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The effect of rearing system and length of fattening period on selected parameters of broiler carcass quality

Einfluss von Haltungssystem und Dauer der Mastperiode auf ausgewählte Schlachtkörperqualitätsparameter bei Broilern

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Introduction

Poultry rearing systems have captured the attention of both scientists and producers in many countries worldwide for a number of years. Huge efforts have been made to introduce innovative ideas and establish new technologies in poultry rearing for egg and meat production aimed at improving rearing conditions, protecting the environment and enhancing the quality of poultry products. The above has been undertaken due to consumer demands for high-quality products and legal regulations on welfare in poultry rearing imposed by numerous groups of ecologists.

For several decades after the Second World War, poultry production had been practised on industrialized farms. This enabled high-volume production and pronounced profitability (Havenstein et al., 1994; Remignon et al., 1994), which resulted in a very high level of production and the overall volume of production reaching maximum limits of poultry biological potential and maximum consumption. It was then that the above demands for a change of rearing and production methods, particularly as regards poultry meat, ensued. Poultry rearing system is becoming increasingly important as is the fact that the modern poultry market is being radically transferred from a market where only price competitiveness existed to a market which gives an equal opportunity to quality competitiveness.

The above stated has resulted in the ever-increasing importance of non-industrial systems and organic production which are in some countries, such as those of the EU, strictly regulated under different directives (VO/EWG 1538/91 and VO/EG 1804/99) laying out minimum conditions required for satisfaction of non-industrial and organic poultry production standards (Ristic, 2003).

In line with the said requirements, a number of studies have been conducted on extensive and semi-intensive systems of poultry rearing (free range production, slow-growing broiler hybrids, prolonged fattening) as well as on the quality of the broiler meat thus produced (Sütő et al., 1998; Grashorn and Clostermann, 2002; Bokkers and Koene, 2003; Filho et al., 2003).

In view of the above stated and of the importance of length of fattening period in non-industrial poultry production, experimental studies were conducted in order to evaluate selected traits of carcass quality (dressing percentage, proportion of primal carcass cuts, proportion of major tissues) of broilers raised under two different non-industrial rearing systems (extensive indoor and free range) at different lengths of fattening period.

Material and Methods

Test animals, housing and diet

As slow-growing broiler lines, either imported or domestic ones, are not reared in Serbia, the experimental material used in this study included a total of 200 one-day-old fast-growing Cobb 500 broilers. This was considered scientifically and professionally justified as previous studies (Bogosavljevic-Boskovic et al., 2006a, 2008) revealed that the broilers of this strain as well can be successfully reared under non-industrial systems with the meat produced having some improved quality traits. The rearing systems employed conformed to "extensive indoor" ("barn-reared") and "free-range" standards (Commission Regulations EEC VO/EWG 1538/91 and VO/EG 1804/99). During the first 4 weeks, the broilers were kept in the same facility in a deep litter system (extensive indoor). On day 28, the broilers were divided into 2 groups, the first being kept in the poultry house at a stocking density of 12 chicks/m^2 (extensive indoor), the second one being provided free range of 1m^2/chick, apart from being reared at an identical stocking density. Extensive indoor (Group 1) and free range (Group 2) rearing systems showed differences not only in stocking density but also in a number of other factors related to rearing conditions. Group 1 broilers were reared in a deep litter consisting of wood shavings. The litter was not refreshed during the fattening period so as not to disturb the test broilers i.e. so as to avoid the potential stress effect. Electric lighting system was used. Optimal microclimate conditions were provided by ventilation system (through roof openings and using ventilation fans). As for Group 2 broilers, grass-covered free range was provided. Apart from the natural environment i.e. grass, fresh air and sunlight, and higher roaming potential, the free range system used also involved foraging and feeding on natural food from the range. The fattening period lasted for 56 and 63 days (one group of broilers were slaughtered on day 56

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and the others were fattened 7 days longer). The broilers were fed two complete feed mixtures: broiler starter diet (BS) until day 28 and broiler finisher diet (BF) from day 28 to day 42 of fattening, which was followed by a diet containing a mixture of ground maize, barley, mineral and vitamin supplements (70%) and a complete feed mixture (30%) fed until the end of the fattening period. The broilers were fed ad libitum.

Until day 28 of age, the broilers were given an all-mash starter diet (BS) (manufactured by the Veterinary Institute Zemun, Republic of Serbia). From day 28 to day 42 of fattening, the tested broilers were fed an all-mash broiler finisher diet (BF) (manufactured by the Veterinary Institute Zemun, Republic of Serbia) (Table 1).

Sample collection

Following the first fattening period of 56 days, 12 male and 12 female broilers were randomly selected from each experimental group and slaughtered to examine major carcass quality traits at this age. The fattening period for the other broilers was prolonged for another 7 days. Then, at 63 days of age, another 12 male broilers and as many females were selected from each group, slaughtered and used to evaluate carcass quality traits. Immediately prior to slaughter, the selected broilers were weighed. Upon slaughter and primary carcass processing, the processed carcasses were cooled in a cooling chamber for 24 hours at 0–4°C. Following the chilling procedure, the carcasses were weighted to obtain the dressing percentage of the test broilers. Thereafter, the dressed cold carcass of each broiler was dissected into primal cuts (breast, drumstick, thigh, wing, pelvis and back) following the method prescribed by the Regulation on Poultry Meat Quality (RASETA and DAKIĆ, 1984). The removal of the thighs and drumsticks from the carcass was performed by cutting above the thigh, towards the acetabulum and behind the pubic bone (the pelvic/thigh incision). Then, the drumsticks were separated from the thighs by cutting perpendicular to the joint between the drumstick and thigh bones. The wings were removed by the so-called "shoulder" cut through the joint (articulation) surfaces of the scapula and the coracoid. The breast was separated by a cut perpendicular to the ventral joints of ribs – the "rib" incision. The back-pelvis separation was performed by cutting perpendicularly to the vertebral column at the level of the final vertebra – the "lumbar" incision. Following the carcass dissection, the cuts were weighed and their amount as a percentage of dressed cold carcass weight was measured. Then, the right drumstick, right thigh and breast were dissected into main tissues (muscle, bone and skin). The separated tissues were weighed, and their respective proportions in the main carcass were recorded.

Statistical analyses

The obtained data were analyzed by conventional methods of statistics. The significance of differences was tested by the following mathematical model of analysis of variance:

$$Y_{ijk} = \mu + RS_i + FP_j + G_k + (RSxFP)_{ij} + (RSxG)_{ik} + (FPxG)_{jk} + (RSxFPxG)_{ijk} + e_{ijkl}$$

i.e. in a three-factor design of 2x2x2 (2 rearing systems – RS, 2 lengths of fattening period – FP and 2 genders – G).

The test parameters were subjected to an analysis of variance using ANOVA, Microsoft Statistica Ver. 5.0, STATSOFT INC. (1995).

Results and Discussion

The data in Table 2 also suggest that differences in dressing percentage were larger in terms of the effect of broiler gender (the differences were also statistically significant, $P < 0.05$). The differences induced by the effect of rearing system and length of fattening period were smaller and, as determined by the analysis of significance, statistically insignificant ($P > 0.05$). Apart from revealing the significantly higher body weights of male broilers, this study confirmed the findings of HORN et al. (1998) reporting a substantially higher increase in the coefficient of variation of broiler body weight in male broilers during the second part of the

Table 1. Ingredients and chemical composition of broiler starter diet (BS) and broiler finisher diet (BF)
Zusammensetzung und kalkulierte Nährstoffgehalte der Starter- (BS) und Finisher- (BF) Ration

Ingredients	Formulation (calculated values)	Starter broiler diet (BS)	Finisher broiler diet (BF)
• Grained feeds • Oil industry products • Animal-derived feeds • Other plant-derived • products • Mineral feeds • Amino acids	Proteins min.	22.0%	20.0%
	Fats	5.00%	5.00%
	Moisture max.	13.5%	13.5%
	Cellulose max.	4.00%	5.00%
	Ash max.	8.00%	8.00%
	Ca	0.90–1.10%	0.80–1.00%
	P	0.65–0.75%	0.60–0.80%
	Useable P min.	0.400%	0.350%
	Na	0.15–0.20%	0.15–0.20
	Lysine min.	1.15%	0.900%
	Methionine + cystine min.	0.850%	0.700%
	Metabolic energies (ME)min.	13.00 MJ/kg	13.0 MJ/kg
Premix VZ Vit B-1 (vitamins, minerals, antioxidant)		1%	–
Premix VZ Vit B-2 (vitamins, minerals, antioxidant)		–	1%

Table 2. Life weight, carcass weight and dressing percentage of the tested broilers
Lebendgewicht, Schlachtkörpergewicht und Schlachtausbeute der untersuchten Broiler

Rearing system (RS)	Fattening period, days (FP)	Gender (G)	Broiler weight before slaughter, g		Dressed carcass			
					Weight, g		Dressing percentage, %	
			$\bar{x}$	C_v	$\bar{x}$	C_v	$\bar{x}$	C_v
I (Extensive indoor)	56	male	3283	5.20	2404	6.39	73.2	2.34
		female	2986	11.3	2204	12.0	73.8	1.28
	63	male	3510	16.8	2526	18.2	71.9	3.80
		female	2887	3.19	2118	3.49	73.4	1.59
II (Free range)	56	male	3277	5.70	2362	6.67	72.1	3.18
		female	2950	6.06	2162	6.94	73.3	2.11
	63	male	3637	12.6	2668	14.0	73.3	1.50
		female	3298	4.00	2412	5.07	73.8	2.56
F_{exp}		F_{RS}	1.86^{ns}		1.45^{ns}		0.063^{ns}	
		F_{FP}	5.25*		4.08^{ns}		0.114^{ns}	
		F_G	18.9**		13.2**		2.30^{ns}	
		F_{RSxFP}	2.54^{ns}		3.15^{ns}		1.78^{ns}	
		F_{RSxG}	0.496^{ns}		0.266^{ns}		0.278^{ns}	
		F_{FPxG}	0.863^{ns}		0.815^{ns}		0.381^{ns}	
		$F_{RSxFPxG}$	0.740^{ns}		0.266^{ns}		1.23^{ns}	

^{ns} – $P > 0.05$, * – $0.01 < P < 0.05$, ** – $P < 0.01$

rearing period than in females. Identical reports on body weight being significantly higher in male broilers than in females were also found in studies conducted by Ristic (1995), Melo et al. (1996), Ozkan et al. (1997), Bogosavljevic-Boskovic et al. (2006b) etc.

The obtained results on the proportions of primal cuts in dressed broiler carcasses are listed in Table 3. The data in Table 3 show that the extensive indoor bred broilers had a somewhat higher breast proportion and a lower proportion of drumsticks and thighs than the free-range broilers. However, the differences were small and insignificant ($P > 0.05$). As the length of fattening period increased, a somewhat higher breast proportion in the dressed carcasses was recorded, but likewise the observed difference was not significant ($P > 0.05$). These results and those on the proportion of wings, pelvis and back suggest the insignificant effect of the first two tested factors (rearing system and length of fattening period) on the proportions of major primal carcass cuts of the test broilers. Conversely, the effect of gender on the proportion of carcass cuts (breast, drumsticks, thighs and wings) was statistically very significant ($P < 0.01$). A significantly higher proportion of breast was recorded in female broilers and that of drumsticks, thighs and wings in the males. The analysis of significance of differences in the proportion of primal carcass cuts in terms of the interaction between the tested factors revealed that only the length of fattening period-gender interaction for the pelvis proportion was found to be significant ($P < 0.05$). The said proportion of carcass weight decreased with increasing length of fattening period in the male broilers tested. An increasing length of fattening period generally results in an increase in the proportion of high-value primal carcass cuts (breast, drumsticks and thighs), as suggested by Havenstein et al. (1994), Lewis et al. (1997), Ristic (2002), Milosevic et al. (2003).

The tissue proportion in the dressed carcass is another important parameter of broiler meat quality. Table 4 shows results on the muscular tissue, bone and skin proportions in high-value carcass cuts being classified as first-category meat by the Regulation on Poultry Meat Quality (Raseta and Dakić, 1984).

Table 4 suggests that small i.e. insignificant ($P > 0.05$) differences in the muscular tissue proportion in breasts, drumsticks and thighs were established, resulting from the effect of the tested rearing systems and length of fattening period. The gender effect was significant ($P < 0.05$); therefore, the breast and drumstick muscle proportion was higher in female broilers than in males. The breast and drumstick bone proportion was significantly higher ($P < 0.05$) in males than in females. The factors tested had no significant effect on the thigh muscle proportion in broilers. Only the rearing system-broiler gender interaction was significant. The extensive indoor female broilers had a significantly higher proportion of muscular tissue as compared to the free-range females. The thigh bone proportion was significantly higher ($P < 0.01$) in male broilers than in females. Furthermore, the obtained data suggest that the tested rearing systems and length of fattening period did not significantly affect the proportion of main tissues in the high-value carcass cuts of the tested broilers. Irrespective of the above factors hampering comparison of the present findings with those from the available literature, these results partly conform to those reported by Lewis et al. (1997), Ristic (2003) and Bogosavljevic-Boskovic et al. (2006a).

Conclusions

- As compared to female broilers, males had higher body weights at slaughter (at 56 and 63 days of age) and higher dressed cold carcass weights. The observed differences (the gender effect) were statistically very significant ($P < 0.05$).

Table 3. Proportion of primal cuts (%)
Anteile der Teilstücke (%)

Rearing system (RS)	Fattening period, days (FP)	Gender (G)	Breasts %		Drumsticks %		Thighs, %		Wings, %		Pelvis, %		Back, %	
			$\bar{x}$	C_v	$\bar{x}$	C_v	$\bar{x}$	C_v	$\bar{x}$	C_v	$\bar{x}$	C_v	$\bar{x}$	C_v
I (Extensive indoor)	56	male	33.8	8.14	13.3	6.34	14.4	12.1	10.8	4.76	11.1	7.75	8.98	9.58
		female	36.0	2.57	12.2	5.28	13.6	3.28	10.2	6.73	10.0	9.02	9.14	3.53
	63	male	34.0	5.50	13.8	8.92	14.7	3.19	10.6	10.5	10.2	5.85	9.15	9.04
		female	36.5	4.64	12.3	4.52	13.6	3.93	10.2	5.39	10.1	4.55	9.21	8.46
II (Free range)	56	male	32.3	5.84	14.1	4.66	14.9	3.57	11.0	4.79	10.4	6.08	9.22	5.37
		female	35.3	7.03	13.0	10.3	14.0	5.60	10.5	6.60	10.3	18.4	9.16	9.05
	63	male	34.1	6.83	14.1	6.77	15.3	6.06	10.9	5.68	10.0	6.14	8.75	6.45
		female	36.1	4.16	12.3	2.77	13.8	3.98	10.1	6.72	10.4	9.80	8.92	7.00
F_{exp}		F_{RS}	1.06^{ns}		3.75^{ns}		2.91^{ns}		0.571^{ns}		0.612^{ns}		0.643^{ns}	
		F_{FP}	2.08^{ns}		0.002^{ns}		0.184^{ns}		0.714^{ns}		0.390^{ns}		0.087^{ns}	
		F_G	17.3^{**}		28.0^{**}		18.8^{**}		7.83^{**}		2.71^{ns}		0.018^{ns}	
		F_{RSxFP}	0.702^{ns}		1.67^{ns}		0.007^{ns}		0.150^{ns}		1.69^{ns}		0.768^{ns}	
		F_{RSxG}	0.022^{ns}		0.150^{ns}		0.233^{ns}		0.093^{ns}		0.867^{ns}		0.173^{ns}	
		F_{FPxG}	0.100^{ns}		1.23^{ns}		0.579^{ns}		0.003^{ns}		5.13^{*}		0.208^{ns}	
		$F_{RSxFPxG}$	0.294^{ns}		0.128^{ns}		0.176^{ns}		0.396^{ns}		0.012^{ns}		0.506^{ns}	

^{ns} – P > 0.05, * – 0.01 < P < 0.05, ** – P < 0.01

Table 4. Tissue proportion in high-value carcass cuts (%)
Gewebliche Zusammensetzung der wertvollen Teilstücke (%)

Rearing system (RS)	Fattening period, days (FP)	Gender (G)	Breasts			Drumsticks			Thighs		
			muscle, %	bones, %	skin, %	muscle, %	bones, %	skin, %	muscle, %	bones, %	skin, %
I (Extensive indoor)	56	male	76.7	14.4	8.93	60.1	30.2	9.65	73.4	15.9	10.7
		female	77.4	12.9	9.70	62.7	24.6	12.6	76.2	14.5	9.34
		m + f	77.0	13.6	9.31	61.4	27.4	11.1	74.8	15.9	10.0
	63	male	75.1	16.6	8.26	58.4	31.2	10.4	70.8	20.4	8.71
		female	78.9	13.2	7.97	64.5	26.5	8.99	75.7	15.8	9.11
		m + f	77.0	14.9	8.12	61.5	28.8	9.70	73.3	17.8	8.91
II (Free range)	56	male	75.1	15.3	9.61	61.6	29.1	9.36	73.3	18.5	8.19
		female	75.3	15.0	9.64	63.5	26.4	10.1	71.2	18.5	10.2
		m + f	75.2	15.2	9.62	62.5	27.8	9.71	72.3	18.5	9.21
	63	male	76.8	14.9	8.26	63.9	26.2	10.0	75.1	17.7	7.24
		female	78.1	12.5	9.38	62.8	25.6	11.6	74.9	14.7	10.4
		m + f	77.6	13.7	8.84	63.3	25.9	10.8	75.0	16.2	8.80
F_{exp}		F_{RS}	1.13^{ns}	0.139^{ns}	1.53^{ns}	2.03^{ns}	2.04^{ns}	0.110^{ns}	1.45^{ns}	0.752^{ns}	0.957^{ns}
		F_{FP}	4.30^{ns}	0.405^{ns}	6.51^{*}	0.159^{ns}	0.067^{ns}	0.124^{ns}	0.483^{ns}	0.070^{ns}	1.89^{ns}
		F_G	5.05^{*}	7.95^{*}	0.148^{ns}	5.29^{*}	13.1^{**}	3.57^{ns}	0.720^{ns}	11.7^{**}	5.18^{*}
		F_{RSxFP}	3.93^{ns}	4.84^{*}	0.007^{ns}	0.140^{ns}	3.20^{ns}	6.33^{*}	1.02^{ns}	13.3^{**}	5.14^{*}
		F_{RSxG}	0.18^{ns}	0.246^{ns}	0.000^{ns}	3.55^{ns}	3.77^{ns}	0.116^{ns}	6.22^{*}	1.45^{ns}	7.06^{*}
		F_{FPxG}	0.460^{ns}	1.07^{ns}	0.153^{ns}	0.017^{ns}	0.672^{ns}	3.16^{ns}	0.204^{ns}	6.27^{*}	3.74^{ns}
		$F_{RSxFPxG}$	1.18^{ns}	0.075^{ns}	2.03^{ns}	2.42^{ns}	0.112^{ns}	6.85^{*}	0.129^{ns}	0.040^{ns}	0.125^{ns}

^{ns} – P > 0.05, * – 0.01 < P < 0.05, ** – P < 0.01

- The effect of gender on the proportion of primal carcass cuts was statistically confirmed. Female broilers had a significantly ($P < 0.05$) higher breast proportion than males, whereas, the proportion of drumsticks and thighs was found to be significantly higher in male broilers than in females.
- Length of fattening period had a significant effect only on breast skin percentage ($P < 0.05$). Broiler gender affected significantly both the bone and muscle proportion in breast and drumsticks, and the percentage of bones and skin in thighs ($P < 0.05$).
- The combined effect of rearing system and length of fattening period showed significant differences in the proportion of bones in breast and thighs as well as in skin percentage in thighs and drumsticks ($P < 0.05$).
- Differences in the proportion of muscles and skin in thighs were significant in terms of the combined effect of rearing system and broiler gender ($P < 0.05$).
- The length of fattening period–broiler gender interaction revealed significant differences in bone proportion in thighs ($P < 0.05$).
- The combined effect of the three factors tested (rearing system, length of fattening period and broiler gender) showed a significant difference only in the percentage of skin in drumsticks ($P < 0.05$).

Summary

This study involved analysis of some carcass quality parameters in broilers reared under two different non-industrial systems (extensive indoor and free range) at two different lengths of fattening period (56 and 63 days). The quality parameters tested included dressed carcass yield, dressing percentage, proportion of primal cuts (breast, drumstick, thigh, wing, pelvis and back) in dressed carcass, and proportion of major tissues (muscular tissue, bone and skin) in high-value carcass cuts (breast, drumstick and thigh). The objective of the study was to evaluate the effect of broiler rearing system, length of fattening period and gender on the carcass quality traits tested.

The male broilers had a higher carcass weight at the slaughtering line at both lengths of fattening period, and the obtained differences were statistically significant. The broilers raised under extensive indoor system had a somewhat higher proportion of breast and a lower proportion of thigh and drumstick. A significant effect of gender was observed on these traits. The proportion of muscular tissue, bone and skin in the high-value primal cuts, including breast, drumsticks and thighs, dependent also on broiler gender and partly on the rearing system and length of fattening period.

Zusammenfassung

Einfluss von Haltungssystem und Dauer der Mastperiode auf ausgewählte Schlachtkörperqualitätsparameter bei Broilern

In der Studie wurden einige Merkmale der Schlachtkörperqualität bei Broilern, die in zwei unterschiedlichen Haltungsumwelten (extensive Bodenhaltung, Freiland) über zwei verschiedene Mastzeiträume (56, 63 Tage) gehalten wurden, untersucht. Als Kennwerte der Schlachtkörperqualität wurden das Schlachtkörpergewicht, die Schlachtausbeute, der Anteil der Teilstücke (Brust, Oberschenkel, Unterschenkel, Flügel, Becken, Rücken) am Schlachtkörper und der Anteile der Gewebe (Muskelgewebe, Knochen, Haut) an den wertvollen Teilstücken (Brust, Oberschenkel, Unterschenkel) bestimmt. Das Ziel der Untersuchung war die Ermittlung des Einflusses von Haltungsumwelt, Dauer der Mastperiode und Geschlecht auf die untersuchten Merkmale der Schlachtkörperqualität.

Die männlichen Broiler wiesen das signifikant höchste Schlachtkörpergewicht zu beiden Schlachtzeitpunkten auf. Die im Stall aufgezogenen Broiler hatten im Vergleich zum Freiland einen etwas höheren Brust- und einen etwas geringeren Schenkelanteil. Der Einfluss des Geschlechts war hier signifikant. Der Anteil an Muskelgewebe, Knochen und Haut bei den Teilstücken Brust, Ober- und Unterschenkel wurde im wesentlichen vom Geschlecht, dem Haltungssystem und der Mastdauer bestimmt.

Stichworte

Broiler, Haltungssystem, Mastdauer, Schlachtkörperqualität

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