Influence of Nutrition, Sex and Slaughter Age on the Carcass Characteristics at Broiler Chicken Ross-308

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Abstract
In this paper was studied the effect of feed with different energy and protein level on the carcass characteristics at broiler chickens, which were sacrificed at 35 and 42 days old. The genetic material was represented by broiler chickens that belonged to the „Ross-308" hybrid, with two groups (LC-control group and LE-experimental group). During the growth periods (starter, growing and finishing) they have received compound feed ad libitum, with different energy and protein levels (LC-conforming to recommendations of Aviagen Company; LE-higher with 10%). After slaughter, from each group were sampled 30 carcasses (15 carcasses per sex) and was determined slaughter yield and participation percentage of the cut parts from the whole carcasses structure. The meat/bones ratio from carcass and from major parts of the carcass was determined on 10 carcasses from each group (five per sex). The results of this experiment showed that the nutrition and age had significant influence on the slaughter yield, the participation percentage of the cut parts from the whole carcass and meat/bones ratio in breast and legs, while the sex influenced participation share and meat quantity in breast and legs.

Keywords: broiler chicken, carcass, meat/bones ratio, nutrition, slaughter yield

1. Introduction

Raising chickens for meat can be a profitable business in the conditions of modern technology and the use of good quality biological material [1].
In last period consumption of poultry meat increased, because is a food source with high biological value, has high digestibility, very good nutritional value and superior technological characteristics allowing easy processing in a various range of food [2].
Lately researching in poultry genetics carried out by breeding companies was concentrated on developing new commercial hybrids of meat chicken with superior performances [3-4]. Thus, the selection objectives were: improving growth performance, superior carcass quality, high yields of the breast, drumsticks and thighs [5].
The broiler chickens performances are influenced by several genetic and environmental factors which are particularly important for achieving the proposed objectives and to achieve maximum economic efficiency [6-10].
Several authors [11-19] have shown that factors such as genetics, nutrition, sex, age, and environmental conditions influence the slaughter yield of broiler chickens, yields of the cut parts from carcass, the muscles weight and poultry meat quality.
Jackson et al. [20] showed that the poultry feed represent 70 percent of total production costs, while the feed proteins have higher prices than any other food. Thus in Broiler Nutrition Specification [21] were recommended diets with optimal energy and protein levels for this specie in order to use the maximum capacity of the animals and obtain great benefits in poultry farms.

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Studies on effect of feeding with different levels of protein and energy on broiler metabolism and body composition are differing and more researches are necessary in order to understand broilers response [14-16, 18].
The studies showed that feed intake is decreasing at high levels of energy in diets and positively influenced the growth performances, carcass characteristics and breast meat quantity [22-27]. Also, increasing or decreasing the energy and protein levels of diets has positively or negative influenced the growth performances, slaughter yield and the carcass characteristics in broiler chickens [22-28].
Besides nutrient amount, the feed quality is another important factor affecting carcass characteristics. Among the different nutritional components, the proteins had fundamental role, because they are involved in the synthesis of muscle tissues [29].
Tabeidian et al. [30] showed that increased protein level with 10 percent over 21.16% not affected carcass weight, but in the study of Hickling et al. [31] levels of protein and other components of diets are important and can influence obtained results.
Energy is one of the major factors with important role in the feed intake and in formulation of the compound feed recipes for poultry [14, 21]. In formulating of the feeding recipes the nutrients intake may be influenced by the different levels of energy in diets [14, 32]. Thus Saleh et al. [33] showed that the thighs yield was not influenced by increase of energy levels in feed, but in other studies diets with different protein and energy levels have influenced the slaughter yield, breast yield and generally the carcass characteristics and meat quality [15, 22-27].
Broiler chickens have high nutritional requirements and are necessary studies on the topic for understand to which extent the bird feed can affect the traits of carcass and meat quality [14, 34].
Some studies revealed that slaughter results in broiler chickens were different according on sex [15-19]. Thus the breast muscle yields was statistically different as dependent on sex and maybe indicate that rearing males and females separately is justified to obtain more equalized body weight prior to bird slaughter [15, 35].
Broilers reared in Romania are represented by different strains of commercial hybrids for meat as: Ross, Cobb, Hybro, Indian River, Avian 34, Arbor Acres and Hubbard that can be using as whole carcasses based on the final body weight and unit management system. On the other hand, broilers are used as cut pieces and for processing in food products.
Usually broiler chickens are slaughtered at 42 days of age, which is associated with the attainment of optimum body weight, the high slaughter yield, high content of breast muscles and very good feed conversion index, but depending on company management or market requirements broiler chickens may be sacrificed before 42 days of age.
In last time, development of broiler chickens industry and high consumer requirements for poultry meat it seems to be inevitable to undertake studies on the topic for understand which extent carcasses characteristics and meat quality were influenced by factors as: nutrition, sex and slaughter age.
The purpose of this study was the determination of the effect of nutrition, sex and slaughter age on the carcasses yield, percentage of cut parts in the whole carcasses structure and meat quantity obtained in Ross-308 broiler chickens.

2. Materials and methods

The experiment was organized on broiler chickens of one day old belonging to the commercial hybrid „Ross-308", which were reared up to 35 and 42 days. Chickens were reared in an intensive system on the permanent litter, with a density of 12 chick/ m^2. The total birds of the experimental population were 200 broilers of both sexes (2 groups×5 replications×20 broilers). Broilers were randomly assigned into two equal groups (control group-LC and experimental group-LE).
Broiler chickens were reared in the same house and environmental conditions, conforming to the recommendations found in the „Broiler Management Manual Ross-308" [10]. The growth technological system was in accordance with new European Union regulation on animal welfare compulsory from 2012 in all EU member states [36].
Feed and water were given ad libitum. During the growth period (1 to 42d) chickens were fed with three recipes of compound mixtures, as follow: the starter up to 14^{th} d, the grower from 15^{th} d to 35^{th} d

and the finisher from 36th d to 42th d. The recipes of compound feed used had different levels of energy and protein: standard at LC (SPE) [14, 21] and with 10% higher at LE (HPE).
The values for different levels of crude protein (CP) and metabolizable energy (ME) are showed in Table 1.

Table 1. Features of feed compound recipes

Group		LC	LE
CP	*Starter*	24.02	26.23
	Grower	22.63	24.90
	Finisher	21.06	23.12
ME	*Starter*	3041	3270
	Grower	3144	3435
	Finisher	3190	3490

CP (g/100 g feed)-crude protein;
ME (kcal/kg feed)-metabolizable energy

At the end of the growing period (35d and 42d), chickens were slaughtered and from each group were sampled 30 carcasses (15 females and 15 males), which were weighed before and after refrigeration (24 hours at +4°C) and was determined the slaughter yield of fresh and chilled carcasses. The slaughter yield is ratio between fresh or chilled carcass weight and live weight, in percent expressed [37]. To calculate the slaughter yield were used carcasses gutted, without: head, neck and legs.

After cutting the carcasses were determined weight of the cut parts, by gravimetric measurements. With this data were calculated the participation quotas of the cut parts in the whole carcasses structure. The cut parts in the carcass were: breast with bone and skin, thighs, drumstick, wings and back. The participation quota of the cut parts is ratio of each part weight from carcass and carcass weight, percent expressed [37].
The meat/bones ratio expressed in g meat/1 g bones was calculated for major parts of the carcass after the manually deboning of ten carcasses for each group (five per each sex).
The cutting and deboning was performed by the same person for all replications of the experiment.
The 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, an analysis of variance using test MANN WHITNEY from the program MINITAB 14 was applied [38].

3. Results and discussion

Values on carcass weight and slaughter yield determined on hot carcasses (after gutting) and chilled (24h at +4°C) are shown in Table 2.

Table 2. The values for slaughter yield

Specification	***LC***				***LE***			
	♀- 35d *(n=15)*	♀- 42d *(n=15)*	♂- 35d *(n=15)*	♂- 42d *(n=15)*	♀- 35d *(n=15)*	♀- 42d *(n=15)*	♂- 35d *(n=15)*	♂- 42d *(n=15)*
Live weight	2178.93^{a}	2517.00^{b}	2513.07^{b}	2954.33^{a}	2345.93^{b}	2616.67^{a}	2649.67^{a}	3140.33^{b}
$\bar{x}\pm S\bar{x}$ (g)	±30.83	±29.56	±28.95	±32.92	±22.88	±27.29	±21.34	±52.68
[1]Carcass weight	1564.67^{a}	1847.00^{b}	1804.20^{b}	2171.33^{a}	1726.07^{b}	1954.13^{a}	1947.67^{a}	2342.40^{b}
$\bar{x}\pm S\bar{x}$ (g)	±23.29	±22.55	±15.21	±25.64	±16.37	±21.06	±15.20	±38.87
[2]Slaughter yield	71.82^{a}	73.38^{b}	71.84^{a}	73.49^{b}	73.58^{b}	74.68^{a}	73.51^{b}	74.60^{a}
$\bar{x}\pm S\bar{x}$ (%)	±0.41	±0.27	±0.39	±0.11	±0.10	±0.24	±0.10	±0.16
[3]Carcass weight	1548.87^{a}	1817.80^{b}	1789.67^{b}	2138.00^{a}	1698.80^{b}	1924.07^{a}	1916.67^{a}	2305.93^{b}
$\bar{x}\pm S\bar{x}$ (g)	±23.84	±22.48	±19.72	±25.16	±16.43	±20.82	±15.16	±38.27
[4]Slaughter yield	71.07^{a}	72.22^{b}	71.22^{a}	72.36^{b}	72.42^{b}	73.53^{a}	72.34^{b}	73.44^{a}
$\bar{x}\pm S\bar{x}$ (%)	±0.21	±0.27	±0.16	±0.11	±0.11	±0.25	±0.10	±0.17

Means followed by different superscript letters in the same row differ significantly to P≤0.05 by test MANN WHITNEY;
n= carcasses number; $\bar{x}$=mean; $\pm S\bar{x}$= Standard error;
[1]Hot carcasses weight; [2]Hot carcasses yield; [3]Chilled carcasses weight; [4]Chilled carcasses yield.

Following gravity measurements on eviscerated carcasses (hot) from LC were obtained values ranged from 1564.67 to 2171.33 g and LE mean carcass weight was 1726.07 g to 2342.40 g and after 24 hours of refrigerated (+4°C) the average weight of the carcass was decreased by 0.83 to

1.59%. For the two cases presented (hot and chilled carcass) were higher values for chickens slaughtered at 42d vs. 35d, for carcasses obtained from males vs. females and in the case of carcasses of chickens in LE vs. LC. The test for analysis of variance has revealed statistical differences ($P \leq 0.05$) depending of nutrition, slaughter age and the chickens sex.

Slaughter yield is the ratio between the carcass weight and live weight, and is considered the most important quantitative index of meat. After applying the formula for calculation, for hot and chilled carcasses have obtained the slaughter yield values. Thus, data presented in Table 2 showing that for slaughter yield of the hot carcasses were obtained values which ranged from 71.82% (females of LC at 35d) up to 74.68% (females of LE at 42d) while for same indicator at chilled carcasses were recorded lower values with 0.64 up to 0.94%. This reducing trend for carcasses weight was due to dehydration process, which occurs normally, during refrigeration period.

From Table 2 it is noted that the average values calculated for slaughter yield at hot and chilled carcasses were higher at: broilers slaughtered at 42d vs. 35d, at experimental group compared control group, male chickens in LC and female chickens in LE. For the two cases (hot and chilled carcasses yield), after applying the statistical test were identified significant differences ($P \leq 0.05$) depending of slaughter age and nutrition, while the chickens sex not significantly affected the slaughter yield of hot and chilled carcasses ($P > 0.05$).

From data presented in Table 2, it is noted that was a reduction trend for slaughter yield calculated on chilled carcasses compared to the yield on hot carcasses and is in consistent with results obtained of other researchers which reported differences between 0.56 up to 1.54% in broiler chickens Ross-308 which were slaughtered at age of 42d and between 1.38 up to 1.47% in broiler chickens Indian River Meat [15].

In this experiment were obtained values over superior limit of the range specified by the company „Aviagen" for the hybrid „Ross-308", which ensures the achievement of values between 71.91% to 73.42%, for the slaughter yield at completely drawn carcasses (without head, neck, legs and abdominal fat) [39]. Also, Kokoszyński and Bernacki [40] have shown values of 74.5% for slaughter yield in Ross-308 chickens, but in other study Kokoszyński et al. [41] had found lower values with 2.3 percentage points.

The results recorded in that study were higher by 2.54 to 4.68%, compared to values obtained by Gornowicz et al. [35] which reported for slaughter yield at Ross 308 chickens slaughtered at 42d values of 70.95% for male and 70.50% for females.

Values obtained for the yield of cut parts from whole carcasses structure and values for meat/bones ratio of the broiler chickens from this study were presented in Table 3 and Table 4, respectively.

Table 3. The yield of cut parts as percentage of carcasses weight

Specification	***LC***				***LE***			
	♀- 35d *(n=15)*	♀- 42d *(n=15)*	♂- 35d *(n=15)*	♂- 42d *(n=15)*	♀- 35d *(n=15)*	♀- 42d *(n=15)*	♂- 35d *(n=15)*	♂- 42d *(n=15)*
Breast	31.90^{a}	32.91^{b}	30.85^{b}	31.80^{a}	33.47^{b}	35.06^{a}	32.13^{a}	33.88^{b}
$\bar{x}\pm S\bar{x}$ (%)	±0.44	±0.36	±0.25	±0.19	±0.25	±0.29	±0.19	±0.16
Thighs	17.82^{a}	18.05^{b}	17.73^{b}	17.92^{a}	18.14^{b}	18.36^{a}	17.85^{a}	18.05^{b}
$\bar{x}\pm S\bar{x}$ (%)	±0.05	±0.04	±0.03	±0.03	±0.05	±0.04	±0.03	±0.04
Drumsticks	13.01^{a}	12.81^{b}	13.97^{b}	14.09^{a}	13.24^{b}	12.99^{a}	14.20^{a}	14.45^{b}
$\bar{x}\pm S\bar{x}$ (%)	±0.02	±0.02	±0.03	±0.02	±0.05	±0.06	±0.05	±0.04
Wings+back	37.27^{a}	36.23^{b}	37.45^{a}	36.20^{b}	35.15^{b}	33.59^{a}	35.82^{b}	33.62^{a}
$\bar{x}\pm S\bar{x}$ (%)	±0.40	±0.32	±0.22	±0.19	±0.28	±0.25	±0.23	±0.20

Means followed by different superscript letters in the same row differ significantly to P≤0.05 by test MANN WHITNEY;
n= carcasses number; $\bar{x}$=mean; $\pm S\bar{x}$= Standard error;

From the data in Table 3 it is seen that the cut portions were breast, thighs, drumsticks, wings and back which were different weights in the composition of the whole carcasses. Of these parts the breast has represented between 30.85 to 35.06%, the thighs from 17.73 up to 18.36%,

drumsticks from 12.81 up to 14.45% and values between 33.59 up to 37.45% for back+wings. Female broilers produce higher yields of breasts and thighs, but lower yields of drumsticks, than those of male broilers. The breast, thighs and drumsticks yield in the two groups was statistically different ($P \leq 0.05$) as dependent on sex, nutrition and slaughter age.

Effect of the sex on yield of cut parts from whole carcass was shown by Young et al. [8], but they no found significant effect of age on the yields of breast, thighs and drumsticks. Effect of the sex on yield of cut parts from whole carcass was shown by Young et al. [8], but they no found significant effect of age on the yields of breast, thighs and drumsticks. While, Marcu et al. [15] showed significant differences by sex to Ross 308 broilers slaughtered at 42d age.

Therefore, the breast and legs, regarded as the most valuable parts of the carcass, represented between 62.55 up to 66.52% of the whole carcass weight (1548.87 to 2305.93 g), with the lower limits in LC chickens slaughtered at 35 days (62.55% in males and 62.73% at females) and upper limits in LE chickens slaughtered at 42d (66.31% at females and 66.52% in males).

For expressed the meat production and carcass quality, after manually deboning was calculated the meat/bones ratio for the most important parts of the carcass such as the breast and legs (thighs+drumsticks), and values was shown in Table 4.

Table 4. Meat/ bones ratio

Specification	LC				LE			
	♀- 35d *(n=5)*	♀- 42d *(n=5)*	♂- 35d *(n=5)*	♂- 42d *(n=5)*	♀- 35d *(n=5)*	♀- 42d *(n=5)*	♂- 35d *(n=5)*	♂- 42d *(n=5)*
[1]Carcass	721.57^{a}	894.58^{b}	862.02^{b}	1036.63^{a}	872.98^{b}	979.83^{a}	955.25^{a}	1174.54^{b}
$\bar{x}\pm S\bar{x}$ (g)	±23.24	±16.51	±27.47	±28.59	±14.08	±20.09	±12.82	±22.66
Bones	149.38^{a}	166.05^{a}	182.72^{b}	199.25^{b}	163.24^{a}	168.73^{a}	184.60^{b}	208.18^{b}
$\bar{x}\pm S\bar{x}$ (g)	±4.73	±2.53	±2.42	±5.12	±5.67	±3.02	±1.90	±7.91
Meat/bones	4.83/1^{a}	5.39/1^{b}	4.71/1^{b}	5.20/1^{a}	5.35/1^{b}	5.81/1^{a}	5.17/1^{a}	5.64/1^{b}
$\bar{x}\pm S\bar{x}$	±0.03	±0.03	±0.02	±0.02	±0.04	±0.02	±0.04	±0.03
[2]Breast	392.70^{a}	497.60^{b}	456.38^{b}	558.11^{a}	476.10^{b}	557.88^{a}	510.16^{a}	647.46^{b}
$\bar{x}\pm S\bar{x}$ (%)	±13.71	±11.01	±17.75	±12.24	±10.28	±10.70	±7.64	±12.74
Bones	56.60	63.16	65.62	72.09	63.20	66.86	67.84	77.74
$\bar{x}\pm S\bar{x}$ (g)	±2.67	±3.35	±2.49	±4.76	±1.98	±2.83	±2.64	±3.86
Meat/bones	6.94/1^{a}	7.88/1^{b}	6.95/1^{a}	7.75/1^{b}	7.78/1^{b}	8.51/1^{a}	7.66/1^{b}	8.44/1^{a}
$\bar{x}\pm S\bar{x}$	±0,19	±0,13	±0.18	±0.09	±0.07	±0.15	±0.10	±0.16
[3]Thighs+Drumsticks	328.87^{a}	396.98^{b}	405.64^{b}	478.52^{a}	396.88^{b}	421.95^{a}	445.09^{a}	527.08^{b}
$\bar{x}\pm S\bar{x}$ (%)	±5.73	±4.74	±8.56	±7.95	±6.03	±3.91	±5.30	±6.83
Bones	92.78^{a}	102.89^{a}	117.10^{b}	127.16^{b}	100.04^{a}	101.87^{a}	116.76^{b}	130.44^{b}
$\bar{x}\pm S\bar{x}$ (g)	±2.14	±2.93	±3.53	±3.49	±1.85	±2.13	±0.85	±4.44
Meat/bones	3.54/1^{a}	3.85/1^{b}	3.46/1^{a}	3.76/1^{b}	3.97/1^{b}	4.14/1^{a}	3.81/1^{b}	4.04/1^{a}
$\bar{x}\pm S\bar{x}$	±0.075	±0.08	±0.06	±0.05	±0.03	±0.04	±0.04	±0.05

Means followed by different superscript letters in the same row differ significantly to P≤0.05 by test MANN WHITNEY;
n= carcasses number; $\bar{x}$=mean; ±S$\bar{x}$= Standard error;
[1]superior quality meat in carcass (without skin and bones); [2]breast deboned without skin; [3] thighs+drumsticks deboned without skin; meat/bones ratio=g meat/1 g bones

Thus, for breast the meat/bones ratio values were in the range 6.94/1 to 8.51/1 (g meat/1 g bones), and for the legs the lower limit was 3.46/1 and the upper limit of 4.14/1. Therefore, meat/bones ratio for these parts (breast+legs) recorded values between 4.71/1 to 5.81/1, and high quality meat in carcasses (breast+thighs+drumsticks) represented between 47.39 to 49.01% in chickens slaughtered at 35d and from 49.89 up to 52.22% for broilers slaughtered at 42d.

The results of this study revealed high yield for the meat of superior quality over 47% of the eviscerated carcase weight and confirms that the Ross-308 hybrid are a very good genetic material for meat production. Thus, for this commercial hybrid the meat quantity of the breast muscles which is the meat of best quality represented more

than 25% (25.08 to 29.75%) and leg muscles over 21% (21.71 to 23.25%).

The results show that in examined broiler carcasses the breast muscle yield was higher with 2.77 up to 7.28% in comparison with the legs yield. These differences were influenced by nutrition, slaughter age and sex.

The differences from this study confirm the results obtained by Gornowicz et. al. [35], that has noted that breast meat yield, was higher with 2.96 to 3.65% compared with legs. Similar results were obtained by Horniakova and Abas [12], which showed that the interaction between sex and nutrition was significant.

Results showed that at LC chicken feed with SPE level were determinate lower values for the slaughter yield, participation share of breast and legs in the whole carcasses structure and amount of meat in breast and legs, as compare with LE group.

Alleman et al. [42] showed that the relation between raw proteins in fodder mixtures with breast muscles, meaning that as the protein quantity decreases in fodder mixture, share of pectoral muscles in carcass decreases.

Also, Steiner et al. [43] which studied effect of dietary protein/energy combinations on Ross-308 male broiler performance showed that breast muscle and muscle amount in eviscerated carcasses increased in case of diets with higher energy and protein level. Thus, lowering the protein and energy level resulted in lower percentage of muscles in breasts, legs and entire body.

4. Conclusions

This study showed the possibility of using in broilers feeding of higher levels of protein and energy, which allow obtaining the carcasses with a higher meat quantity of superior quality.

Slaughter yield was statistically different ($P \leq 0.05$) and influenced by nutrition and age of slaughter, while the carcass meat quantity for the two groups was statistically influenced ($P \leq 0.05$) by sex, nutrition and slaughter age.

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