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EFFECTS OF LOW PROTEIN DIET FORTIFIED WITH LYSINE AND METHIONINE ON PERFORMANCE OF LAYER HEN

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By

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EFFECTS OF LOW PROTEIN DIET FORTIFIED WITH LYSINE AND METHIONINE ON PERFORMANCE OF LAYER HEN

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Protein is one of the important nutrient in diet that needs to be fulfilled for the basic nutrient requirement of animals. Ideal protein diets are based on meeting animals' amino acid requirements for protein accretion and maintenance, while avoiding deficiencies and excesses. The present study was conducted to evaluate the effects of reducing dietary crude protein fortified with lysine and methionine on layer hen performance. Two experiments were conducted in this study. In the first experiment, a total of 144 Hisex Brown aged 16 weeks were randomly assigned to four dietary treatments. The birds were offered 17.5% to 16.5% crude protein supplemented with commercial amino acids (L-Lysine, DL-Methionine) till the birds are 32 weeks old. The amino acids from the different treatment groups were adjusted to similar levels. In continuation from the first experiment, the optimum level of the crude protein diet was maintained whilst the level of methionine and lysine was manipulated to the high, normal and low levels in the diets. A total of 144 Hisex Brown birds aged 19 weeks were used in this study with 9 treatments till they were of 32 weeks of age. Dietary treatments consisted of 0.77%, 0.97% and 1.77% lysine and 0.42%, 0.46% and 0.50% methionine in 17% crude protein. In the first experiment, higher ($P<0.05$) egg production, egg mass, Lactic Acid Bacteria microflora and Lactic Acid Bacteria to *Enterobacteriacea* ratio was observed in 17% CP. The 17% CP had lower ($P<0.05$) Feed Conversion Ratio and faecal pH compared to other treatment groups. The 17% crude protein diet with amino acid supplementation had a better egg production, increased small intenstine villus height, increased liver and spleen weight and promoted growth of beneficial Lactic Acid Bacteria microflora than birds fed with commercial diet. The second experiment concluded that 0.97% lysine and 0.50% methionine levels in the diets had a better Feed Conversion Ratio, Plasma Immunoglobulin G, Plasma Immunoglobulin M, increased Lactic Acid Bacteria microflora, increased Lactic Acid Bacteria to *Enterobacteriacea* ratio, reduced *Enterobacteriacea* count and faecal pH,. In conclusion, feeding 17% CP with 0.97% lysine and 0.50% methionine to layer hen could be optimal for maximizing production performance, small intestine absorptive capacity and immune response in layer hens.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN DIET RENDAH PROTEIN DENGAN PENAMBAHAN LYSINE DAN METHIONINE KEPADA AYAM PENELUR

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Protein adalah salah satu nutrien yang penting dalam diet yang perlu dipenuhi bagi keperluan asas haiwan. Konsep protein ideal adalah berdasarkan kepada memenuhi keperluan asid amino haiwan untuk pertambahan protein dan penyelenggaraan, sambil mengelakkan kekurangan dan lebihan. Kajian ini telah dijalankan untuk menilai kesan mengurangkan protein kasar di dalam diet dan diperkaya dengan lysine dan methionine terhadap prestasi ayam penelur. Dua eksperimen telah dijalankan dalam kajian ini. Dalam eksperimen pertama, sebanyak 144 Hisex Brown yang berusia 16 minggu telah dibahagikan secara rawak kepada empat diet. Ayam telah diberi 17.5% sehingga 16.5% protein kasar ditambah dengan asid amino komersial (L-Lysine dan DL-Methionine). Asid amino di dalam diet yang berbeza telah diselaraskan ke tahap yang sama. Daripada lanjutan daripada exsperimen pertama, eksperimen kedua dijalankan. Tahap optimum diet protein kasar dikekalkan iaitu 17% manakala tahap lysine dan methionine telah dimanipulasi ke tahap yang tinggi, normal dan rendah dalam diet. Sebanyak 144 ayam Hisex Brown berumur 19 minggu telah digunakan dalam kajian ini dengan 9 diet sehingga mereka adalah 32 minggu. Rawatan diet terdiri daripada 0.77%, 0.97% dan 1.77% lysine dan 0.42%, 0.46% dan 0.50% methionine. Dalam eksperimen pertama, 17% protein kasar menunjukkan peningkatan ($P<0.05$) penghasilan telur, mass telur, mikroflora Bakteria Laktik Asid, Bakteria Laktik Asid nisbah Enterobakteria. Kumpulan yang mengandungi 17% protein kasar menunjukkan Nisbah penukaran makanan dan pH tinja yang rendah ($P<0.05$) berbanding kumpulan rawatan lain. Kumpulan yang mengandungi 17% protein kasar dengan tambahan asid amino mempunyai pengeluaran yang lebih baik telur, peningkatan tinggi villus dalam morfologi usus, penambahan berat hati dan limpa dan mikroflora Bakteria Laktik Asid bermanfaat meningkat berbanding makanan diet komersial. Eksperimen kedua memberi kesimpulan bahawa 0.97% lysine dan 0.50% methionine dalam diet mempunyai nisbah penukaran makanan yang lebih baik, nilai lebih tinggi bagi Plasma Immunoglobulin G, Plasma Immunoglobulin M, meningkatkan mikroflora Bakteria Laktik Asid, meningkat Bakteria Laktik Asid nisbah Enterobakteria dan mengurangkan kiraan Enterobakteria dan pH tinja. Kesimpulannya, memberi makanan 17% CP dengan 0.97% lysine dan 0.50% methionine untuk ayam penelur boleh memberikan keputusan yang optimum untuk memaksimumkan prestasi pengeluaran, kapasiti penyerapan usus kecil dan tindak balas imun dalam ayam penelur.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

°C	Degree Celsius
µL	Microliter
µm	Micrometer
AA	Amino Acid
ACN	Acetonitrile
ANOVA	Analysis Of Variance
AOAC	Association of Analytical Communities
BW	Body Weight
CD	Crypt Depth
CFU	Colony forming units
cm	Centimeter
CP	Crude Protein
dH_2O	Deionized water
DM	Dry Matter
EAA	Essential Amino Acid
EDTA	Ethylene Diaminetetraacetic Acid
EE	Ether Extract
ENT	*Enterobacteriaceae*
FCR	Feed Conversion Ratio
FI	Feed Intake
FMOC	Fluorenylmethoxycarbonyl chloride
g	Gram
H	Hydrogen Atom
H_2O_2	Hydrogen Peroxide
H_2SO_4	Hydrogen Sulfuric Acid
HBr	Hydrogen Bromide
HCL	Hydrochloric Acid
HPLC	High Pressure Liquid Chromatography
IBD	Infectious Bursal Disease
IgG	Immunoglobulin G
IgM	Immunoglobulin M
Kcal	Kilo Calorie
LAB	Lactic Acid Bacteria
LBWG	Live Body Weight Gain
Log_{10} CFU	Logarithm at base of 10
Lys	Lysine
M	Molarity
ME	Metabolizable Energy
MeOH	Methanol
Met	Methionine
mg	Milligrams
mL	Milliliter
mM	Milli Molar
mm	Millimeter
MRS – agar	Lactobacillus – Agar De Man, Rogosa and Shape
MRS	Man Rogosa Sharpe
N	Nitrogen
Na_2HPO_4	Di-Sodium Hydrogen Phosphate
NaOH	Sodium hydroxide

NEAA	Non- Essential Amino Acid
$-NH_2$	Amino Group
NH_3	Ammonia
nm	nanometer
OPA	O - phthaldialdehyde
P	Significant level
R	Variable Group
rpm	Revolutions per minute
SAS	Statistical analysis system
SBM	Soybean Meal
SEM	Standard Error Means
TiO_2	Titanium Oxide
TSAA	Total Sulfur Amino Acid
UPM	University Putra Malaysia
UPP	Proteasome pathway
v/v	Volume Versus Volume
VH	Villi Height
w/v	Weight Versus Volume

CHAPTER 1

INTRODUCTION

Over the past years, worldwide poultry industry has developed significantly to fulfill and accommodate the ever increasing demands for poultry products. In developing countries, poultry production is one of the rapidly growing animal protein supply (Adeyemo *et al*., 2012). Despite its rapid progress, there still lies several concerns in the poultry industry, for example production, growth reduction and increase in feed costs. Increase in feed cost will subsequently lead to increase in poultry products prices and eventually followed by increase of other food prices (MacDonald, 2008).

Nutritionists and poultry producers have shown immense interest in lowering protein level in poultry rations as this will have several benefits. Firstly, there will be diet costs reduction. Production cost can be reduced with lower crude protein diet, as a big SRUWLRQRIWKHFRVWOLHVLQIXOILOOLQJWKHELUGV¶PLQRDFLGUHTXLUHPHQWV7K by environmental reasons; by reducing crude protein in the diet, nitrogen emission could be reduced. Other than that, there would be reduction in excess amino acids that are not used by the birds (Perry *et al*., 2004). Maintaining growth and profitability, producing high quality products and decreasing production cost are important in the poultry industry (Eits *et al.,* 2005; Corzo *et al.,* 2004).

Similarly, Kamran *et al*. (2004) pointed out that reducing feed cost for optimum economic return proved to be major concern for the modern poultry as feed represents approximately 70% of total production cost. Diets can be formulated on a crude protein (CP) basis if several protein supplying feed ingredients such as corn, soybean meal, and meat and bone meal are used. Laying hens have a physiological requirement for protein and amino acids for body and egg proteins synthesis (Bregendahl and Roberts, 2006).

Ideal protein concept was established in order to meet the requirement of the bird and at the same time to maximize production and profitability. This can be achieved by lowering CP in diets combined with inclusion of limiting amino acid to their required levels. The goal is to provide ideal levels of essential amino acids to optimize hen performance while minimizing excess amino acid provided by dietary CP (Novak *et al*., 2006). This feeding strategy is becoming increasingly popular with a variety of synthetic amino acid becoming more available and affordable (Keshavarz and Austic, 2004; Meluzzi *et al*., 2001).

In laying hens fed corn soybean diets, methionine and lysine are usually the first and the next limiting amino acids. Specifically for laying hens, methionine is considered the first limiting amino acid in low protein corn soybean meal diet. However, there is still controversy about this subject in the literature (Abdel-Maksoud *et al.,* 2010). Numerous studies have reported that the efficiency of protein utilization is increased by supplementation of methionine and lysine (Alagawany *et al*., 2014; Burley *et al*., 2013; Waldroup *et al*., 2005; Novak *et al.,* 2004).

Formulating diets based on an ideal protein concept with supplementation of amino

acid has been done in many studies in different animal species such as laying hens, broilers, pigs and turkeys (Namroud *et al*., 2008; Roberts *et al*., 2007ab; Keshavarz and Austic, 2004). Burley *et al*. (2013) highlighted a number of university scale studies regarding feeding laying hen on ideal amino acid basis. Burley *et al*. (2013) observed that this feeding strategy can maintain most egg production parameters for various durations of time and production phase and at the same time increase producer revenue by lowering feed costs. The promising results of these studies have led to the question of whether reduced CP in laying hen diets, supplemented with essential amino acid, has effecWRQODLQJKHQV¶HUIRUPDQFH

The objectives of this study are to investigate the effect of feeding low CP diet with different levels of lysine and methionine on production performance, egg quality, faecal Lactic acid bacteria (LAB) and *Enterobacteriacea* (ENT) count, gut morphometric and immune response of layer hen. Thus the specific objectives of this study are:

1. To determine the production performance, egg quality, LAB and ENT intestinal microflora, villus height and crypt depth, spleen and liver weight and IgG and IgM levels as a result of low CP diet.

2. To determine the effect of different levels of lysine and methionine levels in low CP diet on production performance, egg quality, LAB and ENT intestinal microflora, villus height and crypt depth, spleen and liver weight and IgG and IgM levels.

REFERENCES

Abbasi, M.A., Mahdavi, A.H., Samie, A.H. and Jahanian, R. (2014). Effects of different levels of dietary crude protein and threonine on performance, humoral immune responses and intestinal morphology of broiler chicks. Brazilian Journal of Poultry Science. 16(1): 35-44.

Abdel-Maksoud, A., Yan, F., Cerrate, S., Coto, C., Wang, Z. and Waldroup, P.W. (2010). Effect of dietary crude protein, lysine level and amino acid balance on performance of broilers 0 to 18 days of age. International Journal of Poultry Science. 9: 21-27.

Adeyemo, G.O., Abioye, S.A. and Aderemi, F.A. (2012). The effect of varied dietary crude protein levels with balanced amino acids on performance and egg quality characteristics of layer at first laying phase. Food and Nutrition Sciences. 3(4): 526-529.

Alagawany, M., El-Hindawy, M.M. and Attia, A.I. (2014). Impact of Protein and Certain Amino Acids Levels on Performance of Growing Japanese Quails. Universal Journal of Applied Science. 2(6): 105-110.

Aletor, V.A., Hamid, I.I., Nied, E. and Pfeffer, E. (2000). Low protein amino acid supplemented diets in broiler chickens:effects on performance, carcass characteristics, whole-body composition and efficiencies of nutrient utilization. Journal of the Science of Food and Agriculture. 80: 541-554.

AOAC International. (2005). Official Methods of Analysis of AOAC International. 18th Edition. Gaithersburg, MD.

Applegate, T.J., Adedokun, S.A., Adeola, O., Parsons, C.M. and Lilburn, M.S. (2008). Amino acid digestibility-methodology and application. In: Multistate Poultry Feeding Conference, Indianapolis, IN.

Asyifah, M.N., Abd-Aziz, S., Phang, L.Y. and Azlian, M.N. (2012). Brown rice as a potential feedstuff for poultry. Journal Applied Poultry Research. 21: 103±110.

Audisio, C.M., Oliver, G. and Apella, M.C. (2000). Protective effect of Enteroccocus faecium J96, apotential probiotic strain, on chicken infected with Salmonella pullorum. Journal of Food Protection. 10: 1333-1337.

Azarnik, A., Bojarpour, M., Eslami, M., Ghorbani, M.R. and Mirzadeh, K. (2010). The effect of different levels of diet protein on broilers performance in ad libitum and feed restriction methods. Journal of Animal and Veterinary Advances. 9: 631-634.

Azzam, M.M.M., Dong, X.Y., Xie, P., Wang, C. and Zou, X.T. (2011). The effect of supplemental l-threonine on laying performance, serum free amino acids, and immune function of laying hens under high-temperature and high-humidity environmental climates. Poultry Science. 90(10): 2251-2256.

Baker, D. H., Batal, A. B., Parr, T. M., Augspurger, N. R. and Parsons, C. M. (2002). Ideal ratio (relative to lysine) of tryptophan, threonine, isoleucine, and valine for chicks during the second and third weeks post hatch. Poultry Science. 81: 485-494.

Baker, D. H. (2003). Ideal Amino Acid Patterns For Broiler Chicks. In: Amino Acids In Animal Nutrition, 2nd Edition. Cabi Publishing, Wallingford, UK.

Banerjee, S., Melesse, A., Dotamo, E., Berihun, K. and Beyan, M. (2013). Effect of feeding different dietary protein levels with Iso-Caloric ration on nutrients intake and growth performances of dual-purpose koekoeck chicken breeds. International Journal of Applied Poultry Research. 2: 27-32.

Baurhoo, B., Phillip L. and Ruiz-Feria, C.A. (2007). Effects of purified lignin and mannan oligosaccharides on intestinal integrity and microbial populations in the ceca and litter broiler chickens. Poultry Science. 86: 1070±1078.

Bender, D.A. (2005). Amino Acids. In: A Dictionary of Food and Nutrition. 3rd Edition. Oxford University Press, USA.

Bikker, P., Dirkzwager, A., Fledderus, J., Trevisi, P., Huerou-Luron, I. le, Lalles, J. P. and Awati, A. (2006). The effect of dietary protein and fermentable carbohydrates levels on growth performance and intestinal characteristics in newly weaned piglets. Journal of Animal Science. 84: 3337-3345.

Blake, J.P. (2008). Nutrition for backyard chicken flocks. Retrieved 4 January 2010 from http://www.aces.edu/pubs/docs/A/ANR-1317.

Bouyeh, M. and Gevorgian, O.X. (2011). Influence of Different Levels of Lysine, Methionine and Protein on the Performance of Laying Hens after Peak. Journal of Animal and Veterinary Advances. 10 (4): 532-537.

Bouyeh, M. (2012). Effect of Excess Lysine and Methionine on Immune system and Performance of Broilers. Annals of Biological Research. 3(7): 3218-3224.

Bouyeh, M. (2013). Effects of excess dietary lysine and methionine on performance and economical efficiency of broiler chicks. Annals of Biological Research. 4 (5): 241-246.

Bregendahl, K. and Roberts, S. (2006). Nutritional strategies to reduce ammonia emissions from laying hens. In 408Proc. Midwest Poultry Federation Convention. St. Paul, MN. 19 pages.

Bregendahl, K. and Roberts, S. (2008). The ideal amino acid profile for laying hens. Iowa State University Animal Industry Report.

Bregendahl, K., Roberts, S.A., Kerr, B. and Hoehler. D. (2008). Ideal ratios of isoleucine, methionine, methionine plus cystine, threonine, tryptophan, and valine relative to lysine for white leghorn-type laying hens of twenty-eight to thirty-four weeks of age. Poultry Science. 87: 744±758.

Brosnan, J.T. and M.E. Brosnan. (2006). The sulfur-containing amino acids: An overview. Journal of Nutrition. 136:1636S±1640S.

Brown. (2011) ISA. Nutrition Management Guide Instituted selection Animale. BV Boxmeer, the Netherlands.

Bryden, W. L. and Li, X. (2004). Utilisation of digestible amino acids by broilers. RIRDC. Rural Industries Research and Development Corporation and University of Sydney. ISBN 064258740 X.

Brzoska, F., Buluchevskij, S., Stecka, K. and Sliwinski, B. (2007). The effects of lactic acid bacteria and mannanoligosaccharide, with or without fumaric acid, on chicken performance, slaughter yield and digestive tract microflora. Journal of Animal and Feed Sciences.16: 241±251.

Bunchasak, C. and Silapasorn, T. (2005). Effects of adding methionine in low-protein diet on production performance reproductive organs and chemical liver composition of laying hens under tropical conditions. International Journal of Poultry Science. 5: 301-308.

Bunchasak, C. and Keawarun, N. (2006). Effect of methionine hydroxy analog free acid on growth performance and chemical composition of liver of broiler chicks fed a cornsoybean based diet form 0 to 6 weeks of age. Animal Science Journal.77: 95-102.

Bunchasak, C., Ratchadapornvanitch, Y. and Thiengtham, J. (2012). Comparative Effects of Supplemental DL-2-hydroxy-4-methylthio, Butanoic Acid and DL-methionine in Diet on Egg Production and Quality in Laying Hens. Journal of Poultry Science.49: 260-267.

Burley, H.K., Patterson, P.H. and Elliot, M.A. (2013). Effect of a reduced crude protein, amino acid-balanced diet on hen performance, production costs, and ammonia emissions in a commercial laying hen flock. Journal of Applied Poultry Research. 22: 217±228.

Buwjoom, T., Yamauchi, K., Erikawa, T.and Goto, H. (2010). Histological intestinal alterations in chickens fed low-protein diet. Journal of Animal Physiology and Animal Nutrition. 94: 354±361.

Cadirci, S., Smith, W.k. And Devit Mc, R.M. (2009). Determination of the appetite of laying hens for methionine drinking water by using color cue. Journal of European Poultry Science. 73(1): 21-28.

Canibe, N., Miettinen. H. and Jensen, B.B. (2008). Effect of adding Lactobacillus plantarum or a formic acid containing product to fermented liquid feed on gastrointestinal ecology and growth performance of piglets. Livestock Science. 144: 251- 262.

Centraal Veevoederbureau Dutch. (1996). Amino acid requirements for laying hens and broiler chickens. Documentation Report nr. 18 (in Dutch). Lelystad, The Netherlands.

Cheeke, P.R. (2005). Livestock Feeds and Feeding. 3rd Ed. Pearson Prentice Hall. Upper Saddle River, New Jersey.

Cherian, G.,O,A., Burke,I.C. and Pan, W. (2013). Feeding Artemisia annual alters digesta pH and muscle lipid oxidation products in broiler chickens. Poultry Science. 92: 1085±1090.

Chiang, Q., Lu, W.Q., Piao, Q.S., Hu, J.K., Gongand, L.M. and Thacker, P.A. (2010). Effects of feeding solid state fermented rapeseed meal on performance, nutrient digestibility, intestinal ecology and intestinal morphology of broiler chickes. Asian Australasian Journal of Animal Science. 23: 263-271

Choe, D.W., Loh, T.C., Foo, H.L., Hair Bejo, M. and Awis, Q.S. (2012). Egg production, faecal pH and microbial population, small intestine morphology, and plasma and yolk cholesterol in laying hens given liquid metabolites produced by Lactobacillus plantarum strains. British Poultry Science. 53: 106-115.

Collett, S.R. (2012) Nutrition and wet litter problems in poultry. Animal Feed Science and Technology. 173: 65±75.

Coon, C. and Zhang, B (1999). Ideal amino acid profile for layers examined. Feedstuffs. 71(14): 13±15.

Corzo, A., McDaniel, C. D., Kidd, M. T., Miller, E. R., Boren, B. B. and Fancher, B. I. (2004). Impact of dietary amino acids concentration on growth, carcass yield and uniformity of broilers. Australian Journal of Agricultural Research. 55: 1133-1138.

Corzo, A., Fritts, C.A., Kidd, M.T. and Kerr, B.J. (2005). Response of broiler chicks to essential and non-essential amino acid supplementation of low crude protein diets. Animal Feed Science and Technology. 118: 319-327.

Costa, F.G.P., Oliveira, C.F.S., Dourado, L.R.B., Neto, R.C.L., Campos, M.A.S.F. and Lima, A.G.V.O. (2008) Levels of calcium in diets for brown layers post-peak production. Brazillian Journal of Animal Science. 37(4): 624-628.

Dahiya, J.P., Wilkie, D.C., Van Kessel, A.G. and Drew. M.D. (2006). Potential strategies for controlling necrotic enteritis in broiler chickens in post-antibiotic era. Animal Feed Science. Technology129: 60±88.

Dahiya, J.P., Hoehler, D., Van Kessel A.G. and Drew, M.D. (2007a). Dietary encapsulated glycine influences Clostridium perfringens and Lactobacilli growth in the gastrointestinal tract of broiler chickens. Journal of Nutrition. 137: 1408±1414.

Dahiya, J.P., Hoehler, D., Van Kessel, A.G. and Drew, M.D. (2007b). Effect of Different Dietary Methionine Sources on Intestinal Microbial Populations in Broiler Chickens. Poultry Science. 86: 2358±2366.

Dalloul, R.A., Lillahoj, H.S., Shellem, T.A. and Doerr, J.A. (2003). Enhanced mucosal immunity against Eimeria acervulina in broilers fed a Lactobacillus-based probiotic. Poultry Science. 82: 62-66.

Dari, R.L., Penz, A.M., Kessler, A.M. and Jost, H.C. (2005). Use of digestible amino acids and the concept of ideal protein in feed formulation for broilers. Journal of Applied Poultry Research. 14: 195-203.

Dean, D.W., Bidner T.D. and Southern, L.L. (2006). Glycine supplementation to low protein, amino acid-supplemented diets supports optimal performance of broiler chicks. Poultry Science. 85: 288-296.

Deng, P.and Zhongtang, Y. (2014). Intestinal microbiome of poultry and its interaction with host and diet. Gut Microbes. 5(1): 108-119.

Ding, B.A., Pirone, A., Lenzi, C., Baglini, A. and Romboli, I. (2011). Effect of hen diet supplemented with 25-OH-D3 on the development of small intestinal morphology of chick. Journal of Animal and Feed Sciences. 20: 420±431.

Donsbough, A.L., Powell, S., Waguespack, A., Bidner, T.D. and Southern, L.L. (2010). Uric Acid, Urea, and Ammonia Concentrations in Serum and Uric Acid Concentration in Excreta as Indicators of Amino Acid Utilization in Diets for Broilers. Poultry Science. 89: 287-294.

Dudle-Cash, B. (2012). Breeder hen lysine levels in surplus. Feedstuffs. 84(19): 12.

Eits, R.M., Kwakkel, R.P., Verstegen, M.W.A. and Den Hartog, L.A. (2005). Dietary balanced protein in broiler chickens. A flexible and practical tool to predict dose-response curves. British Poultry Science. 46(3): 300-309.

Figueiredo, G.O., Bertechini, A.G., Fassani, E.J., Rodrigues, P.B., Brito, J.A.G. and Castro, S.F. (2012). Performance and egg quality of laying hens fed with dietary levels of digestible lysine and threonine. Brazillian Journal of Veterinary and Animal Sciences. 64(3): 743-750.

Foo, H.L., Loh, T.C, Law, F.L., Lim, Y.Z., Kufli, C.N. and Rusul, G. (2003). Effects of feeding Lactobacillus plantarum I-UL4 isolated form Malaysian Tempeh on growth performance, faecal flora and lactic acid bacteria and plasma cholesterol concentrations in postweaning rats. Journal of Food Science and Biotechnology. 12: 403±408.

Franco, J., Murakami, A., Natali, M., Garcia, E. and Furlan, A. (2006). Influence of delayed placement and dietary lysine levels on small intestine morphometrics and performance of broilers. Braziilian Journal of Poultry Science. 8.

Fuller, M. F. (2004). The Encyclopedia of Farm Animal Nutrition. CAB International Publishing; UK.

Furlan, R.L., Faria, F.D., Rosa, P.S. and Macari, M. (2004). Does low-protein diet improve broiler performance under heat stress conditions? .Brazilian Journal of Poultry Science. 6(2): 71-79.

Gao, J., Zhang, H. J., Yu, S. H., Wu, S. G., Yoon, I., Quigley, J., Gao, Y. P. and Qi G. H. (2008). Effects of yeast culture in broiler diets on performance and immunomodulatory functions. Poultry Science. 87: 1377±1384.

Garcia, A.R., Batal, A.B. and Dale, N.M. (2007). A comparison of methods to determine amino acid digestibility of feed ingredients for chickens. Journal of Poultry Science. 86: 94-101.

Geraert, P.A. and Mercier, Y. (2010).Amino acids: beyond the building blocks. Antony: ADISSEO France SAS.

Ghasemi, H.A., Ghasemi, R. and Torki, M. (2014). Periodic usage of low-protein methionine-fortified diets in broiler chickens under high ambient temperature conditions: effects on performance, slaughter traits, leukocyte profiles and antibody response. International Journal of Biometeorology. 58(7): 1405-1414.

Gheisar, M.M., Foroudi, F. and Shad, A.G. (2011). Effect of using L-Threonine and reducing dietary levels of crude protein on egg production in layers. Iranian Journal of Applied Animal Science. 1(1): 65-68.

Gholamhasan,V., Masoud, T., Shahab, B., Heyder F. and Saeed H. (2011). Effects of Different Levels of Lysine on Small Intestinal Villous Morphology in Starter Diet of Broiler Chickens. Global Veterinaria 7(6): 523-526.

Golian, A., Azghadi, M.A. and Pilevar, M. (2010). Influence of various levels of energy and protein on performance and humoral immune responses in broiler chicks. Global Veterinaria. 4 (5): 434-440.

Gomez, S. and Angeles, M. (2009). Effect of threonine and methionine levels in the diet of laying hens in the second cycle of production. Journal of Applied Poultry Research. 18: 452-457.

Gong J, S.W, Forster, R.J., Huang, R., Yu, H., Yin, Y., Yang, C. and Han, Y. (2007). 16S rRNA gene±based analysis of mucosa±associated bacterial community and phylogeny in the chicken gastrointestinal tracts: from crops to ceca. FEMS Microbiology Ecology. 59(1): 147 ± 157.

Grindstaff, J.L., Gregory, E. Demas.and Ellen, D.K. (2005). Diet quality affects egg size and number but does not reduce maternal antibody transmission in Japanese quail Coturnix japonica. Journal of Animal Ecology. 74: 1051±1058.

Gunawardana, P., Roland Sr D.A. and Bryant, M.M. (2008). Effect of energy and protein on performance, egg components, egg solids, egg quality, and profits in molted Hy-Line W36 Hens. Journal of Applied Poultry Research. 17: 432-439.

Gunawardana, P., Roland, D.A. and Byrant, M.M. (2008a). Performance comparison and Lysine requirements of seven commercial brown egg layer strains during phase one. International Journal of Poultry Science. 7: 806-812.

Gunawardana, P., Roland, D.A. and Byrant, M.M. (2008b). Performance comparison and Lysine requirements of seven commercial brown egg layer strains during phase two. International Journal of Poultry Science. 7: 1156-1162.

Gusils, C., Oppezzo, O., Pizarro, R. and Gonzalez S. (2003). Adhesion of probiotic lactobacilli to chick intestinal mucus. Canadian Journal of Microbiology. 49: 472±478.

Hamilton, R. M. G. (1978). The effects of dietary protein level on productive performance and egg quality of four strains of White Leghorn hens. Poultry. Science. 57: 1355±1364.

Hammershoj, M. Kjaer, J. B. (1999). Phase Feeding for Laying Hens: Effect of Protein and Essential Amino Acids on Egg Quality and Production. Acta Agriculturae Scandinavica, Section A -Animal Science. 49: 31±41.

Harms, R. H., and G. B. Russell. (1993). Optimizing egg mass with amino acid supplementation of a low-protein diet. Poultry Science. 72: 1892±1896.

Hegedus, M., Andrasofszky, E., Brydll, E., Veresegyhazy, T. and Tamas. J. (1993). Biological activities of methionine derivatives: I. Microbiological activity of methionine derivatives. Hungarian Veterinary Journal. 48: 527±532.

Henderson, J.H., Ricker, R.D., Bidlingmeyer, B.A. and Woodward, C. (2000). Rapid, accurate and reproducible HPLC analysis of amino acids. Amino acid analysis using Zorbax Eclipse AAA columns and the Agilent 1100 HPLC. Agilent Technologies. 10 Pages.

Hisex Brown Management Guide. (2008). North American edition of the HISEX BROWN Management guide for commercial layers. www.centurionpoultry.com

Hofshagen, M. and Kaldhusdal, M. (1992). Barley inclusion and avoparcin supplementation inbroiler diets. 1. Effect on small intestinal bacterial flora and performance. Poultry Science. 71: 959±969.

Hughes, R.J. (2005). An integrated approach to understanding gut function and gut health of chickens. Asia Pacific Journal Clinical Nutrition. 14: S27.

Humphrey, B. D., Koutsos, E.A. and Klasing, K.C. (2002). Requirements and priorities ofthe immune system for nutrients Nutrition biotechnology in the feed and food industries. Proceedings of Alltech's 18th annual symposium Pages 69±77 Lyons T.P. Jasques K.A. Nottingham, UK Nottingham University Press

Incharoen, T. and Yamauchi, K. (2009a). Production performance, egg quality and intestinal histology in laying hens fed dietary dried fermented ginger. International Journal of Poultry Science.8: 1078-1085.

Incharoen, T., Khambualai, O. and Yamauchi, K. (2009b) Performance and histological changes of the intestinal villi in chickens fed dietary natural zeolite including plant extract. Asian Journal of Poultry Science. 3: 42-50.

Incharoen, T., Yamauchi, K., Erikawa, T. and Gotoh, H. (2010). Histology of intestinal villi and epithelial cells in chickens fed low crude protein or low crude fat diets. Italian Journal of Animal Science. 9: 429-434.

Jardim, F. R. M., Stringhni, J. H., Andrade, M. A., Nunes, A. B., Leandro, N. S. M., Cafe, M. B. and Leandro, N. S. M. (2008). Egg quality, blood biochemical parameters and reproductive tract development for Lohmann LSL hens fed increasing levels of digestible lysine. Acta Scientiarum. Animal Sciences. 30(1): 25-31.

Jardim, F. R. M., Stringhni, J. H., Andrade, M. A., Cafe, M. B., Leandro, N. S. M. and Carvalho, F. B. (2010). Levels of digestible lysine for Hy-Line W-36 hens in production period. Brazillian Journal of Animal Science. 39(4): 787-795.

Jensen, L. S., Wyatt, C. L. and Fancher. B. I. (1989). Sulfur amino acid requirement of broiler chickens. Poultry Science. 68: 163-168.

Joerger, R.D.(2003). Alternatives to antibiotics: bacteriocins, antimicrobial peptides and bacteriophages. Poultry Science. 82: 640-647.

Jordao F, J., Vilar Da Silva, J. H., Lindolfo Da Silva, E., Ribeiro, M.L.G., Costa, F.G.P. and Rodrigues, P.B. (2006a) Lysine requeriment of semi-heavy laying hens duringthe peak of egg production. Brazillian Journal of Animal Science. 35(4): 1728-1734.

Jordao, F., Silva, J.H.V., Silva, E.L., Araujo, D.M., Ribeiro, M.L.G. And Lima, M.R. (2006b). Effects of methionine plus cystine:lysine ratio on the productive and economic performance and internal and external egg quality, before and 28 days after storage. Brazillian Journal of Animal Science. 35(4): 1735-1743.

Kamran, Z., Mirza, M.A., Haq, A.U. and Mahmood, S. (2004). Effect of decreasing dietary protein levels with optimal amino acids profile on the performance of broilers. Pakistan Veterinary Journal. 24:161-164.

Kashani, S., Mohebbifar, A., Habibian, M. and Torki, M. (2014). Effects of phytase supplementation of low protein diets on performance, egg quality traits and blood biochemical parameters of laying hens. Annual Research and Review in Biology.4(4): 684-698.

Kucukersan, K., Derya, Y. and Seher, K. (2010). Influence of Different Dietary Oil Sources on Performance and Cholesterol Content of Egg Yolk in Laying Hens. Journal of Biology and Environmental Science. 4(12): 117-122.

Keser, O., Bilal, T. and Can Kutay, H. (2008). The effect of different dietary crude protein level on performance and serum immunoglobulin G in male kivircik ODPEV%XOJDULDQ-RXUQDORI9HWHULQDU\0HGLFLQHí

Keshavarz, K. and Jackson, M.E. (1992) Performance of growing pullets and laying hens fed low-protein, amino acid supplemented diets. Poultry Science. 71: 905±918.

Keshavarz, K. and Nakajima,S. (1995) . The Effect of Dietary Manipulations of Energy, Protein, and Fat during the Growing and Laying Periods on Early Egg Weight and Egg Components. Poultry Science, 74(1): 50-62.

Keshavarz, K., and Austic, R. (2004). The use of low protein, low-phosphorus, amino acid and phytase supplemented diets on laying hen performance and nitrogen and phosphorus excretion. Poultry Science. 83: 75±83.

Khajali, F., Faraji, M. and Saeid, K.D. (2007). Effects of reduced- protein diets at constant total sulphur amino acids: lysine ratio on pullet development and subsequent laying hen performance. American Journal of Animal and Veterinary Sciences. 2(4):89-92.

Kidd, M.T., Gerard, P.D., Heger, J., Kerr, B.J., Rowe, D., Sistani, K. and Burnham, D.J. (2001).Threonine and crude protein responses in broiler chicks. Animal Feed Science and Technology. 94: 57-64.

Kidd, M.T., McDaniel, C.D., Branton, S.L., Miller, E.R., Boren, B.B. And Fancher, B.I. (2004). Nutritional Modulation of Immune Function in Broilers. Journal of Applied Poultry Research. 13: 593-604.

Koenen, M.E., Boonstra-Blom, A.G. and Jeurissen, S.H.M. (2002). Immunological differences between layer and broiler-type chickens. Veterinary Immunology and Immunopathology. 89:47-56.

Kumar, S., Tyagi, P.K., Prasad, Y., Mandal, A.B., Tyagi, P.K. and Deo, C. (2012). Influence of methionine and protein supplementation in corn-soya and wheat-soya based diets on laying hens performance, egg size and egg quality in early stage of egg production. Indian Journal of Poultry Science. 47(1): 54-59.

Lan, P.T., Binh le, T. and Benno, Y. (2003). Impact of two probiotic lactobacillus strains feeding on faecal lactobacilli and weight gains in chicken. Journal of General and Applied Microbiology. 49: 29±36.

Latshaw, J.D. and Zhao, L. (2011). Dietary protein effects on hen performance and nitrogen excretion. Poultry Science. 90: 99-106.

Laudadio, V., Passantino, L., Perillo, A., Lopresti, G., Passantino, A., Khan, R.U. And Tufarelli, V. (2012). Productive performance and histological features of intestinal mucosa of broiler chickens fed different dietary protein levels. Poultry Science. 91: 265-270.

Leeson, S. and Summers, J.D. (2005). Commercial Poultry Production. 3rd ed. University Books, Guelph, ON. Rostagno,

Lewis, A. J. and Southern, L.L. (2001). Swine Nutrition. 2nd ed. CRC Press, Boca Raton, FL.

Li, P.F., Xue, L.F., Zhang, R.F., Piao, X.S., Zeng, Z.K. and Zhan, J.S. (2011). Effects of fermented potato pulp on performance, nutrient digestibility, carcass traits and plasma parameters of growing-finishing pigs. Asian-Australasian Journal of Animal Science. 24: 1456-1463.

Lima, M.R.L., Costa, F.G.P., Goulart, C.C., Pinheiro, S.G., Souza, R.B., Morais, S.A.N.and Lima, R.C. (2012) Nutritional reduction of protein and usage of enzyme in the diet of light Layers. Brazillian Journal of Animal Science. 41(9): 2055-2063.

Liu, Z., Wu, G., Bryant, M.M. and Roland Sr, D.A. (2004). Influence of added synthetic lysine for first phase second cycle commercial leghorns with the methionine cysteine/lysine ratio maintained at 0.75. International Journal of Poultry Science. 3: 220-227.

Loh, T.C., Law, F.L., Foo, H.L., Goh, Y.M and Zulkifli, I. (2007). Effects of feeding a fermented product on egg production, faecal microflora and faecal pH in laying hens. Journal of Animal and Feed Sciences. 16: 452-462.

Loh, T.C., Law, F.L., Foo, H.L., Goh, Y.M. and Zulkifli, I. (2009a). Effects of feeding fermented fish on egg cholesterol content in hens. Animal Science Journal. 80:27±33.

Loh, T.C., Chong, S.W., Foo, H.L. and Law, F.L. (2009b). Effects on growth performance,faecal microflora and plasma cholesterol after supplementation of spray-dried metabolite to postweaning rats. Czech Journal of Animal Science. 54(1): 10±16.

Loh, T.C., Thanh, N,T., Foo, H.L., Bejo, M.H. and Azhar, B. K. (2010). Feeding of different levels of metabolite combinations produced by Lactobacillus Plantarum on growth performance, faecal microflora, volatile fatty acids and villi height in broilers. Animal Science Journal. 81: 205±214.

Lohmann, H. (2010). Management Guide for Lohmann Brown-Classic. Lohman Tierzucht GmbH, Cuxhaven, Germany.

MacDonald, J.M. (2008). The economic organization of U.S. broiler production. Economic Information Bulletin No. 38. Economic Research Service, USDA.www.ers.usda.gov

Maneewan, B. and Yamauchi, K. (2004). Intestinal villus recovery in chickens reefed semi-purified protein, fat, or fibre free pellet diets. British Poultry Science. 45: 163-170.

Manju, G. U., Reddy, B. S. V., Gideon, G., Prabhu, T. M., Giridhar, K. S. and Suma, N. (2015). Effect of supplementation of lysine producing microbes vis-a-vis source and of dietary protein on performance and egg quality characteristics of post-peak layers.Veterinary World. 8(4): 453-460.

Matos, M. S., Leandro, N. S. M., Stringhini, J. H., Cafe, M. B., Carvalho, F. B. and Gomes, N. A.(2009). Lysine and threonine levels for commercial laying hens Lohmann LSL 24-44 weeks old=digestible lysine and threonine levels for Lohmann LSL laying hens from 24 to 44 weeks of age. Acta Scientiarum. Animal Sciences. 31(1): 19-24.

Meluzzi, A., F. Sirri, N., Tallarico, A. and Franchini. (2001). Nitrogen retention and performance of brown laying hens on diets with different protein content and constant concentration of amino acids and energy. British Poultry Science. 42:213±217.

Montagne, L., Pluske, J.R. and Hampson, D.J. (2003). A review of interactions between dietary fibre and the intestinal mucosa, and their consequences on digestive health in young non-ruminant animals. Animal Feed Science Technology. 108: 95±117.

Moura, A.M.A. (2004). Concept of ideal protein applied in nutrition of poultry and pork. Journal of Electronic Nutritime. 1(1): 31-34.

Mousavi, S.N., Khalaji, K., Jirdehi, A.G. and Foroudi, F. (2013). Investigation on the effects of dietary protein reduction 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. Italian Journal of Animal Science, Vol 12(2): 9-15.

Mujahid, A., Akiba, Y. and Toyomizu, M. (2009). Progressive changes in the physiological responses of heat-stressed broiler chickens. Journal of Poultry Science. 46: 163-167.

Nahashon, S.N., Aggrey, S. E., Adefope, N. A., Amenyenu A and Wright, D. (2010).Gompertz-Laird model prediction of optimum utilization of crude protein and metabolizable energy by French guinea fowl broilers. Journal of Poultry Science. 89: 52-57.

Nahm, K. H. (2002). Efficient Feed Nutrient Utilization to Reduce Pollutants in Poultry and Swine Manure. Critical Reviews in Environmental Science Technology. 32(1): 1-16.

Nahm, K. H. (2007). Feed formulations to reduce N excretion and ammonia emission form poultry manure. Bioresource Technology. 98: 2282±2300.

Namazu, L.B., Kobashigawua, E., Albuquerque, R., Schammass, E.A., Takeara, P. And Trindade Neto M.A. (2008). Digestible lysine and zinc chelate to male broiler: Performance in the pre-initial phase and nitrogen retention. Brazillian Journal of Animal Science. 37: 1634-1640.

Namroud, N.F., Shivazad, M. and Zaghari, M. (2008). Effects of fortifying low crude protein diet with crystalline amino acids on performance, blood ammonia level and excreta characteristics of broiler chicks. Poultry Science. 87: 2250-2258.

Nasr, J. and Kheiri, F. (2012). Effects of Lysine Levels of Diets Formulated Based on Total or Digestible Amino Acids on Broiler Carcass Composition. Brazilian Journal of Poultry Science. 14 (4): 233-304.

Nichols, N.L. and Bertolo, R.F. (2008). Luminal threonine concentration acutely affets intestinal mucosal protein and mucin synthesis in piglets. Journal of Nutrition. 138:1298-1303.

Normanno, G., La Salandra, G., Dambrosio, A., Quaglia, N.C., Corrente, M., Parisi, A., Santagada, G., Firinu, A., Crisetti, E. and Celano, G.V. (2007). Occurrence, characterization and antimicrobial resistance of enterotoxigenic Staphylococcus aureus isolated from meat and dairy products. International Journal of Food Microbiology. 115: 290-296.

Novak, C., Yakout, H. and Scheideler, S. (2004). The Combined Effects of Dietary Lysine and Total Sulfur Amino Acid Level on Egg Production Parameters and Egg Components in Dekalb Delta Laying Hens. Poultry Science. 83: 977±984.

Novak, C., Yakout, H.M. and Scheideler, S.E. (2006). 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. Poultry Science. 85: 2195-2206.

NRC. National Research Council. (1994). Nutrient requirements of poultry (9th ed.). NationalAcademy Press Washington, D. C.

NRCS. National Resources Conservation Service (2007). Manure Chemistry-Nitrogen, Phosphorus, and Carbon. Manure Management Information Sheet, 7: 1-4.

Nyachoti, C. M., Omogbenigun, F. O., Rademacher, M. and Blank, G. (2006). Performance responses and indicators of gastrointestinal health in early weaned pigs fed low protein amino acid supplemented diets. Journal Animal Science. 84: 125-134.

Ogunbode, S.M., Owoade, A.A. and Iyayi, E.A. (2014). Performance, Immune Response and Carcass Characteristics of Broilers Fed with Low Crude Protein and Ideal Methionine to Lysine Ratio Diets. American Journal of Experimental Agriculture. 4(10): 1165-1177.

Palliyeguru, M.W.C.D., Rose, S.P. and Mackenzie, A.M. (2010). Effect of dietary protein concentrates on the incidence of subclinical necrotic enteritis and growth performance of broiler chickens. Poultry Science. 89: 34±43.

Patterson, J.A. and Burkholder, K.M. (2003). Application of prebiotics and probiotics in poultry production. Poultry Science. 82: 627-631.

Penz, A. M. Jr. and Jensen, L.S. (1991). Influence of protein concentration, amino acid supplementation and daily time of access to high or low-protein diets on egg weight and components in laying hens. Poultry Science. 70: 2460±2466.

Perry, T.W., Cullison, A.E. and Lowrey, R.S. (2004). Feeds and Feeding. 6th Ed. Pearson Education, Inc. Upper Saddle River, New Jersey.

Plumstead, P. W., Romero-Sanchez, N. D., Paton, N. D., Spears, J. W. and Brake. J. (2007). Effects of dietary metabolizable energy and protein on early growth responses of broilers to dietary lysine. Poultry Science. 86: 2639-2648.

Pope, T. and Emmert, J.L. (2002). Impact of phase-feeding on the growth performance of broilers subjected to high environmental temperatures. Poultry Science. 81(4): 504-511.

Praes, M.F.F.M., Junqueira, O.M., Pereira, A.A., Filardi, R.S., Duarte, K.F., Sgavioli, S., Alva, J.C.R. and Domingues, C.H.F. (2014). High- fiber diets with reduced crude protein for commercial layers. Brazillian Journal of Poultry Science. 16(2):43-50.

Praharaj, N.K., Ramarao, S.V., Reddy, M.R., Shyamsunder G. and Reddy, B.L.N. (1998). Sire by protein interactions for growth, feed efficiency and immunoresposiveness in colored broilers. Indian Journal of Animal Sciences. í

Praharaj, N.K., Reddy, M.R., Panda, A.K., Rama Rao, S.V. and Sharma, R.P. (2002). Genotype by dietary interaction for growth and response to sheep red blood cells and Escherchia coli inoculation in commercial broiler chicks. Asian Australasian Journal of Animal Science. 5: 1170-1177.

Prochaska, J.F., Carey, J.B. and Shafer, D.J. (1996). The Effect of L-Lysine Intake on Egg Component Yield and Composition in Laying Hens1 Poultry Science 75:1268-1277.

Rao, R.S.V, Ravindran, V., Srilatha, T., Panda, A.K. and Raju, M.V.L.N. (2011). Effect of dietary concentrations of energy, crude protein, lysine and methionine on the performance of White leghorn layers in the tropics. Journal of Applied Poultry Research. 20: 528-541.

Rao, R.S.V, Kumari, K.N.R., Latha, T.S., Raju, M.L.N. and Panda, A.K. (2013). Influence of lysine levels on performance of layers with sub optimal protein in diet. International Journal of Food,Agriculture and Veterinary Sciences. 3(1): 17-25.

Riedijk, M. A., Stoll, B., Chacko,S., Schierbeek, H., Sunehag, A.L., Van Goudoever, J.B. and Burrin. D.G. (2007). Methionine transmethylation and transsulfuration in the piglet gastrointestinal tract. Proceedings of National Academy of Sciences. USA 104: 3408±3413.

Roberts, S.A., Xin, H., Kerr, B.J., Russell, J.R. and Bregendahl, K. (2007a). Effects of dietary fiber and reduced crude protein on nitrogen balance and egg production in laying hens. Poultry Science 86: 1716±1725.

Roberts, S.A., Xin, H., Kerr, B.J., Russell, J.R. and Bregendahl, K. (2007b). Effects of dietary fiber and reduced crude protein on ammonia emission from laying-hen manure. Poultry Science. 86: 1625±1632.

Rocha, T. C., Gomes, P. C., Donzele, J. L.,Barreto, S.L.T., Mello, H.H.C. and Brumano, G. (2009). Digestible lysine levels in feed for 24 to 40-week old laying hens. Brazillian Journal of Animal Science. 38(9): 1726-1731.

Rostagno, H. S. (2005). Brazilian tables for poultry and swine. Composition of feedstuffs and nutritional requirements. 2nd edition. Department of Animal Science, Federal University of Vicosa, Brazil.

Rutz, F. (2002). Proteínas: digestão e absorção. In: Macari M, Furlan RL, Gonzales E. Avian Physiology. 2nd edition. Jaboticabal: FUNEP. 135-141.

Sa, L.M., Gomes, P.C.G., RostDJQR +6 6DELQR $7 DQG '$RVWLQL Nutritional requirement of lysine for laying hens in the period from 34 to 50 weeks old. Brazillian Journal of Animal Science. 36(6): 1829-1836.

Saki, A.A., Harsini, N.R., Tabatabaei, M.M., Zamani, P. and Haghight, M. (2012). Estimates of methionine and sulfur amino acid requirements for laying hens using different models. Brazilian Journal of Poultry Science. 14(3): 159-232

Samanya, M. and Yamauchi, K. (2002). Histological alterations of intestinal villi in chickens fed dried Bacillus subtilis var. natto. Comparative Biochemistry an Physiology Part A. 133: 95-104.

Shakouri, M.D., Iji, P.A., Mikkelsen, L.L. and Cowieson, A.J. (2009). Intestinal function and gut microflora of broiler chickens as influenced by cereal grains and microbialenzyme supplementation. Journal of Animal Physiology and Animal Nutrition. 93: 647 ± 658.

Shen, Y. B., Weaver, A.C. and Kim, S.W. (2014). Effect of feed grade l-methionine on growth performance and gut health in nursery pigs compared with conventional dl-methionine. Journal of Animal Science. 92: 5530±5539.

Shini, S., Li, X and Bryden, W.L. 2005. Methionine requirement and cell-mediated immunity in chicks. British Journal of Nutrition. 94: 746-752.

Shirpoor, A., Ilkhanizadeh, B., Saadatian, R., Darvari, B.S., Behtaj, F., Karimipour, M., Ghaderi- Pakdel, F. and Saboori, E. (2006). Effect of vitamin E on diabetes-induced changes in small intestine and plasma antioxidant capacity in rat. Journal of Physiology and Biochemistry. 62: 171-177.

Shoveller, A. K., Brunton, J.A., House, J.D., Pencharz, P.B. and Ball, R.O. (2003). Dietary cysteine reduces the methionine requirement by an equal proportion in both parenterally and enterally fed piglets. Journal of Nutrition. 133: 4215±4224.

Si, J., Fritts, C.A., Burnham, D.J. and Waldroup, P.W. (2001). Relationship of Dietary Lysine Level to the Concentration of All Essential Amino Acids in Broiler Diets. Journal of Applied Poultry Research. 80: 1472-1479.

Silva, J.H.V., Mukami, F., Albino, L.F.T. (2000). Use of Digestible Amino Acids Based Diets for Laying Hens. Brazillian Journal of Animal Science. 29(5): 1446-1451.

Silva, E.L., Silva, J.H.V., Jordao F,J., Ribeiro, M.L., Martins, T.D.D. and Costa, F.G.P. (2006). Decreasing dietary levels of crude protein and supplementation of methionine and lysine for light laying hens. Brazillian Journal of Animal Science. 35(2): 491-496.

Sklan, D. and Plavnik, I. (2002). Interactions between dietary crude protein and essential amino acid intake on performance in broilers. British Poultry Science. 43(3): 442-449.

Sohail, S.S., Bryant, M.M. and Roland Sr, D.A.(2003). Influence of Dietary Fat on Economic Returns of Commercial Leghorns. The Journal of Applied Poultry Research. 12(3): 356-361.

Spring, P., Wenk, C., Dawson, K.A. and Newman, K.E. (2000). The effects of dietary mannaoligosaccharides on cecal parameters and the concentrations of enteric bacteria in the ceca of salmonella challenged broiler chicks. Poultry Science. 79: 205-211.

Sritiawthai, E., Sakulthai, S., Sakdee, J., Bunchasak, C., Kaewtapee, C. and Poeikhampha,T. (2013). Effect of Protein level and Dietary Energy on Production, Intestinal Morphology and Carcass Yield of Meat Duck during Starter Phase of 14 days. Journal of Applied Sciences, 13: 315-320.

Sterling, K.G., Vedenov, D.V, Pesti, G.M. and Bakalli, R.I. (2005). Economically optimal dietary crude protein and lysine levels for starting broiler chicks. Poultry Science. 84: 29-36.

Tabeidian, A., Sadeghi, G. H. and Pourreza J. (2005). Effect of Dietary Protein Levels and Soybean Oil Supplementation on Broiler Performance. International Journal of Poultry Science 4 (10): 799-803.

Torki, M., Mohebbifar, A., Ghasemi, H. A. and Zardast, A. (2014). Response of laying hens to feeding low-protein amino acid-supplemented diets under high ambient temperature: performance, egg quality, leukocyte profile, blood lipids, and excreta pH. International Journal of Biometeorology. 59(5): 575-584.

Trindade Neto, M.A., Pacheco, B.H.C., Albuquerque, R., Schammass, E.A. And Rodriguez-Lecompte, J.C. (2011). Dietary effects of chelated zinc supplementation and lysine levels in ISA Brown laying hens on early and late performance and egg quality. Poultry Science. 90: 2837-2844.

Ushijima T. and Seto A. (1991). Selected faecal bacteria and nutrioents essential for antagonism of Salmonella typhimurium in anaerobic continuous flow cultures. Journal of Medical Microbiology. 35: 111-117.

Van Nevel, C.J., Decuypere, J.A., Dieric, N.A. and Moll, K. (2005). Incorporation of galactomannans in the diet of newly weaned piglets: Effect on bacteriological and some morphological characteristics of the small intestine. Archives of Animal Nutrition. 59: 123±138.

Waguspack, A. M., Powell, S., Bidner, T.D, Payne, R.L. and Southern, L.L (2009). Effect of incremental levels of L-lysine and determination of the limiting amino acids in low crude protein corn-soybean meal diets for broilers. Poultry Science. 88: 1216-1226.

Waldroup, P.W., Jiang, Q. and Fritts, C.A. (2005). Effects of supplementing broiler diets low in crude protein with essential and nonessential amino acids. International Journal of Poultry Science. 4(6): 425-431.

Wang, W. W., Qiao, S.Y. And Li, D.F. (2009). Amino acids and gut function. Amino Acids. 37: 105±110.

White, L.A., Newman, M.C., Cromwell, G.L. and Lindemann, M.D. (2001). Brewers dried yeast as a source of mannanoligosaccharides for weanling pigs. Journal of Animal Science. 80(10): 2619-2628.

Wu, G., Bryant, M.M., Gunawardana, P. and Roland, D.A. (2007). Effect of nutrient density on performance, egg components, egg solids, egg quality, and profits in eight commercial leghorn strains during phase one. Poultry Science. 86: 691±697.

Wu, G., Liu, Z., Bryant, M.M. and Roland, Sr. D.A. (2005). Performance comparison and nutritional requirements of five commercial layers strains in phase IV. International Journal of Poultry Science. 4: 182-186

Xu, Z.R., Wang, M.Q., Mao, H.X., Zhan, X.A. and Hu, C.H. (2003). Effects of L-Carnitine on Growth Performance, Carcass Composition, and Metabolism of Lipids in Male Broilers. Poultry Science. 82: 408-413.

Xu, F.Z., Li, L.M., Liu, H.J., Zhan, K., Qian, K., Wu, D. and Ding, X.L. (2012). Effects of fermented soybean meal on performance, serum biochemical parameters and intestinal morphology of laying hens. Journal of Animal and Veterinary Advances. 11(5): 649-654.

Yakout, H.M (2010). Effects of reducing dietary crude protein with amino acids supplementation on performance of commercial white leghorn layers during late production period. Egypt Poultry Science. 30(4): 975-988.

Yamane, H., Kurauchi, I., Denbow, D.M. and Furuse, M. (2009). Central functions of amino acids for the stress response in chicks. Asian Australasian Journal of Animal Science. 22(2): 296-304.

Yasmeen, F., Mahmood, S., Hassan, M., Akhtar, N., and Yaseen, M. (2008). Comparative productive performance and egg characteristics of pullets and spent layers. Pakistan Veterinary Journal. 28(1): 5-8.

Yegani, M. and Korver, D.R. (2008). Factors affecting intestinal health in poultry. Poultry Science. 87: 2052-2053

Younis. D.T. (2014). Effect of sorghum and methionine supplementation in productive performance and the quality of hatching eggs of two quail strains. The Iraqi Journal of Veterinary Medicine. 38(2): 22-27.

Yuan, J., Karimi, A., Zornes, S., Goodgame, S., Mussini F., Lu C. And Waldroup, P. W. (2012). Evaluation of the role of glycine in low-protein amino acid-supplemented diets. Journal of Applied Poultry Research. 21: 726±737.

Zeweil, H.S., Abdalah, A.A., Ahmed, M.H., Marwa, R.S. and Ahmed. (2011). Effect of different level of proteins and methionine on performance of Baheij laying hens and environmental pollution. Egypt Poultry Science. 31(2): 621-639.

Zou, S.G. and Wu, Y.Z. (2005). Effects of Protein and Supplemental Fat on Performance of Laying Hens. International Journal of Poultry Science. 4(12): 986-989.

Zulkifli, I., Abdullah, N., Azrin, M.N. and Ho, Y.W. (2000). Growth performance and immune response of two commercial broiler strains fed diets containing Lactobacillus culture and oxytetracycline under heat stress condition. British Poultry Science. 41: 593-597.