

THE EFFECT OF GENOTYPE, REARING SYSTEM AND DURATION OF FATTENING ON PHYSICAL CHARACTERISTICS OF TIBIA IN BROILERS

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The aim of the research was to investigate the effects of medium-growing broiler genotypes, age of broilers at slaughter and rearing system in non-conventional meat production on the physical characteristics of the tibia. The study was conducted on Redbro and Redbro Naked Neck chickens, which were reared in the free range system. The quality of tibia was tested on Redbro chickens in free range and extensive conditions in the closed facility, until 42 or 84 days of age. Physical characteristics of tibia: length, mass, cross sectional area of the diaphysis, breaking force and specific breaking force, were established after slaughtering of the sample of 12 broilers per treatment and separation of the left tibia from the skeleton. The studied chicken genotypes have not exerted significant effect on osteometrical and biomechanical characteristics of the tibia. The effect of rearing system is not statistically confirmed, but the potential for improving the quality parameters of the tibia in the rearing system with free range could be established. Duration of fattening period in extensive rearing system in the closed poultry house, as well as gender, have demonstrated a significant effect on the physical characteristics of the tibia.

Key words: broilers; *tibia*; medium-growing genotype; non-conventional production system

ВЛИЈАНИЕ НА ГЕНОТИПОТ, СИСТЕМОТ НА ОДГЛЕДУВАЊЕ И ВРЕМЕТРАЕЊЕТО НА ГОЕЊЕ ВРЗ ФИЗИЧКИТЕ КАРАКТЕРИСТИКИ НА ТИБИЈАТА КАЈ БРОЈЛЕРИТЕ

Целта на истражувањето беше да се испитаат влијанијата на среднорастечките бројлерски генотипови, возраста на бројлерите за колење и системот на одгледување во неконвенционално производство на месо врз физичките карактеристики на тибията. Студијата беше спроведена на генотипот Redbro и Redbro голошијанери, кои беа одгледани во слободен систем (free range). Квалитетот на тибията беше тестиран кај пилињата одгледани во слободни и екстензивни услови во затворен објект до 42 и 84 дена, соодветно. Физичките карактеристики на тибията: должина, маса, пресек на дијафизата, сила на кршење и специфична сила на кршење, беа утврдени по колењето на примерокот од 12 бројлери по третман и одвојување на левата тибия од скелетот. Испитуваните генотипови на пилињата не покажале значителен ефект врз остеометриските и биомеханичките карактеристики на тибията. Влијанието на системот за одгледување не е статистички потврдено, но беше утврден потенцијал за подобрување на параметрите за квалитет на тибията во рамките на слободниот систем на одгледување. Значително влијание врз физичките карактеристики на тибията покажаа времетраењето на периодот на гоеење во екстензивниот систем на одгледување пилиња во затворен простор, како и полот,

Клучни зборови: бројлери; тибия; среднорастечки генотип; неконвенционален систем на производство

INTRODUCTION

Problems with the skeleton are usually related to the commercial broiler genotypes and their genetic predisposition for early rapid growth. The rapid development of muscle mass in the first two

weeks of life of broilers is not accompanied by adequate development of the skeleton. The consequences of that, as well as conditions in intensive, commercial rearing systems, with a large density and minor physical activity of broiler chickens, lead to several leg problems (lameness, deformity, frac-

tures) which influence the productivity and efficiency of production, the quality of the carcass at the slaughter and animal welfare (Sanotra *et al.* [10]; Bessei [1]; Škrbić *et al.* [13]). The results of comprehensive research of Knowles *et al.* [5] conducted on 176 commercial broiler flocks show that at the age of 40 days over 27.6% of broilers show locomotor problems and 3.3% were hardly able to walk.

Reducing the intensity of the early growth of broilers in order to reduce the incidence of leg problems can be achieved using the slower growing genotypes and less intensive growing conditions. This is corroborated by the results obtained by Vitorović *et al.* [17], who have established differences in morphometric and biomechanical parameters of tibio-tarsus between broiler hybrids with different genetic potential for growth. Đukić-Stojčić and Bessei [2] have demonstrated that broiler chickens of reduced body mass show higher activity, thus confirming the importance of body weight for physical activity of broiler chickens. The influence of gender of chickens on the incidence of broken and deformed bones, as well as the gait score, Oviedo-Rondon *et al.* [8] associate with body mass. However, there are results indicating that the reduction in the rate of growth does not improve the quality of the bones (Leterrier *et al.* [6]) and that the leg problems mainly relate to the interaction of genetic, nutritional and management factors (Waldenstedt [18]).

The aim of the experiment was to examine the physical properties of the tibia of broilers in non-conventional production, as an effect of broiler genotype of moderate growth, rearing systems, i.e. duration of fattening. Together with the determined production parameters and the quality parameters of the carcass (Škrbić *et al.* [14]), the study of the quality of the tibia shall provide a more complete understanding of the production and qualitative indicators, as well as indicators of animal welfare in non-conventional chicken meat production.

MATERIALS AND METHODS

The study was conducted in several stages. In the first trial, the effects of genotype broilers moderate growth on the quality of the tibia were studied, using the Redbro Naked Neck and Redbro variety of chickens with feathers, reared in the system with the free range by the age of 84 days, according to the technology of Škrbić *et al.* [15]. The research was conducted on a total of 300 broiler chickens divided into two groups and 3 repetitions. Access to

the free range/pasture was provided on a daily basis after the age of 42 days. In the second and third trial, the quality of the tibia was tested on Redbro variety of chickens with feathers. In the second trial, the effect of the rearing system was studied on total of 300 chickens divided into two groups. The first group of Redbro chickens was grown extensively in the poultry house and the other on the free range. The duration of the fattening period was 84 days. In the third trial, Redbro chickens were reared extensively in the poultry house by the age of 42 and 84 days. In each group there were 150 chickens, distributed in boxes, with 3 repetitions per group. The physical characteristics of the tibia: length, mass, cross-sectional area of the diaphysis, breaking force and the specific breaking force, were determined after slaughtering of the sample of 12 broilers per treatment, with the equal share of genders. After the separation of the left tibiae from the skeleton, the mass of the wet bone and the length from the proximal to the distal end of the bone were measured. Based on the measured outer diameter, anteroposterior and latero-medial, using the equation for the surface of an ellipse (Vitorović [16]) the cross sectional area of the diaphysis of the bone was calculated. Bone strength was determined by the direct method for the determination of the breaking force (Mašić *et al.* [7]). Specific breaking force was calculated as the ratio of breaking force and cross-sectional surface of the tibia diaphysis.

Statistical analysis was performed by analysis of variance One-way ANOVA using statistical software STATISTICA package, version 8, StatSoft, Inc. (www.statsoft.com [12]).

RESULTS AND DISCUSSION

The measured parameters of the tibia of Redbro and Redbro Naked Neck broiler chickens at the age of 84 days, are presented in Table 1.

The differences found between the properties of the tibia in the Naked Neck Redbro genotype and Redbro chickens with feather showed no statistical significance. Redbro chicks had greater length and mass of the tibia (15.33 cm; 38.11 g vs. 15.14 cm; 34.51 g), as well as the absolute and relative indicators of the tibia strength (40.01 kg; 0.65 kg/mm² vs. 38.64 kg; 0.62 kg/mm²), while the cross sectional area of the tibia was greater in Redbro Naked Neck chickens (63.01 mm² vs. 61.96 mm²). The lack of significant differences in body mass of Redbro and Redbro Naked Neck broilers (Škrbić *et al.* [14]) can

be brought into connection with the lack of significant differences in the quality parameters of the tibia, which is in accordance with the determined unfavourable genetic correlations between leg health indicators and body mass of broilers (Kapell *et al.* [4]). A statistically significant effect of the gender was determined, wherein all the values except for the specific breaking force were higher for

the male chickens. In contrast, in the study of Oviedo-Rondon *et al.* [8], problems with the legs are more pronounced in male chickens, based on the higher incidence of broken, deformed bones and poorer gait scores, compared to female chickens.

Data on the quality parameters of the tibia in Redbro chickens, depending on the studied rearing systems, are shown in Table 2.

Table 1

The properties of tibia in Redbro and Redbro Naked Neck broilers

Factors	Length (cm)		Mass (g)		Cross-section surface of the diaphysis (mm ²)		Breaking force (kg)		Specific breaking force (kg/mm ²)	
	x	SD	x	SD	x	SD	x	SD	x	SD
Genotype										
RB	15.33	1.38	38.11	11.37	61.96	14.53	40.01	9.93	0.65	0.10
RBNN	15.14	1.93	34.51	9.29	63.01	11.02	38.64	7.91	0.62	0.10
Pol										
M	16.56	1.22	45.18	5.78	71.85	8.07	44.84	8.28	0.63	0.13
F	13.91	0.59	27.43	4.18	53.12	8.75	33.81	5.22	0.64	0.07
Genotype × Gender										
RB × M	16.53	0.33	48.12	4.43	73.65	5.48	46.65	7.97	0.64	0.12
RB × F	14.12	0.76	28.10	4.95	50.27	10.30	33.37	6.91	0.67	0.09
RBNN × M	16.58	1.77	42.25	5.76	70.05	10.26	43.03	8.91	0.63	0.15
RBNN × F	13.70	0.30	26.77	3.59	55.98	6.55	34.25	3.43	0.61	0.04
Significance										
Genotype	ns		ns		ns		ns		ns	
Gender	p<0.01		p<0.01		p<0.01		p<0.01		ns	
Genotype × Gender	ns		ns		ns		ns		ns	

RB – Redbro; RBNN – Redbro Naked Neck; M – male; F – female

Table 2

The impact of rearing system on physical properties of tibia

Factors	Length (cm)		Mass (g)		Cross-section surface of the diaphysis (mm ²)		Breaking force (kg)		Specific breaking force (kg/mm ²)	
	x	SD	x	SD	x	SD	x	SD	x	SD
Rearing system										
EPH	14.95	1.78	35.66	11.10	61.30	15.91	38.99	5.27	0.66	0.11
FR	15.33	1.38	38.11	11.37	61.96	14.53	40.01	9.93	0.65	0.10
Gender										
M	16.37	1.12	46.43	6.26	73.36	10.52	44.80	5.97	0.62	0.11
F	13.91	0.76	27.33	4.21	49.90	7.32	34.21	5.50	0.69	0.09
Rearing system × Gender										
EPH × M	16.20	1.61	44.75	7.74	73.07	14.60	42.94	2.57	0.60	0.10
EPH × F	13.70	0.77	26.57	3.61	49.53	3.37	35.05	4.13	0.71	0.10
FR × M	16.53	0.33	48.12	4.43	73.65	5.48	46.65	7.97	0.64	0.12
FR × F	14.12	0.76	28.10	4.95	50.27	10.30	33.37	6.91	0.67	0.09
Significance										
Rearing system	ns		ns		ns		ns		ns	
Pol	p<0.01		p<0.01		p<0.01		p<0.01		ns	
Rearing system × Gender	ns		ns		ns		ns		ns	

EPH – extensive in poultry house; FR – free-range; M – male; F – female

The chickens reared extensively in the poultry house had lower values for length, mass, cross section surface of the diaphysis and the breaking force of the tibia (14.95 cm; 35.66 g; 61.30 mm²; 38.99 kg/mm²) in comparison with free-range chickens (15.33 cm; 38.11 g; 61.96 mm²; 40.01 kg/mm²). Identified differences in these parameters between the studied rearing systems were not statistically confirmed. The male chickens had significantly greater length, mass, surface of the cross-section and the absolute breaking force of the tibia relative to the females, however the relative indicator of the strength of the tibia was not under the significant influence of the chicken gender. The effect of the rearing system is based on a variety of conditions for the physical activity of broilers and, respectively, the impact on the quality of bones. A direct impact of physical inactivity on the development and firmness of the tibia is presented by Foutz *et al.* [3]. In their study, the immobilization of tibia for two weeks reduced the length of the shank by 58–85% and the strength of the tibia by 40% compared to the control group. Based on the presented results it can be concluded that favourable conditions for the physical activity of the free range system had no significant effect on the development of the tibia. Sherlock *et al.* [11] have inferred the importance of broiler genotype in semi-intensive rearing conditions for the quality of the bones and have concluded that the fast-growing broiler genotype does not increase their physical activity sufficiently in order to positively impact on the quality of the bone. This may be the explanation

for our results, given that the Redbro chickens have moderate genetic potential for growth and can attain a body mass close to fast-growing broiler genotypes. Similarly, Özhan *et al.* [9] have found differences in mass, length and width of the tibia of broilers in the floor and cage rearing system, while reduced ash content in the cage system is explained by the reduced physical activity that leads to oxidative stress.

By prolonging the fattening period, Redbro chickens in extensive rearing system in the poultry house up to age at slaughter of 84 days increased significantly all absolute parameters of the tibia in relation to chickens at slaughter age of 42 days (Table 3). The relative indicator of the tibia strength was greater at the age of 42 days compared to 84 days (0.73 kg/mm² vs. 0.66 kg/mm²), but without statistical confirmation of established difference. A significant effect of age of broilers on the physical activity, wherein the younger chickens were active than older (Sherlock *et al.* [11]), despite less load of bones by the body mass, are the reasons for the greater specific breaking force of the tibia at the age of 42 days compared to 84 days. A significant interaction effect of the duration of fattening and gender of chickens was determined on the tibia length and mass. The effect of gender on the length and mass of the tibia was not manifested at the age of 42 days, indicating the lack of maturity of the skeleton at this age, while at the age of 84 days, male chickens had significantly greater length and mass of the tibia.

Table 3
The impact of duration of fattening period in extensive rearing system in poultry house on physical properties of tibia

Factors	Length (cm)		Mass (g)		Cross-section surface of the diaphysis (mm ²)		Breaking force (kg)		Specific breaking force (kg/mm ²)	
	x	SD	x	SD	x	SD	x	SD	x	SD
Duration of fattening in EPH										
42	10.50	0.40	20.93	3.00	42.09	7.11	30.62	7.70	0.73	0.13
84	14.95	1.78	35.66	11.10	61.30	15.91	39.00	5.27	0.66	0.11
Pol										
M	13.44	3.09	33.73	12.68	59.95	17.16	38.99	6.07	0.68	0.13
F	12.01	1.87	22.87	5.05	43.44	7.86	30.62	7.08	0.71	0.12
Duration of fattening × Gender										
42 x M	10.68 ^C	0.26	22.70 ^B	1.48	46.83	4.67	35.04	6.09	0.75	0.13
42 x F	10.31 ^C	0.44	19.17 ^B	3.18	37.35	5.95	26.19	6.80	0.70	0.14
84 x M	16.20 ^A	1.61	44.75 ^A	7.74	73.07	14.60	42.94	2.57	0.60	0.10
84 x F	13.70 ^B	0.77	26.57 ^B	3.61	49.53	3.37	35.05	4.13	0.71	0.10
Significance										
Duration of fattening	p<0.01		p<0.01		p<0.01		p<0.01		ns	
Gender	p<0.01		p<0.01		p<0.01		p<0.01		ns	
Duration of fattening × Gender	p<0.01		p<0.01		ns		ns		ns	

EPH – extensive in poultry house; M – male; F – female

CONCLUSION

Based on the presented results, it can be concluded that osteometrical and biomechanical characteristics of the tibia were not under significant influence of studied broiler genotypes and implemented non-conventional rearing systems.

The lack of the impact of genotype is associated with a similar genetic potential of studied moderate growth broilers and achieved increase in body mass. The effect of rearing system was not fully manifested, although there was a tendency of better physical properties of the tibia in free-range conditions, which is associated with physical activity broilers.

By prolonging the fattening period of Redbro chickens in extensive rearing system in the poultry house, all absolute quality parameters of the tibia increased significantly. The relative strength indicator of the tibia had a tendency to decrease with the prolongation of the fattening period. Length and mass of the tibia were under significant interaction influence of the duration of fattening period and broiler gender.

Acknowledgment: This research is part of the Project EVB: TR-31033 financial supported by Ministry of Education, Science and Technological Development of the Republic of Serbia.

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