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PHYSIOLOGICAL PARAMETERS IN BROILER CHICKENS REARED UNDER DIFFERENT HOUSING SYSTEMS DURING A PERIOD OF HIGH TEMPERATURES

Iwona Skomorucha✉, Ewa Sosnówka-Czajka

Department of Technology, Ecology and Economics of Animal Production, National Research Institute of Animal Production, 32-083 Balice, Poland

ABSTRACT

The experiment was conducted during the summer production cycle. Broiler chickens kept on litter – group I and on litter with access to pasture – group II. Throughout the experiment, mortality were recorded. During the second rearing period, when outdoor temperatures were high, radiation and rectal temperature was measured in birds, and blood was collected to determine the levels of thyroid hormones, glucose, corticosterone, and hematocrit. Broiler chickens from group I were characterized by higher mortality compared to group II. In group I, rectal temperature was found to increase during the 6th week of rearing. In broilers from group II, T_3 decreased and T_4 increased with an increase in air temperature. The lower body temperature of broiler chickens and the smaller proportion of dead chickens in the group with outdoor access may suggest that this housing system helped to increase the thermal comfort of birds during the summer heat. It can therefore be concluded that housing with outdoor access improves the welfare of broiler chickens exposed to heat stress.

Key words: broiler chickens, air temperature, rearing system, rectal temperature, thyroid hormones, welfare

INTRODUCTION

One of the main factors determining the comfort of raised animals is ambient temperature whose increases above, or decreases below, the thermoneutral zone elicit stress reactions and may adversely affect the physiology and productivity of animals. Compared to other farm animals, modern lines of broilers are particularly sensitive to high ambient temperature [Gu et al. 2012], because their rapid growth, high body weight and good feed conversion increase thermal energy production [Giloh et al. 2012, Lara and Rostagno 2013], which inhibits the body's adaptation to adverse thermal conditions.

According to Olanrewaju et al. [2010], the body temperature of an adult chicken is 40.6 to 41.7°C, and the thermoneutral zone that allows chickens to maintain their body temperature is 18 to 24°C. Increases in ambient temperature above the thermoneutral zone interfere with proper heat exchange between the avian body and the environment, possibly leading to physiological disorders [Sosnówka-Czajka et al. 2006, Skomorucha et al. 2010, Giloh et al. 2012, Lara and Rostagno 2013, Mayes et al. 2015] and behavioural changes [Olanrewaju et al. 2010, Lara and Rostagno 2013], and having a negative effect on productivity [Akşit et al. 2006, Skomorucha et al. 2009, Olanrewaju et al. 2010]. Yalçin et al. [1997] report that high ambient temperatures may cause economic losses due to lower weight gains and higher mortality of the birds. Likewise, Ritz et al. [2005] and Petracci et al. [2006] report that poultry mortality is higher during the summer season compared to the other seasons. Also in Poland, losses to poultry farmers in the summer season are often caused by hyperthermia in broiler chickens, especially in the second rearing period [Sokołowicz and Herbut 2004].

One of the body's responses to high ambient temperature is to increase the body's radiation temperature [Skomorucha et al. 2012, Mayes et al. 2015]. Vasodilation increases blood flow to the skin, especially to the unfeathered areas, leading to increased heat dissipation from the body via radiation, convection, and conduction [Giloh et al. 2012]. Exposure of poultry to

✉iwona.skomorucha@izoo.krakow.pl

high ambient temperature may also increase rectal temperature, thus contributing to mortality of birds incapable of regulating the body temperature during heat stress [Berrong and Washburn 1998].

The body's adaptive response to high ambient temperatures is to reduce the metabolic rate, i.e. to decrease heat production [Lin et al. 2004, Star et al. 2008]. Essential to metabolic processes are thyroid hormones thyroxine (T_4) and triiodothyronine (T_3), the concentration of which is related, among others, to ambient temperature [Özkan et al. 2003, Tao et al. 2006, Giloh et al. 2012]. In general, birds exposed to higher environmental temperatures show a decrease in T_3 blood levels [Lin et al. 2004, Star et al. 2008, Elnagar et al. 2010, Giloh et al. 2012, Mack et al. 2013], while the level of T_4, depending on the research, decreases [Skomorucha et al. 2012], increases [Lin et al. 2004, Elnagar et al. 2010, Giloh et al. 2012] or remains unchanged [Mack et al. 2013].

Another factor that has a definite effect on physiological status of birds is the housing system [Skomorucha et al. 2008, Skomorucha et al. 2011]. Al-Aqil and Zulkifli [2009] report that birds are exposed to different stress levels depending on the housing system. Skomorucha et al. [2007] showed improved welfare of broiler chickens raised in the free-range system compared to those raised indoors. Olanrewaju et al. [2010] report that the highest and lowest temperatures that are critical for optimal performance are dependent, among others, on the housing system.

The aim of the study was to determine the effect of indoor and free-range production systems on mortality, body temperature and levels of thyroid hormones, glucose, corticosterone, and hematocrit during the period of high temperatures.

MATERIAL AND METHODS

The experiment was conducted during the summer production cycle (June/July) with 320 one-day-old Ross 308 broiler chickens originating from the Poultry Hatchery in Łężkowice. On the first day of life, after weighing and identifying with tags, chicks were allocated to two treatment groups, each of which included four replicates. In group I, birds were kept on litter without access to pasture, and those in group II were raised on litter with access to pasture from the first day of rearing. Stocking density in both groups was 13 birds per m^2, which did not exceed 33 kg · m^{-2} specified by Council Directive 2007/43/EC of 28 June 2007 [Official Journal of the European Union, L182 of 12 July 2007], and the pasture provided an area of 1 m^2 per bird. Pastures were equipped with drinkers and shelters protecting birds from excessive sunshine. Birds used the pastures between 07:00 and 20:00.

In both groups, temperature inside the broiler house was 30°C during the first days and was gradually decreased to 20°C at 5 and 6 weeks of rearing. The lighting schedule was 23 h light per day from days 1 to 7, 20 h light per day from days 8 to 38, and 23 h light per day from days 39 to 42.

Chickens were fed *ad libitum* mixtures based on concentrates (Table 1). Throughout the rearing period, broiler chickens had free access to feed and water drinkers.

Table 1. Ingredient composition (%) and nutritive value of the diets

Tabela 1. Skład i wartość pokarmowa mieszanek paszowych dla kurcząt brojlerów

Item Wyszczególnienie	Diet – Mieszanka	
	Starter 1–21 days – dni	Grower-Finisher 22–42 days – dni
Maize Kukurydza	55.35	47.21
Soybean meal Śruta sojowa	37.50	33.75
Wheat Pszenica	–	10.00
Rapeseed oil Olej rzepakowy	2.90	4.80
Ground limestone Kreda pastewna	1.10	1.15
Dicalcium phosphate Fosforan dwuwapniowy	2.10	2.00
Sodium chloride Chlorek sodu	0.30	0.30
Vitamin-mineral premix Premiks	0.50	0.50
L-Lysine Lizyna	0.03	0.09
DL-Methionine Metionina	0.22	0.20
Nutritive value per 1 kg – Wartość odżywcza na 1 kg		
Crude protein, % Białko surowe, %	22.00	20.50
Metabolisable energy, MJ Energia metaboliczna, MJ	12.50	13.00
Lysine, g Lizyna, g	12.00	11.50
Methionine, g Metionina, g	5.50	5.20
Calcium, g Wapń, g	9.50	9.30
Phosphorus, g Fosfor, g	4.30	4.10

During the experiment, data were collected on air temperature and humidity inside and outside the broiler house, and mortality of broilers were recorded. The climatic measurements were made using the Technoline type WS 3650 IT weather station, which recorded data at 1-hour intervals throughout the experiment. Temperature and humidity inside the broiler house were recorded on a Stienen PL-9000 poultry house computer. Microclimate sensors were placed in the area occupied by broilers. In addition, at 13:00 air temperature and humidity were measured with Testo 435 instrument at 3 locations diagonally across each compartment (subgroups) and at 3 locations diagonally across the outdoor area on the bird level. Microclimate data in Figure 1 and Table 2 are the average calculated from the readings of all measuring devices.

Table 2. Relative humidity (%) inside and outside the broiler house measured at 13:00

Tabela 2. Względna wilgotność powietrza wewnątrz i na zewnątrz brojlerni mierzone o godzinie 13:00

Days of rearing Dni odchowu	Indoor relative humidity Względna wilgotność powietrza wewnątrz budynku		External relative humidity Względna wilgotność zewnętrzna
	group – grupa I	group – grupa II	
22	60	63	56
23	62	60	87
24	60	58	76
25	67	49	76
26	69	64	75
27	70	62	88
28	71	66	73
Mean Średnio	66	60	76
29	70	70	76
30	67	68	87
31	65	62	55
32	56	52	75
33	59	53	40
34	69	56	36
35	66	60	76
Mean Średnio	65	60	64
36	71	74	78
37	70	77	80
38	75	76	56
39	62	62	35
40	63	61	38
41	63	62	41
42	66	62	38
Mean Średnio	67	68	52

During the second rearing period, when outdoor temperatures were high during the 4th and 6th week of the experiment (Fig. 1), radiation and rectal temperature was measured in feathered parts (back) and nonfeathered parts (shanks) of 10 birds per group, and blood was collected to determine the levels of thyroid hormones thyroxine (T_4) and triiodothyronine (T_3), glucose, corticosterone, and hematocrit. These tests were performed between 13:00 and 15:00 on days 24, 27, 36 and 41 of rearing. Similar tests were done on the 3rd day after the decrease in external temperature, i.e. on day 31 of growth (Fig. 1). Rectal temperature was measured using a veterinary thermometer with an accuracy of 0.1°C, and radiation temperature using a Cole Parmer infrared thermometer. The thermometer was placed around 25 cm from the skin of the birds. Thyroid hormones and corticosterone were measured by radioimmunoassay on an automated gamma counter (RIA Gamma, LKB, Wallac). Blood glucose levels were analysed with a Mindray BS-120 chemistry analyser using kits and methodology from Alpha Diagnostics. Blood for hematocrit determination was centrifuged (MPW-52) in hematocrit capillaries and the result was read with a reader mounted directly on the centrifuge rotor.

The results were statistically analysed using Student's t-test for the comparison of two means and with one-way analysis of variance and the differences were estimated using Duncan's test. Statgraphics Plus 6.0 was used for the statistical calculations. The mean values, standard deviations (SD), coefficients of variation (V) and (SEM) were calculated. Effects were considered significant at a probability of $P \leq 0.05$ and $P \leq 0.01$

The experiment was conducted with approval (no. 1205/2015) of the Local Ethics Committee for Animal Experimentation.

RESULTS

Mortality was higher in group I than in group II (Table 3). On day 41 of the experiment, rectal and radiation temperature of the unfeathered body parts was higher in broilers from group I compared to birds from group II at $P \leq 0.01$ (Tables 4, 5). There was also increase in rectal temperature of broilers raised indoors on days 36 and 41 compared to day 31 at $P \leq 0.05$. Chickens from group I also showed differences in radiation temperature of unfeathered areas between day 24 and days 36 and 41, and between 31 and 41 days of rearing ($P \leq 0.01$). In the system with outdoor access, differences in the radiation temperature of unfeathered parts were observed between day 27 and days 24, 31 and 41 at $P \leq 0.01$ (Table 5).

Table 3. Broiler mortality, %

Tabela 3. Śmiertelność kurcząt brojlerów, %

Days of rearing Dni odchowu	Group – Grupa I	Group – Grupa II
1–21	0.63	0
22–42	4.43	2.86
1–42	5.06	2.86

Group I – broiler chickens without access to pasture – grupa I – kurczęta brojlery bez dostępu do wybiegu.
Group II – broiler chickens with access to pasture – grupa II – kurczęta brojlery mające dostępu do wybiegu.

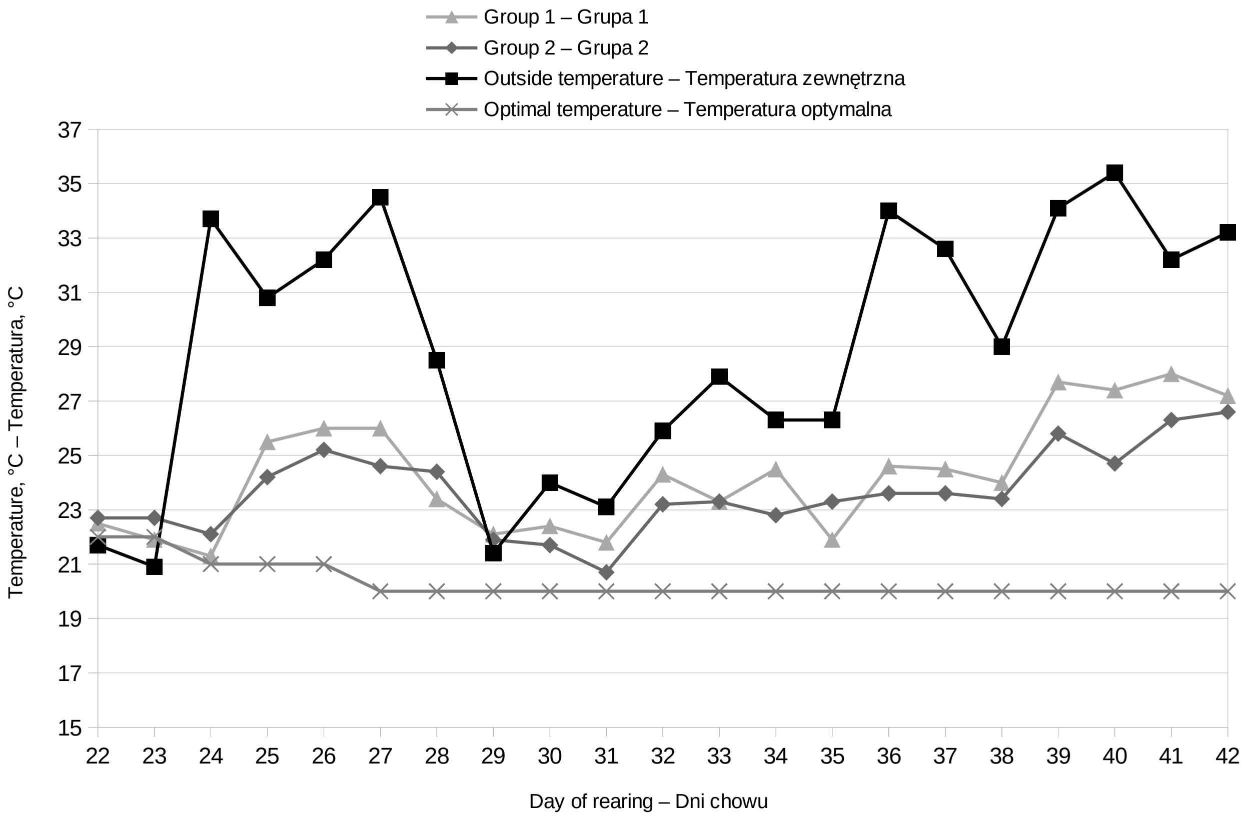

Fig. 1. Daily external and indoor temperatures measured at 13:00

Rys. 1. Dzienne temperatury zewnętrzne i wewnątrz brojlerni mierzone o godzinie 1300

Table 4. Rectal temperature of broiler chickens, °C

Tabela 4. Temperatura rektalna kurcząt brojlerów, °C

Days of rearing Dni odchowu	Group – Grupa		SD	V, %	
	I	II		I	II
24	41.44^{ACa}	41.32	0.50	1.2	1.2
27	41.58	41.65	0.53	1.3	1.3
31	41.38^{A}	41.51	0.32	0.8	0.8
36	41.88^{BCb}	41.81	0.26	0.6	0.6
41	41.93^{B**}	41.41**	0.36	0.9	0.9
SEM	0.12	0.13	–	–	–

Values in rows marked with ** differ highly significantly (P ≤ 0.01).
Wartości w wierszach oznaczone ** różnią się statystycznie wysoce istotnie (P ≤ 0,01).
A, B, C – values in columns with different letters differ highly significantly (P ≤ 0.01).
A, B, C – wartości w kolumnach oznaczone różnymi literami różnią się statystycznie wysoce istotnie (P ≤ 0,01).
a,b – values in columns with different letters differ significantly (P ≤ 0.05).
a,b – wartości w kolumnach oznaczone różnymi literami różnią się statystycznie istotnie (P ≤ 0,05).
Group I – broiler chickens without access to pasture; grupa I – kurczęta brojlery bez dostępu do wybiegu.
Group II – broiler chickens with access to pasture; grupa II – kurczęta brojlery mające dostępu do wybiegu.

On days 31, 36 and 41 of rearing, differences were found between the groups in the blood triiodothyronine level of birds at $P \leq 0.01$ (Table 6). In group I there were also differences in T_3 concentration between days 31 and 41 and days 24, 27 and 36 at $P \leq 0.01$. Differences in the blood T_3 levels in broilers from group II were noted between days 36 and 41 and days 24, 27 and 31 ($P \leq 0.01$). Chickens from group II were characterized by a higher level of thyroxine on days 36 and 41 compared to days 27 and 31 ($P \leq 0.01$).

Table 7 shows the levels of glucose and hematocrit in blood of broiler chickens. Birds from group II had lower glucose levels compared to birds from group I on days 27 and 31 at $P \leq 0.01$ and $P \leq 0.05$, respectively. In broilers raised indoors, blood glucose levels increased on days 27, 31, 36 and 41 compared to day 24 at $P \leq 0.01$. Difference in blood glucose concentration of birds was found in this group between days 27 and 31 vs. days 36 and 41 at $P \leq 0.05$. In both group I and II, blood hematocrit was the highest on day 31 compared to the other test days at $P \leq 0.01$ (Table 7).

On day 27 of rearing, corticosterone level was higher in the blood of chickens raised with outdoor access at $P \leq 0.05$ (Table 8). In group I, differences in blood corticosterone concentration were found between day 27 and days 31, 36 and 41, and between days 24 and 36 at $P \leq 0.01$. Differences in blood corticosterone levels of broiler chickens from group II were noted between day 24 and days 36 and 41, between days 31 and 36 ($P \leq 0.01$), and between day 27 and days 36 and 41 ($P \leq 0.05$).

DISCUSSION

Skomorucha et al. [2007] found no relationship between bird mortality and housing system. In turn, Skomorucha et al. [2008] observed no deaths of broiler chickens raised with outdoor access throughout the rearing period. Different results were obtained by Połtowicz and Doktor [2011], who reported 100% survival in broiler chickens raised in confinement compared to 4% mortality in the outdoor system. In our study we observed chicken mortality to be 2.2% higher in the indoor system. According to Weitzenbürger et al. [2005], poultry mortality is dependent on multiple factors and therefore cannot be used to evaluate housing systems. In turn, May and Lott [2000] report that bird mortality is the best indicator of normal rearing temperature. The increase in air temperature above the thermoneutral zone disturbs the body's homeostasis due to increased plasma corticosterone concentration and the resulting deterioration in bird health. Many studies confirm the negative effect of elevated air temperatures on poultry survival [Özkan et al. 2003, Skomorucha and Herbut 2006, Skomorucha et al. 2009, Quinteiro-Filho et al. 2010, Sohail et al. 2012]. It can therefore be concluded, that in our study temperature/humidity conditions affecting the birds with outdoor access were more favourable, as evidenced by the lower proportion of dead birds throughout the rearing period.

In our study, at 27, 36 and 41 days of rearing the external temperature measured at 13:00 exceeded 30°C, and the temperature inside the broiler house was higher than optimal for that period of rearing by 6, 4.6 and 8°C in group I, and by 4.6, 3.6 and 6.3°C in group II. Birds, being warm-blooded animals, can balance body energy by reducing heat production and increasing heat loss (via panting, convection and radiation). High air temperatures in broiler rearing reduce the dissipation rate of heat generated during digestion and metabolism, which is the reason for higher body temperature in the birds. Skomorucha et al. [2009] and Skomorucha et al. [2012] found the radiation temperature of birds exposed to high air temperature to increase. Likewise in our study, higher radiation temperature of the unfeathered body parts was observed in both experimental groups when ambient temperature increased. However, on day 41 of the study, higher radiation temperature of the unfeathered areas was observed in broilers reared without outdoor access. This may indicate that broiler chickens were exposed to higher heat loads indoors than outdoors, despite the fact that the birds outdoors were exposed to an external temperature of 32°C. In our study, rectal temperature of birds from the indoor group was also found to increase during the second increase in external temperature, which according to Lin et al. [2005] indicates that the heat balance of the birds was disturbed. Broiler chickens with outdoor access were characterized by constant rectal temperature during the study despite the high external temperatures, which must have been influenced by other environmental parameters such as air motion and the related cooling, and the relatively lower stocking density per m^2, which enabled better heat exchange between the bird and the surroundings. Not without significance was also the fact that outdoor areas were shaded, which protected the broilers from direct sunlight.

An increase in ambient temperature beyond the recommendation decreases heat production by birds through changes in thyroid hormones circulation [Giloh et al. 2012]. According to Tao et al. [2006], during summer production broiler chickens are exposed to warm cyclic temperatures, which reduces daily mean concentration of T_3 and slows the response of T_4. In our study, on days 36 and 41 of rearing, blood triiodothyronine level was lower by 2.6 and 1.35 nmol $\cdot$ l^{-1} in chickens with access to pasture compared to birds reared indoors. The lower T_3 concentration in birds from group II was probably associated with depressed metabolism, and thus with a decrease in heat energy, resulting in lower radiation temperature of unfeathered parts and lower rectal temperature in these birds at 41 days of the experiment. Lin et al. [2004] showed that heat stress up to 28 days of age was associated with a decrease in blood triiodothyronine and a concurrent increase in thyroxine. Also Giloh et al. [2012] observed the level of triiodothyronine to decrease and the level of thyroxine to increase in the blood of birds exposed to high ambient temperatures. We obtained similar results in the group of chickens with outdoor access. The high temperatures in the last week of the experiment were related to a decrease in T_3 and an increase in T_4 hormone levels. In the second experimental group, the relationship between T_3 and ambient temperature was no so consistent, whereas the increase in blood levels of T_4 on days 36 and 41 was not statistically significant. Different results were obtained by Skomorucha et al. [2012], who found thyroxine concentration to decrease and triiodothyronine to remain unchanged in the blood of Ross 308 chickens exposed to elevated ambient temperature for 4 days. Xie et al. [2015] noted the blood level of T_3 hormone to decrease in response to acute heat stress, while chronic heat stress did not alter the blood concentration of this hormone in birds.

Table 5. Radiation temperature of broiler chickens, °C

Tabela 5. Temperatura radiacyjna kurcząt brojlerów, °C

Days of rearing Dni odchowu	Radiation temperature of feathered parts Temperatura radiacyjna części opierzonych					Radiation temperature of unfeathered parts Temperatura radiacyjna części nieopierzonych				
	Group – Grupa		SD	V, %		Group – Grupa		SD	V, %	
	I	II		I	II	I	II		I	II
24	32.83	33.67	1.83	5.6	5.4	36.67^{Aa}	35.96^{B}	1.76	4.8	4.9
27	33.16	33.63	1.69	5.1	5.0	38.07^{b}	38.50^{A}	1.00	2.6	2.6
31	30.64	33.74	3.40	11.1	10.1	37.54^{AC}	36.44^{BCa}	1.41	3.8	3.9
36	32.72	33.40	1.61	4.9	4.8	38.51^{BC}	37.82^{ABb}	1.26	3.3	3.3
41	33.09	32.37	1.50	4.5	4.6	39.11^{B**}	36.74^{BC**}	1.10	2.8	3.0
SEM	0.71	0.62	–	–	–	0.39	0.61	–	–	–

Explantions see Table 4.
Oznaczenia patrz tabela 4.

Table 6. Serum levels of triiodothyronine T_3 and thyroxine T_4 in broiler chickens

Tabela 6. Poziom trójjodotyroniny T_3 i tyroksyny T_4 w surowicy krwi kurcząt brojlerów

Days of rearing Dni odchowu	T_3, nmol · l^{-1}					T_4, nmol · l^{-1}				
	Group – Grupa		SD	V (%)		Group – Grupa		SD	V (%)	
	I	II		I	II	I	II		I	II
24	6.77^{B}	6.47^{A}	1.78	26.3	27.5	77.72	65.56^{AB}	17.8	22.9	27.2
27	6.02^{B}	6.82^{A}	1.45	24.1	21.3	72.92	57.81^{A}	17.14	23.5	29.7
31	4.23^{A**}	6.94^{A**}	0.99	23.4	14.3	56.50	58.80^{A}	15.09	26.7	25.7
36	6.89^{B**}	4.29^{B**}	1.00	14.5	23.3	83.08	84.77^{BCa}	16.29	19.6	19.2
41	4.57^{A**}	3.22^{B**}	0.66	14.4	20.5	82.07	90.16^{Cb}	10.48	12.8	11.6
SEM	0.38	0.41	–	–	–	8.93	5.09	–	–	–

Explantions see Table 4.
Oznaczenia patrz tabela 4.

Table 7. Levels of glucose and hematocrit in blood of broiler chickens

Tabela 7. Poziom glukozy i hematokrytu we krwi kurcząt brojlerów

Days of rearing Dni odchowu	Glucose, mmol · l^{-1} – Glukoza, mmol · l^{-1}					Hematocrit, % – Hematokryt, %				
	Group – Grupa		SD	V (%)		Group – Grupa		SD	V (%)	
	I	II		I	II	I	II		I	II
24	11.64^{A}	13.05	2.65	22.8	20.4	33.50^{A}	35.30^{Aa}	2.69	8.0	7.6
27	15.63^{Bb**}	13.66^{**}	1.38	8.8	10.1	31.30^{A}	31.90^{Ab}	1.72	5.5	5.4
31	15.62^{Bb*}	13.92^{*}	1.64	10.5	11.8	41.10^{B}	41.00^{B}	8.28	20.1	20.2
36	14.33^{Ba}	12.88	2.03	14.2	15.8	34.00^{A}	33.00^{A}	2.31	6.8	7.0
41	14.29^{Ba}	13.79	0.80	5.6	6.4	32.70^{A}	34.30^{A}	2.29	7.0	6.7
SEM	0.39	0.71	–	–	–	1.58	1.05	–		–

Explantions see Table 4.
Oznaczenia patrz tabela 4.

Table 8. Levels of corticosterone in blood of broiler chickens, ng · ml^{-1}

Tabela 8. Poziom kortykosteronu we krwi kurcząt brojlerów, ng · ml^{-1}

Days of rearing Dni odchowu	Group – Grupa		SD	V (%)	
	I	II		I	II
24	21.77^{ACa}	15.90^{A}	5.08	23.3	25.5
27	29.90^{A*}	10.79^{a*}	2.89	9.7	26.8
31	13.78^{BC}	11.88^{AC}	3.06	22.2	17.3
36	4.67^{B}	4.02^{Bb}	1.11	23.8	27.6
41	7.74^{BCb}	4.55^{BCb}	1.09	14.1	24.0
SEM	4.12	2.04	–	–	–

Explantions see Table 4.
Oznaczenia patrz tabela 4.

In the literature attention is drawn to the fact that rearing system has an effect on stress levels in birds [Tuyttens et al. 2005]. Al-Aqil and Zulkifli [2009] demonstrated differences in serum corticosterone and glucose levels in broilers raised under different rearing systems. Skomorucha et al. [2011] noted higher blood glucose and corticosterone levels on day 21 of rearing in Cobb 500 broilers housed in batteries compared to birds raised on litter. In our study, broiler chickens reared indoors had higher glucose concentrations on days 27 and 31 as well as higher corticosterone concentration on day 27 of the experiment, which may suggest that conventionally grown birds were less comfortable during these days compared to chickens from the other housing system.

In our study we observed a significant decrease in blood hematocrit in broilers from both experimental groups during the time when the external temperature increased. The observed changes in hematocrit value are the body's response to heat stress, which is consistent with the findings of Yahav and Hurwitz [1996], Altan et al. [2003] and Olanrewaju et al. [2010]. Quinteiro-Filho et al. [2010], Giloh et al. [2012] and Sohail et al. [2012] showed blood corticosterone levels to increase in birds exposed to acute heat stress. In turn, Xie et al. [2015] observed increases in blood glucose and corticosterone levels of broiler chickens exposed to acute heat stress, whereas chronic heat stress had no effect on these levels. In our study, broiler chickens raised with outdoor access were characterized by stable blood glucose levels, while the level of corticosterone decreased significantly during the second period of high external temperatures. In birds confined indoors, blood glucose and corticosterone levels increased during the 4th week of growth, i.e. during the first heat wave, and decreased in the 6th week, i.e. during the second period of increased temperature. According to El-Lethey et al. [2003], repeated exposure of chickens to stressors reduces blood corticosterone levels, which is supported by our study.

CONCLUSION

It is concluded from the results obtained that even a small increase in ambient temperature beyond the recommendation did influence the broiler's body homeostasis regardless of the housing system. Broiler chickens with outdoor access had a normal thermoregulatory system, as indicated by the decrease in the level of T_3 thyroid hormone and the fact that rectal temperature remained constant during high external temperatures. The lower body temperature of broiler chickens and the smaller proportion of dead chickens in the group with outdoor access possibly suggests that this housing system helped to improve the "thermal comfort" of the birds during the summer heat wave. Hence it may be concluded that housing with access to an outdoor area protected from sunshine improves the welfare of broiler chickens exposed to heat stress.

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KSZTAŁTOWANIE SIĘ WSKAŹNIKÓW FIZJOLOGICZNYCH KURCZĄT BROJLERÓW W RÓŻNYCH SYSTEMACH UTRZYMANIA W OKRESIE WYSOKICH TEMPERATUR POWIETRZA

STRESZCZENIE

Doświadczenie zostało przeprowadzone w letnim cyklu produkcyjnym. Kurczęta brojlery utrzymywano na ściółce (grupa I) oraz na ściółce z dostępem do wybiegów (grupa II). Podczas doświadczenia kontrolowano śmiertelność kurcząt, a w drugim okresie odchowu podczas wysokich temperatur zewnętrznych przeprowadzono pomiary temperatury rektalnej i radiacyjnej oraz oznaczono we krwi ptaków poziom hormonów tarczycy, glukozy, kortykosteronu i hematokrytu. Kurczęta z grupy I charakteryzowały się większą śmiertelnością w stosunku do grupy II. W grupie I odnotowano wzrost temperatury rektalnej w 6. tygodniu odchowu kurcząt brojlerów. U kurcząt z grupy II stwierdzono spadek T_3 i wzrost T_4 przy wzroście temperatury powietrza. Niższa temperatura ciała kurcząt brojlerów oraz mniejszy udział kurcząt padłych w grupie mającej dostęp do wybiegu może sugerować, iż ten system utrzymania przyczynił się do zwiększenia „komfortu cieplnego" ptaków podczas letnich upałów. Stąd można wnioskować, że utrzymanie z dostępem do wybiegów poprawia poziom dobrostanu kurcząt brojlerów narażonych na działanie stresu cieplnego.

Słowa kluczowe: kurczęta brojlery, temperatura powietrza, system odchowu, temperatura rektalna, hormony tarczycy, dobrostan