COMPARATIVE STUDIES ON THE CHEMICAL COMPOSITION OF MEAT IN BROILER CHICKEN, UNDER SLOW GROWTH CONDITIONS

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Abstract

Most of the chicken meat production in Romania comes from industrial hybrids (fastgrowing), but recently the share of poultry units that apply slow-growth principles to industrial broilers or use slow-growing genotypes has increased. To achieve the proposed goal, samples (pectoral and upper leg muscles, respectively) were taken from individuals belonging to the industrial hybrid Ross-308 (group L-c) and from two slow-growing hybrids (Hubbard=group L-1 and HB Color=group L-2), which were raised under identical conditions and slaughtered at the age of 56 days. Chemical determinations revealed that the highest water content was in the meat of Ross-308 chickens (higher by 0.68-1.42% in the pectoral muscles and by 1.37-1.95% in the thighs), while Hubbard chickens recorded the highest protein content (higher by 0.16-1.14% in the pectoral muscles and by 0.15-1.05% in the thighs) and lipid content (higher by 0.36-0.70% and, respectively, by 0.16-0.93%); moreover, the caloric value of meat in Hubbard chickens recorded higher values both in the case of the pectoral muscles (higher by 3.06-6.79%) and the upper leg muscles (higher by 1.66-7.16%). The data obtained indicate that Hubbard hybrid provides superior meat in terms of chemical composition to other hybrids used in poultry farming in Romania.

Key words: *broiler chicken, slow growth, meat, chemical composition, caloricity*

INTRODUCTION

Poultry meat is consumed all over the world, due to its high nutritional value, specific sensory characteristics and suitability for various types of preparation [14]. However, lately there has been a certain selectivity of consumers regarding the origin of this type of meat, because they want products obtained in farming systems other than industrial ones [6, 17]. Therefore, the consumer public is increasingly interested in the production systems applied in poultry farming, as it prefers high-quality products, but is also concerned with ensuring welfare conditions [3, 23]. In the case of poultry meat producers, the interests are related to the level of performance during their life (growth rate, feed conversion and mortality) and those at slaughter (yield, weight of anatomical portions, chemical composition) [1, 4, 18]. It is well known that free-range systems result in lower body weight and poorer feed conversion efficiency compared to intensive rearing [12, 21]. On the other hand, the quality traits of meat are superior, especially in terms of chemical composition and sensory properties in non-intensive poultry and especially in the organic variant [13, 15, 22]. On the other hand, specialized studies highlight differences in meat quality even within the same rearing system, due to genetic and/or non-genetic factors [2, 8, 24]. Starting from the fact that more and more poultry units apply the principles of slow growth, the present study aims to establish the influence of genotype on the chemical

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composition of the meat in the chicken broiler.

MATERIAL AND METHOD

In order to achieve the proposed goal, three meat hen hybrids were studied, of which one fast-growing, namely Ross-308 (treatment L-c) and two slow-growing ones, respectively Hubbard and HB Color (treatments L-1 and L-2).

The chicks from the three groups benefited from identical maintenance and feeding conditions throughout the entire growing period and were slaughtered at 56 days of age. The determinations that were the subject of the present study were performed on meat samples taken from the pectoral muscles and from the muscles of the upper thighs, respectively, from 10 specimens from each group.

The methods used to determine the crude chemical composition and heat of the meat were those accredited for this purpose, as follows:

- Water content - oven drying method at $+105^{oC}$ (SR ISO 1442:2010):

$$\text{Water (\%)} = \frac{m1}{m2} \times 100$$

m2 = final mass of the test (g);
m1 = initial mass of the sample (g).

- Dry Matter Content-With Relationship: D.M. (%) = 100 - % Water
- protein content - Kjeldahl mineralizing distillation method (SR EN ISO 937:2007):

$$P (\%) = \frac{0.0014 \times 2 \left(v1 - \frac{V2}{2} \times f\right) \times 6.26}{M} \text{ X } 100$$

v1 = volume of H_3BO_3 4% of the drip cup (ml) (25 ml);
v2 = volume of H_2SO_4 0.1N used for titration (ml);
f = solution factor H_2SO_4 (1,1);
m = sample mass (g).

- lipid content - organic solvent extraction method - Soxhlet (SR ISO 1443: 2008):

$$\text{Fat (\%)} = \frac{m2 - m1}{m} \times 100$$

m = sample mass (g DM);
m2 = final mass of the extraction vessel (g);
m1 = initial mass of the extraction vessel (g).

- ash content-calcination method at $+550^{\circ C}$ (SR ISO 936:2009):

$$\text{Ash (\%)} = \frac{m2 - m1}{M} \times 100$$

m = sample mass (g);
m2 = crucible mass and ash (g);
m1 = empty crucible mass (g).

- Nitrogen free extract- by computation, using the relation:

NFE (%) = DM (%) – Ash (%) – Prot. (%) – Fat (%)

- gross energy-to-relationship (SR ISO 1444:2008):

GE (kcal/100 g)=g protein x 5.7+g fat x 9.5+g NFE x 4.2

All the data obtained were statistically processed, calculating the arithmetic mean, the standard error of the mean, the coefficient of variation, as well as the significance of the differences between the treatments.

RESULTS

In order to identify any differences in chemical composition between the meat of fast-growing and slow-growing chickens, samples were taken from the pectoral muscles and the upper legs, respectively.

The chemical composition of the pectoral muscles. For the dry matter content, values of 28.95-30.90% were recorded (the difference of 69.10-71.05% represented water), of which 18.58-19.63% were proteins, 8.25-9.18% lipids, 1.39-1.45% ash and 0.41-0.73% non-nitrogenous extractive substances *(Table 1).*

Table 1 The chemical composition of the pectoral muscles

Parameters	Statistical estimators	Treatment (n=10/group)		
		L-c	L-1	L-2
Water	Mean±StdMeanError (%)	72.45±1.34	71.03±1.11	71.77±1.24
	Variability (%)	5.86	4.94	5.48
	p values	**L-c vs. L-1: p=0.0082 *L-c vs. L-2: p=0.0420 *L-1 vs. L-2: p=0.0388		
Dry substance	Mean±StdMeanError (%)	27.55±0.49	28.97±0.47	28.23±0.47
	Variability (%)	5.65	5.15	5.25
	p values	**L-c vs. L-1: p=0.0080 *L-c vs. L-2: p=0.0412 *L-1 vs. L-2: p=0.0397		
Protein	Mean±StdMeanError (%)	22.83±0.50	23.97±0.45	23.81±0.54
	Variability (%)	6.97	5.99	7.18
	p values	**L-c vs. L-1: p=0.0087 *L-c vs. L-2: p=0.0425 ns L-1 vs. L-2: p=0.6988		
Fat	Mean±StdMeanError (%)	2.15±0.06	2.85±0.05	2.49±0.06
	Variability (%)	8.54	6.01	7.22
	p values	*L-c vs. L-1: p=0.0321 ns L-c vs. L-2: p=0.4281 ns L-1 vs. L-2: p=0.4337		
Ash	Mean±StdMeanError (%)	1.48±0.06	1.50±0.05	1.46±0.05
	Variability (%)	12.59	10.10	11.05
	p values	ns L-c vs. L-1: p=0.5248 ns L-c vs. L-2: p=0.6014 ns L-1 vs. L-2: p=0.8355		
NFE	Mean±StdMeanError (%)	1.09±0.04	0.65±0.02	0.47±0.02
	Variability (%)	11.99	9.46	11.39
	p values	ns L-c vs. L-1: p=0.0008 ns L-c vs. L-2: p=0.0006 ns L-1 vs. L-2: p=0.7866		

* Significant differences (0.01 < p < 0.05); ** distinctly significant differences (0.001 < p < 0.01); *** very significant differences (p < 0.001); ns=not significant differences (p > 0.05)

Chemical composition of the muscles of the thighs. The water content showed values of 71.03-72.45%, and the DM content of 27.55-28.97%. Proteins were at levels of 22.83-23.97%, lipids 2.15-2.85%, ash 1.46-1.50%, and non-nitrogenous extractives 0.47-1.09% *(Table 2).*

The gross energy of the meat was between 155.14±3.05 kcal/100 g (Ross-308 chicken) and 166.44±2.94 kcal/100 g (Hubbard chicken) in the case of the pectoral muscles and respectively, between 187.34±3.90 kcal/100 g (Ross-308) and 201.79±3.78 kcal/100 g (Hubbard) in the case of the thighs *(Table 3).*

DISCUSSIONS

The chemical composition of the pectoral muscles. Water content of this muscle group showed that the lowest level was in Hubbard chickens (71.03±1.11%), followed by HB Color chickens (71.77±1.24%) and Ross-308 in which the highest proportion of water was found (72.45±1.34%); good homogeneity of the studied characteristic was found (variability = 4.94-5.86%).

Table 2 The chemical composition of the thigh muscles

Parameters	Statistical estimators	Treatment (n=10/group)		
		L-c	L-1	L-2
Water	Mean±StdMeanError (%)	71.05±1.69	69.10±1.24	69.68±1.34
	Variability (%)	7.52	5.65	6.09
	p values	**L-c vs. L-1: p=0.0057 **L-c vs. L-2: p=0.0081 ns L-1 vs. L-2: p=0.6582		
Dry matter	Mean±StdMeanError (%)	28.95±0.72	30.90±0.45	30.32±0.60
	Variability (%)	7.89	4.65	6.23
	p values	**L-c vs. L-1: p=0.0059 **L-c vs. L-2: p=0.0082 ns L-1 vs. L-2: p=0.6587		
Protein	Mean±StdMeanError (%)	18.58±0.38	19.63±0.28	19.48±0.32
	Variability (%)	6.44	4.50	5.24
	p values	**L-c vs. L-1: p=0.0078 **L-c vs. L-2: p=0.0085 L-1 vs. L-2: p=0.7782		
Fat	Mean±StdMeanError (%)	8.25±0.16	9.18±0.12	9.02±0.15
	Variability (%)	6.09	4.06	5.43
	p values	*L-c vs. L-1: p=0.0388 *L-c vs. L-2: p=0.0429 L-1 vs. L-2: p=0.8889		
Ash	Mean±StdMeanError (%)	1.39±0.04	1.45±0.03	1.41±0.04
	Variability (%)	9.98	7.24	8.60
	p values	ns L-c vs. L-1: p=0.6418 ns L-c vs. L-2: p=0.6504 ns L-1 vs. L-2: p=0.8111		
NFE	Mean±StdMeanError (%)	0.73±0.03	0.64±0.02	0.41±0.01
	Variability (%)	12.90	11.06	11.52
	p values	ns L-c vs. L-1: p=0.7544 ns L-c vs. L-2: p=0.9296 ns L-1 vs. L-2: p=0.8788		

* Significant differences (0,01 < p < 0,05); ** distinctly significant differences (0.001 < p < 0,01); *** very significant differences (p < 0.001); ns=not significant differences (p > 0.05)

Table 3 Gross energy content of the meat

Cut	Statistical estimators	Treatment (n=10/group)		
		L-c	L-1	L-2
Breast	Mean±StdMeanError (kcal/100 g)	155.14±3.05	166,44±2,94	161,35±3,10
	Variability (%)	6.21	5,59	6,08
	p values	ns L-c vs. L-1: p=0.0005 *L-c vs. L-2: p=0.0285 *L-1 vs. L-2: p=0.0297		
Thighs	Mean±StdMeanError (kcal/100 g)	187.34±3.90	201.79±3.78	198.45±4.03
	Variability (%)	6.58	5,92	6,42
	p values	ns L-c vs. L-1: p=0.0004 **L-c vs. L-2: p=0.0087 ns L-1 vs. L-2: p=0.5087		

* Significant differences (0,01 < p < 0,05); ** distinctly significant differences (0.001 < p < 0,01); *** very significant differences (p < 0.001); ns=not significant differences (p > 0.05)

Distinctly significant differences were identified between the L-c vs. Lc-1 treatments, and significant differences were found between the L-c vs. L-2 and L-1 vs. L-2 treatments, respectively.

For the dry matter meat content, values of 28.97±0.47% (Hubbard), 28.23±0.47% (HB Color) and 27.55±0.49 (Ross-308) were determined, also under the conditions of good homogeneity at group level (V%=5.15-5.65%). Between the groups there were the same type of statistical differences as those in the water content.

Proteins were found in proportions of only 22.83±0.50% in Ross-308 chickens, compared to 23.81±0.54% in HB Color and 23.97±0.45% in Hubbard chickens, while lipids showed values of 2.15±0.06% in Ross-308, 2.49±0.06% in HB Color and 2.85±0.05% in Hubbard; Both characteristics showed a good homogeneity at the group level, according to the values resulting from the calculation for the coefficient of variation (5.99-7.18% in the case of proteins and 6.01-8.54% in the case of lipids).

In the case of protein content, in the comparison of L-c vs. L-1, statistically significant differences were found, and in the comparison between L-c vs. L-2, significant differences were found, while statistically significant differences were identified between the L- vs. L-1 groups in lipid content.

As for the ash content, the determined values oscillated between 1.46±0.05% (HB Color) and 1.50±0.05% (Hubbard), while for the content of non-nitrogenated extractive substances the limits were between 0.47±0.02% (HB Color) and 1.09±0.04% (Ross-308). The calculation of the coefficients of variation resulted in a medium variability, both in the case of gray (V%=10.10-12.59) and non-nitrogenated substances (V%=9.46-11.99).

For the ash content, no statistically significant differences were identified between the groups, but for the SEN content, there were very significant differences between the L-c vs. L-1 groups and respectively, L-c vs. L-2 *(Table 1).*

In a study on the chemical composition of meat in different species of birds, Ristic V.M. et al. found levels of 75% for water content, 24% for protein, 0.6% for lipids and 1.2% for ash, and for thigh meat, 75% for water, 20% for protein, 3.9% for lipids and 1.1% for ash [19].

Compared to fast-growing chickens (Hubbard F15), slow-growing chickens (Hubbard JA957) were significantly lighter (by 17%) and with lower yield of chest and thigh muscles, but were characterized by higher protein content and lower fat content of breast meat. In free-range variants, the meat was darker, had a higher protein content and a better water retention capacity, but was less juicy than in those raised in closed halls [16].

In Hubbard Isa Red-JA chickens bred in different production systems (on permanent litter, free-range, on pasture with mobile shelters) it was found that they have significant effects on carcass yield and the proportion of legs and wings in the carcass structure, but did not affect the dry matter, protein, fat and ash content of the pectoral muscles (P>0.05) [20].

Another study in which the variables were growth system, genotype and sex, concluded that slow-growing hybrids bred in freedom recorded significantly better qualitative traits for the pectoral muscles, meaning higher values for color and protein content and lower for fat content [7].

Chemical composition of the muscles of the thighs. The highest water content was in the meat of Ross-308 chickens (71.05±1.69%), and the lowest in Hubbard chickens (69.10±1.24%), while in HB Color there were intermediate values (69.68±1.34%); the studied character was homogeneous at the group level, an aspect confirmed by low values of the coefficient of variation, of only 5.65-7.52%. Statistically, there were distinctly significant differences between the L-c vs. L-1 treatments and between the L-c vs. L-2 treatments, respectively.

The dry matter content showed values of 30.90±0.45% in Hubbard chickens, compared to 30.32±0.60% in HB Color and only 28.95±0.72% in Ross-308 chickens; For the coefficient of variation, values of 4.65-7.89% were produced, which indicate the homogeneity at the group level of the characteristic taken in the study. Also in this case, distinctly significant statistical differences were identified between the L-c lot and the L-1 and L-2 treatments.

The highest protein content (19.63±0.28%) was in Hubbard chickens, followed quite closely by HB Color chickens (19.48±0.32%) and at a fairly long distance from Ross-308 chickens (18.58±0.38%); and in this situation the homogeneity of the studied characteristic was found, the values of the coefficient of variation being only 4.50-6.44%. The comparison between the L-c vs. L-1 treatments and the comparison between the L-c vs. L-2 treatments resulted in distinctly statistically significant differences.

For the meat content in the lipid, values of 9.18±0.12% were found in Hubbard, 9.02±0.15% in HB Color and only 8.25±0.16% in Ross-308; the coefficient of variation showed values of 4.06-6.09%, which attests to the homogeneity of the mentioned characteristic. Statistically, there were significant differences between group L-c and groups L-1 and L-2.

The values determined for the ash content were between 1.39±0.04% (Ross-308 chicken) and 1.45±0.03% (Hubbard chicken), while for the content of non-nitrogenated extractives the limits were between 0.41±0.01% (HB Color) and 0.73±0.03% (Ross-308); the ash content was presented as a fairly homogeneous character (V%=7.24-9.98), while the SEN indicated a medium variability (V%=11.06-12.90). No statistically covered differences were identified for both ash and SEN *(Table 2).*

Between the meat of the broiler raised in freedom and that obtained from broilers in the industrial system, differences were found in the specific characteristics (physical, microbiological and sensory), but also in chemical compositions; thus, the samples taken from the thigh of chickens raised in the open air showed higher levels of protein (18% vs. 16.5%), while the chickens raised industrially recorded higher levels of fat (5.0% vs. 3.4%) [10].

Following research on the effect of the rearing system (on bedding, on technology beds and outdoors) on meat quality in slow-growing chickens of the local Gushi genotype slaughtered at 35 days of age, it was found that the water, protein and fat content, as well as the water retention capacity, shear force and pH of the meat were not affected (P>0.05) by the rearing system [9].

Another study on the effects of the rearing system on the chemical composition of the meat showed that chickens raised organically had higher iron content (thigh muscles) and significantly lower magnesium (in thighs and breast) compared to those raised industrially; overall, the meat of chickens in the organic system showed better nutritional characteristics than those raised in other systems [11].

Lower protein but higher lipid contents were found in the thigh muscles of Hubbard Red-JA chickens raised organically and conventionally, compared to the situation in conventionally bred Ross-308 chickens; in both growth systems, the pectoral muscles of fast-growing birds had a higher water content than that of slow-growing birds [13].

Administration of combination feeds with different levels of protein in fast-growing (Ross 308), medium (JA757) and slow-growing (ISA Dual) chickens showed that slow-growing chickens had higher dry matter ($P < 0.001$) and crude protein ($P < 0.001$) and lower contents of ether extract ($P < 0.001$) and cholesterol ($P < 0.001$) in the case of the low-protein variant [5].

Caloricity of meat. In the case of samples taken from the pectoral muscles, the caloricity recorded values of 155.14±3.05 kcal/100 g in Ross-308 chickens (Lc group), 161.35±3.10 kcal/100g in HB Color (L-2 group) and 166.44±2.94 kcal/100 g in Hubbard chickens (L-1 group), under the conditions of good homogeneity at the lot level (V%=5.59-6.21). From the statistical analysis of the obtained data, it resulted that there were very significant differences between the L-c and L-1 treatments, while in the comparisons of L-c vs. L-2 and respectively, L-1 vs. L-2, only significant differences were determined.

For the leg muscles, caloricity values ranged from a minimum of 187.34±3.90 kcal/100 g (L-c group) to a maximum of 201.79±3.78 kcal/100 g (L-1 group), also under the conditions of a good homogeneity of the studied characteristic (V%=5.92-6.58). The comparison of the values obtained for the caloricity of the legs resulted in very significant statistical differences (L-c vs. L-1) and distinctly significant (L-c vs. L-2) *(table 3).*

CONCLUSIONS

Following the comparative evaluation of the chemical composition of meat from fast-growing hybrids (Ross-308) and slow-growing hybrids (Hubbard and HB Color), respectively, differences resulted due exclusively to the genotype used, because the growth and feeding elements were identical, including the slaughter age.

The highest water content was found in the meat of the Ross-308 chickens (lot L-c), exceeding by 0.68% (breast) and 1.37% (thighs) the content of the HB Color chickens (lot L-2) and by 1.42% (breast) and 1.95% (thighs) respectively the content recorded in the Hubbard chickens (lot L-1).

In the case of meat obtained from Hubbard chickens (L-1 lot), higher levels were recorded for the protein content (0.16-1.14% higher for the pectoral muscles and 0.15-1.05% for the thighs), but also for the lipid content (0.36-0.70% higher for the pectoral muscles and 0.16-0.93% for the thigh muscles) compared to the other two hybrids tested (L-c and L-2 treatments).

In terms of caloricity, the highest values were also determined for the meat of Hubbard chickens (lot L-1), higher by 3.06%-breast and 1.66%-thighs compared to the meat of HB Color (L-2) chickens and by 6.79%-breasts and 7.16%-thighs, respectively, compared to that of Ross-308 chickens (L-c).

The data obtained indicate that the slow-growing genotypes and especially the Hubbard hybrid provide a meat superior in terms of chemical composition to that from industrial hybrids, representing a sustainable alternative that meets the current demands of consumers in our country.

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