Reducing the crude protein content in layer diets

Preeti Mohanty
CJ BIO, Philippines

Abstract

The ever-increasing concern over the cost of feed and impact of intensive poultry farming on the environment through excretion of nitrogen have forced nutritionists to redefine the optimal level of dietary crude protein(CP) and other nutrients in poultry diets. This article highlights the literatures regarding the effect of low CP on productive performance and egg quality parameters in layers. Further reduction in CP level is possible with the balanced amino acid nutrition emphasising on the branched chain amino acids, glycine and with the addition of suitable feed additives. To enable nutritionists for successful integration of synthetic amino acid with the low CP levels in poultry industry proper knowledge on the nutrient requirements, their interactions, its impact on environment and the feasibility to optimise the feed cost, further research in this area is the requirement.

Background

Protein is a vital nutrient in poultry nutrition since it has a great economic importance as well as a significant role in various functions e.g. growth, egg production, immunity, etc. The efficiency of dietary CP utilization depends on the amount, composition, and the digestibility of amino acids in the diet. Hence determination of optimum level of amino acids in feed formulations is fundamental not only from an economics point of view but also to reduce the nitrogen loss in poultry alleviating environmental pollution. After the ideal protein concept, it is common to include synthetic amino acids in diets which allows nutritionists to further decrease CP level while meeting the requirement more precisely for maintenance, egg production, and tissue accretion. This review is a compilation of data on the recent studies conducted on the effect of reduced CP diet in laying hens and its impact on productive performance and egg quality parameters. The aim of this document is to have an idea about current knowledge on the low CP diets in layers and to highlight the use of synthetic amino acids in low CP balanced diets as a tool to optimize feed costs, maintain performance of birds, and simultaneously reducing the excretion of nitrogen.

Reduction of dietary CP in laying hens feed

Impact on productive performance

While formulating a ration with reduced CP level for laying hens, the primary objective is to obtain similar performance in terms of egg production, egg mass, egg weight and feed conversion ratio (FCR) with the reduction of feed cost and nitrogen emission. Recent research studies (2010-2020) conducted in laying hen on reduced CP level on laying hen productive performance is given in Table 1. Most of the studies concluded no significant difference in production performance though numerical reduction is observed in low CP fed group due to the fact that the AAs requirement is met precisely through balanced nutrient supplementation. Though few studies showed statistically significant reduction in production due to lower CP level, the variation observed in suggested amino acid requirements (Waldroup et al., 1995) may be due to differing experimental conditions, including composition of the basal diet, strain of bird, types of feed ingredients, dietary energy content, feed intake (FI) level, and age of layers. These factors are known to influence the energy, protein, and amino acid requirements of layers (Baker et al., 2002). A large part of the differences in nutrient requirements may be attributed to differences in environmental temperature, strain, and age of the birds. Most requirement studies with layers have been conducted during a particular phase of production cycle. Experiments conducted for a short duration or for part of the egg production (EP) cycle may not truly represent the entire production cycle (Rama Rao et al., 2011). Since the ability of laying hens to store protein is limited, the protein concentration in the feed should be equated to achieve the desired egg production (Pesti, 1992).

Table 1. Recent studies conducted between 2010-2020 on effect of reduced CP level on productive performance of laying hens

Reference	Age (wk)	Strain	CP%	AA%	Egg prod %	Egg mass (g. h/d)	Egg wt (g)	Feed intake (g)	FCR	E level (ME/Kg)	Nitrogen Excretion g/d
Nassiri, MH et al., 2012	70-76	Hy-line W36	14.3	Met+ Lys	76.8	52.3	68.1	126.55	2.95	2756	
			12.87	Met+Lys	76.8	53.0	68.9	126.79	2.93	2756	
Bouyeh & Gevorgian, 2011	52-56	Hy-line W36	13		68.75^{b}		59.77	99.27^{b}	2.54	2863	
			14		72.75^{a}		60.37	111.95	2.65	2860	
Rama Rao et al., 2011	21-72	Babcock	15	Met 0.08+Lys HCl 0.34	88.71		51.99	102.1	2.37	2350	
			16.5	Met 0.10+Lys HCl 0.29	84.31		52.61	103.6	2.35	2350	
			18	Met 0.12+Lys HCl 0.23	84.01		52.48	103.3	2.35	2350	
Rama Rao et al., 2011	21-72	Babcock	15	Met 0.08+Lys HCl 0.19	86.68		52.45	102.9	2.27	2600	
			16.5	Met 0.10+Lys HCl 0.09	85.94		52.58	101.8	2.26	2600	
			18	DL-Met 0.12	84.98		52.61	101.6	2.28	2600	
Latshaw and Zhao, 2011	29-57		13g/d	Synthetic AAs meeting NRC (1994)	88.4	52.1	59.1	98.7			
			15g/d	Synthetic AAs meeting NRC (1994)	89.6	52.4	58.5	92.2			
			17g/d	Synthetic AAs meeting NRC (1994)	91.1	52.8	58.0	93.6			
Mousavi et al., 2013	25-33	Hy- line W36 & Lohman LSL	15.5	DL-Met- 0.14%	92.32	49.93^{c}	55.92^{b}	104.14^{a}	1.908^{a}	2900	
			16.5	DL-Met- 0.16%+ L- Lys-0.07 + L- Thr-0.013	93.22	50.91^{bc}	56.76^{a}	100.91^{b}	1.853^{b}	2900	
			17.5	DL-Met- 0.18%+ L- Lys-0.14 + L- Thr-0.05	93.63	51.70^{b}	56.73^{a}	102.20^{b}	1.835^{b}	2900	
			18.5	DL-Met- 0.20%+ L- Lys-0.20 + L- Thr-0.08	92.64	53.08^{a}	57.07^{a}	101.90^{b}	1.836^{b}	2900	
Burley et al.,2013	18-51	Lohmann LSL	21.88		96.68	56.84	60.49		1.92	2864	
			20.35		96.68	56.28	60.43		1.91	2864	
			19.90		96.94	56.13	60.03		1.92	2864	
Torki et al., 2014	52-60	Lohmann LSL	16.5	DL-Met-0.04	79.1^{a}	50.6^{a}	64		2.03	2720	
			15	DL- Met- 0.07	78.7^{a}	50.1^{a}	64.3		2.01	2720	
			13.5	DL- Met- 0.11+ L-Try-0.01	79.0^{a}	50.3^{a}	63.7		1.96	2720	
			12	DL- Met- 0.14 +Lys- HCl-0.06 +L-Try-0.03	76.0^{ab}	47.1^{ab}	61.9		2.02	2720	
			10.5	DL- Met- 0.17 +Lys- HCl- 0.16 +L-Thr- 0.05+L-Try-0.04	70.0^{b}	43.1^{b}	61.5		2.10	2720	
Rojas et al.,2015	30-42	Hy-line W36	15.5		86	51.0	59.3	101.4	1.99	2894	
			13	Ile+Thr	79.6	46.7	58.7	102.5	2.20	2894	
			13	Trp+Ile+ Thr	87.7	52.4	59.8	101.6	13.2	2894	
Alagawany et al., 2016	20-42	Lohmann Brown	16	Lys HCl+DL-Met	72.50	40.23^{b}	54.55^{b}	100.65	2.50^{a}	2800	1.57^{b}
			18	Lys HCl+DL-Met	76.45	45.10^{a}	58.65^{a}	102.85	2.28^{b}	2800	1.95^{a}
Kumari et al ., 2016	25-44	WLH	13.38	Lys HCl 2.15+ DL- Met- 1.45	89.48		53.37		2.27	2700	39.09%
			15.58	Lys HCl 2.30+ DL- Met- 1.29	88.90		54.97		2.38	2700	45.83%
			17.00	Lys HCl 1.45+ DL- Met- 1.80	92.19		53.92		2.34	2700	48.03%
Azzam et al., 2016	28-40	Lohmann Brown	16		94.55^{a}	60.21^{a}	63.67	117.66	1.96^{abc}	2842	
			14	Dig Thr-0.43	89.58^{b}	5613^{b}	62.69	113.86	2.03^{a}	2849	
			14	Dig Thr-0.49	94.39^{a}	59.65^{a}	63.19	117.11	1.96^{abc}	2849	
			14	Dig Thr-0.57	95.66^{a}	60.54^{a}	63.28	116.56	1.93^{bc}	2849	
			14	Dig Thr-0.66	96.07^{a}	61.39^{a}	63.90	116.52	1.90^{c}	2849	
			14	Dig Thr-0.74	94.28^{a}	59.14^{a}	62.73	118.97	2.01^{ab}	2849	
Alagawany et al., 2020	18-34	Lohmann Brown	16	DL- Met+Lys- HCl	73.30		55.02^{b}		2.50^{a}	2800	
			18	DL- Met+Lys- HCl	76.48		58.15^{a}		2.27^{b}	2800	

Impact on egg quality parameters

The present era consumers focus on the product quality in addition to production traits which is emphasized in the current studies conducted. Egg quality is comprised of those characteristics of an egg that affect its acceptability to the consumer. In table 2, some recent studies on the effect of reduced CP level is examined on the egg quality parameters such as albumin, yolk quality, Haugh Unit (HU), and also shell quality i.e. shell thickness and shell strength. The HU is a measure of egg protein quality based on the height of its egg white. Specific gravity also indicates egg shell quality as well as its freshness. Egg shell quality is a an important parameter as it prevents shell damage and ultimately affects its acceptance in the market. In the studies highlighted in table 2, the reduced level of CP did not significantly affect the egg and shell quality mostly because the nutrient requirement for laying hens were taken in to consideration. Sulfur containing amino acids play a vital role in maintaining shell strength as they increase the calcium binding ability (Novak, 2006). As the incidence of shell quality problems and the proportion of broken eggs increase with age in laying hens, so in spite of preferences for large eggs by consumers, a very large increase in egg size in old hens might not be of benefit (Abdallah et al., 1995). As hens grow older, the nutrient requirements decrease with corresponding decreases in egg production. According to Mizumoto et al. (2008), nutrition as well as the breeding system has an influence on egg quality. Some studies have shown that calcium absorption decreases with age in layers (Keshavarz & Nakajima, 1993). Absolute daily retention of Ca (Keshavarz, 2003) and shell weight (Roland et al., 1975) remain constant as hens age. The reason for reduced shell quality is the increase in egg size which distributes a constant amount of shell over a larger egg surface. Consequently, limiting egg size should also prevent loss of shell thickness (Keshavarz, 2003). Increase in egg size has resulted in a reduction in eggshell thickness and eggshell weight (as a percentage of egg weight) (Roland, 1988). Thus, researchers have been interested in reducing egg size during the late stages of the egg production cycle by dietary manipulation of nutrients for increasing eggshell quality.

Table 2. Recent studies conducted between 2010-2020 on effect of reduced CP level on egg quality parameters in laying hen

Reference	Age (wk)	Strain	CP%	AA%	Albumin %	Yolk %	Shell %	HU	Shell Breaking strength	Shell thickness mm	Sp. Gravity %
Latshaw and Zhao, 2011	29-57		CP 13g/d		64.7	25.0	10.3	86.1			
			CP 15g/d		64.8	24.9	10.3	85.7			
			CP 17g/d		64.6	25.1	10.4	84.8			
Nassiri, MH et al., 2012	70-76	Hy-line W36	14.3	Met+ Lys						0.380	1.062
			12.87	Met+Lys						0.381	1.063
Mousavi et al., 2013	25-33	Hy- line W36 & Lohman LSL	15.5	DL-Met- 0.14%	62.09	27.81	10.10	79.39	3.79	0.319[a]	1.080
			16.5	DL-Met- 0.16%+ L- Lys-0.07 + L- Thr-0.013	63.13	27.17	9.69	81.67	3.52	0.312[a]	1.079
			17.5	DL-Met- 0.18%+ L- Lys-0.14 + L- Thr-0.05	63.06	26.99	9.95	80.68	3.67	0.312[a]	1.080
			18.5	DL-Met- 0.20%+ L- Lys-0.20 + L- Thr-0.08	63.02	27.31	9.67	80.29	3.57	0.304[b]	1.079
Burley et al.,2013	18-51	Lohmann LSL	21.88					93.57	4284.91g force at failure	0.36	
			20.35%					94.15	4321.91g force at failure	0.37	
			19.90					94.07	4370.26g force at failure	0.37	
Torki et al., 2014	52-60	150 Lohmann LSL	16.5	DL-Met-0.04		40.12**		80.41		0.374	1.087
			15	DL- Met- 0.07		42.07**		79.78		0.370	1.088
			13.5	DL- Met- 0.11+ L-Try-0.01		39.44**		82.09		0.364	1.086
			12	DL- Met- 0.14 +Lys- HCl-0.06 +L-Try-0.03		40.08**		76.76		0.369	1.090
			10.5	DL- Met- 0.17 +Lys- HCl- 0.16 +L-Thr- 0.05+L-Try-0.04		44.20**		76.35		0.355	1.090
Azzam et al., 2016	28-40	Lohmann Brown	16					71.75	43.24*	0.36	
			14	Dig Thr-0.43				73.15	41.48*	0.35	
			14	Dig Thr-0.49				72.89	39.03*	0.37	
			14	Dig Thr-0.57				75.81	38.24*	0.35	
			14	Dig Thr-0.66				73.07	41.18*	0.36	
			14	Dig Thr-0.74				75.73	42.07*	0.36	
Alagawany et al., 2020	18-34	Lohmann Brown	16	DL- Met+Lys- HCl	62.40	25.02	12.59	88.02		0.407	
			18	DL- Met+Lys- HCl	63.16	23.97	12.82	86.07		0.383	

*Shell strength in Newton units
**Yolk index in %age

Conclusions

A better understanding of the CP and individual amino acids requirements in layers fed different concentrations of ME may increase the possibility of reducing the dietary CP with optimal levels of amino acids, which in turn will reduce the excretion of nitrogen from intensive poultry farming without affecting laying performance. The availability of individual feed grade synthetic amino acids (i.e. L-tryptophan, L-valine, L-arginine, L-isoleucine) in the market increase further scope of reduction in CP level.

REFERENCES

1. Abdallah AG, Harms RH, Russell GB. Effect of age and resting on hens laying eggs with heavy or light shell weight. J Appl Poult Res. 1995; 4:131–137.
2. Alagawany M, El-Hindawy MM, Abd El-Hack ME, Arif M and El-Sayed SA. Influence of low-protein diet with different levels of amino acids on laying hen performance, quality and egg composition. An Acad Bras Cienc .2020; DOI 10.1590/0001-3765202020180230.
3. Azzam MMM, X. Y. Dong XY, and Zou XT. Effect of dietary threonine on laying performance and intestinal immunity of laying hens fed low-crude-protein diets during the peak production period . J Anim Phys and Anim Nutr.2016; DOI: 10.1111/jpn.12559.
4. Baker, D. H., A. B. Batal, T. M. Parr, N. R. Augspurger, and C. M. Parsons. 2002. Ideal ratio (relative to lysine) of tryptophan, threonine, isoleucine, and valine for chicks during the second and third weeks post hatch. Poult. Sci. 81:485–494.
5. Bouyeh M and Gevorgian O. Influence of different levels of lysine, methionine and protein on the performance of laying hens after peak. Int Anim Vet Adv. 2011; 10: 532-537.
6. Burley, et al. Effect of a reduced crude protein, amino acid-balanced diet on hen performance, production cost and ammonia emissions in a commercial laying hen flock. J Appl Poult Res. 2013; 22: 217–228.
7. Grobas S, Mendez J, De Blas C, Mateos GG. Laying hen productivity as affected by energy, supplemental fat, and linoleic acid concentration of the diet. Poult Sci. 1999; 78: 1542–1551.
8. Harms RH, Russell GB. Performance of commercial laying hens when fed diets with various sources of energy. J Appl Poult Res. 2004;13: 365–369.
9. Keshavarz K, Nakajima S. Re-evaluation of calcium and phosphorus requirement of laying hens for optimum performance and eggshell quality. Poult Sci. 1993; 72: 144–153.
10. Keshavarz K. Effects of reducing dietary protein, methionine, choline, folic acid, and vitamin B12 during the late stages of the egg production cycle on performance and eggshell quality. Poult Sci. 2003; 82:1407-1414.
11. Kumari KNR, Chandra KR, Kumar DS (2016). Effect of protein levels in diet on production and emissions in WLH layer. Adv Anim Vet Sci. 2016;4: 7: 357-362.
12. L-Saffar AA, Rose SP. The response of laying hens to dietary amino acids. World's Poult Sci. 2002; 58:209-234.
13. Latshaw JD and Zhao L. Dietary protein effects on hen performance and nitrogen excretion. Poult Sci. 2011; 90:99–106.
14. Mousavi SN, Khalaji S, Ghasemi-Jirdehi A, Foroudi F. Investigation on the effects of various protein levels with constant ratio of digestible sulfur amino acids and threonine to lysine on performance, egg quality and protein retention in two strains of laying hens .Ital J Anim Sci. 2013; 12:2.
15. Nassiri, MH et al. Effect of different levels of methionine, protein and tallow on the productive performance and egg quality of laying hens in the late-phase production. Braz J Poult Sci.2012; 14: 2-149.
16. Novak et al, The Effect of Dietary Protein level and Total Sulfur Amino Acid:Lysine Ratio on Egg Production Parameters and Egg Yield in Hy-Line W-98 Hens. 2006, Poult Sci. 85: 2195 – 2206.
17. NRC. 1994. Nutrient Requirements of Poultry. 9th ed. National Academy Press, Washington, DC.
18. Rama Rao S. Effect of dietary concentrations of energy, crude protein, lysine, and methionine on the performance of white leghorn layers in the tropics. Appl Poult Res. 2011; 20: 528–541.
19. Roland DA Sr, Sloan DR, Harms RH. The ability of hens to maintain calcium deposition in egg shell and egg yolk as the hen ages. Poult Sci. 1975; 54:1720–1723.
20. Roland DA Sr. Research note: Egg shell problem: Estimate of incidence and economic impact. Poult Sci. 1998;67:1801–1803.
21. Sohail SS, Bryant MM, Roland Sr DA. Influence of supplemental lysine, isoleucine, threonine, tryptophan, and total sulphur amino acids on egg weight of Hy-Line W-36 hens. Poult Sci. 2002; 81:1038– 1044.
22. Sohail SS, Bryant MM, Roland Sr DA. Influence of supplemental lysine, isoleucine, threonine, tryptophan, and total sulphur amino acids on egg weight of Hy-Line W-36 hens. Poult Sci. 2002; 81:1038– 1044.
23. US Poultry & Egg Export Council (2009) US Chicken Feet Kicked Out of China. http://www.thepoultrysite.com/poultrynews/18142/us-chicken-feet-kicked-out-of-china.
24. Waldroup PW and Hellwig HM. Methionine and total sulfur amino acid requirements influenced by stage of production. J Appl Poult. Res.1995; 4:283–292.