Avitech
Knowledge | Nutrition | Innovation

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Balanced nutrition for different phases of chicken

The potential of the germ plasm in poultry available in India is manifested to the maximum, when the health and management of the flock is maintained. If either the nutrition or nutrient management is suboptimal, growth and egg production decline, increasing the cost of production. Higher nutrient specifications than required cause nutrient wastage, stress on the bird and increased cost of production.

Nutrition and Nutrient Management

Nutrition provides the cells of the system with all the nutrients required for physiological functions (e.g., growth, production, reproduction, immunity, etc.). Nutrient management includes all aspects concerned with providing nutrition to the bird right from ingredient selection, processing, mixing, storage, and delivery to the bird followed by intake and digestion and absorption of nutrients.

Fig 1: **Feed Additives and their function**

Feed Additive	*Function*
Trace minerals	Nutritionally essential Copper, Iodine, Iron, Manganese, Selenium, Zinc. Organic Trace minerals (Zn, Mn, Cu, Se) improve immunity, shell quality
Vitamins	Nutritionally Essential Biotin, Choline, Folic acid, Niacin, Pantothenic acid, Pyridoxine, Riboflavin, Thiamine, Vitamin A, Vitamin D3, Vitamin K, Vitamin B12
Coccidiostats	Prevent coccidiosis
Toxin binder	Binds toxins (Afla, other mycotoxins). Toxin binders with activated carbon bind pesticides, that are commonly present in ingredients.
Liver protective	Liver cells specialized and active and highly susceptible for damage. All nutrients reach liver first from the intestine.
Electrolytes	Maintain electrolyte (ionic) balance of all living cells.
Antioxidants, Vitamin E, Vitamin C	Prevent free radical formation. Scavenge free radicals. Can be natural or synthetic.
Gut Regulators (Acidifier group)	Improve gut microflora, reduce infections. Synbiotics.
Lyso-phospholipids	Improve nutrient digestion and absorption. Improved immunity, better body weight and egg size. Reduces the effects of stress.
Enzymes	Improve nutrient digestion, availability and absorption. Improves gut health.
Pre and Probiotics	Improve gut health and immunity.
Ammonia Binder	Reduces effects of ammonia on ciliated epithelium and other cells of respiratory tract.

Fig 2: **Feed additives and their usage in different groups of chicken**

	Age (weeks)					In stress
Age (week)	*1-12 wk*	*13-18 wk*	*19-32 wk*	*33-60 wk*	*61-72 wk*	
Trace minerals	√	√	√	√	√	
Vitamins	√	√	√	√	√	√
Choline chloride	√		√	√	√	
Coccidiostats	√	√				
Toxin Binder	√	√	√	√	√	√
Liver tonic	√	√	√	√	√	
Electrolytes	√					√
Antioxidants	√	√	√	√	√	
Vitamin E	√	√	√			√
Vitamin C	√	√	√			√
Gut regulators						
(Acidifiers group)	√	√	√			√
Lyso-phospholipids	√	√	√			√
Enzymes	√	√	√	√	√	
Organic Minerals	√		√		√	
Pre and Probiotics	√	√	√			
Ammonia Binder	Whenever required					

Nutrient Cost: The contribution of different components to the cost of ingredients in feed may be as follows: Energy and protein 90.0 %; Trace minerals 0.4%, Vitamins 1.0 %, Phosphorus 2.6% and other additives 6.0%. Phosphorus is economically the most important macro-mineral. All vitamins and trace minerals are generally added in higher quantity than the requirements/allowances. However, the contribution of these to the cost of feed is much less than the cost of energy, protein and phosphorus. Some feed additives are added as a prophylactic measure to obtain a specific or nonspecific nutritional or non-nutritional effect. The additives to maintain health can have a better effect provided management practices are adequate.

The feed additives and their function is given in Fig. 1 and their usage depending on the age group based on the experience of the author is given in Fig. 2.

Amino acids – Ideal amino acid profile

The protein in any ingredient or animal body is a polymer of amino acids, with specific configurations. The amino acids, about 20, are physiologically essential. Chicken has no ability to synthesize some of these physiologically essential amino acids either adequately or absolutely. These are termed as essential amino acids. Certain essential amino acids are likely to be low in practical feeds and these are known as critical amino acids. Lysine, methionine and threonine, which are available commercially, are the most deficient amino acids and are also referred to as limiting amino acids (Fig 3).

The nutrient requirement/allowances tables specify the amino acids to be provided in the feed at minimum. Amino acid interactions can occur due to imbalance, antagonism or toxicity leading to reduced utilization of amino acids. This can be minimized by following the ideal protein concept in feed formulation. In the ideal protein concept, an amino acid is selected as the reference amino acid and the requirements of all the other amino acids are expressed in terms of ratios to the reference amino acid. Lysine is selected as the reference amino acid in swine and poultry nutrition. The amino acids provided in the diet have to be digested for absorption. Digestibility of the same amino acid differs in different ingredients and the same feed ingredient has varied digestibility for different amino acids. The feed formulation based on digestible amino acids rather than on total amino acids is preferred for obvious reasons. Amino acid digestibility can be

Fig 3. **Nutritional classification of amino acids**

Non-essential amino acids	Essential amino acids		
	Essential including critical and limiting	*Critical*	*Limiting*
1. Alanine	1. Lysine	1. Lysine	1. Lysine
2. Asparatic acid	2. Methionine	2. Methionine	2. Methionine
3. Glutamic acid	3. Methionine+cystine[1]	3. Methionine+cystine1	3. Threonine
4. Hydroxyproline	4. Tryptophan	4. Tryptophan	
5. Proline	5. Threonine	5. Threonine	
6. Glycine + 7. Serine	6. Arginine	6. Arginine	
	7. Isoleucine	7. Isoleucine	
	8. Leucine		
	9. Valine		
	10. Histidine		
	11. Phenylalanine		
	12. Phenylalanine + Tyrosine[2]		

[1]The requirement for cystine can be met by cystine or methionine.
[2]The requirement for tyrosine can be met by tyrosine or phenylalanine.

calculated as follows:

AA digestibility %
= (%AA_{diet} x Feed Intake (g) – %$AA_{excreta}$ x Excreta(g)) x 100

The urine AAs, present in excreta, are not of feed origin but of metabolic origin.
Apparent ileal AA dig % (g), (AID)
= (%AA_{diet} x Feed Intake(g) – %AA_{ileal} x ileal contents(g)) x 100

The ileal contents contain AA of endogenous origin. The endogenous amino acids may be non-specific (related to dry matter intake) and specific (related to the raw material).

True ileal AA dig % or Standardized ileal AA dig % (SID)
= (%AA_{diet} x Feed Intake(g) – (%AA_{ileal} x ileal contents(g)) – (%$AA_{endogenous\ non\text{-}specific}$ x Ileal contents(g)) x 100

In a research study conducted by Hoeler *et al* (2006), both, AID and SID were used. SID values were found to be higher than AID values. The difference between AID and SID values was low for high protein ingredients (1 percentage point of lysine in soybean meal, CP 47% - 89 vs. 90%) and vice versa for low protein ingredients (7 percentage points for wheat, 13% CP - 79 vs. 86%).

NRC (1994) reported the requirement values based on scientific research. These are the minimum values without any margin of safety. Other agencies have suggested nutrient allowances based on their internal research and practical experience and have included margin of safety.

Different firms or organizations have expressed amino acid requirements/allowances as total and digestible amino acids. The digestibility coefficients for amino acids recommended by various breeding organizations/agencies are generally found to be different and are also different for different phases of poultry. The digestion coefficients normally applied to convert total to digestible amino acids and vice versa are given in Table 1. Where both the digestible and total amino acids are given, the digestible amino acids are taken as the standard and converted to total amino acids. Where only methionine requirement is given, the methionine + cystine requirement is calculated assuming that methionine is 55% of methionine + cystine. All the values are given at ME content of 3000 Kcal/kg for broilers, 2800 Kcal/kg during growing period and at 2500 Kcal/kg during laying period for White Leghorn layers, and at 2800 Kcal/kg for broiler breeders.

Table 1: **Digestible Coefficients (D.C.) for amino acids in Chicken**

Amino acid	D.C. %	Amino acid	D.C. %	Amino acid	D.C. %	Amino acid	D.C. %
Arginine	90	Methionine	92	Lysine	89	Tryptophan	88
Isoleucine	88	Methionine+Cystine	88	Threonine	88	Valine	87

D.C. stands for Digestibility coefficient

Table 2: **Nutrient Requirements of broilers recommended by different agencies – Amino acids**

	Ross 308, 2007			Cobb, 2004			NRC, 1994			Hoehler et al., 2006				
	S	G	F	S	G	F	S G	G F	F2	S1	S2	G	F1	F2
Days	**1-10**	**11-24**	**From 25**	**1-14**	**15-28**	**From 28**	**1-21**	**22-42**	**43-56**	**1-5**	**6-14**	**15-35**	**36-45**	**>45**
ME kcal/kg[1]	3025	3150	3200	3150	3200	3250	3200	3200	3200	3011	3059	3107	3155	3203
Pro %	22.00	21.00	19.00	22.50	20.00	19.00	23	20	18	24	22	20	19	18.5
ME kcal/kg[2]	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
TLys %	**1.42**	**1.18**	**1.02**	**1.25**	**1.16**	**1.01**	**1.03**	**0.94**	**0.80**	**1.46**	**1.38**	**1.20**	**1.06**	**0.99**
AA:% of Lysine														
Arg	101	102	104	109	104	107	114	110	118	101	102	104	106	106
Ile	68	69	70				73	73	74	69	69	71	73	74
Lys	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Met	36	36	38	41	42	43	45	38	38	44	44	43	42	42
Met+Cys	75	77	79	74	77	80	82	72	71	73	74	76	78	80
Thr	66	67	68	68	74	69	73	74	80	64	65	66	67	68
Trp	17	16	17	17	16	17	18	18	19	16	16	16	17	17
Val	76	77	79				82	82	82	81	81	82	83	83
dLys %	**1.26**	**1.05**	**0.91**	**1.11**	**1.03**	**0.90**	**0.92**	**0.83**	**0.71**	**1.30**	**1.23**	**1.07**	**0.94**	**0.88**
dArg	103	104	105				115	111	119	102	103	105	107	107
dIle	67	68	69				72	72	73	68	68	70	72	73
dLys	100	100	100	100	100	100	100	100	100	100	100	100	100	100
dMet	37	38	39	43	44	44	47	39	39	45	45	44	43	43
dMet+dCys	74	76	78	74	76	79	81	71	70	72	73	75	77	79
dThr	65	66	67	67	74	68	72	73	79	63	64	65	66	67
dTrp	16	16	16	17	16	17	18	18	19	16	16	16	17	17
dVal	75	76	77				80	80	81	79	79	80	81	81

The digestible amino acids are converted to total amino acids, and the total amino acids to digestible amino acids. The digestibility coefficients are given in Table 1. All nutrients are recalculated at ME of 3000 kcal/kg. d=digestible. ME: Metabolizable energy, Pro: Protein, AA: Amino acid, Arg: Arginine, Ile: Isoleucine, Lys: Lysine, Met: Methionine, Cys: Cystine, Thr: Threonine, Trp: Tryptophan, Val: Valine, S: Starter, G: Grower, F: Finisher

Nutrient requirements for different phases of poultry

1. Broilers: Substantial research data is available on the amino acid requirements/allowances of broilers. The amino acid requirements of broilers recommended by few agencies are given in Table 2. Hoehler *et al.* (2006) expressed the amino acids as SID values. The others (Ross (2007), Cobb (2004)), it is assumed, have expressed the amino acids as AID values. The digestible amino acids and total amino acids when converted to ME content of 3000 Kcal/kg, show wide variation. Hoehler *et al.* (2006) recommended the highest amino acid values, followed closely by Ross (2003) and Cobb (2004). NRC (1994) values are the lowest. An example of digestible lysine requirement is given in Table 3. At the same ileal digestible lysine content, methionine, methionine + cystine and threonine show lot of variation. These are also limiting amino acids.

NRC (1994) has reported the nutrient requirements for linoleic acid, vitamins, and minerals without any

Table 3: **Digestible lysine requirement/allowance for broilers**

Age (days)	*1-5*	*6-14*	*15-35*	*36-45*
Hoehler *et al.* (2006)	**1.30**	**1.23**	**1.07**	**0.94**
Age (days)	1-10		11-24	25+
Ross 308 (2007)	**1.26**		**1.05**	**0.91**
Age (days)	1-14		15-28	28+
Cobb (2004)	**1.11**		**1.03**	**0.90**
Age (days)	1-21		22-42	43-56
NRC (1994)	**0.92**		**0.83**	**0.71**

margin of safety (Table 4). Variable but much higher allowances were suggested in practical diets. The allowances of nonphytin phosphorus (NPP), Vitamin A, vitamin D_3 and vitamin E reported for Ross 308 (Ross, 2007) are much higher than for Cobb (Cobb, 2004). Wang *et al.* (2008) reported that broilers performed well when the trace mineral content was reduced to 20% of the industry norms (% reductions - mg/kg feed: copper, 2; iodine, 0.2; iron, 10; manganese, 20; zinc, 20).

It is possible to follow a wide range of nutrient allowances for broilers and reduce the trace mineral allowances. Trace minerals and vitamins concerned in immunomodulation may not be reduced to the minimum (e.g copper, selenium, zinc, vitamin A, vitamin E and C).

2. Layers: Growing period – A wide variation is seen in the requirements/allowances of all the amino acids, amino acid ratios to lysine (Table 5), phosphorus, trace minerals and vitamins (Table 6), during growing periods. NRC (1994) requirements are the total values for trace minerals and vitamins, while the other agencies have recommended supplemental levels. As evident in Table 5, during the starter period, the percent digestible lysine allowance suggested was 1.13 (0-3 wk) and 0.97 (3-9 wk) for Bovans; 0.98 (0-6 wk), 0.81 (6-9 wk) for HyLine W-36; 0.94 for BV 300, 0.95 (1-3 wk) and 0.82 (4-8 wk) for Lohmann Lite-LS. The requirement reported by NRC was 0.74% digestible lysine for 0-6 wk. Experiments conducted by Rama Rao and Ramasubba Reddy (unpublished) with WL chicks (0-8 weeks), increasing the protein and other amino acids (amino acids bearing a ratio with lysine) with increase in lysine content indicated a digestible lysine requirement of 0.712% (total lysine 0.8%), a value slightly lower than that of NRC (1994).

Differences of similar magnitude are also discerned during the latter part of the growing period (Table 5,6).

3. Layers: Laying period – The egg type chicken consumes about 6 kg feed during the growing period and about 45-50 kg feed during laying. Any economization during laying period is of greater significance to the layer farmers.

The requirements/allowances of amino acids are calculated as g/b/d, during the laying period (Table 7). All the commercial agencies have recommended more digestible lysine when the production is high or during the earlier ages of egg production than in the later stages. This is termed as phase feeding. The methionine and methionine + cystine values also show much variation. The requirements/allowances suggested for other amino acids also are much higher than that of NRC (1994). The linoleic acid, mineral and vitamin requirements of layers during growing and laying period recommended by various agencies show much variation and are higher than the requirements of NRC (1994) (Table 8).

Information is not available in research literature for the phase feeding concept. Amino acid utilization during the earlier phases of production must be low to recommend higher values and must be high to recommend lower values during the latter phase. The bird lays the egg or does not lay the egg - an all-or-none principle. The concept of mathematical calculation for amino acid requirements for egg production is not tenable. Amino acids must be available for production of an egg/b/d, and the bird may not produce egg all the days, resulting in less than 100% production per day.

Recent research conducted by Rama Rao and Ramasubba Reddy (unpublished) on a good sample size of layers (8 x 84/diet; BV 300) during 61-68 weeks age, showed a digestible lysine requirement of about 0.58 g/b/d (total lysine 0.65 g/b/d). In this experiment, all the other amino acid values were increased with increase in lysine content of the diet in a ratio higher than the requirement known, keeping the lysine as the limiting amino acid. If lysine is limiting, the other amino acids are not utilized beyond the limit of lysine and have to be metabolized. The diets and the performance of the layers given in Table 9 and 10, show that digestible lysine requirement is 0.59 g/b/d (total lysine 0.65 g/b/d). Previously, with similar experimental model, Nageswara Rao and Ramasubba Reddy in 2000 (unpublished) at Hyderabad observed that the digestible lysine requirement of layers during the earlier phase of production is 0.614 g/b/d (total lysine 0.69 g/b/d).

Rama Rao *et al.* (1999) showed that WL layers (38-35 wks of age) require nonphytate phosphorus not more than 0.26 g/b/d.

4. Broiler Breeders: The requirements/allowances of broiler breeders during various stages of growth and production are much higher than egg layers. The intake of WL and broiler breeder layer for digestible lysine, digestible methionine+cystine and NPP are much higher than for WL layer (Table 11). The author has the experience of satisfactory performance from broiler breeders with an intake of digestible lysine of 0.88 g/b/d, digestible methionine+cystine of 0.77 g/b/d and nonphytate phosphorus of 0.32 g/b/d. Broiler breeder layer produces less number of eggs than WL

Table 4: **Nutrient Requirements of broilers recommended by different agencies – Linoleic acid, Minerals, vitamins**

		Ross 308, 2007			Cobb, 2004			NRC, 1994		
		S	**G**	**F**	**S**	**G**	**F**	**SG**	**GF**	**F2**
Days		**1-10**	**11-24**	**From 25**	**1-14**	**15-28**	**From 28**	**1-21**	**22-42**	**43-56**
ME	Kcal/kg	3025	3150	3200	3150	3200	3250	3200	3200	3200
Linoleic acid	%	1.25	1.20	1.00	1.25	1.25	1.25	1.00	1.00	1.00
Calcium	%	1.05	0.90	0.85	0.90	0.88	0.84	1.00	0.90	0.80
NPP	%	0.50	0.45	0.42	0.45	0.42	0.40	0.45	0.35	0.30
Sodium	%	0.16	0.16	0.16	0.20	0.17	0.16	0.20	0.15	0.12
Potassium	%	0.40	0.40	0.40	0.65	0.65	0.65	0.30	0.30	0.30
Chloride	%	0.16	0.16	0.16	0.20	0.20	0.20	0.2	0.15	0.12
		Supplemental			**Supplemental**			**Total Levels**		
Copper	mg/kg	16	16	16	20	20	20	8	8	8
Iodine	mg/kg	1.25	1.25	1.25	1.00	1.00	1.00	0.35	0.35	0.35
Iron	mg/kg	40	40	40	40	40	40	80	80	80
Manganese	mg/kg	120	120	120	120	120	120	60	60	60
Selenium	mg/kg	0.30	0.30	0.30	0.3	0.3	0.3	0.15	0.15	0.15
Zinc	mg/kg	100	100	100	100	100	100	40	40	40
Biotin	mg/kg	0.15	0.10	0.10	0.150	0.120	0.120	0.15	0.15	0.12
Cholinea	mg/kg	1600	1500	1400	400	350	300	1300	1000	750
Folic acid	mg/kg	2.00	1.75	1.50	1.5	1	1	0.55	0.55	0.5
Pantothenic acid	mg/kg	15	15	15	15	12	12	10	10	10
Pyridoxine	mg/kg	4	3	2	4	4	3	3.5	3.5	3.5
Nicotinic acid	mg/kg	60	60	40	60	50	50	35	30	25
Riboflavin	mg/kg	8	6	5	9	8	8	3.6	3.6	3
Thiamin	mg/kg	3	2	2	4	2	2	1.8	1.8	1.8
Vitamin A	IU/kg	11000	9000	9000	12000	10000	9000	1500	1500	1500
Vitamin B12	mg/kg	0.016	0.016	0.016	0.020	0.015	0.015	0.01	0.01	0.007
Vitamin D3	IU/kg	5000	5000	4000	4000	4000	3000	200	200	200
Vitamin E	mg/kg	75	50	50	30	30	30	10	10	10
Vitamin K3	mg/kg	3	3	2	4	3	3	0.5	0.5	0.5

S=Starter, G=Grower, F=Finisher ; aCholine: Total requirement (Ross 308, 2007), NRC, 1994); Supplemental (Cobb., 2004).

Table 5: **Lysine (total and digestible) and amino acid ratios to lysine during the growing period for White Leghorn Layer suggested by parent companies (Bovans, HyLine, BV 300, Lohmann) and recommended by NRC**

	Bovans				Hyline 36					BV 300			Lohmann Lite-LS				NRC (1994)			
Wk	0-3	3-9	10-16	17-19	0-6	6-9	9-16	16wk to 5%	5-50% prod	1-8	9-16	16-18	1-3 wk	4-8 wk	9-16 wk	17 wk to 5% Prod	0-6	6-12	12-18	18wk to 1st egg
ME, kcal/kg1	2975	2875	2750	2775	2915	2970	2970	2948	2915	2750	2500	2500	2900	2800	2800	2800	2850	2850	2900	2900
Pro %	20.0	18.0	15.5	16.5	20.0	18.0	16.0	17.0	17.5	20.5	17.0	17.0	20.5	19	15.5	17	18.0	16.0	15.0	17.0
ME, kcal/kg2	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800
tLys %	**1.27**	**1.09**	**0.86**	**0.91**	**1.10**	**0.91**	**0.80**	**0.81**	**0.75**	**1.04**	**0.80**	**0.72**	**1.06**	**0.92**	**0.63**	**0.67**	**0.84**	**0.59**	**0.43**	**0.50**
AA:tLys																				
Arg													118	130	143	148	118	138	149	144
Ile																	71	83	89	87
Met	44	44	44	46	42	45	46	49	55	43	44	56	39	38	50	53	35	42	44	42
Met+Cys	78	80	82	86	70	73	78	85	93	79	80	101	70	69	90	96	73	87	93	90
Thr	66	66	66	66	63	70	72	76	77				100	100	100	100	80	95	82	90
Trp	19	19	19	19	17	19	19	20	20				73	78	87	89	20	23	24	23
Val													20	22	25	25	73	87	91	88
dLys %	**1.13**	**0.97**	**0.76**	**0.81**	**0.98**	**0.81**	**0.71**	**0.72**	**0.67**	**0.93**	**0.71**	**0.64**	**0.95**	**0.82**	**0.56**	**0.60**	**0.74**	**0.52**	**0.39**	**0.45**
AA:dLys																				
dArg													119	132	145	150	119	140	151	146
dIle																	70	82	88	86
dLys	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
dMet	45	45	45	48	43	46	47	51	56	45	45	57	40	39	51	55	36	43	46	44
dMet+dCys	77	79	81	85	69	72	77	84	92	78	79	100	69	68	89	95	72	86	92	89
dThr	65	65	65	65	63	69	71	76	76				72	77	86	88	79	94	81	89
dTrp	19	19	19	19	17	19	19	20	20				20	21	25	25	20	23	24	23
dVal																	71	85	89	86

Table 6: **Linoleic acid, mineral and vitamin allowances suggested by parent companies and NRC (1994) during the growing period for WL Layers**

		Bovansa	Lohmann Lite-LSLHL[b]		BV 300[c]	NRC (1994)[d]		
	/kg	0-19 wk	0-8 wk	9-16 wk	0-16 wk	0-6wk	6-12 wk 12-18 wk	18wk to 1st egg
ME	kcal	2975-2750	2900-2800	2800	2750-2500	2850	2850	2900
Linoleic acid	%	1.50 - 1.25	1.40 - 1.00	1.00	1.20	1.00	1.00	1.00
Calcium	%	1.00 to 0.90	1.05 to 1.03	0.92	1.00	0.90	0.80	2.00
Phosphorus NP	%	0.50 to 0.42	0.48 to 0.46	0.40	0.45-0.40	0.40	0.35-0.30	0.32
Sodium	%	0.16 to 0.15	0.18 to 0.17	0.16	0.18	0.15	0.15	0.15
Chloride	%	0.18	0.20 to 0.19	0.16	0.18	0.15	0.12	0.15
Cobalt	mg	0.25	0.10	0.10				
Copper	mg	10	5	5	15	5	4	4
Iodine)	mg	1	0.5	0.5	1	0.35	0.35	0.35
Iron	mg	70	25	25	60	80	60	60
Manganese	mg	70	100	100	80	60	30	30
Selenium	mg	0.25	0.2	0.2	0.3	0.15	0.1	0.1
Zinc	mg	70	60	60	80	40	35	35
Biotin	mg	0.1	0.050	0.050	0.1	0.15	0.1	0.1
Choline	mg	300	300	300	600	1300	900	500
Folic Acid	mg	1	1	0.5	2	0.55	0.25	0.25
Nicotinic Acid	mg	30	30	30	50	27	11	11
Pantothenic acid	mg	10	8	7	20	10	10	10
Pyridoxine	mg	3	3	2	4.5	3	3	3
Riboflavin	mg	5	6	6	8	3.6	1.8	2.2
Thiamine	mg	2	1	1	3	1	1	0.8
Vitamin A	IU	9500	12000	8000	12000	1500	1500	1500
Vitamin B12	mg	0.020	0.015	0.010	0.015	0.009	0.003	0.004
Vitamin D3	IU	2500	2000	2000	2500	200	200	200
Vitamin E	mg	20	10	10	40	10	5	5
Vitamin K3	mg	3	3	3	4	0.5	0.5	0.5

[a]Bovans: ME (kcal/kg) 0-3 wk 2975, 3-9 wk 2875, 9-17 wk 2750, 17-19 wk 2775; Ca 2.2% (17-19wk).

[b]Lohmann LSL-Lite: ME (kcal/kg) 0-3 wk 2900, 4 wk to 5% prodn 2800, Laying 2775 to 2815.

[c]BV 300: ME (kcal/kg) 0-8 wk 2750,9-40 wk 2500,From 41 wk 2450.Choline requirement 250 mg/kg feed during growing period (9-16 wk).

[d]NRC 1994: ME (kcal/kg) 0-12 wk 2850,From 13 wk 2900. 12-18 wk Thiamine 0.8. Requirements (NRC, 1994): total (not supplemental)

Table 7: **Lysine and amino acid ratios to lysine during the laying period for WL Layers suggested by parent companies and recommended by NRC**

	Bovans				HyLine 36				BV 300			Lohmann LSL-Lite				NRC (1994)
Week	Prod	90%	80-90%	<80%	50%-32 wk	32-44 wk	44-58 wk	From 58 wk	19-40 wk	41-60 wk	From 61	> 90%	> 80%	>70%	< 70%	
Egg mass	g/b/d	>55	50-55	<55								>57.6	>56.0	>51.3	>51.0	
ME, kcal/kg1		3080	2910	2880					2500	2450	2450	2815	285	2815	2815	
Protein	g/b/d				16.0	15.5	15.3	15.0	17.5	16.0	15.5	18.5	16.5	16	15.5	15.0
TLys	g/b/d	0.94	0.79	0.73	0.88	0.82	0.78	0.76	0.80	0.70	0.70	0.82	0.74	0.71	0.70	0.69
AA:TLys																
Arg																101
Ile												65	63	62	62	94
Lys		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Met		50	52	52	49	49	49	49	50	43	43	48	49	49	47	43
Met+Cys		88	91	90	82	85	86	82	91	78	78	87	89	90	85	84
Thr		66	71	71								79	76	82	79	68
Trp		20	22	22	20	21	21	20				24	24	25	24	23
Val												84	82	79	79	101
dLys	g/b/d	0.84	0.70	0.65	0.78	0.73	0.69	0.68	0.71	0.62	0.62	0.73	0.66	0.63	0.62	0.61
dArg																103
dIle												64	63	61	61	93
dLys		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
dMet		52	54	54	51	50	50	50	52	44	44	50	51	51	48	45
dMet+dCys		87	90	89	81	84	85	81	90	77	77	86	88	89	84	83
dThr		65	70	70								78	75	81	78	67
dTrp		20	21	22	20	20	20	20				24	24	25	24	23
dVal												82	80	77	77	99

Table 8: **Linoleic acid, mineral and vitamin allowances suggested by parent companies and NRC (1994) for WL Layers**

		Bovansa	Lohmann Lite-LSLHL[b]	BV 300[c]	NRC (1994)[d]
		Laying	17 to 80 wk	Layer	Layer
ME	kcal/kg	2800-2750	2800	2500-2450	2900
Feed Intake	g/b/d	100	100	100	100
Linoleic acid	g/b/d	2.20 - 1.25	1.70 - 1.20	1.40 - 1.20	1.00
Calcium	g/b/d	3.80 to 4.20	4.10 to 4.50	3.60 to 4.00	3.25
NPP	g/b/d	0.42 to 0.38	0.48 to 0.33	0.40 to 0.30	0.25
Sodium	g/b/d	0.15	0.18 to 0.17	0.18	0.15
Potassium	g/b/d				0.15
Chloride	g/b/d	0.16	0.18 to 0.17	0.18	0.13
Cobalt	mg/b/d	0.25	0.1		
Copper	mg/b/d	15	5	15	?
Iodine	mg/b/d	1	0.5	1	0.035
Iron	mg/b/d	70	25	60	45
Manganese	mg/b/d	80	100	80	20
Selenium	mg/b/d	0.25	0.2	0.3	0.06
Zinc	mg/b/d	80	60	80	35
Biotin	mg/b/d	0.07	0.025	0.1	0.1
Choline	mg/b/d	300	400	500	1050
Folic Acid	mg/b/d	0.5	0.5	1	0.25
Nicotinic Acid	mg/b/d	30	30	30	10
Pantothenic acid	mg/b/d	7.5	8	10	2
Pyridoxine	mg/b/d	2	3	3	2.5
Riboflavin	mg/b/d	5	4	8	2.5
Thiamine	mg/b/d	1	1	2	0.7
Vitamin A	IU/b/d	8000	10000	12500-12000	3000
Vitamin B12	mg/b/d	0.020	0.015	0.015	0.004
Vitamin D3	IU/b/d	2500	2500	2500	300
Vitamin E	mg/b/d	10	10	40	5
Vitamin K3	mg/b/d	2	3	2	0.5

[a]Bovans: ME (kcal/kg) 0-3 wk 2975, 3-9 wk 2875, 9-17 wk 2750, 17-19 wk 2775.

[b]Lohmann LSL-Lite: ME (kcal/kg) 0-3 wk 2900, 4 wk to 5% prodn 2800, Laying 2775 to 2815.

[c]BV 300: ME (kcal/kg) 0-8 wk 2750,9-40 wk 2500,From 41 wk 2450.Choline requirement 250 mg/kg feed during growing period (9-16 wk).

[d]NRC 1994: ME (kcal/kg) 0-12 wk 2850,From 13 wk 2900. 12-18 wk Thiamine 0.8. Requirements: total (not supplemental) from NRC (1994).

layer. That the broiler breeder layer and WL layer differ in efficiency of nutrient utilization has not been indicated in the literature. Bhanja *et al.* (2007) at Hyderabad, showed that broiler breeders performance with 0.12, 0.18, 0.24, 0.30, 0.36 and 0.42% non-phytate phosphorus from 25-44 weeks age (22.02.2001 to 13.06.2001) was similar with respect to egg production, egg weight, shell thickness, shell strength, fertility, hatchability, chick livability).

Wilson and Harms (1984) on experimentation with Cobb color-sex and Cobb feather-sex broiler breeders, reported that broiler breeder diets formulated to meet presently suggested requirements (g/b/d: Calcium 4.5; total Phosphorus, 0.75; Protein 23.0, Methionine + Cystine, 0.85) have a large margin of safety and

Table 9: **Nutrient Profile of diets varying in lysine content fed to WL Layers (61-68 weeks age)**

		Lysine content in the diet, %							
		0.900	**0.850**	**0.800**	**0.750**	**0.700**	**0.650**	**0.600**	**0.551**
Ingredients		Digestible lysine content in the diet, %							
		0.795	**0.753**	**0.712**	**0.670**	**0.629**	**0.587**	**0.546**	**0.504**
Maize	%	58.933	60.320	61.708	63.096	64.484	65.872	67.259	68.647
Soya	%	28.382	24.782	21.182	17.582	13.982	10.382	6.782	3.182
SFM	%	0.000	2.233	4.465	6.698	8.930	11.163	13.395	15.628
Lys-HCl	%	0.000	0.028	0.056	0.083	0.111	0.139	0.167	0.194
DL-Met	%	0.268	0.239	0.209	0.180	0.150	0.121	0.091	0.062
Threonine	%	0.064	0.060	0.056	0.052	0.048	0.044	0.040	0.036
DCP	%	0.600	0.603	0.606	0.609	0.612	0.615	0.618	0.621
LSP	%	10.700	10.714	10.728	10.741	10.755	10.769	10.783	10.796
Salt	%	0.189	0.189	0.189	0.189	0.189	0.189	0.189	0.189
Sodabicarb	%	0.410	0.392	0.374	0.356	0.338	0.319	0.301	0.283
KCL	%	0.103	0.090	0.077	0.064	0.051	0.038	0.025	0.012
TM	%	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Vitamins	%	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Total		100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
ME	Kcal/kg	2596	2596	2596	2596	2596	2596	2596	2596
Pro	%	17.752	16.873	15.994	15.116	14.237	13.359	12.480	11.602
Ca	%	3.971	3.971	3.971	3.971	3.971	3.971	3.971	3.971
NPP	%	0.217	0.217	0.217	0.217	0.217	0.217	0.217	0.217
Na	%	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178
Cl	%	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.206
dArg	%	1.071	1.014	0.957	0.900	0.844	0.787	0.730	0.673
dIle	%	0.675	0.635	0.594	0.553	0.513	0.472	0.431	0.390
dLys	%	**0.795**	**0.753**	**0.712**	**0.670**	**0.629**	**0.587**	**0.546**	**0.504**
dMet	%	0.507	0.473	0.439	0.404	0.370	0.335	0.301	0.267
dMet+Cys	%	0.748	0.706	0.663	0.620	0.577	0.534	0.491	0.448
dThr	%	0.644	0.608	0.571	0.535	0.498	0.462	0.425	0.389
dTrp	%	0.183	0.172	0.161	0.150	0.139	0.128	0.117	0.106
dVal	%	0.748	0.711	0.674	0.637	0.600	0.563	0.526	0.489
AA:dLys									
dArg		135	135	134	134	134	134	134	134
dIle		85	84	83	83	82	80	79	77
dMet		64	63	62	60	59	57	55	53
dMet+Cys		**94**	**94**	**93**	**92**	**92**	**91**	**90**	**89**
dThr		**81**	**81**	**80**	**80**	**79**	**79**	**78**	**77**
dTrp		23	23	23	22	22	22	21	21
dVal		94	94	95	95	95	96	96	97

Table 10: **Performance of WL layers (61-68 weeks) on diets varying in lysine** (22.05.08 – 16.07.08)

			61-64 week					65-68 week					
	Lys Total	Lys Dig	Eg prod	Feed intake		Egg wt	Egg mass	Egg prod	Feed intake		Egg wt	Egg mass	Body wt
	%	%	%	/bird	/egg	g	g	%	/bird	/egg	g	g	g
	0.90	0.80	75.14^{bc}	101.4	135.6^{a}	57.44^{a}	1209^{a}	70.46^{d}	97.56^{b}	139.21^{ab}	56.40^{abc}	1113^{d}	1300
	0.85	0.75	78.99^{a}	97.27	123.1^{c}	56.94^{ab}	1260^{a}	80.02^{ab}	100.01^{b}	125.0^{def}	56.12^{bc}	1258^{abc}	1293
	0.80	0.71	77.49^{abc}	101.9	131.6^{ab}	57.25^{a}	1243^{a}	76.03^{c}	99.23^{b}	130.6^{cd}	56.18^{bc}	1196^{c}	1282
	0.75	0.67	78.22^{ab}	98.52	126.4^{bc}	56.72^{ab}	1242^{a}	76.87^{bc}	96.41^{b}	125.61^{de}	55.99^{c}	1205^{bc}	1260
	0.70	0.63	79.90^{a}	99.62	124.7^{bc}	56.78^{ab}	1271^{a}	80.17^{ab}	96.71^{b}	120.69^{ef}	57.34^{ab}	1287^{a}	1290
	0.65	0.59	80.60^{a}	100.5	124.8^{bc}	56.50^{ab}	1275^{a}	81.66^{a}	96.21^{b}	117.91^{f}	57.03^{abc}	1304^{a}	1202
	0.60	0.55	79.05^{a}	99.11	125.4^{bc}	55.82^{bc}	1236^{a}	79.16^{abc}	106.7^{a}	134.89^{bc}	57.25^{abc}	1269^{ab}	1289
	0.55	0.50	74.36^{c}	101.1	136.0^{a}	54.92^{c}	1144^{b}	68.18^{d}	99.35^{b}	145.9^{a}	57.53^{a}	1098^{d}	1176
N			**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**
SEM			**0.465**	**0.520**	**1.009**	**0.171**	**8.94**	**0.703**	**0.644**	**1.38**	**0.152**	**11.73**	**15.00**
P			**0.003**	**0.323**	**0.0001**	**0.002**	**0.003**	**0.0001**	**0.0001**	**0.0001**	**0.032**	**0.0001**	**0.291**

Lys=Lysine; N=Number of Replicates; SEM=Standard Error of Mean; P=Probability

suggested a reduction of specifications by approximately 10%. Very low protein diets (10%) appear to be adequate for broiler breeder females (Lopez and Leeson 1995[a, b]).

Areas of research required

Nutrient and cost economy for broilers and during laying period for egg type layers and broiler breeders can be affected because of the volume of feed intake and the cost. The areas of future research are indicated in Table 12. The amino acid requirements should be worked out on ideal protein concept.

Table 11: **Intake of WL and broiler breeder layer for digestible lysine, digestible methionine + cystine and NPP**

	WL Chicken	*Broiler Breeder*	*WL Chicken*	*Broiler Breeder*
	% in feed		*Intake, g/b/d*	
Feed			100	165
dLysine	0.71	0.71	0.71	1.18
dMethionine + dCystine	0.62	0.49	0.62	0.81
NPP	0.35	0.45	0.35	0.74

Table 12: **Areas of research required in broilers, egg type layers and broiler breeder layers**

Type & phase of poultry	Period	Feed intake Kg/bird	Area of Research
Broiler	6 weeks	4	Lysine, methionine, threonine
Egg type Layer–Growing	18 weeks	6	
Egg type layer–Laying	19-80 weeks	45	Lysine, methionine, threonine. Nonphytate phosphorus
Broiler breeder layer–Growing	24 weeks	12	Lysine, methionine, threonine. Nonphytate phosphorus
Broiler breeder layer–Laying	25-68	50	Lysine, methionine, threonine

References are available with author and can be made available on request.

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