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EFFECTS OF INTENSITY OF LIGHT AND STOCKING DENSITY ON BROILER BODY WEIGHT AND YIELD OF VALUABLE CARCASS PARTS

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Abstract: In order to determine the effect of intensity of light and stocking density, as well as the interaction of light intensity x stocking density on body weight and individual carcass traits, an experiment was performed on 1200 broilers of the Ross 308 genotype. The investigated factors were the intensity of light (LI): 20 lx (K) ; 150 lx (O) and stocking density (SD): 10 broilers/m^2 (A); 13 broilers/m^2 (B); 15 broilers/m^2 (C), in 4 repetitions. The light source was incandescent bulbs of adequate intensity and a light program 16L: 4D: 2L: 2D was applied. Broiler body weight was controlled on 11th, 21st, 35th and 42nd day, by individual measurement of all chickens in the trial. The average sample containing 12 chickens per treatment with equal gender representation (total of 72 broilers) was used to study the slaughter quality of carcasses based on the parameters of absolute and relative yield of more valuable carcass parts (breast, thighs and drumsticks) and meat in the more valuable parts of the carcass. The effect of light with different intensity on the body weight differed depending on the broiler rearing phase. The interaction effect of the intensity of light and stocking density on the body weight of broilers was confirmed in all stages of growing up to the age of 42 days. A higher intensity of light (150 lx) showed the potential to alleviate the negative effects of higher stocking density (15 broilers/m^2) on the final body weight of the broiler. The carcass traits were not significantly affected by the intensity of the light, while the stocking density, as well as the intensity of the light x stocking density did influence the yield of whole breast and the yield of breast meat.

Key words: light intensity, stocking density, broiler, body weight, carcass characteristics

Introduction

In commercial production conditions, broiler activity has been reduced to a minimum in order to achieve higher growth and more efficient use of food. In such conditions, the problem of endangered welfare and health of broilers occurs, and efforts are made to establish the control of their physical activity by certain environmental factors. The environmental factors that exert the effect on the physical activity of broilers are light and stocking density (*Estevez, 2007; Kristensen et al., 2006b, Deep et al., 2010b*). In addition to the duration of photoperiod and colour, an important aspect of the effect of light is based on its intensity. The intensity of illumination should enable broilers to smoothly navigate the area and find feeders and waterers. The high-intensity light is preferred in the starter phase of broiler rearing due to the favourable effect on the development of locomotor apparatus and the prevention of heart problems (*Classen, 1996*). The use of low-intensity light is based on the effect of reducing the physical activity of broilers (*Downs et al., 2006*) and the expected benefits in terms of gain and quality of the carcass. However, the results of the study of the effect of light of varying intensity on production performance and slaughter characteristics are inconsistent (*Olanrewaju et al., 2011; Lien et al., 2007, 2008; McKee et al., 2009*). Low-intensity light leads to welfare specific problems associated with the incidence of ulcerative foot-pad lesions, eye size disorders, and various eye sight defects (*Deep et al., 2010; Blatchford et al., 2009*). According to *Alvino et al. (2009),* the high-intensity light is desirable for the expression of certain patterns of behaviour.

The stocking density was studied in numerous researches dealing with the welfare aspect of broilers. A better development of the locomotor apparatus and a better condition of legs under conditions of lower stocking density are confirmed, partly as a result of greater physical activity of broilers (*Sanotra et al., 2002*). Also, the stocking density has a confirmed significant impact on the body weight and quality of the broiler carcass (*Dozier et al., 2006; Škrbić et al., 2008*). Stocking density is a factor in rearing that establishes interaction effects with other rearing factors, such as a light program. It has been shown that certain intermittent light programs can mitigate the negative consequences of a higher stocking density on the gain and carcass conformation (*Škrbić et al., 2011*).

The aim of the conducted research was to determine the effect of light intensity, stocking density and their interaction effect on the gain of broilers, yield and quality of valuable parts of the carcass.

Materials and Methods

The trial was performed on 1200 broilers of Ross 308 genotype in the period up to 42 days of age. The design of the experiment was dual-factor by random block system, with 6 treatments and 4 repetitions. The investigated factors were following: the intensity of light (LI): 20 lx (K); 150 lx (O) and stocking density (SD): 10 broilers/m^2 (A); 13 broilers/m^2 (B); 15 broilers/m^2 (C). Broilers were reareded according to the principles of standard technology of fattening in the floor system. The nutrition was *ad libitum* and consisting of complete mixtures based on maize and soybean. The content of energy and protein in the four-phase diet program was 3000 Kcal/kg, 21.0% SP; 3100 Kcal/kg, 19.2% SP; 3110 Kcal/kg, 19.0% SP, respectively, i.e. 3170 Kcal/kg and 17.3% SP. The duration of the photoperiod was 23 hours till 8th day, followed by 18 hours, with the applied light program 16L: 4D: 2L: 2D. The light source was incandescent bulbs of adequate intensity. Light intensity control was carried out by an illuminometer (Testo 540) at the level of the broiler eye in 3 positions, at right angle *(Lewis and Morris, 2006).* The body weight of chickens was controlled on 11th, 21st, 35th and 42nd day, by measuring individualy all chickens in the trial. The average sample containing 12 chickens per treatment with equal gender representation (total of 72 broilers) was used to study the slaughter quality of carcasses based on the parameters of absolute and relative yield of more valuable carcass parts (breast, thighs and drumsticks) and meat in the more valuable parts of the carcass. The cutting of chilled carcasses and the separation of the breast, drumstick and thighwas done in accordance with Commission Regulation (EC) No 543/2008. After determining of their weight, their yields relative to the pre-slaughter body weight were calculated. Weight and share of the breast meat (*m. Pectoralis major* and *m. Pectoralis minor*), drumstick and thigh meat in the pre-slaughter body weight were obtained after the dissection, i.e. separation of muscle tissue from the skin and bones.
Data was analyzed by ANOVA followed by LSD post hoc test using StatSoft software (STATISTICA 8, 2007).

Results

Data on the effect of light intensity, stocking density and their interactions on the body weight of the broilers during the fattening period are shown in Table 1. A significant influence of the intensity of light on the broiler body weight at the 11th day of age was determined and a highly significant impact of the intensity of light on the body weight of broilersat the 42nd day of age. However, the character of the effect determined was opposite. At the initial fattening stage, the chickens of O group showed higher values for body weight (light intensity 150 lx), while in the

last phase, the chickens in the K group (light intensity 20 lx) had significantly higher body weight values. The stocking density showed a significant effect on the body weight of broilers in all control measurements. In the first two control measurements, the highest body weight of chickens was in the C group (15 broilers/ m^2) and the differences between A (10 broilers/m^2) and B (13 broilers/m^2) groups were not statistically significant. After this period, broilers in group A had a more intensive gain of body weight compared to groups B and C, which resulted in significantly higher ($p<0.01$) body weight after 42 days.

The interaction effect of intensity of light and stocking density on body weight was statistically confirmed in all control periods. The lowest body weight was recorded in broilers of OB group as a result of the interaction of light intensity and stocking density of 13 broilers/m^2 in all growth periods of broilers. However, the interaction effect of high-intensity light (O) and higher stocking density (15 broilers/m^2) resulted in the highest broiler body weight values at all ages except for the 42nd day.

Table 1. Effects of intensity of light and stocking density on the body weight of broilers in individual phases of fattening

		Body weight, g / Age, day			
		11	21	35	42
Light intensity (LI)	K	262.0 ± 1.7 ^{b}	725.2 ± 5.3	1659.2 ± 11.5	2302.5 ± 15.0 ^{A}
	O	267.2 ± 1.8 ^{a}	721.7 ± 5.6	1643.2 ± 11.3	2228.6 ± 15.2 ^{B}
Stocking density (SD)	A	257.3 ± 2.3 ^{B}	715.6 ± 7.6 ^{B}	1656.9 ± 16.2 ^{ab}	2330.4 ± 21.8 ^{A}
	B	254.7 ± 2.0 ^{B}	696.0 ± 6.6 ^{B}	1621.6 ± 14.0 ^{b}	2218.7 ± 19.1 ^{B}
	C	277.9 ± 2.0 ^{A}	751.4 ± 5.8 ^{A}	1672.0 ± 12.4 ^{a}	2262.1 ± 15.8 ^{B}
LI x SD	KA	253.0 ± 3.3 ^{C}	707.4 ± 11.2 ^{BC}	1668.6 ± 24.6 ^{A}	2359.5 ± 32.1 ^{A}
	KB	260.3 ± 2.8 ^{BC}	721.5 ± 8.7 ^{B}	1667.7 ± 19.1 ^{A}	2328.5 ± 24.3 ^{AB}
	KC	269.4 ± 2.8 ^{B}	740.2 ± 8.1 ^{AB}	1645.7 ± 17.6 ^{AB}	2242.5 ± 22.7 ^{B}
	OA	261.7 ± 3.2 ^{BC}	724.0 ± 10.3 ^{AB}	1645.2 ±21.2 ^{AB}	2300.1 ± 29.2 ^{AB}
	OB	249.1 ± 2.9 ^{C}	670.8 ± 9.7 ^{C}	1576.2 ± 20.1 ^{B}	2110.0 ± 27.4 ^{C}
	OC	286.8 ± 2.9 ^{A}	762.5 ± 8.3 ^{A}	1698.4 ± 17.3 ^{A}	2281.8 ± 21.8 ^{AB}
Significance					
LI		*	ns	ns	**
SD		**	**	*	**
LI x SD		**	**	**	**

The influence of the different light intensity and stocking density of broilers on the absolute and relative yield of the breast, drumstick and thighis shown in Table 2. The yields of the breast, drumstick and thigh were not significantly affected by the intensity of light. The stocking density showed a significant effect on the breast weight ($p<0.05$) and breast share ($p <0.01$), while yields of drumstick and thigh were not significantly affected by this factor. Absolute and relative breast yield in the C treatment was significantly higher in

relation to B treatment and without statistical confirmation of the difference compared to treatment A. The analysis of the interaction of light intensity and stocking density showed significantly the lowest relative breast yield in the treatment OB compared to other treatments, except KA treatment.

Table 2. Effects of intensity of light and stocking density on the yield of more valuable parts of the carcass

		Breast		Drumstick		Thighs	
		g	%	g	%	g	%
Light intensity (LI)	K	492.15±77.43	22.36±1.82	225.09±31.25	10.23±0.54	260.17±36.91	11.82±0.61
	O	485.14±67.35	22.25±7.71	222.19±26.18	10.21±0.55	257.64±29.28	11.83±0.55
Stocking density (SD)	A	497.38±72.40^{ab}	22.33±1.85^{ab}	224.53±29.95	10.08±0.45	263.69±36.50	11.83±0.56
	B	458.19±66.35^{b}	21.55±1.73^{b}	220.92±26.42	10.41±0.50	252.93±31.56	11.91±0.66
	C	510.36±69.86^{a}	23.03±1.41^{a}	225.47±30.48	10.17±0.54	260.08±31.49	11.75±0.51
LI x SD	KA	492.25±85.82	21.89±2.00^{ab}	227.44±34.83	10.12±0.42	268.27±42.89	11.93±0.63
	KB	485.89±75.56	22.31±1.88^{a}	224.89±30.09	10.34±0.70	259.68±36.84	11.93±0.79
	KC	498.31±76.94	22.87±1.58^{a}	222.94±31.26	10.24±0.49	252.57±31.68	11.61±0.29
	OA	502.51±59.49	22.77±1.64^{a}	221.63±25.38	10.03±0.49	259.12±30.01	11.73±0.49
	OB	430.49±42.69	20.80±1.23^{b}	216.95±22.78	10.47±0.50	246.19±25.04	11.89±0.54
	OC	522.41±63.00	23.19±1.26^{a}	227.99±30.83	10.11±0.60	267.60±30.76	11.89±0.64
Significance							
LI		ns	ns	ns	ns	ns	ns
SD		*	**	ns	ns	ns	ns
LI x SD		ns	*	ns	ns	ns	ns

The intensity of light and stocking density showed a similar effect on the yields of the muscle tissue of the breast, drumstick and thigh (Table 3), as well as on the yields of whole breast, drumstick and thigh. The light intensities tested did not have a significant effect on the yield of breast, drumstick and thigh, as opposed to the studied stocking densities that influenced the yield of breast meat. The difference in the effect of stocking density on the yield of whole breast is at the probability level of the identified differences ($p<0.05$).

Table 3. Effects of intensity of light and stocking density on meat yield of more valuable parts of the carcass

		Breast meat		Drumstick meat		Thigh meat	
		g	%	g	%	g	%
Light intensity (LI)	K	374.09±63.49	16.99±1.71	146.16±22.11	6.64±0.45	189.32±30.16	8.59±0.58
	O	365.26±56.37	16.75±1.61	142.33±16.93	6.54±0.38	186.08±23.29	8.55±0.58
Stocking density (SD)	A	377.85±64.58^{a}	16.93±1.81^{ab}	145.22±20.82	6.51±0.38	190.92±29.04	8.55±0.48
	B	344.68±54.93^{b}	16.21±1.63^{b}	141.71±18.62	6.67±0.46	181.73±26.13	8.55±0.67
	C	386.50±53.15^{a}	17.461.31^{a}	145.80±20.04	6.58±0.39	190.45±25.21	8.60±0.59
LI x SD	KA	374.45±75.91	16.61±1.57^{ab}	147.06±24.81	6.54±0.42	194.72±34.76	8.64±0.52
	KB	370.21±61.75	17.00±1.10^{a}	146.34±22.17	6.72±0.55	189.00±30.53	8.67±0.73
	KC	377.63±56.74	17.36±1.31^{a}	145.07±21.13	6.66±0.38	184.22±26.34	8.46±0.50
	OA	381.25±54.16	17.25±2.05^{a}	143.38±16.82	6.49±0.36	187.12±22.87	8.46±0.45
	OB	319.15±32.76	15.43±1.73^{b}	137.07±13.66	6.62±0.38	174.47±19.52	8.43±0.62
	OC	395.38±50.15	17.56±1.35^{a}	146.53±19.81	6.50±0.40	196.67±23.47	8.75±0.65
Significance							
LI		ns	ns	ns	ns	ns	ns
SD		*	*	ns	ns	ns	ns
LI x SD		ns	*	ns	ns	ns	ns

Discussion

A study of the effect of light of varying intensity showed the opposite effect of high-intensity light on the gain of body weight in the initial and final phases of broiler rearing. In the period of up to 11 days, light intensity of 150 lx showed positively influence on the gain of body weight of the broiler, but as a result of the opposite effect in the subsequent phases, the final weight of broilers was significantly higher in treatment with an intensity of 20 lx. The presented results are partially in line with the results of the research of *Kristensen et al. (2006a)*, which confirm the gain of body weight of the broiler under light intensity of 5.4 to 6.45 lx, and a decrease in body weight as a result of the light intensity of 107.6 to 124.7 lx. The effect of light is reflected on the physical activity of the chickens (*Blatchford et al., 2009*) and, consequently, the body weight gain. The higher physical activity of the chickens under the influence of high-intensity light in the starter phase acted positively on the development of the bone-muscle system (*Classen, 1996*), which can explain the beneficial effect on the body weight. The transient effect of light intensity is stated by *Downs et al. (2006),* with a low-intensity of light inducing higher body weight of females at an early age but up to 56 days of age differences in body weight were not significant. *McKee et al. (2009)* have established a higher body weight of broilers grown at a lower light intensity of up to 51 days of age. The non-significant effect of light intensity on the body weight of broilers was determined by *Olanreway et al. (2010, 2011), Deep et al. (2010a). Kristensen et al. (2006b)* have found that light intensity increases activity of chickens only in treatment that provided alternating light intensity of 5 and 100

lx in 16 hours of photoperiod. The inconsistency of the results obtained on the effect of the light intensity on the body weight of broilers can be explained by different research conditions in terms of the investigated levels of light intensity, the duration of the photoperiod and the applied light program, the duration of the fattening period, the nutrition, etc.

According to *Commission Regulation (EC) No 543/2008*, the applied stocking densities in the trial (10, 13 and 15 broilers/m^2) did not exceed the limit for the extensive rearing system in the facility, suggesting that the conditions for rearing broilers in the trial were "friendly" and in line with the recommendations for broiler welfare preservation. In that sense, it was possible to expect the absence of differences in terms of significant effects on the gain, i.e. body weight of broilers. However, the results of the experiments confirmed that even in conditions of application of stocking density recommended for the preservation of the welfare of broilers, in the extensive rearing system in the facility, there is a significant effect on the body weight. In previous studies, the intensification of the effects of higher stocking density in the last stages of broiler fattening was determined (*Škrbić et al., 2009; Škrbić et al., 2011*), as opposed to the initial stages, when the body warmth, produced as a result of intense metabolism, can be used for growth (*Dozier et al., 2005*), as confirmed by the results of this study. The confirmed interaction effect of light intensity and stocking density is in line with previous research (*Škrbić et al., 2011; Škrbić et al., 2012*) which pointed to the significance of the interaction effect of light with biological and environmental factors on production performance and the welfare of broilers.

The carcass traits were not significantly affected by the intensity of light in the presented study. There are indications of an increase in absolute and relative yields of whole breasts, drumsticks and thighs, as well as breast, drumstick and thigh meat in treatments with lower intensity of light. The positive effect of weaker light (15 FC vs 0.5 FC) on absolute values of breast, file and tender yields, is reported by *Lien et al., (2008*). However, by comparing light intensity 1 FC vs. 0.1 FC *Lien et al. (2007)* have determined the negative effect of reducing the intensity of light on breast yield, primarily on the tender. The relative yield of the drumsticks and thighs decreased linearly with an increase in the intensity of light from 1 to 40 lx in research by *Deep et al. (2010a).* These results indicate that the effect of light intensity on the share of more valuable carcass parts depends to a large extent on the level of applied intensities. *Downs et al. (2006)* link low illumination intensity with the effect of substitution of the part of the breast with the share of the wings and legs as a result of compensatory weight gain which leads to the delay of progressive maturation in the growth process.

Researches of the stocking density on the carcass traits indicate a lower file yield (*Dozier et al., 2006*) and yield of whole breast (*Škrbić et al., 2011*) in treatments with higher stocking densities, which is confirmed by the results of the present study, despite significant differences in the applied stocking densities

between these studies. The intensity of light in interaction with other factors has been the subject of several studies with different effects on the production, slaughter and physiological parameters of broilers (*Lien et al., 2007; Olanrewaju et al., 2008, 2010, 2014).* Our research has shown a significant influence of interaction of light intensity x stocking density on breast size and share of breast meat. A similar effect is reported by *Lien et al. (2007)* as a result of the interaction between the light intensity x duration of the photoperiod. These results indicate that the intensity of light can be a significant factor in interaction with other rearing factors despite the absence of its main effect.

Conclusion

Based on the results of the presented research, it can be concluded that the effect of light of different intensity on the body weight of broilers differed depending on the growing stage (fattening). The interaction effect of the intensity of light and stocking density on the body weight of broilers was confirmed at all phases of fattening until the age of 42 days. A higher intensity of light (150 lx) has the potential to alleviate the negative effects of greater stocking density (15 broilers/m^2) on the final body weight of the broiler.

The carcass characteristics were not significantly affected by the intensity of the light, while the main effect of stocking density was determined for the whole breast yield and the yield of breast meat. The interaction of light intensity and higher stocking density in the treatment of OC resulted in the highest relative yield of whole breast, i.e. breast meat.

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Efekti intenziteta svetlosti i gustine naseljenosti na telesnu masu i prinose vrednijih delova trupa brojlera

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Rezime

U cilju utvrđivanja efekta intenziteta svetlosti i gustine naseljenosti, kao i interakcije intenzitet svetlosti x gustina naseljenosti na telesnu masu i pojedine karakteristike trupa, sproveden je ogled na 1200 brojlera genotipa Ross 308. Ispitivani faktori su intenzitet svetlosti (LI): 20 lx (K); 150 lx (O) i gustina naseljenosti (SD): 10 grlo/m^2 (A); 13 grlo/m^2 (B); 15 grlo/m^2 (C), u 4 ponavljanja. Izvor svetlosti su bile incandescent bulbs odgovarajućeg intenziteta i primenjen je svetlosni program 16L:4D:2L:2D. Telesna masa pilića je kontrolisana 11., 21., 35. i 42. dana, pojedinačnim merenjem svih pilića u ogledu. Na prosečnom uzorku od 12 pilića po tretmanu sa podjednakom zastupljenošću polova (ukupno 72 brojlera) izvršeno je ispitivanje klaničnog kvaliteta trupa na osnovu parametara apsolutnog i relativnog prinosa vrednijih delova trupa (grudi, bataci i karabataci) i mesa u vrednijim delovima trupa. Efekat svetlosti različitog intenziteta na telesnu masu se razlikovao u zavisnosti od faze gajenja brojlera. Interakcijski efekat intenziteta svetlosti i gustine naseljenosti na telesnu masu brojlera je potvrđen u svim fazama gajenja do starosti 42 dana. Veći intenzitet svetla (150 lx) je pokazao potencijal da ublaži negativne efekte većih gustina naseljenosti (15 grlo/m^2) na završnu telesnu masu brojlera. Karakteristike trupa nisu bile pod značajnim glavnim efektom intenziteta svetlosti dok je gustina naseljenosti, kao i interakcija intenzitet svetlosti x gustina naseljenosti, uticala na prinos celih grudi i prinos mesa grudi.

Ključne reči: intednzitet svetlosti, gustina naseljenosti, brojleri, telesna masa, kvalitet trupa

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