

- Newer systems - **stochastic non-linear programme** -formulation software.
- Because variability in ingredient composition is nonlinear, stochastic programmes address this issue in the most cost-effective manner possible.

Advances in Biotechnological Products in Poultry Feeding:

Table 2. Examples of some biotechnological applications that are widely used in animal nutrition

Application	Aim(s) of developing the technology
1. New ingredients	Production of microbial proteins as new feed sources in animal feeding (e.g. single cell protein, yeast protein).
2. Designer ingredients	Nutritional enhancement (e.g. high-oil maize, high-methionine lupins) or reduction in the level of anti-nutritive components in common feed ingredients (e.g. low-phytate maize).
3. Feed additives	
a) Antimicrobials	To suppress the growth of harmful bacteria and promote the establishment of a desirable gut flora balance (e.g. antibiotics)
b) Crystalline amino acids	To increase dietary supply of specific amino acid and improve protein balance in diet formulations.
c) Feed enzymes	To improve availability of nutrients (energy, amino acids, phosphorus etc) in feed ingredients by reducing the negative effects of anti-nutritive components (e.g. microbial phytases acting on phytate, xylanases acting on arabinoxylans in wheat).
4. Gut ecosystem enhancers	
a) Probiotics	To promote the establishment of a desirable gut ecosystem through the proliferation of beneficial species (e.g. direct-fed microbials).
b) Prebiotics	To competitively exclude harmful organisms and promote the establishment of a desirable gut ecosystem (e.g. mannan oligosaccharides).

Future Biotechnological Applications:

Application	Aim(s) of developing the technology
1. Modification of gut microbes	To genetically modify microorganisms naturally present in the gut to enhance their capacity for defined functions or add new functions (e.g. rumen microbes to improve cellulose digestion).
2. Introduction of new gut microbes	To introduce new species or strains of microorganisms into the gut.
3. Bioactive peptides	Improved growth and efficiency (e.g. growth hormone-releasing peptides), improved gut function, immunomodulation, antibacterial properties
4. Antimicrobial replacers	Antimicrobial enzymes (e.g. lysozyme), delivery of specific antibodies via spray-dried plasma and egg products
5. Transgenesis	To modify nutrient metabolism and improve growth efficiency by transfer of genes

Advances in Feed Processing:

The technology has progressed from simple mixing of mash feed to pelleting, which involves various physical, chemical and thermal processing operations (Schofiled, 2005).

1. Decreased feed wastage,
2. Higher nutrient density,
3. Reduced selective feeding,
4. Decreased time and energy spent for eating,
5. Destruction of pathogenic organisms and,
6. Thermal modification of starch and protein

(Behnke, 1996; Amerah et al., 2007).

Future directions in Poultry Nutrition:

- In the future, we may have to modify feed formulations to accommodate not only science-based needs but also the needs of the society.
- The impact of social issues like -

Use of antibiotic , growth promoters, environment, welfare, traceability, use of meat and bone meal and genetically modified ingredients will influence the decision-making from farm level to retail distribution of poultry products *(Leeson,2007).*

- 1. Additives of Interest for the Future
  2. Feed Enzymes - Next Generation
  Preparations with multiple enzyme activities may provide a competitive strategy to improve nutrient utilization in poultry diets (Cowieson et al., 2006; Selle and Ravindran, 2011).
- Technologies are being evolved to maintain enzymes activity in their dry enzyme products in order to protect them from the heat, moisture and high pressures generated during feed processing and number of thermo-stable enzymes, especially phytases, is now commercially available (Amerah et al., 2013).
- Beneficial effects of super-doses of microbial phytase have been shown to be substantial and consistent (Cowieson et al., 2013).

Alternatives to Antibiotic Growth Promoters

- Potential alternatives include:
- Enzymes, Probiotics, Prebiotics, Essential oils, Botanicals and Organic acids.
- Exhaustive reviews are available on AGP alternatives and large volume publications are accumulating on their influence in modifying gut microflora profile and animal performance *(Partanen and Mroz, 1999; Dibner and Buttlin, 2002; Patterson and Burkholder, 2003; Ricke, 2003; Dibner and Richards, 2005; Gianneanas, 2008; Yang et al., 2009)*.

Limitation of AGP's

1. Performance are variable.
2. Scientific data come from studies conducted under controlled experimental conditions are not repeated when the products are applied under commercial conditions.
3. More costly than conventional AGP programmes.
4. None of the current generation of AGP alternatives, on their own, are capable of fully replacing them.
5. Within each class of alternatives, numerous products are available in the market and their efficacy is variable.
6. There is an urgent need to standardise the methodology to evaluate AGP alternatives and to optimise animal responses varying conditions.

Huyghebaert et al. (2011)

Strategies to optimize the use of AGP's

1. Use of highly digestible pre-starter diets
2. Use of lower dietary protein levels and better balance of amino acids
3. Use of coarse particle size or whole grain feeding to enhance gizzard development
4. Maintenance of good litter quality
5. Stocking density, improved climate control etc.

Environmental Concern:

- Precision feeding of birds.
- Improve the nutrient utilisation efficiency - use of feed enzymes is most promising.

Alternative Raw Materials

Nutritional aspects: Variability in nutrient quality; limited information on the variability in the profile and digestibility of amino acids; high fibre (or non-starch polysaccharide) content; presence of anti-nutritional factor(s); need for amino acid supplementation
Technical aspects: Seasonal and unreliable supply; Bulkiness, physical characteristics; Need for processing (drying/ physical processing/ heat treatment/ chemical processing); Limited research and development efforts
Socio-economic aspects: Competition as human food; poor prices relative to other arable crops (farmer); cost per unit of protein (or limiting amino acids) relative to soybean meal (feed manufacturer); cost of processing

Things to be looked into……

In Broilers feeding:

Loss of 25-30% of ingested dry matter,

20-25% of gross energy,

30-50% of nitrogen

45-55% of phosphorus intake in the manure.

(*Ravindra. 2011)*

Conclusion

- Poultry nutritionists need to combine their expertise with those of specialising in other biological sciences, including immunology, microbiology, histology and molecular biology.
- Such collaboration across scientific areas should continue in the future and will be necessary for the

Literature cited:

Amerah AM, Gilbert C, Simmins PH, Ravindran V 2011 Influence of feed processing on the efficacy of exogenous enzymes in broiler diets. Wld's Poult Sci J. 67:29-46.

Amerah AM, Ravindran V, Lentle RG, Thomas DG 2007 Feed particle size: Implications on the digestion and performance of poultry. Wld's Poult Sci J 63:439-455.

Kornegay, ET [editor]. Lewis Publishers, New York. pp. 41-53.

Bedford MR, Schulze H 1998 Exogenous enzymes in pigs and poultry. Nutr Res Rev 11:91-114.

Behnke KC 1996 Feed manufacturing technology: Current issues and challenges. Anim Feed Sci Technol 62:49-57.

Bryden WL, Li X, Ravindran G, Hew, LI, Ravindran V 2009 Ileal Digestible Amino Acid values in Feedstuffs for Poultry. Rural Industries Research and Development Corporation, Canberra, Australia. p. 76.

Cowieson AJ 2010 Strategic selection of exogenous enzymes for corn/soy-based poultry diets. J Poult Sci 47:1-7.

Cowieson AJ, Hrub

y M, Pierson EEM 2006 Evolving enzyme technology: impact on commercial poultry nutrition. NutrRes Rev 11:91-114.Cowieson AJ, Wilcock P, Bedford MR. 2011 Super-dosing effects of phytase in poultry and other monogastrics. Wld's Poult Sci J 67:225-235.

D'Mello JPF (Editor) 2003 Amino Acids in Animal Nutrition. CABI Publishing, Wallingord, U.K. Dahiya JP, Wilke DC, Van Kessel AG, Drew MD 2006 Potential strategies for controlling necrotic enteritis in broiler chickens in post-antibiotic era. Anim Feed Sci Technol 129:60-88

Dibner JJ, Buttlin P 2002 Use of organic acids as a model to study the impact of gut flora on nutrition and metabolism. J Appl Poult Res 11:453-463.

Dibner JJ, Richards JD 2005. Antibiotic growth promoters in agriculture: History and mode of action. Poultry Sci 84:634- 643.

Gianneanas I 2008 How to use plant extracts and phytogenics in animal diets. In: The Future of Animal Production. Binder EM, Schatzmayr G [editor]. Nottingham University Press, Nottimgham: 111-129.

Havenstein GB, Ferket PR, Qureshi MA 2003 Growth, liveability and feed conversion of 1957 versus 2001 broilers when fed representative 1957 and 2001 broiler diets. Poultry Sci 82:1500-1508.


THANK YOU!