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Review Article
Positive and Negative Impacts of Dietary Protein Levels in Laying Hens

[1]Mahmoud Alagawany, [1]Mohamed Ezzat Abd El-Hack, [2]Mayada Ragab Farag, [3]Ruchi Tiwari, [4]Swati Sachan, [5]Kumaragurubaran Karthik and [6]Kuldeep Dhama

[1]Department of Poultry, Faculty of Agriculture, [2]Department of Forensic Medicine and Toxicology, Faculty of Veterinary Medicine, Zagazig University, Zagazig 44511, Egypt
[3]Department of Veterinary Microbiology and Immunology, College of Veterinary Sciences, Uttar Paradesh Pt. Deen Dayal Upadhayay Pashu Chikitsa Vigyan Vishwavidyalay Evum Go-Anusandhan Sansthan (DUVASU), Mathura 281001, India
[4]Immunology Section, [5]Division of Bacteriology and Mycology, [6]Division of Pathology, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly 243122,Uttar Pradesh, India

Abstract
Protein plays an important role in the diet formulation of poultry to maintain/improve growth, feed utilization, immune functions and maximize productive performance, ensure bird welfare, as well as mitigate environmental risks and pollution by optimizing the use of this nutrient. Also, proteins assist in the biosynthesis of tissues and have many biological functions for growth and renewal of the body. Moreover, proteins exist in forms of hormones and enzymes which play crucial roles in the physiological processes in the body. Layer birds have low dietary Crude Protein (CP) requirements, thus identification of the optimum level of CP in layer diets, for either maximizing productive performance or economic returns of laying hens, requires more and more information/knowledge about birds needs of protein and its impacts on performance parameters and environmental pollution. This biomolecule plays active role in physiological dynamics, in stabilizing the immune barrier and to drive the forces for maintaining the enhanced production performance of layers. The broad goal of the current review is to highlight the importance of CP-diet and its positive and negative effects on body weight change, performance, feed and nutrient utilization, egg production parameters, egg quality criteria as well as chemical composition of egg and its fractions, egg shell quality, blood biochemical parameters, immune function, nutrient digestibility and nitrogen pollution. The discussed concepts and knowledge would be useful for both backyard poultry rearers and poultry industry holders by optimizing the level of crude protein in the fed diet and will definitely be helpful for gaining the economic profits and consumers satisfaction.

Key words: Protein, laying hens, performance, egg quality, egg composition, blood parameters, environmental pollution

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Corresponding Author: Mahmoud Alagawany, Department of Poultry, Faculty of Agriculture, Zagazing University, Zagazing 44511, Egypt

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INTRODUCTION

Protein is a vital nutrient of animal and poultry feeds and along with other major components classes of fats, carbohydrates, minerals, vitamins and water, is substantial for life (Pond *et al*., 1995; Beski *et al*., 2015). Proteins are complicated compounds (polymers) which are formulated from many amino acids linkage by peptide bonds and the structure of any amino acid includes a carbon skeleton with a carboxyl group and an amino group, as well as a side chain that differs for each amino acid (Cheeke, 2005). Protein components are broken down by hydrolysis in digestive tract via digestion to produce these amino acids, which play many beneficial roles in the body, such as in development of structural components of muscle, feathers, skin, blood plasma proteins, hormones, enzymes, nucleotides and antibodies which are all individually involved in specific functions in the body (Pond *et al*., 1995; Abbasi *et al*., 2014; Van Emous *et al*., 2015a).

The important/crucial role of nutritionists is to reduce the costs of ingredients/feedstuffs, whilst ensuring efficiency of utilization of low or high protein diets supplemented with crystalline amino acids to meet or exceed minimum amino acid standards reported by NRC (1994). Proper nutrition is a first step to optimize growth and productive performance in poultry and animals as well as to decrease the adverse effects on the environment (Namroud *et al*., 2008; Rama Rao *et al*., 2011; Zhu *et al*., 2012; Moraes *et al*., 2014; Zeng *et al*., 2015).

Maximization of egg output (egg number, egg weight and egg mass) and henceforth profits depends on bird's productive performance, feed and egg prices, as well as farm management. Several factors have certain impacts on performance of laying birds. Factors like nutrient concentrations of the diet must be optimized not maximized to improve returns and economic feasibility (Koreleski and Swiatkiewicz, 2009; Alagawany *et al*., 2011; Alagawany and Abou-Kassem, 2014). For example, depending on prices of feed and egg, the maximization of productive performance may or may not result in maximum returnes/profits (Alagawany *et al*., 2014a, b).

Maintaining or/and improving performance of birds, may be achieved by improving nutrient utilization of feedstuffs. In spite high feed utilization, egg production and laying performance are characteristics of the modern laying hens; reductions in the costs of production and environmental pollution are required (Keshavarz, 2003; Gunawardana *et al*., 2008; Alagawany and Mahrose, 2014). In Egypt, maize and soybean meal are the first and second feedstuffs supplying energy and Crude Protein (CP), respectively in commercial poultry diets (Zanaty, 2006; Reda *et al*., 2015).

Hitherto, the major issue is loading of excreta with nitrogen. The nitrogen content in poultry and animal disposal is the most variable factor where feeding and housing system as well as type of excreta storage can have a dramatic impact on nitrogen loss as ammonia emissions (Alagawany, 2012). Most of the excretion of nitrogen by the birds relates to undigested feedstuffs and those amino acids that are imbalanced to immediate needs of body for synthesis of tissue or eggs. Moreover, nitrogen excretion can be significantly decreased by supplying a balance of amino acids that more exactly meets the requirements of birds with minimum of excess and also by providing these amino acids in readily digested and absorbed forms. Methionine is the second limiting amino acids and now available at competitive prices, it is needed to formulate the commercial diets of poultry that provide a minimum excess of amino acids. Unfortunately, it is unable to consider this issue to its logical recommendation and formulate poultry diets with very low contents of protein that contain regular concentrations of indispensable amino acids. It can readily decrease dietary protein supply by 20% if the use of crystalline amino acids is economical or if there is a cost associated with the elimination of excreta nutrients (Pens and Jensen, 1991; Alagawany *et al*., 2014b). The strategy of poultry feeding has been given a new perception with the advent of environmental risks related to nitrogen pollution from poultry excreta. Formerly, dietary adjustments of nutrients to poultry needs were aimed at improving growth and productive performance without special concern for nutrient oversupply, chiefly crude protein and amino acids.

The manuscript describes the impacts of dietary protein on the performance and egg quality as well as digestibility of nutrients in the diet, environmental pollution by nitrogen, some biochemical blood parameters and chemical composition of the egg for laying hens.

Effect of CP-diet on body weight and body weight change: Live body weight of white leghorn layers was decreased with decreasing low protein diets (12.0, 14.0 and 16.0%) compared to the high levels (18 and 20%) of CP (Babatunde and Fetuga, 1976). Many researches have examined the impacts of low-protein diets in laying hen nutrition (Alagawany *et al*., 2011; Alagawany, 2012). A study of Keshavarz (1984) observed lower body weight at 20 weeks of age and decreased productive performance through the first stage of the egg production cycle when birds fed low-protein diet throughout the rearing phase.

Calderon and Jensen (1990) found that body weight gain was increased along with increased CP levels from 13-16 or 19% throughout the production period. Yakout (2010) found that the best value of body weight change was recorded by layers fed diet contained high CP levels. The change of body weight of Hy-Line layers had significantly influenced by dietary protein concentrations, since the highest level of CP (14%) achieved the highest value of body weight compared to the lowest CP level (13%) during egg production cycle (Bouyeh and Gevorgian, 2011).

Contrarily, Hassan *et al.* (2000) and Yakout (2000) showed that there were no significant differences in the overall mean of body weight with the different CP levels in diets of laying hens, while final body weight slightly increased ($p<0.05$) with low-CP-protein (16%) diet compared to other diets. Meluzzi *et al.* (2001) reported that live body weight at 40 weeks-old of Hy-Line Brown hens did not affect by the different CP (170 control, 150 and 130 g kg^{-1} diet) levels. On the same line, final body weight and body weight change of commercial laying hens (Babcock B-308) did not significantly ($p<0.05$) affect by dietary CP levels (14, 16, 18 and 20%) (Bunchasak *et al.*, 2005; Junqueira *et al.*, 2006). On the other hand, Grobas *et al.* (1999), Keshavarz and Nakajima (1995) and Sohail *et al.* (2003) pointed out that there was no significant impact of reducing dietary CP levels on body weight, this effect might be attributed to the balance and availability of amino acids provided in tested diets.

Another study showed that when controlled concentration of nitrocompounds as nitroethanol or nitropropanol was included in the bird's diet no adverse effect concerning to growth, production or performance was noticed however growth performance remain optimum (Mowrer *et al.*, 2016).

Effect of CP-diet on feed utilization: Feed intake and feed conversion ratio were not significantly affected by different CP (170, 150, 140 and 130 g kg^{-1}) levels of commercial leghorn hens through the first stage of production cycle (Hsu *et al.*, 1998; Meluzzi *et al.*, 2001). On this context, also during the first stage of egg production cycle, Moustafa *et al.* (2005) found that feed intake was insignificantly affected by dietary CP levels in diets of laying hens. Moreover, Bunchasak *et al.* (2005) studied the effect of dietary CP levels (14, 16 and 18% CP) on laying hen performance and they found that feed intake was not significantly affected by these levels. But, the ratio of feed intake to egg mass (feed conversion ratio) and protein conversion ratio were statistically ($p<0.05$) influenced by the different levels of CP, since the best values of these traits were achieved with 18% CP compared to the other levels (14 or 16% CP).

Junqueira *et al.* (2006) observed that increases in dietary CP levels up to 20% significantly improved feed intake through the second phase of production, while the increases in dietary CP level did not improve feed conversion. Abd El-Maksoud *et al.* (2011) found that an increase in feed intake of laying hens when feeding low-CP (12 or 14 vs. 16%) diets during time period (32-44 weeks of age). But, the best significant ($p<0.01$) value of feed conversion (2.62 g feed/g egg) was recorded with 16% CP diet compared to low-CP diet. Also, Bouyeh and Gevorgian (2011) reported that feed consumption and feed conversion ratio in Hy-Line layers had significantly affected by dietary CP levels (13 and 14%), since the 14% CP recorded the highest value of feed consumption (111.95 g day^{-1}) vs. the 13% CP which recorded the lowest one (99.27 g day^{-1}). Moreover, protein utilization was affected by the higher level of CP (14.6%) vs. the lower level (13.6%) throughout the experiment.

Feed conversion ratio was improved from 1.680-1.645 g feed/g egg mass with decreasing dietary CP, when laying hens (Hy-Line W36) fed on different CP diet (17.8, 19.9, 18.5 and 15.5%) through the first stage of production (Novak *et al.*, 2006). Contrarily, reducing dietary CP lowered feed conversion ratio in laying hen during 18-60 weeks of age (Novak *et al.*, 2008). Also, findings obtained by Hassan *et al.* (2000), Moustafa *et al.* (2005) and Yakout *et al.* (2004) reported that feed conversion ratio was improved when CP level of layer diet increased. The impact of feeding various levels of CP (12, 14 and 16%) on productive performance of Baheij laying hens through time period (28-48 weeks of age) was reported by Zeweil *et al.* (2011) who showed that feed intake and feed conversion were insignificantly affected by dietary CP levels.

Murakami (1991) concluded that improved feed intake to egg mass ratio in hens fed diets contained 19-20% CP, whereas Pinto (1998) found an improvement in feed conversion ratio in laying hens fed diet up to 22% CP. Feed conversion ratio was maintained well on the low-CP diet through the first 8 mo. (months) of production but tended to be impaired there after. In mo. (months) 10 and 11 of the laying period, feed conversion value was significantly ($p<0.05$) increased on the reduced-CP diet compared to the control diet (Khajali *et al.*, 2008). On the other hand, Van Emous *et al.* (2015b) suggested that birds fed low-CP diet had a 12.8% higher feed intake vs. high-CP level.

Effect of CP-diet on productive performance: Egg production and egg weight were significantly increased with the levels of 16 and 18% CP compared to the low level 14.3% (McDonald, 1979). Saxena *et al.* (1986) conducted a study to evaluate the impact of different levels of dietary protein (15, 17 and 19%) on performance of laying hens during period 18-33 weeks of age and they reported the optimum (15%) dietary protein for layers in winter season. Egg number and egg weight were statistically highly improved by increasing dietary protein level from 13-19% in diets of laying hens (white leghorn) (Calderon and Jensen, 1990). Harms and Russell (1996) found that birds consumed 13.8 g of CP per day had ($p<0.05$, significantly) reduced egg weight compared with birds consumed 14.6 or 16.3 g of CP through 44-63 weeks-old. On this trend, egg production percentage and egg output (g/hen/day) had influenced ($p<0.05$, significantly) by CP levels (130, 150 and 170 g kg^{-1} CP) in layer (Hy-line brown hens) diets. Since, the high CP level (170 g kg^{-1}) achieved the best values of egg production and egg mass as compared to other levels (Meluzzi *et al.*, 2001). Bunchasak *et al.* (2005) stated that birds received 14% CP had poor egg production, egg weight and egg mass than those received 16 or 18% CP groups through peak period for laying hens.

A study of Abd El-Maksoud *et al.* (2011) confirmed the significant effect of different CP levels on layer performance, where egg production and egg mass were increased with increasing CP levels from 12-16% for laying hen diets. Also, Bouyeh and Gevorgian (2011) observed that hen-day egg production was ($p<0.0$, significantly) affected by the different CP levels, where the 14% CP (high level) achieved the highest values of egg production and egg mass of layers (Hy-line- laying hens) after peak production period. Moreover, many authors stated that egg production and egg weight were Improved by increasing dietary CP amounts (Hassan *et al.*, 2000; Yakout *et al.*, 2004; Novak *et al.*, 2006, 2008).

Hsu *et al.* (1998) studied the effect of low-protein (14%) and normal (17%) diet during the experimental period (5 weeks) and reported similar response in tow levels in egg production parameters. In addition to, Junqueira *et al.* (2006) pointed out that layer-hen performance (egg number, egg weight and egg mass) was comparable between the 16 and 20% CP-diets during the second phase of production. Zeweil *et al.* (2011) noted that egg production and egg mass were not affected by dietary CP levels (12, 14 and 16%) of Baheij laying hens.

The percentage of egg production, egg weight and egg mass were maintained well with the birds fed diet contained low-CP through the first eight month of production cycle but these parameters tended to be impaired thereafter. The productive performance of layer can remain satisfactory on low-CP diets for short periods of production, while feeding on long-term of low-CP diets may not be enough especially during the late stage of production (Khajali *et al.*, 2008; Alagawany *et al.*, 2014b). Egg weight, egg production and egg output were increased by diet including 15% of CP levels (Saki *et al.*, 2015).

Effect of CP-diet on egg quality criteria: Zimmermann and Andrews (1987) did not find any positive or negative effect on shell quality and Haugh units score with 2 levels of CP (14.6 and 15.5%) in layer diets during the second production phase. In addition to De Mendonca and Lima (1999) did not observe any impact of dietary CP level on egg albumen, but during the second production stage, eggshell quality of layers fed 14.5% CP was improved than those fed diets with 16.5% CP. These findings confirmed by Novak *et al.* (2006) who found that the percentages of dry and wet albumen, albumen solids as well as percentages of yolk and albumen protein were decreased with feeding low-CP diets.

Meluzzi *et al.* (2001) concluded that the treatment of CP 150 g kg^{-1} diet had the higher egg size compared to the other levels of protein (170 or 130 g kg^{-1}) which contrast with Summers *et al.* (1991) and Lopez and Leeson (1995) who reported that layer egg weight is strongly related to the content of CP in the diet. However, Summers and Leeson (1983) found that early egg size did not affect by increases in dietary CP. On this respect, the increases in CP diets did not improve Haugh unit score, egg shell and shell thickness (Junqueira *et al.*, 2006; Alagawany, 2012).

Lowering CP in laying hen diets reduced egg weight through the experimental period (18-60 weeks-old) (Novak *et al.*, 2008), while, the internal and external egg quality parameters did not influence by low CP diets. The preferable value of yolk weight was achieved with 14% CP vs. other levels (Abd El-Maksoud *et al.*, 2011).

The percentages of dry and wet shell weight and dry yolk weight as well as shell thickness were increased ($p<0.05$, significantly) by decreasing CP levels in layer diets. Contrarily, the percentages of wet and dried albumen, wet yolk weight as well as egg yolk index and egg shape were not affected by dietary CP (12, 14 and 16%) levels (Zeweil *et al.*, 2011). On the other hand, Yolk color index was higher in egg layers which fed diets contained 12 and 10.5% CP compared with those of control layers (Torki *et al.*, 2015).

Effect of CP-diet on chemical composition of whole egg and its fractionations: Dietary CP levels did not show any significant differences in all parameters of albumen (moisture content, albumen solids, dry albumen, albumen protein and nitrogen free extract) except for organic matter and ash percentages that differed significantly (p<0.01). There were no significant impacts due to different CP-diet on all constituents of yolk (dry yolk, yolk protein, yolk fat and organic matter) except yolk solids and moisture percentages (Alagawany, 2012). Babatunde and Fetuga (1976) found that the percentages of crude protein and total moisture were increased as the dietary CP amounts increased while the variations in percentages of ash, shell and total fat were not significant, when layer fed on the different levels of CP (12.0, 14.0, 16.0, 18.0 and 20.0%) throughout egg production period.

Garcia *et al.* (2005) pointed out that the yolk protein content was affected (p<0.01, significantly) by different CP levels. Since, layers fed CP 18 or 20% achieved the high content of yolk protein compared to the layers fed CP 16% in the diet. Moreover, Andersson (1979) and Akbar *et al.* (1983) stated that the content of yolk protein increased with higher CP level in laying hen diets.

Effect of CP-diet on blood and immunity parameters: Blood parameters are usually related to the health conditions of animals. These parameters are vital indices of physiological and nutritional status in the body. Glick *et al.* (1983) pointed out that diets deficient in CP by 33% of requirements could reduce the count of lymphocytes in chicken thymus. This response varies with some factors such as strain environment, stress, production state and health status (Cheema *et al.*, 2003; Humphrey and Klasing, 2004). Findings obtained by Hsu *et al.* (1998) reported that the level of plasma uric acid and excreta nitrogen of the high level of protein (170 g kg^{-1} diet) was significantly (p<0.05) higher than the other low levels for commercial laying hens. All serum fractions of protein and total protein as well as triglyceride, serum non-esterified fatty acid and Newcastle Disease (ND) titre of hens were tended to increase but alpha-globulin and albumin to globulin ratio tended to decrease as CP diets increased from 14 to 16 to 18% for commercial laying hens (Bunchasak *et al.*, 2005). Moreover, uric acid in plasma and excreta was increased with increasing dietary CP intake (Donsbough *et al.*, 2010). In this context, Plasma total protein and globulin were increased by increasing the dietary CP levels from 12-14 and 14-16% in layer hen. On the contrary, albumen in plasma was insignificantly influenced by the different CP diets (Zeweil *et al.*, 2011). Also in our study, there were no significant effects of the levels CP-diets on plasma uric acid, creatine and globulin but plasma total protein, albumen and urea of layers (Lohmann laying hens) fed the 20 and 18% of CP diets were significantly greater than those of birds fed the 16% of diet during period 30-34 weeks (Alagawany *et al.*, 2011).

In groups contained 13.9% CP, uric acid in plasma was decreased (p<0.05); while the plasma triglyceride concentration was increased (p<0.05) compared to groups contained 15.4% CP in Lohmann laying hens (Ghasemi *et al.*, 2014). Blood ammonia and uric acid concentrations were not significantly affected by dietary treatments varying in protein content (16, 16.5, 17, 17.5 and 18%) (Ji *et al.*, 2014). Blood triglyceride concentration was significantly (p<0.05) higher in layers received 12 and 10.5% CP diets compared with those of control (16.5% CP) layers. The ratio of heterophil to lymphocyte was significantly (p<0.05) declined by diets contained 15, 13.5 and 12% of CP (Torki *et al.*, 2015).

Blood constituents including total protein, glucose, high density lipoprotein and triidothyronine, were increased by layer diets including 15% of CP levels. But, blood total cholesterol, thyroxine and low density lipoprotein were not significantly (p>0.05) influenced by different concentration of CP (Saki *et al.*, 2015).

Effect of CP-diet on nitrogen emission/pollution and nutrient digestibility: The diets of laying-hen that are formulated using some feedstuffs like maize, soybean meal, corn gluten, sunflower meal and meat meal to meet the nutrient requirements or recommended levels of indispensable amino acids which contain relatively high concentrations of total protein and excessive levels of these amino acids other than the first (methionine) and second (lysine) limiting amino acids (McGill *et al.*, 2012; Burley *et al.*, 2013). Since, the birds have no storage methods/mechanisms of consumed amino acids beyond the needs of protein biosynthesis, the extra amino acids consumed over bird requirements are deaminated and the amino acid–derived N is removed in the urine as uric acid (80%), ammonia (10%) and urea (5%) (Goldstein and Skadhauge, 2000; Ferket *et al.*, 2002; Corzo *et al.*, 2009).

The excretion of nitrogen, digestion coefficients of crude protein and amino acid of conventional feedstuffs, quality variation of ingredient as well as the requirements of ideal protein and amino acid are known, substantial reductions in nitrogen emission and pollution can be achieved by decreasing the levels of CP diets and balancing the requirements of digestible amino acid profiles with crystalline amino acid. Forms of crystalline/synthetic amino acids like lysine and methionine, threonine, valine, tryptophan are available in local markets or feed additives companies at a price that is competitive with the costs of intact digestible protein (Corzo *et al*., 2005; Pavan *et al*., 2005; Alagawany *et al*., 2014b). Crude fiber and ether extract digestibilities did not significantly ($p<0.05$) affect with different CP levels of laying hen diets (El-Husseiny *et al.,* 2005). Danicke *et al.* (2000) reported that increasing CP in layers diets did not statistically affect CP digestibility and amino acids.

Kerr (1995) reported a comprehensive review contains over 35 studies of supplementation of amino acid in poultry diets and pointed out that excretion of nitrogen could be lowered from 2.3-22.50% per each unit decrease in CP diets. Where, inclusion of amino acid in poultry low-protein diets decreased the excretion of nitrogen by 8.5% per one percent unit reduction in dietary protein.

Nitrogen excretion was lowered by 10% when CP diets reduced by 1% (Aarnik *et al.,* 1993; Van der Peet-Schwering *et al*., 1997). Although, the diets contained low-protein can be supplemented with crystalline amino acid to meet the requirements of amino acid and significantly mitigate nitrogen pollution, it may not be economic in all times (Schutte *et al*., 1992; Alagawany and Abou-Kassem, 2014). This reason may be returned to some points: there is a limit to decrease the levels of CP diet, because the huge reduction in CP level may cause adverse effects on growth performance and meat yield. Second, the economic efficiency of synthetic amino acids supplementation to low protein diets which dependent on market prices and prices of traditional feedstuffs soybean meal and yellow corn. Indeed, the costs of disposal for excreta/manure or nitrogen emission from poultry farms should be considered with the total costs of poultry production projects (Alagawany and Abou-Kassem, 2014). Likewise, Koreleski and Swiatkiewicz (2010) found that the supplementation of amino acids to layer diets reduced nitrogen excreta content and daily nitrogen excretion. In the same context, Alagawany *et al.* (2011) and Zeweil *et al.* (2011) concluded that different levels of dietary protein influences the nitrogen consumption and excretion in hens, since the low-protein diet resulted in a decrease in nitrogen intake and excretion vs. the high-protein diet. Reduction in nitrogen excretion plays a crucial role in mitigating ammonia emission and environmental pollution from poultry manure in poultry farms, in addition to decreasing uric acid in litter.

Ammonia pollution is an important issue for poultry industry and it can be decreased by manipulating the level of CP diet. Roberts *et al.* (2007) found that decreasing dietary CP level to 19% did not affect nitrogen consumption, while excreted nitrogen was decreased compared to normal 20% CP diet. Moreover, Alagawany (2012) reported that the nitrogen digestibility was not affected by low (16%) or high (20%) dietary protein. Recently, increasing poultry production with intensive systems and ammonia emission in poultry houses led to manipulation of poultry diet formulations to reduce the nitrogen content in excreta. Since, birds can utilize about 40% of CP diet, consequently it seems logical to reduce the CP levels in poultry diet (Lopez and Leeson, 1995).

Due to the strong relationship between the different levels of dietary protein and excreted nitrogen, the radical solution to increase excreta nitrogen is to decrease CP level in the diet. Several researchers have been successful in decreasing excretion of nitrogen by decreasing the level of CP in the diet with or without synthetic amino acids supplementation (Schutte *et al*., 1992; Summers, 1993; Jamroz *et al*., 1996).

Blair *et al.* (1999) found that reduction in CP diet to 13.5% resulted in a 30-35% reduction in daily nitrogen content in layer excreta; moreover the low-CP-diet (13.5%) was associated with an improvement in retention of nitrogen and dry matter as compared to high CP diet (17%). The content of feacal nitrogen linearly ($p<0.05$, significantly) decreased with decreasing dietary CP and was about 50% of the intake. Considering the ratio of faecal nitrogen to nitrogen intake, the group of 150 g kg^{-1} of CP reported better utilization of nitrogen at each tested time (Meluzzi *et al*., 2001).

CONCLUSION

In conclusion, this literature review highlights that dietary proteins have reported impacts beyond their bioactive roles of building blocks of tissues in the body, growth, egg production, egg quality, chemical composition of eggs, blood constituents, immune response, and environmental pollution by nitrogen emission. Also, the present review illustrated the benefits and hazards of using different protein levels in laying hen diets. Since, adequate amount of dietary CP is necessary for different body functions such as maintaining normal immunity and protecting the host from risks/diseases in all species. Ammonia emissions are an important issue for poultry industry and it can be decreased by manipulating the level of CP diet. Where, birds can utilize about 40% of CP diet, consequently it seems logical to reduce the CP levels in poultry diet. Numerous studies have been successful in decreasing excreted nitrogen by decreasing CP level in poultry diets with/without synthetic amino acids supplementation. Decreasing CP in poultry diets is a good strategy to reduce the nitrogen content in excreta and litter as well as mitigate ammonia emission which causes respiratory disorders for birds and workers in poultry houses.

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