

The Influence of Feed Energy and Protein Level on Meat Quality at „Hubbard F15” Broiler Chickens

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Abstract

In this paper was studied the influence of feed energy-protein level on the carcasses characteristics (participation of the cut parts from the whole carcasses structure and meat/bone ratio) and meat chemical composition from different anatomical regions at broiler chickens belonging „Hubbard F15” hybrid, slaughtered at 42 days old. Broilers were divided in three groups: control group (Lc) and two experimental groups, which had received feed compound with different level of energy and protein (Lc-according standard; Lexp₁-higher by 10% and Lexp₂-lower by 10%). After slaughter, on each group were determined carcass characteristics, using gravimetric measurements and chemical composition of meat, using STAS methods. For participation quota of the cut parts from the whole carcasses structure were registered the highest values at Lexp₁ group for thighs and breast, and at the Lexp₂ group were the lowest values for these parts and the highest values for the other remaining parts from carcasses. The meat/bones ratio has registered values from 3.66/1, at Lexp₂ group up to 4.07/1, at Lexp₁ group. For chemical composition of meat, in the breast muscles was a greater amount of proteins, and the situation was reversed in the muscles of the thighs and drumsticks. Consequently, after chemical composition assessment in the studied muscles at Lexp₁ group was found the highest protein content and lowest lipids content, as compared with Lc and Lexp₂ groups. At the Lexp₁ group, feed with higher content protein and energy level have positively influenced participation quota of the cut parts in the whole carcasses structure (breast and thighs), the meat/bone ratio and the chemical composition of meat (proteins and lipids).

Keywords: broiler chicken, carcasses, chemical composition of meat, meat/bones ratio

1. Introduction

One of the most actual problems for human nutrition, discussed and studied in wide circles of contemporary society, is the problem of protein nutrition and especially the current deficiencies in providing the body with proteins [1]. Meat is a commodity product for human nutrition, which is obtain from various animals species.

From the nutritional standpoint, meat obtained from animals and poultry represent one of the very important foods for humans, because has an energetic and plastic role [2]. Poultry meat is a valuable source of proteins, minerals, vitamins and has low fat content and high proteins content [2]. Thus, the chemical composition of muscles from the major parts in the whole carcass structure is an important element of broiler meat quality [3, 4].

The chicken meat quality is dependent upon genetic and non genetic factors. [2, 5, 6]. Among non genetic factors that influencing the meat quality, the chickens alimentation has a very

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important role and can affect chemical composition of muscles from major parts of the carcass [7, 8].

Broiler chickens have specific nutritional requirements by that have possible to achieve the objectives of the growing and slaughtering [9, 10, 11, 12]. Recipes of compound feed must be balanced, so as to ensure an energy-protein ratio correlated with the development stages of offspring. Ensuring an appropriate program of feeding is necessary for obtain a maximum production potential [1, 11, 12]. Only an adequate feeding program can ensure maximum expression of genetic potential and achieving quality carcasses [5-7, 13-15].

A superior quality carcass is characterized by a maximum proportion of meat and minimum proportion of bones and fats, and rations with deficient in protein, although is not clearly reflected on growth performance have a negative impact on carcass meat percentage [10, 16-20].

The chemical composition of meat is greatly influenced by the rations used in feeding the broiler chickens [7, 10, 17, 21, 22]. The meat obtained from broilers specialized in this area is known for its sensory, technological, physical, chemical, nutritional and dietary qualities. The poultry meat is requested by consumers, because has special flavor characteristics, high nutritional value and high degree of digestibility.

Major chemical components (proteins, fats, minerals) are important indicators of meat quality [23-25]. Besides these qualities, poultry meat is occurs at lower cost as compared with meat from the other animal species domestic [4, 13, 14].

Since research on improving the growth performance of broiler chickens carried both in our country and abroad has followed primarily quantitative aspects of meat production, in this work was studied the effect of different levels of dietary protein and energy on carcass characteristics, and meat quality at „Hubbard F15” hybrid.

2. Materials and methods

The experiment was organized on broiler chickens of one day old, belonging to the commercial hybrid „Hubbard F15”. The experiment was terminated when broiler chickens were at the age

of 42 days. For this study, broiler chickens were divided into three groups (male and female chickens in equal ratio), control group (Lc) and two experimental group (Lexp₁ and Lexp₂), reared in the same microclimate conditions.

In the growth period (1-42 days) for microclimate factors of the house (air temperature and air relative humidity), the values have been according to the manual „Hubbard F15” hybrid [26]. The growth system was on the permanent litter, with a density of 12 chicks/m² and ad libitum feeding.

At the three groups of chickens was given feed mixed with different protein and energy levels as follows: Lc-protein and energy level was in accordance with „Hubbard” company recommendation for the „Hubbard F15” hybrid [26]; at Lexp₁ protein and energy levels were higher with 10% and at Lexp₂ protein and energy levels were lower with 10%. Depending on chickens age in growing period (one day-42 days) for each group were given three recipes compound feed, ad libitum: the starter up to 14th day, the grower from 15th to 35th day and the finisher from 36th to 42th day (Table 1).

After the slaughter, from each group were sampled 30 carcasses (15 carcasses for each sex), which were weighed and were cut into pieces. Using gravimetric measurements was determined weight of the cut parts from the carcass. With this data was calculated the participation quota of the cut parts in the whole carcasses structure. The cut parts in the carcass were: breast with bone and skin, thighs, drumsticks, wings and carcass remnants (head, neck, back and legs). The participation quota of the cut parts is ratio between weight for each part from carcass and carcass weight, percent expressed.

From each group were sampled 10 carcasses (five carcasses for each sex) and was determined the chemical composition of meat (water, dry matter, proteins, lipids and minerals) for three anatomical regions (breast, thighs and drumsticks).

Methods of analysis used to determine the chemical composition of the meat were: drying method for dry matter determination (Standard ISO 1442/1997); calcinations method for determination of totals minerals (Standard ISO 936/1998); Soxhlet method on modern appliances-Soxtest Raypa PG-16 E01 to determine the amount of lipids (Standard ISO 1443/2008); Kjeldahl method adapted on appliances FOSS

TECATOR to determine protein substances (Standard ISO 937/2007) [25].

Raw data obtained from measurements were processed using methods of biostatistics with Microsoft Excel spreadsheet application. To test

the statistical significance of differences between mean values of the characters studied has been applied analysis of variance using Mann Whitney test using the program MINITAB 14 [27].

Table 1. Features of feed compound recipes for chickens

Growth period	Recipe features	Chicken groups		
		Lc	Lexp ₁	Lexp ₂
Starter 1-14 days	Crude protein (%)	23.80	26.18	21.40
	M. E. (kcal/kg feed)	3036	3281	2839
	Energy/protein ratio	127.56	125.32	132.62
Grower 15-35 days	Crude protein (%)	21.86	24.03	19.72
	M. E. (kcal/kg feed)	3142	3439	2861
	Energy/protein ratio	143.73	143.11	145.08
Finisher 36-42 days	Crude protein (%)	20.18	22.27	18.21
	M. E. (kcal/kg feed)	3196	3483	2877
	Energy/protein ratio	158.37	156.47	157.99

3. Results and discussion

The values related to the participation quota of the cut parts in the whole carcasses structure, are presented in table 2.

For the breast with bone and skin were values from 26.42%, for chickens from Lexp₂ group, at 27.49%, for chickens from Lc group up to 28.66%, at chickens from Lexp₁ group. Analysis of variance revealed the presence of statistical differences for p≤0.05 or p≤0.001, between average values obtained at studied groups.

Table 2. Participation quota of the cut parts in the whole carcasses structure

Specification	Lc (n=30)		Lexp ₁ (n=30)		Lexp ₂ (n=30)	
	$\bar{x} \pm S\bar{x}$ (%)	V%	$\bar{x} \pm S\bar{x}$ (%)	V%	$\bar{x} \pm S\bar{x}$ (%)	V%
Breast with bone and skin	^{ad} 27.49±0.49	9.86	^a 28.66±0.42	8.01	^d 26.42±0.47	9.69
Thighs	^a 15.50±0.29	8.32	^a 15.76±0.22	7.55	^d 14.85±0.24	8.89
Drumsticks	^c 12.01±0.19	8.75	^d 11.76±0.19	8.76	^a 12.24±0.17	7.60
Wings	^a 10.85±0.24	12.35	^{bd} 10.44±0.20	10.64	^a 10.99±0.25	12.56
Back, head, neck and legs	^{ad} 34.16±0.57	9.19	^{bd} 33.39±0.63	10.39	^a 35.50±0.59	9.13

Mann Whitney-test: ^{ab}significant differences p≤0.05; ^{ac} distinguished significant differences p≤0.01; ^{ad}high significant differences p≤0.001; n-Carcass number; \bar{x} -Mean; $\pm S\bar{x}$ -Standard error; V%-Coefficient of variation

For thighs, were obtained the lowest values at chickens from Lexp₂ group (14.85%), the highest values at chickens from Lexp₁ group (15.76%) and intermediary values at chickens from Lc group (15.50%). The coefficient of variation, with values up to 8.89%, revealed very good uniformity for the three chicken groups studied. Analysis of variance revealed the presence of high significant

differences (p≤0.001), between average values obtained of chickens from Lc and Lexp₁, compared with Lexp₂, but not revealed statistical differences between Lc and Lexp₁.

The drumsticks, had registered highest values at chickens from Lexp₂ group (12.24%) and lowest values at chickens from Lexp₁ group (11.71%), with a good uniformity for this characteristic

(V%=7.60 up to 8.76%). High significant differences ($p \leq 0.001$) were revealed between average values obtained at Lexp₂ with Lexp₁ and distinguished significant differences ($p \leq 0.01$) between average values registered at Lexp₂ and Lc.

The participation quota of the wings in the whole carcasses structure has registered values from 10.44%, at chickens from Lexp₁ group up to 10.99%, at chickens from Lexp₂ group. After apply the test of variance analysis were present various stages of statistical significance ($p \leq 0.05$, between Lc and Lexp₁, or $p \leq 0.001$ between Lexp₂ and Lexp₁).

For other components in the carcass (head, neck, back and legs), the participation quota had the highest values in chickens from Lexp₂ group and the lowest values in Lexp₁ group. The test of variance analysis revealed presence of statistical differences between: Lc with Lexp₁ ($p \leq 0.05$), Lc with Lexp₂ ($p \leq 0.001$) and Lexp₁ with Lexp₂ ($p \leq 0.001$).

If we compared the two experimental groups (Lexp₂ and Lexp₁) with the control group (Lc), in terms of participation quota of cut parts in the whole carcasses structure was observed that there are differences in both plus and minus. At the Lexp₁ group, were recorded the highest values for breast and thighs, followed, in descending order, by Lc and Lexp₂, and the lowest values were obtained for other pieces (wings, drumsticks and remnants of carcass), followed, in ascending order, the Lc and Lexp₂.

For the participation quota of the cut pieces, the different levels of dietary protein and energy, had determined statistical differences between chickens from Lc group with Lexp₁ group for breast, wings and of carcass remnants; the Lexp₁ group with Lexp₂ group (for all cut pieces) and the Lc group with Lexp₂ group (breast, thighs, wings and remnants of carcass).

To better expressed the carcass quality and meat production, after deboning was calculated the ratio meat/bones for the whole carcass, and the values obtained are presented in Table 3.

Table 3. Meat/bones ratio

Specification	Lc (n=10)	Lexp ₁ (n=10)	Lexp ₂ (n=10)
	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$ (%)
¹ Carcass (g)	^{ab} 1507.99±27.07	^a 1630.71±39.48	^{cd} 1350.10±32.82
V%	5.68	7.66	7.69
² Carcass deboned (g)	^{ac} 1190.71±20.56	^a 1307.73±28.75	^{cd} 1059.90±26.05
V%	5.46	6.95	7.77
Bones in carcass (g)	317.28±7.79	322.98±11.35	290.20±8.37
V%	7.77	11.12	9.06
Meat/bone ratio	^c 3.76/1±0.06	^a 4.07/1±0.08	^d 3.66/1±0.05
V%	4.84	6.21	4.65

Mann Whitney-test: ^{ab}significant differences $p \leq 0.05$; ^{ac} distinguished significant differences $p \leq 0.01$; ^{ad}high significant differences $p \leq 0.001$; ¹Carcass weight without head, neck and legs; ²Carcass deboned with skin; n-Carcass number; \bar{x} -Mean; $S\bar{x}$ - Standard error; V%-Coefficient of variation

Meat quantity in carcass was influenced by the protein and energy level of the compound feed. Thus, at Lexp₁ group, were found the highest values (1307.73±28.75 g), followed, in descending order by Lc group (1190.71±20.56 g) and Lexp₂ group (1059.90±26.05 g). The coefficient of variation had low values (from 6.95 up to 7.77%) and revealed very good uniformity for carcasses studied, and the differences between the studied

groups had different degrees of statistical significance ($p \leq 0.01$ or $p \leq 0.001$).

At Lexp₃ group, administration of combined fodder with lower protein and energy level has negatively influenced the meat quantity from carcass, but situation was reversed for Lexp₁ group. For Lc group were obtained satisfactory values, with differences vs. Lexp₁ group and Lexp₂ group (-9.83%, respectively of +10.99%).

Average values for the meat/bones ratio ranged between 3.66/1±0.05 (Lexp₂) up to 4.07/1±0.08 (Lexp₁), with a very good uniformity (V%<6.21%), and in statistically terms, with differences between Lexp₁ group vs. Lc group (p≤0.01) and Lexp₁ group vs. Lexp₂ group (p≤0.001).

At Lexp₁ group, administration of combined fodder with higher protein and energy level has positively influenced the meat/bone ratio at the

whole carcasses, but for Lc group and especially at Lexp₂ group the situation was reversed.

The values obtained in this study are consistent with other results obtained in scientific works [10, 28].

Data related to meat chemical composition in the samples taken from breast, thighs and drumsticks are presented in Table 4.

Table 4. Chemical composition of meat

Specification	Lc (n=10)		Lexp ₁ (n=10)		Lexp ₂ (n=10)		
	$\bar{x} \pm S\bar{x}$ (%)	V%	$\bar{x} \pm S\bar{x}$ (%)	V%	$\bar{x} \pm S\bar{x}$ (%)	V%	
Breast	Water	^{ad} 73.69±0.41	1.75	^{cd} 73.24±0.72	3.11	^a 74.58±0.78	3.33
	Dry matter	^{ac} 26.31±0.09	1.09	^a 26.76±0.09	1.05	^d 25.42±0.15	1.90
	Proteins	^{ad} 23.14±0.11	1.50	^a 24.04±0.13	1.26	^d 21.82±0.25	3.56
	Lipids	^{ac} 1.78±0.10	17.17	^{cd} 1.27±0.06	15.81	^a 2.28±0.11	15.17
	Ash	1.17±0.06	11.05	1.19±0.06	10.69	1.16±0.06	10.76
Thighs	Water	72.31±0.49	2.16	72.32±0.47	2.05	71.39±0.80	3.54
	Dry matter	27.69±0.49	5.65	27.68±0.47	5.35	28.61±0.80	8.83
	Proteins	18.05±0.39	6.88	^a 18.91±0.50	8.36	^b 17.55±0.53	9.55
	Lipids	^{ab} 8.33±0.23	8.58	^{bd} 7.48±0.18	7.76	^a 9.66±0.37	12.24
	Ash	0.95±0.01	4.60	0.97±0.02	7.13	0.92±0.02	6.07
Drumsticks	Water	71.57±0.37	1.63	71.64±0.52	2.29	71.97±0.47	2.06
	Dry matter	28.43±0.37	4.11	28.36±0.52	5.79	28.03±0.47	5.30
	Proteins	^a 20.02±0.39	6.10	^a 21.20±0.41	6.07	^{cd} 18.74±0.35	5.96
	Lipids	^{ab} 7.08±0.22	9.73	^d 5.76±0.29	15.95	^a 7.82±0.28	11.41
	Ash	1.03±0.03	8.89	1.07±0.03	8.36	1.00±0.02	6.65

Mann Whitney-test: ^{ab} significant differences p≤0.05; ^{ac} distinguished significant differences p≤0.01; ^{ad}high significant differences p≤0.001; n-Carcass number; \bar{x} -Mean; S \bar{x} - Standard error; V%-Coefficient of variation

In meat samples from breast, for water content were found values between 73.24 up to 74.58%. The lowest values were observed at chickens from Lexp₁ group (73.24%), and the highest values at chickens from Lexp₂ group (74.58%).

The analysis of variance showed high significant differences (p≤0.001), between Lexp₁ with Lexp₂ and Lc with Lexp₂ and distinguished significant differences (p≤0.01), between Lexp₁ with Lc.

At these samples for the dry matter content the highest values were obtained at the chickens from Lexp₁ group (26.76%), followed by Lc group (26.31%) and Lexp₂ group (25.42%). In statistical term the differences between the three chicken groups were insurance for p≤0.01 or p≤0.001.

For the protein substances in breast meat were found values higher at Lexp₁ group (24.04%), followed Lc group (23.14%) and Lexp₂ group (21.82%). In all cases, the differences between groups were highly significant (p≤0.001).

The values obtained at Lexp₁ group are to the upper limit specified in the literature and those recorded in Lexp₂ group to the lower limit for this meat type [2, 3, 14-16, 23].

For total lipids content was an inferior limit of 1.27%, at Lexp₁ group and a superior limit of 2.28%, at Lexp₂ group. With values for coefficient of variation between 15.17 up to 17.17%, lipids are the breast meat component with the largest variability.

After apply the test of variance analysis, various stages of statistical significance were present between Lexp₁ with Lexp₂ ($p \leq 0.001$) or between Lc with Lexp₁ and Lc with Lexp₂ ($p \leq 0.01$).

At Lexp₁ group, the breast muscles were characterized by lower lipids content (1.27%) and higher protein content (24.04%) compared with Lc group or Lexp₂ group which had higher lipids contents (from 1.78% at Lc, up to 2.28%, at Lexp₂) and lower protein content (from 21.82%, at Lexp₂ up to 23.14%, at Lc).

When making reference to the meat chemical composition for samples taken from thighs area, the data presented the table 4 shows the following:

-in muscles from thighs area, the water content has ranged from 71.39 to 72.32%, with higher values for Lexp₁ group as compared with Lc group or Lexp₂ group (72.32% vs. 72.31%, at Lc, respectively 72.32% vs. 71.39%, at Lexp₂). Thus that, at these samples for the dry matter content situation was reversed.

-for proteins in thighs meat, were found values of: 17.55%; at Lexp₂ group, 18.05%, at Lc group and 18.91%, at Lexp₁ group. Coefficient of variation no was exceeding of 9.55% and revealed a good homogeneity for this characteristic. Analysis of variance revealed statistical differences only between average values obtained at Lexp₁ group with Lexp₂ group.

-the lipids proportion in thighs muscles was higher at Lexp₂ group (9.66%), followed, in descending order, by Lc group (8.33%) and Lexp₁ group (7.48%). The test for analysis of variance revealed statistical differences for $p \leq 0.05$ or $p \leq 0.001$ between the three studied groups (Lc, Lexp₁ and Lexp₂).

Water content of drumsticks muscles had the highest values at Lexp₂ group (71.97%) and the lowest values at Lc group (71.57%), and for the dry matter content situation was reversed. For water and dry matter content, the between studied groups, there were no significant differences.

However, samples taken from drumsticks in the Lexp₁ group had the highest content in protein, with differences +5.89% vs. Lc group up to +13.13%, vs. Lexp₂ group and the lowest content in lipids, with differences of -10.20% vs. Lc group up to -22.57% vs. Lexp₂ group. Of statistically point, for protein content were revealed differences between Lexp₁ with Lexp₂ ($p \leq 0.001$) and between Lc with Lexp₂ ($p \leq 0.01$), and for lipids content between all groups studied (Lc with

Lexp₁, for $p \leq 0.01$; Lc with Lexp₂, for $p \leq 0.05$ and Lexp₁ with Lexp₂, for $p \leq 0.001$).

Chemical analysis of meat (water, dry matter, proteins and lipids) from breast, thighs and drumsticks revealed differences between values obtained at experimental groups (Lexp₁ and Lexp₂), compared with control group (Lc), but also according to anatomical region studied.

As regards the anatomic region, the protein proportion in the breast had higher values (from 21.82 up to 24.04%), compared with the thighs and drumsticks (from 17.55 up to 18.91%, in thighs and from 18.74 up to 21.20%, in drumsticks), and if we mean lipids content the situation was reversed.

Thus, most authors emphasize differences in the chemical composition of breast, thigh and drumstick muscles. Suchy et al. (2002) [29] have reported that at hybrids „Ross 308”, „Cobb” and „Hybro”, the protein content of breast muscle was higher on the average with 3.6 to 4.2 percentages points, than that of thighs muscles, similar data was reported by Diaz et al. (2010) [2], Bogosavljević-Bošcković et al. (1999) [17], Marcu et al. (2009, 2011) [9, 10, 21, 22], Simeonová (1999) [3], Zelender et al. (1995) [2].

Other studies showing that, by comparing the lipids content from breast, thighs and drumsticks muscles were found even greater differences than for protein content [9, 10, 21, 22].

Nutrition is one of the most important external factors, which can have crucial effect on the chemical composition of broiler meat. Higher protein diets induce high meat protein content, while the lipids content of the muscles have reduced.

The effect of feeding with different protein and energy levels on the chemical composition of breast muscles was reported in the literature by several authors. Thim et al. (1997) [19] using feed recipes, with 16% and 24% proteins had reported 15.2%, respectively 16.97% protein content in broiler meat. Marcu et al. (2009) [9] reported at „Cobb 500” broiler that diets with protein levels greater than 2% have increased with 0.48, 0.74 and 0.64% the protein content in breast, thighs, respectively drumsticks. Same authors reported statistical differences for protein and lipid content in samples taken from breast, thighs and drumsticks in broilers „Ross 308”, „Lohmann Meat” and „Arbor Acres”, if it was used recipes

compound with different energy and protein level [10, 21, 22].

4. Conclusions

At the Lexp₁ group, administration of combined fodder with higher protein and energy level has positively influenced the participation of the cut parts in the structure of whole carcasses (breast and drumsticks), meat/bone ratio, dry matter contents and proteins contents from meat.

In breast fillet the water proportion, proteins and minerals was higher, as compared with shanks and drumsticks muscles, which have the higher lipids content.

At the Lexp₁ group, the feeding with higher protein and energy level has increased protein content and decreased lipids content of meat.

Lipids of the meat had the biggest variation between muscles analyzed, with minimum values in the breast muscles and maximum values in the thighs muscles.

References

1. Duran-Melensez, L.A., Poultry carcass evaluation and cutting, in Guerrero-Legarreta I., (edit)–Handbook of poultry science and technology, vol. II–Primary processing, Wiley & Sons Inc, London, 2010, pp.101-106.
2. Bogosavljević-Bošković, S., Pavlovski, Z., Petrović, M.D., Dosković, V., Rakonjac, S., Broiler meat quality: Proteins and lipids of muscle tissue, Afr.J.of Biotech., 2010, 9(54), 9177-9182.
3. Simeonovová, J., Technology of poultry, eggs and other minor animal products (in Czech) MZLU, Brno, 1999, pp. 247.
4. Ristic, M., Sensory and chemical criteria for broiler meat of different breeds from alternative livestock keeping, Proceedings of XIV European Symposium on the Quality of Poultry Meat, Bologna, Italy, 2003, pp.291-294.
5. Furlan, R.L., Faria, F., Rosa, P.S., Macari, M., Does low-protein diet improve broiler performance under heat stress condition, Braz. J. Poultry Sci., 2004, 6 (2), 71-79.
6. Lewis, D.P., Perry, C.G., Farmer, J.L., Patterson, S.R.L., Responses of two genotypes of chicken to the diets and stocking densities typical of UK and Label Rouge production systems: Performance, behaviour and carcass composition, Meat Sci., 1997, 45, 501-516.
7. Larbier, M., Leclercq, B.: Nutriția și alimentația păsărilor. Editura Alutus, București, 1994, pp.163-189.
8. Leeson, S., Summers, J. D., Commercial poultry nutrition, Nottingham Univ. Press., England, 2005, pp.230-295.
9. Marcu, A., Vacaru-Opriș, I., Marcu, A., The influence of feed protein and energy level on meat chemical composition from different anatomical regions at „Coob 500” hybrid, Sci.Papers Anim. Sci. and Biotech., Timișoara, 2009, 42(1), 147-150.
10. Marcu, A., Vacaru-Opriș, I., Marcu, A., Nichita, I., Nicula, M., Dronca, D., Kelciiov, B., Influence of energy and protein level of the feed on carcass characteristics and meat quality at hybrids „Ross 308” and „Arbor Acres”, Sci.Papers Vet. Med., 2011, XLIV (2), 211-219.
11. Jackson, S., Summers, J. D., Lesson, S., Effect of dietary protein and energy on broiler carcass composition and efficiency of nutrient utilization, Poultry Sci.J., 1982, 61, 2224-2231.
12. Kamran, Z., Sarwar, M., Nisa, M., Effect of two-protein diets having constant energy to protein ratio on performance and carcass characteristics of broiler chickens from one to thirty days of age. World's Poultry Sci. J., 2008, 87, 468-474.
13. Aletori, V.A., Hamid, I.I., Hiess, E., Pfeffer, E., Low protein aminoacids supplemented diets in broiler chickens: effects on performances, carcass characteristics, whole body composition and efficiencies of nutrient utilization. J.Sci.Food and Agric., 2000, 80, 547-555.
14. Smith, D.P., Fletcher, D.L., Buhr, R.J., Beyer, R.S., Pekin duckling and broiler chicken pectoralis muscle structure and composition. Poultry Sci.J., 1993, 72, 202-208.
15. Sterling, K.G., Pesti, G.M., Bokolli, R.I., Performance of different broiler genotypes fed diets with varying levels of dietary crude protein and lysine, World's Poultry Sci.J., 2006, 85, 1045-1054.
16. Al-Taleb, S.S., Effect of an early feed restriction on broilers on productive performance and carcass quality, J.Anim. Vet. Adv., 2003, 2(5), 289-292.
17. Bogosavljević-Bošković, S., Gajic, S., Mitrović, S., Djokovic, R., Meat quality parameters selected in yield of carcasses and parts of broilers on two non-industrial rearing system, 49th International Congress of Meat Sci. and Techn., Brazil Proceedings, 2003, pp.41-42.
18. Ghahri, H., Gaycani, R., Toloie, T., Effect of dietary crude protein level on performance and lysine requirements of male broiler chickens, Afr.J.Agric.Res., 2010, 5 (11), 1228-1234.
19. Thim, K.C., Melvin, L.H., Craig, N.C., Effect of environmental temperature, dietary protein and energy levels on broiler performance, 1997, J.Appl.Poultry Res., 6, pp.1-17.
20. Waldroup, P.W., Yang, Q., Frits, A., Effects of supplementing broiler diets low in crude protein with essential and nonessential aminoacid, World's Poultry Sci.J., 2005, 4, 425-431.

21. Marcu, A., Vacaru-Opriș, I., Marcu, A., Nicula, M., Dumitrescu, G., Nichita, I., Dronca, D., Kelciov, B., The influence of the feed protein and energy level on the meat chemical composition at „Lohmann Meat” hybrid., *Sci.Papers, Anim.Sci. and Biotech. Timișoara*, 2011, 44 (2), 439-443.
22. Marcu, A., Vacaru-Opriș, I., Marcu, A., Nicula, M., Dronca, D., Dumitrescu, G., Kelciov, B., The influence of feed protein and energy level on meat chemical composition at „Arbor Acres” hybrid, *Sci.Papers, Anim. Sci., USAMV Iași*, 2011, 55(16), 458-463.
23. Berii, C., Wacrenier, N., Millet, N., Le Bihan-Duval, E., Effect of selection for improved body composition on muscle and meat characteristics of broilers from experimental and commercial lines, *Poultry Sci.J.*, 2001, 833-838.
24. Diaz, O., Rodriguez ,L., Torres, A., Cobos, A., 2010 Chemical composition and physico-chemical properties of meat from capons as affected by breed and age. *Span. J.Agric.Res.* 8(1), 91-99.
25. Lourdes, M., Chabela, P., Chemical analysis of poultry meat, in Guerrero-Legarreta I., (Edit.) *Handbook of poultry science and technology, vol.II, Secondary processing*, London, 2010, p.517-520.
26. Broiler Management Guide „HUBBARD F15”, 2009, pp.2-61.
27. Brudiu, I., *Biostatistică în abordarea practică*, Ed.Eurobit, Timișoara, 2010, p.23-151.
28. Bălău, R., Vacaru-Opriș, I.: Researches concerning the production performances of ROSS-308 chicken broilers reared in familial-type farms, *Sci.Papers, Anim. Sci., USAMV Iași*, 2010, 53, 410-414.
29. Suchy, P., Jelínek, E., Straková, J. Hucl, J., Chemical composition of muscles of hybrid-broiler chickens during prolonged feeding. *Czech.J.Anim.Sci.* 2002, 47 (12), 511-518.