Acta agriculturae Slovenica, suplement 2 (september 2008), 107–115.

http://aas.bf.uni-lj.si

Agris category codes: L02 COBISS Code 1.08

EFFECT OF DIETARY PROTEIN/ENERGY COMBINATIONS ON MALE BROILER BREEDER PERFORMANCE

Zvonimir STEINER, Matija DOMAĆINOVIĆ, Zvonko ANTUNOVIĆ, Zdenko STEINER, Đuro SENČIĆ, Jasenka WAGNER and Darko KIŠ

Faculty of agriculture, Trg sv. Trojstva 3, HR-31000 Osijek, Croatia, e-mail: zsteiner@pfos.hr

ABSTRACT

A study was conducted to evaluate the effect of crude protein level and low energy supply on broiler production parameters. Three hundred Ross 308-day-old male broiler chicks were divided in three basic groups and placed in three separate pens littered with wood shavings. Treatments consisted of a control diet (220 g/kg CP), the second diet with a crude protein diet (205 g/kg CP), and the third one with a crude protein diet (190 g/kg CP) with the same ratio 1: 573–575 KJ/kg crude protein and ME in starter (first 21 days). Finisher (22 day till end) control diet consisted of 200 g/kg CP, the second diet consisted of 185 g/kg CP, and the third one of 170 g/kg CP, with the ratio 1: 649–650 KJ/kg crude protein and ME. Feed intake tended to decrease with increasing the crude protein and energy. Feed conversion (g gain per g feed) improved as crude protein and energy increased. Muscle amount in groups K and P_1 was statistically much higher ($P < 0.01$) than in group P_2. Concentration of biochemical indicators showed less organism strain in groups fed on blends with less crude protein and energy.

Key words: poultry / broilers / animal nutrition / energy / proteins

VPLIV RAZMERJA MED BELJAKOVINAMI IN ENERGIJO V KRMI NA PROIZVODNE LASTNOSTI OČETOV PITOVNIH PIŠČANCEV

IZVLEČEK

V pričujoči študiji smo želeli oceniti vpliv ravni surovih beljakovin in zmanjšane preskrbe z energijo na proizvodne lastnosti pitovnih piščancev. Tristo dan starih petelinčkov (očetov pitovnih piščancev) provenience Ross 308 smo razdelili v tri osnovne skupine in jih namestili v tri ločene kletke z nastilom iz lesnih oblancev. V prvih 21 dnevih smo jih krmili s tremi krmnimi mešanicami: kontrola (K) je vsebovala 220 g/kg SB, druga mešanica (P_1) 205 g/kg SB in tretja (P_2) 190 g/kg SB v enakem razmerju surovih beljakovin in PE v krmi (1 %: 573–575 KJ/kg). Od 21. dneva starosti dalje so piščanci v kontrolni skupini dobivali 200 g/kg SB, v drugi skupini 185 g/kg SB in v tretji 170 g/kg SB v razmerju surovih beljakovin in PE 1 % : 649–650 KJ/kg. Količina zaužite krme se je zmanjševala s povečano vsebnostjo surovih beljakovin in energije v krmi. Konverzija krme (g prirasta na g krme) se je izboljšala s povečano vsebnostjo surovih beljakovin in energije. Količina mišic v skupinah K in P_1 je bila statistično precej večja ($P < 0,01$) kot v skupini P_2. Biokemijski kazalci so bili nižji v skupini, krmljeni z mešanico z manj surovimi beljakovinami in energije.

Ključne besede: perutnina / pitovni piščanci / prehrana živali / energija / beljakovine

INTRODUCTION

The improvement of poultry production highly depends on synergy between science and practice. By use of modern technology, genetics, microbiology, informatics and nutrition knowledge, production of fattening chicken highly increased in the whole world in last 30 years,

with significant changes on quantity of food needed for 1kg of weight gain and necessary time for achieving desired body mass.

Poultry feeding is, by biology and ecology means, very important factor in poultry production. The heart of the matter of feeding is to satisfy vital and productive needs of an animal by giving all nutritive and biology worth substances and putting them in organism.

Determination of the required amount of energy and protein in feedstuff is probably the most important decision to be made when it comes to feed formulation for broiler breeders. Energy itself comprises 70% of the total cost of feed.

The right relation between nutrients in fodder mixture requests good knowledge of needed concentrations of energy and proteins, amino acids, minerals and vitamins. In chicken production, it is very important to evaluate the ratio between raw protein level and metabolic energy level in fodder mixtures. The recommendation is that the ratio between raw proteins (%) and metabolic energy (KJ) is from 1:570 in starter mixture to 1:649 in finisher. Today's trend is to reduce protein and energy in feedstuff and on the other side to maintain an appropriate level of amino acids in order to optimize the performance. When it comes to a rational use of protein from feed it is good to know that animal organisms do not use protein but amino acids. The aim of this research project is to determine the influence of different nutritive values, crude protein and metabolic energy, on broiler breeding.

MATERIALS AND METHODS

Biological research on broiler breeders was performed on a specialized broiler farm. Ross 308 broiler breeders were researched. During the research we acted according to the Animal Welfare Law.

The research included 300 one-day old male ROSS – 308 broiler breeders. Each broiler breeder was weighed and they were divided into three groups. Each group consisted of 100 broilers. The ratio of crude protein (in %) and metabolic energy (kJ) in starter and finisher feed was 1:573 and 1:650, respectively.

Table 1. Scheme of research

Groups	K	P_1	P_2
Crude protein, %	22.06/20.0	20.5/18.5	19/17
MJ/kg ME	12.64/12.98	11.76/12.03	10.92/11.05
Ratio of crude protein and metabolic energy (KJ), (1:X)	573/649	574/650	575/650
Weigh-days	1^{st}, 7^{th}, 14^{th}, 21^{st}, 28^{th}, 35^{th} and 42^{nd} day	1^{st}, 7^{th}, 14^{th}, 21^{st}, 28^{th}, 35^{th} and 42^{nd} day	1^{st}, 7^{th}, 14^{th}, 21^{st}, 28^{th}, 35^{th} and 42^{nd} day
Blood sampling	35^{th} day	35^{th} day	35^{th} day

Each broiler chick was weighed, labeled and placed in ground departments on a litter of wood shavings. The broilers ate and drank as much as they wanted. Microclimatic conditions (light, temperature, and air circulation) were regulated automatically according to the recognized technological parameters.

The feed formulation was determined by linear optimization programming, based on the chemical composition and nutritive quality of the feed. The chemical composition of the feed was determined by acknowledged chemical procedures in a chemical laboratory. The metabolizable energy of the diets was calculated according to NRC 1994.

In our experiments we used the VAM PT (0.5%) premix.

Table 2. Composition of feedstuff

Feeds	Broiler breeder groups					
	Starter feed			Finisher feed		
	K	P_1	P_2	K	P_1	P_2
Maize grain	51.11	49.60	37.00	51.20	53.00	47.13
Broken wheat	0.80	4.50	11.73	2.60	5.30	8.00
Wheat bran	0.00	5.75	17.00	0.00	4.30	16.86
Soybean cake	24.00	22.50	17.12	18.60	15.80	15.50
Yeast	3.00	4.00	4.00	4.00	4.00	3.00
Fish meal	4.00	2.00	0.00	1.00	0.00	0.00
Full fat soybean	11.38	7.30	9.07	15.60	13.27	5.50
Animal fat	2.20	0.50	0.00	3.00	0.00	0.00
Phosphonal	0.90	1.00	1.00	1.20	1.40	1.00
Limestone	1.70	1.95	2.20	1.90	2.05	2.05
Salt	0.30	0.30	0.30	0.30	0.30	0.30
VAM(premix)	0.50	0.50	0.50	0.50	0.50	0.50
Meth + Cyst	0.11	0.10	0.08	0.10	0.08	0.06
Total:	100.00	100.00	100.00	100.00	100.00	100.00
Chemical composition						
Crude proteins, %	22.07	20.51	19.04	20.02	18.54	17.09
ME, MJ/kg	12.64	11.77	10.91	12.98	12.02	11.13
Lysine, %	1.35	1.2	1.06	1.21	1.07	1.01
Meth + cyst, %	0.84	0.78	0.72	0.78	0.72	0.66
Trypthophan, %	0.26	0.25	0.25	0.25	0.23	0.22
Ca, %	0.97	0.96	0.95	0.89	0.88	0.88
P, %	0.68	0.68	0.69	0.64	0.67	0.66
Ratio of crude protein, % : ME, KJ	1:573	1:574	1:573	1:648	1:649	1:651

The contents of individual nutrients were subject to standard chemical methods. Crude protein was determined on the basis of Kjedahl method, in which case the researched samples were extracted by ethyl ether during a six-hour period. The content of raw fibers was determined on the basis of Henneberg & Stochmann method.

Ash content was determined by burning the samples in a muffle furnace at 550 °C during a two-hour period.

Raw fats were determined by extraction of the analyzed samples by ether on the basis of Soxhleth method.

Water content was determined by drying the samples to a constant mass in a dryer at 105 °C during a one-hour period.

Non-nitrogen extractive matters (NET) were determined by calculation on the basis of the following pattern: NET = dry matter – (crude protein + raw fats + raw fibres + raw ash).

The following production factors subject to the experiment were observed: body weight of broilers, which was individually measured on a seven-day basis as well as the feed consumption, which was determined for the same period. Based on these data the average daily body weight gain was determined as well as the daily feed consumption and conversion (kg/kg) of feed for the breeding weeks as well as the total amount.

Health condition of the broiler chicks was controlled by a veterinary service. A special attention was paid to a possible occurrence of diarrhea or other gastrointestinal complications due to switching from starter to grower feed, and every possible complication was recorded. Every dead chick was examined by the farm veterinary service and a diagnosis was determined.

Blood sampling was done when the broilers were 35 days of age. Ten broilers were randomly selected from each of the three groups. Blood samples were obtained by wing vein punction. The needle was directly inserted and it was connected to a vacuum test tube. Blood serum samples were taken to the Medical-biochemical laboratory of the Clinical Hospital in Osijek. They were held for 20 minutes in a water bath at 37 °C in order to separate the serum from other blood cells. After that the serum was separated in a centrifuge for 10 minutes at 3 000 rotations per minute. The serum was placed in an Olimpus AU640 automatic analyzer. A statistic analysis of research results was performed on the basis of STATISTICA (StatSoft, Inc.2005) programme system. The differences among treatments were tested using Duncan's multiple range test.

RESULTS AND DISCUSSION

A comparison of male broilers divided into three groups showed (Table 3, Chart 1) that K group and P_1 group chicks gained a very significant mass ($P < 0.01$) from the point of view of statistics compared to P_2 group chicks. At the end of the fifth week a statistically important difference appeared ($P < 0.01$) among all the groups. Body weights were statistically very different for K and P_1 groups ($P < 0.01$) compared to P_2 group. The average daily gain was in accordance with body mass. Food conversion was the lowest in control group and increased with lowering of raw protein and metabolic energy levels. Mortality was lower in the P_2 group (6%), and increased in P_1 group (8%). The highest mortality was in control K group (12%).

Leeson *et al*. (1996) examined the influence of energy and protein and determined that male chicks can breed very well even when the energy level in feed is lower. Research investigation which involved the same issue had similar results as far as broiler breeding is concerned (Edmonds *et al*., 1985; Fancher and Jensen, 1989; Ferguson *et al*., 1998; Holsheimer and Janssen, 1991; Jensen, 1991; Pinchasov *et al*., 1990; Moran *et al*., 1995; Bregendahl *et al*., 2002). The differences of results in broiler breeding can be explained on the basis of the examined levels of crude protein and determination of different contents of amino acids needed. Similar results were achieved by Smith *et al*. (1998), Surisdiarto *et al*. (1991). They all came to the conclusion that the level of digestible protein in feed influences broilers' weight gain.

Solangi *et al*. (2003) studied the influence of different protein levels in feed on broiler breeding. A, B, C, and D groups were fed a feed with 17%, 20%, 23%, and 26% crude protein, respectively. On the basis of the collected data they concluded that there was a statistically significant link between body mass and the increasing levels of proteins in feed. Body mass for A, B, C, and D groups was 1 402; 1 639; 1 844.9; and 1 866.54 g, respectively.

Table 3. Body mass of male broiler breeders divided into three groups and fed feed blends with different contents of protein and energy

Periods of breeding	K	P_1	P_2
	Body mass, g		
1st week	$112^{A} \pm 19$	$116^{A} \pm 15$	$99^{B} \pm 10$
2nd week	$309^{A} \pm 48.6$	$306^{A} \pm 43$	$246^{B} \pm 36.3$
3rd week	$605^{A} \pm 87$	$585^{A} \pm 76$	$448^{B} \pm 78$
4th week	$934^{A} \pm 137$	$888^{A} \pm 143$	$683^{B} \pm 144$
5th week	$1\,376^{A} \pm 216$	$1\,272^{B} \pm 190$	$980^{C} \pm 190$
6th week	$1\,830^{A} \pm 289$	$1\,730^{A} \pm 264$	$1\,321^{B} \pm 258$
	Food conversion		
1–6 week	2.17	2.4	2.63

Different letters refer to statistically more significant differences among the groups; capital letters $P < 0.01$, lowercase letters $P < 0.05$

Alster *et al.* (1984) achieved similar results. They determined that a reduction of protein level in feed and a maintenance of the energy value result in a statistically higher weight gain ($P < 0.05$) of the group fed the feed with a higher protein level.

Protein or energy concentration increase in food causes a statistically significant increase of body mass (Pesti, 1983).

The results achieved by Bartov and Plavnik (1998) concern the influence of different protein and energy levels in broiler breeding feed, which had lower or identical ratios of energy and protein recommended by NRC (1994). The high-energy feed blend resulted in a higher body weight gain between the 7th and 28th day of breeding.

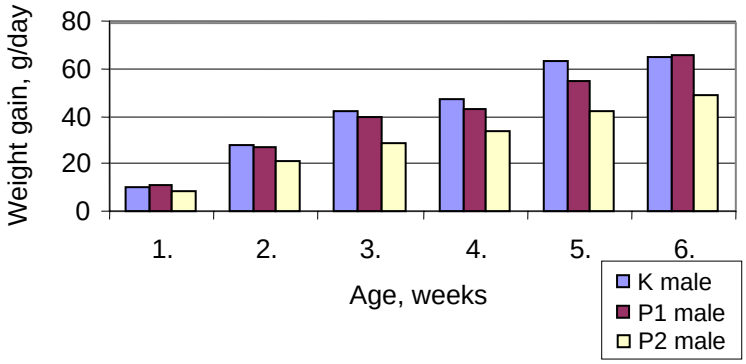

Figure 1. Daily weight gain of male broiler breeders divided into groups and fed feed blends with different protein and energy content.

Saleh (2004) studied energy influence on breeding characteristics of broiler chicks and determined that body weight increased significantly on 21st, 42nd, and 49th day of breeding ($P < 0.05$) in case of chicks bred up to the energy levels of 13.7% MJ/kg ME and 22.32% of crude proteins.

Kamran *et al.* (2008) examined effect of low protein-diets having constant energy-to-protein ratio. Weight gain was linearly decreased ($P < 0.001$), whereas feed intake and feed conversion

ratio were increased ($P < 0.001$) linearly as dietary protein and energy decreased during grower, finisher, and overall experimental periods

Table 4. Relative amounts (in %) of basic body parts of male broiler chicks in eviscerated carcasses, divided into groups and fed feeds with different protein and energy contents

Body parts	K	P1	P2
Breast, %	30.40 ± 2.35	32.41 ± 1.65	31.63 ± 1.98
Drumstick with thighs (whole chicken leg), %	28.88^{a} ± 1.46	30.97 ± 1.90	31.60^{b} ± 1.18
Wings, %	$12.38^{A,a}$ ± 0.33	11.06^{B} ± 0.82	$11.43^{B,b}$ ± 0.60
Back, %	24.06^{a} ± 1.87	20.93 ± 2.20	20.24^{b} ± 1.47
Neck, %	4.28 ± 0.55	4.61 ± 0.93	5.10 ± 0.79

Different letters refer to statistically more significant differences among the groups; capital letters $P < 0.01$, lowercase letters $P < 0.05$

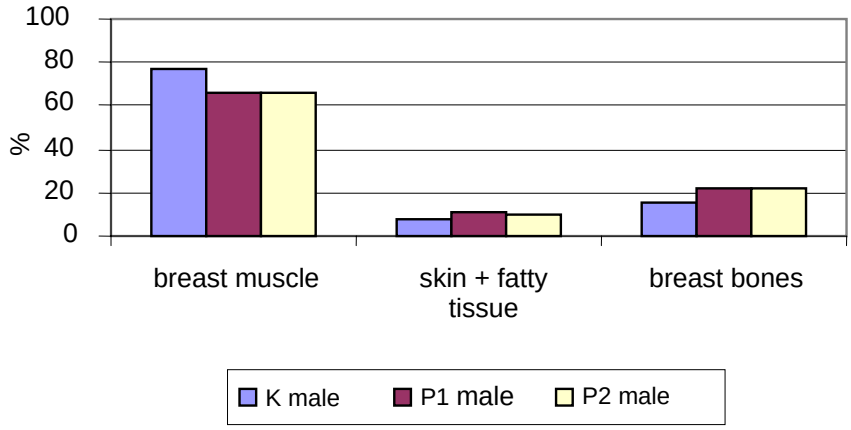

Figure 2. Relative amount of different tissue in the breast of the male broiler breeders divided into groups and fed feed blends with different protein and energy levels.

Fig. 2 and 3 present relative amounts of breast tissue and amounts of breast tissue in trunks. Muscle amount in groups K and P_1 was statistically much higher ($P < 0.01$) than in group P_2, which was fed the feed with the lowest energy and protein level. Relative amount of bones was statistically much higher ($P < 0.01$) in group P_2 compared to group K in breast and trunk. Similar results were achieved by Alleman *et al.* (2000). Group K had a statistically much lower ($P < 0.01$) amount of bones, in breast and trunk, compared to group P_1. Lowering the raw protein and metabolic energy level, among K and P groups, resulted in lower percentage of muscles in highly evaluated parts of body; breasts and legs, and entire body as well. Consistently with that, as a result of lowering percentage of muscles, relative shares of fat tissue under skin and bones have increased. Obtained results are consistent with those of Alleman *et al.* (2000) that showed the relation between raw proteins in fodder mixtures with breast muscles, meaning that as the protein quantity decreases in fodder mixture, share of breast muscles in body decreases as well. Kamran *et al.* (2008) examined effect of low protein-diets having constant energy-to-protein ratio. Carcass yield, breast meat yield, thigh yield, abdominal fat, and relative liver and heart weights were not affected by the treatments.

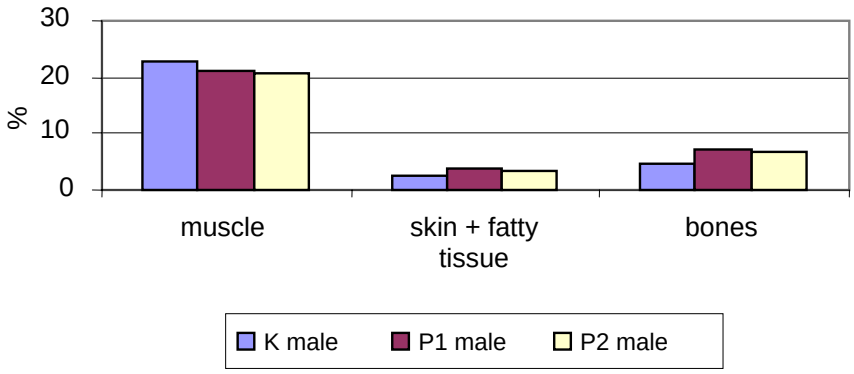

Figure 3. Relative amounts of breast tissue in the trunks of the male broiler breeders divided into groups and fed feed blends with different protein and energy levels.

Level of total protein, Fe and cholesterol was highest in control group, but there were no significant differences among the groups. However, biochemical indicators showed less organism strain in groups fed blends with less crude protein and energy.

Table 5. Biochemical indicators in the serum of broiler breeders aged 35 days and fed feeds with different levels of protein and energy

Groups	K	P_1	P_2	Reference values
Glucosis, mmol/L	12.53 ± 0.89	12.82 ± 0.86	12.72 ± 0.75	9.3 [1], (10.51–9.51) [2], (13.22) [3]
Urea, mmol/L	0.72 ± 0.1	0.65 ± 0.15	0.72 ± 0.33	
Total protein, g/L	31.0 ± 2.01	27.38 ± 1.88	28.20 ± 2.48	56 [1], (28.7–29.3) [2], (39–45) [3], (29.2) [4]
Fe, mmol/L	24.83 ± 5.41	17.25 ± 4.57	17.14 ± 2.66	
Cholesterol, mmol/L	3.62 ± 0.74	2.69 ± 0.75	2.94 ± 0.34	4.75 [1], (3.07–3.29) [2], (3.7) [4]

[1] Kaneko *et al.* (1997); [2] Krasnodebska-Depta and Koncicki (2000); [3] Peebles *et al.* (1996); [4] Basmacioglu *et al.* (2005);

Malheiros *et al.* (2003) did not notice that level of glucose significantly changed with chemical composition of fodders mixture, and that fact is in harmony with our research.

Rosebrough and Steele (1985) concluded that raising the protein share in meal led to raising the glucose concentration in blood.

Protein values were the highest in control group, although there were no statistically significant differences. Corzo (2005) got results harmonious to these. The highest Fe values were in group K. Fe in serum is bounded on protein named transferin, so better accessibility of proteins in group K probably resulted in higher Fe values in serum. Similar results got Rama Rao *et al.* (2006) that confirmed the relation between protein intake with food and biological measurements of Fe in blood. The higher protein content in fodder mixture in group K could ensure higher transferin synthesis.

CONCLUSIONS

The research results point to a different influence of energy and protein levels on the examined broiler breeders characteristics.

A better weight and mass gain were achieved in the groups fed the feed with a higher content of crude protein and energy.

Food conversion was the lowest in control group and increased with lowering of raw protein and metabolic energy levels.

Lowering the levels of raw proteins and metabolic energy, bellow recommended optimum, in fodder mixtures has an adverse effect on muscles share in highly evaluated parts of body.

Biochemical indicators showed less organism strain in groups fed blends with less crude protein and energy.

REFERENCES

Alleman F./ Michel J./ Chagneau AM./ Leclercq B. The effects of dietary protein independent of essential amino acids on growth and body composition in genetically lean and fat chickens. British Poultry Science, 41(2000)2: 214–218.

Alster, F.A. and CAREW, L.B. Energy balance and thyroid function in protein-deficient chicks. Nutrition Reports International 30 (1984): 1231–1240.

Basmacioglu, H./ Oguz, H./ Ergul, M./ Col, R./ Birdane, Y.O. Effect of dietary esterified glucomannan on performance, serum biochemistry and haematology in broilers exposed to aflatoxin. Czech J. Anim. Sci., 50(2005)1: 31–39.

Bartov, I./ Plavnik, I. Moderate excess of dietary protein increases breast meat yield of broiler chicks. Poult. Sci., 77(1998)5: 680–688.

Bregendahl, K./ Sell, J.L./ Zimmerman, D.R. Effect of low-protein diets on growth performance and body composition of broiler chicks. Poult. Sci., 81(2002)8: 1156–1167.

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

Edmonds, M.S./ Parsons, C.M./ Baker, D.H. Limiting amino acids in low-protein corn–soybean meal diets fed to growing chicks. Poult. Sci., 64(1985): 1519–1526.

Fancher, B.I./ Jensen, L.S. Influence on performance of three to six-week-old broilers of varying dietary protein contents with supplementation of essential amino acid requirements. Poult. Sci., 68(1989): 113–123.

Ferguson, N.S./ Gates, R.S./ Taraba, J.L./ Cantor, A.H./ Pescatore, A.J./ Ford, M.J./ Burnham, D.J. The effect of dietary crude protein on growth, ammonia concentration, and litter composition in broilers. Poult. Sci., 77(1998): 1481–1487.

Holsheimer, J.P./ Janssen, W.M. Limiting amino acids in low protein maize-soybean meal diets fed to broiler chicks from 3 to 7 weeks of age. British Poultry Science, 32(1991)1: 151–158.

Jensen, L.S. Broiler performance as affected by intact protein versus synthetic amino acids. In: Proceedings Georgia Nutrition Conference, Atlanta, GA, 1991, 83–89.

Kaneko, J.J./ Harvey, J.W./ Bruss, M.I. Clinical Biochemistry of Domestic Animals, 5th ed., Academic Press. San Diego, London, Boston, New York, Sydney, Tokyo, Toronto. 1997, pp. 900–901.

Kamran, Z./ Sarwar, M./ Nisa, M/ Nadeem; M. A./ Mahmood, S./ Babar, M. E./ Ahmed, S. Effect of Low-Protein Diets Having Constant Energy-to-Protein Ratio on Performance and Carcass Characteristics of Broiler Chickens from One to Thirty-Five Days of Age. Poult Sci 87(2008)3: 468–474.

Krasnodebska-Depta/ Koncicki, A. Physiological values of selected serum biochemical indicies in brioler chickens. Medycina Wet., 56(2000), 456–460.

Leeson, S./ Caston, L./ Summers, J.D. Broiler response to energy or energy and protein dilution in the finisher diet. Poultry Science, 75(1996)4: 522–528.

Moran, W.T. Body composition. In: Poultry production. World Animal Science C.9. (Ed.: Hunton, P.). Amsterdam, Elsevier, 1995: 139–156.

Malheiros R.D./ Moraes V.M.B./ Collin A./ Janssens G.P.J./ Decuypere E., Buyse J. Dietary macronutrients, endocrine functioning and intermediary metabolism in broiler chickens - Pair wise substitutions between protein, fat and carbohydrate. Nutrition research 23(2003)(4): 567–578.

National Research Council. Nutrient Requirements of Poultry. 9 rev. ed. Washington, DC, National Academy Press, 1994.

Peebles, E.D./ Cheaney, J.D./ Vaughn, K.M./ Latour, M.A./ Smith, T.W./ Haynes, R.L./ Boyle, C.R. Changes in gonadal weights, serum lipids and glucose during maturation in juvenile Northern Bobwhite quail (*Colinus virginarius*). Poultry Sci., 75(1996): 1411–1416.

Pesti, G.M./ Fletcher, D.L. The response of male broiler chickens to diets with various protein and energy contents during the growing phase. Br. Poult. Sci., 24(1983)1: 91–99.

Pinchasov, Y./ Mendonca, C.X./ Jensen, L.S. Broiler chick response to low protein diets supplemented with synthetic amino acids. Poult. Sci., 69(1990)11: 1950–1955.

Rama Rao SV./ Raju MV./ Panda A.K./ Reddy M.R. Sunflower seed meal as a substitute for soybean meal in commercial broiler chicken diets. Br Poult Sci. 47(2006)5: 592–8.

Rosebrought, R.W./ Steele, N.C. Energy and protein relations in the broiler. Effect of protein leveles and feeding regimes on growth, body composition and in vitro lipogenesis of broiler chicks. Poultry Sci., 64(1985), 119–124.

Saleh, E.A./ Watkins, S.E./ Waldroup, A.L./ Waldroup, P.W. Effect of Dietary Nutrient Densiti on performance and Carcass quality of Male Broilers Grown for Further Processing. International Journal of Poultry Science, 3(2004)1:1–10.

Smith, E.R./ Pesti, G.M./ Bakalli, R.I./ Ware, G.O./ Menten, J.F.M. Further studies on the influence of genotype and dietary protein on the performance of broilers. Poult. Sci., 77(1998): 1678–1687.

Solangi, A.A./ Baloch, G.M./ Wagan, P.K./ Chachar, B./ Memon, I.A. Effect of diferent levels of dietary protein on the growth of broiler. Journal of Animal and Veterinary Advances, 2(2003)5: 305–311.

STATISTICA - StatSoft, Inc. (data analysis software system), version 7,1 2005, www.statsoft.com

Surisdiarto/ Farrell, D.J. The relationship between dietary crude protein and dietary lysine requirement by broiler chicks on diets with and without the «ideal» amino acids balance. Poultry science, 70(1991)4: 830–836.