The effect of sex and rearing system on carcass composition and cut yields of broiler chickens

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ABSTRACT: The objective of this study is an analysis of meat quality in broilers of standard fast-growing hybrid Hybro G, reared in two different non-industrial systems (extensive rearing in a poultry house or "extensive indoor" system and rearing in a poultry house using a free range or "free-range" system). Quality parameters, i.e. proportions of basic carcass parts (breasts, drumsticks and thighs), abdominal fat, and proportions of basic tissues (muscles, bones and skin) in more valuable carcass parts, were investigated. The aim of the investigation was to analyse the effect of the two non-industrial rearing systems and broiler sex on the above-mentioned traits of broiler meat quality. The used rearing systems (free-range and extensive indoor ones) did not have a statistically significant effect on the proportions of major basic carcass parts and of abdominal fat in broiler chickens ($P > 0.05$). Heavier carcasses at slaughter (on the 56th day of fattening) were recorded in the male broilers compared to the female ones, the differences being statistically significant ($P < 0.01$). The drumstick proportion in the male broiler carcasses was statistically significantly higher ($P < 0.05$) than the proportion in the female broilers. The interaction between the investigated effects (of sex and rearing system) did not exert a statistically significant effect on the proportions of major basic carcass parts and abdominal fat in broiler chickens ($P > 0.05$). The rearing system (free-range and extensive indoor) and the interaction between the investigated effects (of sex and rearing system) did not affect statistically significantly the differences expressed in the meat, skin and bone proportions in breasts, drumsticks and thighs of the broilers ($P > 0.05$). The sex effect on the skin proportions in breasts, drumsticks and thighs was not statistically significant ($P > 0.05$). Average muscle proportions in drumsticks and thighs of the female broilers were statistically highly significantly ($P < 0.01$) and significantly ($P < 0.05$) higher compared to those in the male broilers. Average bone proportions in the breasts of the male broilers were statistically significantly higher ($P < 0.05$) than those in the female ones, and statistically highly significantly higher ($P < 0.01$) in drumsticks and thighs.

Keywords: broiler; fattening; rearing system; carcass composition

As generally known, broiler meat quality is a very complex issue that can be looked at from several aspects. In terms of the meat processing industry and consumers' interests, fattened chicks should be characterised by good dressing percentage, desired conformation, as much meat on the carcass as possible, optimal distribution of fat tissues, appropriate skin colour and least damage possible occurring during fattening, loading and unloading. With respect to that, the proportions of major basic carcass parts (breast, drumstick and thigh) as well as the presence of certain tissues in them are regarded as vital parameters determining broiler meat quality (Lewis et al., 1997; Sütö et al., 1998; Holcman et al., 2003; Ristic, 2003). The above-mentioned quality traits depend on a number of factors. Of the biological ones, the greatest impact is produced by genotype, sex and age (Lewis et al., 1997; Bokkers and Koene, 2003; Hellmeister et al., 2003).

Among numerous non-genetic factors that may have a considerable effect on meat quality, a broiler rearing system has been recognised over the past years by a large number of authors as being particularly important (Lewis et al., 1997; Bokkers and Koene, 2003; Hellmeister et al., 2003; Ristic, 2003).

This goes without considering the fact that poultry production in the last few decades (Havenstain et al., 1994) has been so intensified that nowadays it has all characteristics of industrial production, including rearing of highly productive hen strain hybrids, rearing in closed facilities and limited space with strictly controlled microclimatic conditions and balanced nutrition, adequate care and health protection. This intensification in modern poultry results also in high performance. As illustrated, in 1950 the fattening period required to achieve the slaughter chicken weight of 1.8 to 2 kg was 12 weeks and it is only a little more than four decades later that the duration of the fattening period required is even less than 6 weeks (Remignon et al., 1994). Nevertheless, this development trend of poultry production sets more and more frequently new questions and dilemmas before breeders and researchers. One of the most frequently asked questions is the issue of the quality of products from intensive poultry production.

This has resulted in a growing number of supporters (researchers, consumers, producers) of the use of non-industrial broiler rearing systems for the production of meat with better quality traits.

Justification for the use of the non-industrial rearing system is analysed not only in terms of the product quality but also in terms of its price (Grashorn and Clostermann, 2002).

Considering the aforementioned, the objective of this research was an analysis of meat quality in broilers reared in two different non-industrial systems (extensive indoor and free-range rearing). The meat quality parameters selected for the analysis included the proportions of major carcass parts (breasts, drumsticks and thighs), abdominal fat and the proportions of basic tissues (muscular tissue, bones and skin) in better-quality carcass parts. The aim of the investigation was to analyse the above-mentioned quality traits of broiler meat from the standpoint of the non-industrial rearing systems used.

MATERIAL AND METHODS

Experimental animals, keeping and feeding

Since neither imported strains nor domestic slow-growing crossbreeds existed in Serbia and

Table 1. Formulation and chemical composition of starter (BS) for broiler fattening fed until 21 days of age (VI Zemun, SM)

Content	Formulation (calculated values)	
Grain feeds Oil industry products Animal-derived feeds Other plant products Mineral feeds Amino acids	Proteins min.	22.0%
Premix VZ Vit B-1 1% (vitamins, minerals, antioxidant)	Fats	5.00%
	Moisture max.	13.5%
	Cellulose max.	4.00%
	Ash max.	8.00%
	Ca	0.900–1.10%
	P	0.650–0.750%
	Useable P min.	0.400%
	Na	0.150–0.200%
	Lysine min.	1.15%
	Methionine + cystine min.	0.850%
	Metabolic energies (ME) min.	13.00 MJ/kg

Montenegro, the trial material used for these studies consisted of 200 (50% males and 50% females) one-day-old chicks of the intensive-growing line hybrid Hybro G. The fattening of the broilers lasted 56 days. The selected rearing technologies were in accordance with the extensive indoor (barn-reared) and free-range standards (EEC Commission Regulation No. 1538/91). In the first 4 weeks the rearing was conducted in a poultry house with the deep floor covering (extensive indoor). Then, at 28 days, the experimental chicks were divided into two groups. The one was still reared in the poultry house at floor density of up to 12 chicks per m^2 (extensive indoors). The other group was provided with the same useful area within the poultry house and also with a grass free range with 1 m^2 per chick. The chicks from both trial groups were slaughtered at 56 days of age in accordance with the aforementioned regulation (EEC Commission Regulation No. 1538/91).

The trial chicks were fed two complete feeds: starter (BS) until 28 days and finisher (BF) from 28 to 49 days of fattening. In the last week of the fattening period (from 49th to 56th day), the diet consisted of broken maize grain (70%) and 30% of finisher (BF) for broiler fattening. The broilers were fed ad libitum (Tables 1 and 2).

Sampling

The trial was conducted from the 5th September to 31st October 2003; data on weather conditions recorded by the agro-meteorological station of the Serbia Institute, Fruit Research Centre, Cacak, were used for this period. The data are presented in Table 3.

Following the fattening period, 12 broilers selected at random from each experimental group were slaughtered, with the aim of examining major quantity traits of broiler meat. The processed and cold carcasses were dissected into basic parts (breasts, drumsticks, thighs, wings, pelvis and backs) following the method prescribed by the Poultry Meat Quality Regulation (Official Gazetteer of the SFRY 1/81 and 51/88). Joint drumstick and thigh separation was done by a cut starting above the thigh, stretching towards the acetabulum and ending behind the pubis (the pelvic-thigh cut). The drumstick-thigh separation was then performed by a cut vertical to the joint between drumstick and thigh bones. The wings were separated by the so-called "shoulder" cut going through the joint (articulation) regions of the shoulder blade and the raven bone. The breasts were separated by a cut vertical to the ventral joint rib region – the "rib" cut. The back-pelvis separation was performed by a cut ver-

Table 2. Formulation and chemical composition of finisher (BF) for broiler fattening fed from 21 to 56 days of age (VI, Zemun, SM)

Content	Formulation (calculated values)	
Grain feeds		
Oil industry products		
Animal-derived feeds	Proteins min.	22.0%
Dried plant products		
Mineral feeds		
	Fats	5%
	Moisture max.	13.5%
	Cellulose max.	5%
	Ash max.	8%
	Ca	0.8–1.0%
Premix VZ Vit B-2 1% (vitamins, minerals, coccidiostatic and antioxidant)	P	0.6–0.8%
	Useable P min.	0.35%
	Na	0.15–0.20
	Lysine min.	0.9%
	Methionine + cystine min.	0.7%
	Metabolic energies (ME) min.	13.0 MJ/kg

Table 3. Atmospheric conditions during the trial (5 September–31 October 2003)

	September 2003							October 2003						
	temperature (°C)						precipitation (mm)	temperature (°C)						precipitation (mm)
	7h	14h	21h	average	min.	max.		7h	14h	21h	average	min.	max.	
1	10.0	21.0	16.0	15.8	9.00	22.0	0.8	3.00	20.0	19.0	15.3	3.00	21.0	
2	13.0	16.0	11.0	12.8	10.0	17.0	1.3	6.00	24.0	16.0	15.5	6.00	26.0	
3	9.00	17.0	11.0	12.0	9.00	18.0		9.00	26.0	16.0	16.8	9.00	27.0	
4	2.00	17.0	12.0	10.8	2.00	18.0		9.00	27.0	24.0	21.0	9.00	28.0	
5	8.00	19.0	14.0	13.8	5.00	20.0		12.0	25.0	21.0	19.8	11.0	25.0	
6	3.00	22.0	20.0	16.3	3.00	24.0		14.0	10.0	5.00	8.50	2.00	14.0	
7	4.00	21.0	22.0	17.3	3.00	25.0		–2.00	17.0	13.0	10.3	–2.000	19.0	
8	9.00	26.0	20.0	18.8	7.00	26.0		8.00	2.00	3.00	4.00	1.00	12.0	0.9 snow
9	12.0	17.0	13.0	13.8	12.0	20.0		4.00	15.0	3.00	6.30	3.00	15.0	
10	13.0	17.0	15.0	15.0	13.0	18.0		1.00	11.0	6.00	6.00	0.000	14.0	17.1
11	14.0	17.0	14.0	14.8	12.0	17.0	22.3	1.00	19.0	13.0	11.5	0.000	20.0	
12	11.0	12.0	11.0	11.3	11.0	14.0		3.00	18.0	14.0	12.3	3.00	20.0	
13	11.0	12.0	10.0	10.8	10.0	13.0		9.00	15.0	7.00	9.50	7.00	16.0	
14	10.0	12.0	12.0	8.50	9.00	16.0		5.00	13.0	10.0	9.50	3.00	14.0	
15	8.00	16.0	10.0	11.0	7.00	22.0	13.5	6.00	5.00	2.00	3.80	2.00	8.00	
16	7.00	21.0	10.0	12.0	4.00	22.0		0.000	9.00	6.00	5.30	–2.000	9.00	2.3
17	8.00	21.0	11.0	12.8	6.00	22.0		4.00	4.00	4.00	4.00	3.00	7.00	
18	5.00	23.0	13.0	13.5	5.00	24.0		2.00	7.00	3.00	3.80	1.00	8.00	
19	6.00	24.0	14.0	14.5	6.00	26.0		1.00	4.00	4.00	3.30	0.000	4.00	
20	6.00	23.0	17.0	15.8	6.00	23.0		3.00	8.00	7.00	6.30	3.00	9.00	9.0
21	6.00	22.0	19.0	16.5	5.00	27.0		7.00	14.0	10.0	10.3	6.00	15.0	
22	6.00	27.0	13.0	14.8	5.00	29.0		8.00	7.00	7.00	7.30	7.00	11.0	2.5
23	7.00	28.0	14.0	15.8	5.00	29.0		6.00	6.00	5.00	5.50	4.00	7.00	28.2
24	9.00	23.0	15.0	15.5	7.00	23.0		5.00	7.00	4.00	5.00	2.00	7.00	
25	10.0	12.0	10.0	10.5	10.0	12.0		0.00	0.00	0.00	0.00	–1.00	1.00	
26	9.00	16.0	10.0	11.3	9.00	16.0	1.7	–1.00	3.00	–1.00	0.00	–3.00	6.00	
27	9.00	17.0	12.0	12.5	6.00	21.0		–2.00	–1.00	–2.00	–1.80	–2.00	–1.00	
28	5.00	22.0	14.0	13.8	4.00	24.0		–6.00	4.00	–3.00	–2.00	–6.00	4.00	32.2
29	10.0	18.0	13.0	13.5	8.00	18.0		–4.00	0.00	2.00	0.00	–4.00	6.00	
30	12.0	17.0	8.00	11.3	6.00	18.0	2.1	5.00	13.0	10.0	9.50	1.00	14.0	
31								0.00	17.0	8.00	8.30	0.00	17.0	
							Σ = 41.7							Σ = 92.2

tical to the spinal column at the final vertebra – the "lumbar" cut. The weight of the separated fat tissue (abdominal fat) was determined according to its weight in the pelvic-abdominal cavity.

Following the basic part separation, dissection of the right drumstick, right thigh and breast was performed and data on the weights of muscular tissue, bones and skin were recorded.

Statistical analyses

The data obtained in these studies were analysed by standard variation statistics methods. Testing of the significance of differences was done by the following mathematical variance analysis model:

$$Y_{ijk} = \mu + (RS)_i + (S)_j + (RSS)_{ij} + e_{ijk}$$

The presented model corresponds to the plan of a two-factorial trial 2 × 2 (2 rearing systems – *RS* and 2 sexes – *S*).

The investigated parameters were processed by the analysis of variance using the ANOVA procedure, Microsoft STATISTICA Ver. 5.0, StatSoft Inc. (1995).

RESULTS AND DISCUSSION

Table 4 shows the weights of dressed and cold carcasses and the proportions of major basic parts and abdominal fat in the dressed carcasses of the male and female broilers.

Based upon the data from Table 4 it could be concluded that the male chicks had heavier carcasses compared to the female ones. The differences exhibited in terms of the sex influence were statistically highly significant. Horn et al. (1998) stressed that the coefficient of live weight variation increased more in male chicks in the second part of the rearing period, compared to the females with the less pronounced increase. Grashorn and Clostermann (2002) calculated by regression analyses that the slow-growing hybrids needed 10–32 days more to reach the body weight of 2.000 g, which the Ross hybrid had at 42 days of age. In this study the feed conversion ratio was worse and the meat yield in the carcass and breasts was lower in the slow-growing hybrids than in the Ross hybrid. The meat had a darker colour, the ratio of abdominal fat and meat content in the drumstick were partially higher in the slow-growing hybrids than in the Ross hybrid. Differences in terms of sex were recorded for almost all the tratis. The carcass weight in the studies by Bilgili et al. (1992), Moran (1995), Ristic (1995), Melo et al. (1996), Ozkan et al. (1997) as well as by a large number of other authors was significantly higher in the male chicks compared to the female ones, being the result of large differences in body weight. On the other hand, differences in the weights of dressed and cold carcasses of the chicks investigated in terms of the effect of the tested rearing systems were low and they were not statistically significant. Data from Table 4 show that the highest breast proportion (31.69%) was registered in the female chicks reared in the free-range system and the lowest in the male chicks reared extensively in the poultry house. A somewhat higher drumstick proportion was recorded in the male chicks in both rearing systems compared to the females. Similar thigh proportions were established for the broiler

Table 4. Effect of sex and rearing systems on the proportions of major basic carcass parts and abdominal fat (%) in broiler chickens

Trial group	Sex		Dressed and cold carcass (g)	Breasts (%)	Drumsticks (%)	Thighs (%)	Abdominal fat (%)
Free range	male	x	2690	30.4	14.3	16.1	1.74
		Cv	5.62	5.06	7.47	6.21	28.2
	female	x	2295	31.7	13.4	16.0	2.02
		Cv	5.57	4.98	5.00	3.37	44.5
Extensive indoor	male	x	2523	29.8	14.5	16.4	1.71
		Cv	13.8	3.58	3.79	6.71	24.6
	female	x	2279	31.1	13.7	15.9	2.24
		Cv	3.81	5.97	4.08	4.40	27.2
F_{exp}	F_1		0.990	0.710	0.560	0.050	0.110
	F_2		12.1**	3.37	6.37*	0.580	2.02
	F_{12}		0.680	0.010	0.060	0.220	0.190

x = mean, *Cv* = coefficient of variation, *n* = 12

chicks of both sexes. It was determined by the analysis of the significance of differences between the trial chicks in the breast and thigh proportions that the differences were not statistically significant ($P > 0.05$). It was only for the drumstick proportion that a significantly higher ($P < 0.05$) percentage in the male carcass weight was determined. The proportions of major carcass parts (breasts, drumsticks and thighs) established by this study were somewhat higher than the results obtained by some authors (Bogosavljevic-Boskovic et al., 1999; Milosevic et al., 2003) who used similar methodology in their studies. Certain differences compared to the results from available literature were due to the fact that the results of these investigations were significantly affected by both genetic (breed or line hybrid used for fattening) and numerous non-genetic factors (nutrition, duration of the fattening period, live weight of chicks prior to slaughter, dressed carcasses weights, manner of dissection, etc.). The abdominal fat proportion in the female chicks from both rearing systems was higher than that recorded in the male chicks, but the differences were not significant. These results were in accordance with the results reported by Sütö et al. (1998), who determined that in commercial broiler hybrid Arbor Acres Regular the abdominal fat deposition was similar in both sexes until 5 weeks of age. The same authors suggested that the abdominal fat deposition was significantly affected by age and sex, but only after 5 weeks of age, when the female chicks deposited abdominal fat considerably faster than the males. Until 16 weeks of age, the abdominal fat proportion did not exceed 2% in the male chicks and was almost 5% in the females. In the 20th week, 5.90% (264 g) and 2.40% (130 g) of abdominal fat were deposited by the female and male chicks, respectively. The results obtained by Holcman et al. (2003) also confirmed a significant effect of sex on broiler meat quality (the females were more fatty than the males of the same age).

The abdominal fat proportion in the broilers in our investigation was a bit higher than compared to the results of Havenstain et al. (1994), who examined the effect of genotype and feeding on the weight gain and carcass composition in broilers.

Table 5 shows the results of dissection of major carcass parts (breasts, drumsticks and thighs) into basic tissues (muscular tissue, bones and skin).

The data in Table 5 indicate that the chicks of both sexes reared in the free-range system had a higher muscular tissue proportion in the breast weight compared to the chicks fattened extensively in the poultry house. Conversely, the chicks reared extensively were found to have a somewhat higher bone proportion. The skin proportion in the breast weight ranged from 11.0% (the male chicks fattened

Table 5. Effect of sex and rearing system on the proportions of meat, skin and bones in breasts, drumsticks and thighs (%) of broiler chickens

Trial group	Sex		Breasts			Drumsticks			Thighs		
			muscles	bones	skin	muscles	bones	skin	muscles	bones	skin
Free range	male	x	75.1	12.3	12.0	63.1	24.8	10.9	71.7	16.1	10.8
		Cv	5.39	29.8	28.1	5.72	15.0	17.7	5.42	10.1	21.0
	female	x	76.8	10.8	11.8	64.8	23.5	10.5	70.5	13.8	14.6
		Cv	3.87	17.2	23.2	3.69	14.7	20.5	3.91	11.0	15.8
Extensive indoor	male	x	74.6	13.9	11.0	62.5	28.2	9.30	69.4	15.0	14.3
		Cv	4.99	26.0	11.2	6.15	12.6	17.8	7.75	18.7	36.2
	female	x	72.7	13.0	13.5	64.3	24.0	10.7	72.4	14.6	12.3
		Cv	2.05	11.2	14.3	4.71	11.1	15.9	6.74	30.8	11.7
F_{exp}	F_1		2.58	2.23	0.080	0.170	1.70	0.740	0.010	0.020	0.190
	F_2		0.010	0.940*	1.17	1.42**	3.25**	0.360	0.200*	1.13**	0.400
	F_{12}		1.56	0.070	1.56	0.010	0.910	1.09	1.16	0.560	4.38

x = mean, Cv = coefficient of variation, n = 12

extensively) to 13.5% (the female chicks fattened extensively in the poultry house). The differences in the proportions of muscular tissue, bones and skin in the breast weight were significant both between the sexes and between the investigated rearing systems.

The proportions of the muscular tissue in the drumsticks were somewhat higher in the chicks reared in the free-range system as well as in the female chicks compared to the male ones. The bone content in the drumstick weight varied from 23.5% (the female chicks reared in the free-range system) to 28.2% (the males fattened extensively in the poultry house). The lowest skin proportion in the drumstick weight was registered in the male chicks fattened extensively in the poultry house (9.30%), and the highest (10.9%) was recorded with the males reared in the free-range system. However, the differences in the proportions of basic parts in the drumsticks between the investigated rearing systems and between the sexes of the examined chicks were not significant.

There were small differences between the chicks of both trial groups in the proportion of muscular tissue in the thighs. The proportion of the tissue in the thighs ranged from 69.4% (the male chicks, fattened extensively in the poultry house) to 72.4% (the females of the same group). The lowest bone proportion in the thighs was registered in the female chicks reared in the free-range system (13.8%) and the highest in the males from the same rearing system (16.1%). Furthermore, the lowest and the highest skin proportions in the thigh weight 10.8% for the males and 14.6% for the females, respectively, were recorded for the chicks reared in the free-range system. The differences in the proportions of basic tissues in the thigh weight were not statistically significant between the sexes nor between the broilers reared in different rearing systems.

CONCLUSIONS

Based upon the investigations conducted, the following may be inferred:

The rearing system (free-range and extensive indoor ones) did not have a statistically significant effect on the proportions of major basic carcass parts and abdominal fat in the broiler chickens ($P > 0.05$).

Heavier carcasses at slaughter (on the 56th day of fattening) were recorded in the male broilers (2 690 g in the free-range rearing system and 2 523 g in the extensive indoor rearing system) compared to the female ones (2 295 g and 2 279 g, respectively), the differences being statistically highly significant ($P < 0.01$).

The drumstick proportion in the male broiler carcasses (14.3% in the free-range rearing system and 14.5% in the extensive indoor rearing system) was statistically significantly higher ($P < 0.05$) than the proportion in the female broilers (13.4 and 13.7%, respectively).

The interaction between the investigated effects (of sex and rearing system) did not exert a statistically significant effect on the proportions of major basic carcass parts and abdominal fat in the broiler chickens ($P > 0.05$).

The rearing system (free-range and extensive indoor ones) and the interaction between the investigated effects (of sex and rearing system) did not affect statistically significantly the differences in the meat, skin and bone proportions in breasts, drumsticks and thighs of the broiler chickens ($P > 0.05$).

The effect of sex on the skin proportion in breasts, drumsticks and thighs was not statistically significant ($P > 0.05$).

An average muscle proportion in the drumsticks and thighs of the female broilers (64.8% in the free-range rearing system and 64.3% in the extensive indoor rearing system) was statistically highly significantly ($P < 0.01$) higher compared to the male broilers (63.1% and 62.5%, respectively).

An average muscle proportion in the thighs of the female broilers (70.5% and 72.4% in the free-range and extensive indoor rearing system, respectively) was statistically significantly ($P < 0.05$) higher compared to that in the male broilers (71.7% and 69.4%, respectively).

An average bone proportion in the breasts of the male broilers (12.3% and 13.9% in the free-range and extensive indoor rearing system, respectively) was statistically significantly higher ($P < 0.05$) compared to that in the females (10.8% and 13.0%, respectively).

An average bone proportion in the drumsticks of the male broilers (24.8% and 28.2% in the free-range and extensive indoor rearing system, respectively) was statistically highly significantly higher ($P < 0.01$) compared to that in the females (23.5% and 24.0%, respectively).

An average bone proportion in the thighs of the male broilers (16.1% and 15.0% in the free-range and extensive indoor rearing system, respectively)

was statistically highly significantly higher ($P < 0.01$) than that in the thighs of the females (13.8% and 14.6%, respectively).

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