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# EFFECTS OF AIR TEMPERATURE IN THE FINAL GROWING PERIOD AND OF BIRD STRAIN ON CARCASE AND MEAT QUALITY IN BROILER CHICKENS

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The purpose of study was to compare the effects of lower and higher (by ±3°C) air temperature in the poultry house in the period from 28 to 42 days of the growing period with the standard (medium) air temperature conditions in Ross 308 and Hybro G commercial broilers chickens, taking into consideration the main performance traits of birds and quality of carcase and meat.

The experimental findings demonstrated that increasing or decreasing standard air temperature in the poultry house by ±3°C significantly deteriorated the examined performance traits. A higher negative effect on the physicochemical traits of muscles was noted in the case of higher air temperature. It pertained mainly to the degree of muscle acidification *post mortem* and intramuscular fat content. The studied ambient air temperatures influenced to the same degree the economic effectiveness of bird growing and quality of carcase and meat in the two examined strains of broiler chickens.

## INTRODUCTION

The problem of the temperature in growing poultry is still an open issue [Nichelmann, 1984; Herbut *et al*., 2002; Nichelmann, 2004]. A solution emerged more than 70 years ago. Giaja [1931] has developed the concept of the thermoneutral temperature and has shown that in a small temperature range the zone of minimal metabolism may exist. He called it the thermoneutral zone and assumed that in this range of ambient temperature (Ta) the performance of an animal must be maximal, because only a minimum of energy should be used for heat production (HP).

The optimum temperature for keeping of domesticated animals must be characterized by a minimum of thermoregulatory heat production and therefore by optimum food conversion rate, by satisfaction of all the demands, and by maximal wellness of the animals [Nichelmann, 2004].

Continuous improvements in the management systems have to be introduced in the commercial growing of poultry to obtain high quality and wholesome meat products [Herbut & Wężyk, 2000; Duncan, 2002].

Due to the observed climate warming and the occurrence of periods of extreme air temperatures, numerous studies have been conducted in the recent time on the modification of air temperature conditions in broiler chicken growing and the effects on bird performance traits and carcase quality [Sokołowicz & Herbut, 1998; Yalcin *et al*., 2001; Sosnówka-Czajka *et al*., 2002].

The purpose of study was to compare the effects of lower, higher or medium air temperature in the poultry house from the 4$^{th}$ week of bird age onwards in growing Ross 308 and Hybro G broiler chickens on their main performance traits and quality of carcase and meat.

## MATERIAL AND METHODS

The experimental material comprised Ross 308 and Hybro G commercial broiler strains, each divided into three groups grown under three different air temperatures. In total there were six experimental groups of birds in 4 replications each, one replication consisted of 200 broilers grown on litter in a pen of 13 m$^2$ floor area. The detailed programme of air temperatures applied was as follows: for all groups: day 1: 35° to 34°C; day 2: 33° to 32°C; days 3 to 7: 32° to 31°C; week 2: 31° to 28°C; week 3: 28° to 25°C; groups under increased air temperature: week 4: 28° to 25°C; weeks 5 to 6: 25° to 22°C; groups of medium (standard) air temperature: week 4: 25° to 22°C; weeks 5 to 6: 22° to 20°C; and groups of lowered air temperature: week 4: 22° to 20°C; weeks 5 to 6: 20° to 18°C.

The other management factors during bird growth were the same in all experimental groups. Broilers were fed *ad libitum* on the same compound feed. After 42 days of growing period ten males and ten females from each group of broilers in the weight range from 1900 to 2300 g were taken for post mortem examination. Meat yield was examined acc. to Ziołecki & Doruchowski [1989]. The pH value of muscles was determined with the use of mobile Inlab 427 pH meter with calomel electrode, while the water holding capacity by the modified Grau and Hamm method. Muscle samples from the right breast of carcase (*m. superficialis* and *m. profundus)*

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and from the right leg were taken for the chemical analysis. The chemical composition of muscles was determined by standard methods [PN-75/A-04018; PN-ISO 1444:2000; PN--ISO 1442-2000; PN-ISO 936:2000)]

The experimental finding were subjected to a one-way analysis of variance.

## RESULTS AND DISCUSSION

Broiler chickens from the groups grown under standard (medium) air temperature conditions demonstrated the highest final body (Table 1), *i.e*. it amounted to 2287 g in Hybro G birds and 2261 g in Ross 308 birds.

Broilers kept under lower air temperature during the second part of the growing period reached final body weight by 58 g (Ross 308) and by 64 g (Hybro G) lower and the found differences were not statistically significant. On the other hand, a significantly (by ≤0.05) lower final body weight was observed in birds grown under higher air temperature over the period from 4$^{th}$ to 6$^{th}$ week of age. That difference amounted to 213 g in Ross 308 and 211 g in Hybro G broilers in comparison with those under the standard air temperature, whereas to 155 g in Ross 308 and 147 g in Hybro G broilers in comparison with those under decreased air temperature. However, attention has to be drawn to the much higher standard deviation and coefficient of variation in the groups of broilers grown under decreased air temperature.

Feed consumption was significantly different at $p \leq 0.05$ in the experimental groups grown under various air temperatures, but was found non significant in birds of two broiler strains. The highest feed intake was noted in groups of broilers kept under lowered air temperature and attained 4582 g/bird in Ross 308 while 4579 g/bird in Hybro G strain. On the other hand, the feed conversion ratio in broiler groups grown under standard and lowered air temperature was statistically non significant and amounted from 1.80 kg/kg to 1.86 kg/kg. Feed consumption in groups of birds under lowered air temperature demonstrated by 15 g higher standard deviation.

Mortality rate in the groups of broilers grown under standard and lowered air temperature level was very similar, *i.e*. from 1.50 to 2.25%. However, in the broiler groups kept under higher air temperature the mortality rate was significantly different at $p \leq 0.05$ between Ross 308 and Hybro G broilers and attained 10.83 and 12.17%, respectively, with very high variation coefficients 25.63 and 35.63%, respectively.

Many authors report that thermal stress, including heat stress, generally has a negative effect on performance [Sokołowicz & Herbut, 1998; Sosnówka–Czajka & Herbut, 2001]. Also in our study we found decreased gains and final body weight and increased mortality of birds exposed to heat stress. However, thermal stress was observed to exert no influence on feed intake, which is in agreement with the findings of Sokołowicz *et al*. [1996].

The economic performance index (EPI) of broiler production was significantly best at $p \leq 0.05$ in birds kept under standard air temperature. That index amounted to 285 in Ross 308 and 290 in Hybro G broiler chickens and the difference in comparison with the two other experimental groups grown at higher and lower air temperature attained circa 40 points. Herbut *et al.* [2002] obtained better performance in broiler chickens exposed to heat stress compared with birds kept under normal thermal conditions.

Slaughter yield (Figure 1) amounted from 70.40 to 71.54% and was statistically not significant at $p \leq 0.05$. Total muscle yield was found slightly higher by 0.57% in broilers grown under lower air temperature and that difference was not significant at $p \leq 0.05$. Total muscle yield was affected by slightly higher leg muscle yield in broilers grown under lower air temperature in comparison with the two other groups of birds. No differences were noted in the breast muscle yield (Figure 2) as

TABLE 1. Main performance traits of broiler chickens after 42 days growing period.

| Trait | Temperature | | | | | |
|---|---|---|---|---|---|---|
| | higher | | standard | | lower | |
| | Ross 308 | Hybro G | Ross 308 | Hybro G | Ross 308 | Hybro G |
| Body weight (g) | 2048$^{c}$ | 2076$^{c}$ | 2261$^{ab}$ | 2287$^{a}$ | 2203$^{b}$ | 2223$^{ab}$ |
| Feed intake (g/bird) | 3710$^{c}$ | 3737$^{c}$ | 4202$^{b}$ | 4186$^{b}$ | 4582$^{a}$ | 457$^{a}$ |
| Feed conversion (kg/kg) | 1.81$^{b}$ | 1.80$^{b}$ | 1.86$^{b}$ | 1.85$^{b}$ | 2.08$^{a}$ | 2.06$^{a}$ |
| Mortality (%) | 10.83$^{b}$ | 12.17$^{a}$ | 1.50$^{c}$ | 1.50$^{c}$ | 1.51$^{c}$ | 2.25$^{c}$ |
| EPI | 240$^{b}$ | 241$^{b}$ | 285$^{a}$ | 290$^{a}$ | 248$^{b}$ | 251$^{b}$ |

$^{ab}$ – different letters in the row denote statistically significant difference at $p \leq 0.05$

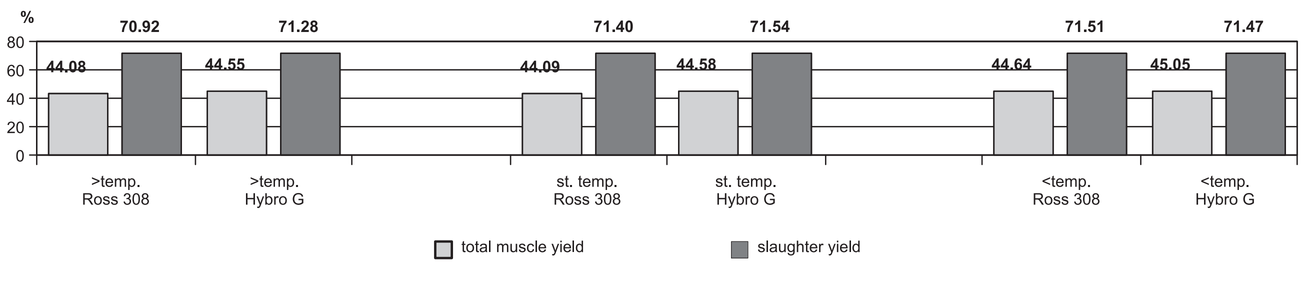


FIGURE 1. Percentage slaughter yield and total muscle yield in the carcase.

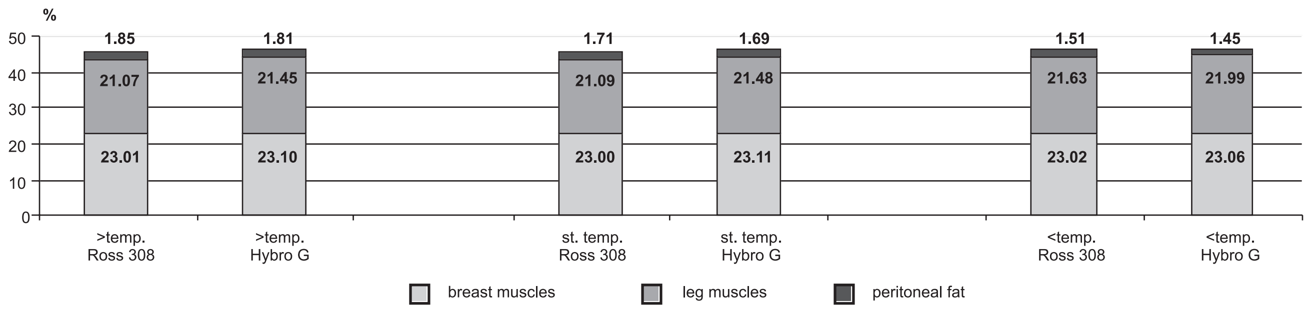


FIGURE 2. Percentage yield of breast and leg muscles and peritoneal fat tissue in the carcase.

affected by the air temperature during growing birds. A tendency to lower peritoneal fat tissue content was observed with the drop of air temperature. However, the found differences were non significant at $p \leq 0.05$ and amounted from 0.12% (Hybro G) to 0.14% (Ross 308) between the groups of broilers grown under higher or standard air temperature and from 0.20% (Ross 308) to 0.24% (Hybro G) in the groups grown under standard and lower temperature.

Sosnówka-Czajka & Herbut [1999] examined slaughter yield, leg muscle yield and peritoneal fat tissue content in broiler carcases and also found the best quality traits in birds subjected only once to air temperature decrease.

Birds grown under lower temperature during the last three weeks demonstrated a higher acidification of breast and leg muscles (Tables 2 and 3). The $pH_{15}$ value was in those birds significantly (at $p \leq 0.05$) lower than in the muscles of birds grown under higher air temperature. The $pH_{15}$ value was not dependent upon the strain of broilers.

Over the 24 h period from slaughter, the concentration of hydrogen ions in the muscles of broilers grown under lower air temperature decreased at a faster rate than in the muscles of broilers in the two other groups. In the breast muscles of birds kept under higher temperature, the pH value decreased on average by 0.11 points during 24h period and in birds kept under lower air temperature the pH values decreased as much as by 0.23 points. The observed difference was statistically significant at $p \leq 0.05$.

Another physical trait of the breast and leg muscles *i.e*. the water holding capacity (WHC) was affected by air temperature level during growing broilers but not by bird strain. Higher water holding capacity was observed in broilers kept under lower air temperature and it amounted to 35.12 mg% in Ross 308 and 35.03 mg% in Hybro G breast muscles. In birds grown under higher air temperature the WHC in the breast muscles was by 4.22 mg% in Ross 308 and by 4.28 mg% in Hybro G broilers lower and the observed difference was statistically significant at $p \leq 0.05$. In the leg muscles the WHC values were found similar and the statistically significant difference at $p \leq 0.05$ was observed only in Ross 308 broilers grown under extreme air temperatures.

As far as the chemical composition of breast muscles is concerned (Table 2), no differences were observed in ash and water content regardless of bird strain or air temperature during bird growing. The water content in the breast muscles varied from 71.68 to 73.10% and the ash content from 2.24 to 2.79%. Small differences were noted in the protein content in breast muscles, *i.e*. a little higher content was in Hybro G that in Ross 308 breast muscles of broilers. However, those differences were statistically non significant at $p \leq 0.05$. In regard to the intramuscular fat content, in Hybro G chickens a significantly at $p \leq 0.05$ lower fat content was found in broilers kept under lower air temperature during the final part of growing period. Attention has to be drawn to the high coefficient of variation of that trait (above 10%) in all examined broilers but it was particularly high (around 20%) in birds grown under higher temperatures.

In the proximate chemical composition of leg muscles (Table 3) no differences were observed in the ash, water and protein content irrespective of bird strain or air temperature during bird growing. On the other hand, significant at $p \leq 0.05$

TABLE 2. Physicochemical traits of breast muscles.

| Trait | Temperature | | | | | |
|---|---|---|---|---|---|---|
| | higher | | standard | | lower | |
| | Ross 308 | Hybro G | Ross 308 | Hybro G | Ross 308 | Hybro G |
| $pH_{15}$ | $6.25^{a}$ | $6.22^{ab}$ | $6.11^{bc}$ | $6.12^{bc}$ | $6.04^{c}$ | $6.05^{c}$ |
| $pH_{24}$ | $6.13^{a}$ | $6.12^{a}$ | $5.94^{b}$ | $5.95^{b}$ | $5.81^{c}$ | $5.83^{bc}$ |
| WHC (mg%) | $30.90^{b}$ | $30.75^{b}$ | $34.45^{ab}$ | $33.44^{ab}$ | $35.12^{a}$ | $35.03^{a}$ |
| Protein (%) | $22.37^{b}$ | $22.94^{ab}$ | $22.88^{ab}$ | $23.16^{ab}$ | $22.99^{ab}$ | $23.49^{a}$ |
| Fat (%) | $2.17^{ab}$ | $2.27^{a}$ | $2.03^{ab}$ | $2.10^{ab}$ | $1.93^{ab}$ | $1.86^{b}$ |
| Water (%) | 73.09 | 72.28 | 72.65 | 72.08 | 72.46 | 71.92 |
| Ash (%) | 2.38 | 2.52 | 2.44 | 2.67 | 2.63 | 2.73 |

$^{ab}$ – different letters in the row denote statistically significant difference at $p \leq 0.05$

TABLE 3. Physicochemical traits of leg muscles.

| Trait | Temperature | | | | | |
|---|---|---|---|---|---|---|
| | higher | | standard | | lower | |
| | Ross 308 | Hybro G | Ross 308 | Hybro G | Ross 308 | Hybro G |
| $pH_{15}$ | 6.48[ab] | 6.57[a] | 6.43[bc] | 6.43[bc] | 6.31[c] | 6.31[c] |
| $pH_{24}$ | 6.34[a] | 6.39[a] | 6.27[a] | 6.32[a] | 6.15[b] | 6.11[b] |
| WHC (mg%) | 32.42[b] | 32.37[b] | 34.60[ab] | 34.48[ab] | 36.40[a] | 36.02[ab] |
| Protein (%) | 18.59 | 18.92 | 18.63 | 18.50 | 18.84 | 18.70 |
| Fat (%) | 8.46[a] | 8.58[a] | 7.56[ab] | 8.02[ab] | 7.22[b] | 7.32[b] |
| Water (%) | 71.35 | 71.40 | 72.07 | 71.60 | 72.14 | 71.90 |
| Ash (%) | 1.63 | 1.53 | 1.76 | 1.69 | 1.81 | 1.87 |

[ab] – different letters in the row denote statistically significant difference at $p \leq 0.05$

differences were noted in the intramuscular fat content of Ross 308 and Hybro G broilers as affected by air temperature level in the poultry house. The muscles of broilers grown under higher air temperature contained higher fat content than those grown under lover temperature.

Howlider & Rose [1989], Smith [1993] and Sosnówka-Czajka *et al.* [2001] also reported that adequate air temperature in the poultry house stimulates a proper and harmonic body growth *i.e*. good fleshing and low fatness.

## CONCLUSIONS

The experiments aimed at the comparison of the effect of increasing or decreasing of standard (medium) air temperature by ±3°C in the poultry house after the 4th week of growing period in Ross 308 and Hybro G broilers revealed that temperature changes in the above range significantly worsened bird performance traits. A higher air temperature in the poultry house demonstrated a greater negative effect upon the physicochemical traits of the muscles. That pertained before all to the degree of muscle acidification and fat content. The examined air temperature levels in poultry house affected to the same extent in Ross 308 and Hybro G birds the economic effectiveness of broiler production as well as the quality of carcase and meat.

Air temperature above the recommended standard level in the final period of bird growth caused economic losses and influenced the traits of meat resulting in its susceptibility to microbial contamination.

The production of farm animals depends not only on their genetics and feeding, but also on their relation to the environment. The high level of the environmental hygiene in stables is the first step to the health of the animal and the background for the high level of productivity. The high productivity of animals means the step to the appropriate financial reward. Healthy animals mean a source for the production of healthy food of animal origin for the food chain of a man – according to the role "from stable, through the retailers and shops chains, to the consumers' table" [Novak *et al*., 2004].

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## WPŁYW TEMPERATURY W KOŃCOWYM OKRESIE ODCHOWU ORAZ POCHODZENIA KURCZĄT BROJLERÓW NA JAKOŚĆ TUSZKI I MIĘSA

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Celem przeprowadzonego doświadczenia było porównanie wpływu obniżenia (o 3°C) i podwyższenia (o 3°C) zakresów temperatur w kurniku po 4 tygodniu odchowu kurcząt brojlerów oraz standardowego programu termicznego w odchowie kurcząt brojlerów Ross 308 i Hybro G na podstawowe wskaźniki użytkowości ptaków oraz jakości tuszki i mięsa.

Wskaźnik ekonomicznej efektywności odchowu EWW istotnie $p \leq 0,05$ najkorzystniejszy był w grupach kurcząt brojlerów odchowywanych w temperaturze standardowej. Wydajność rzeźna wynosiła w poszczególnych grupach od 70,40% do 71,54%, co nie było różnicą statystycznie istotną $p \leq 0,05$. Nieco więcej mięśni ogółem stwierdzono u kurcząt odchowywanych w niższej temperaturze. Różnica wynosiła 0,57% i nie była istotna $p \leq 0,05$.

Negatywnie na kształtowanie się cech fizykochemicznych mięśni większy wpływ miało zwiększenie temperatury. Dotyczyło to przede wszystkim takich cech jak stopień zakwaszenia oraz otłuszczenia mięśni. Badane czynniki środowiska w takim samym stopniu kształtowały ekonomiczną efektywność odchowu oraz jakość tuszek i mięsa u kurcząt brojlerów Ross 308, jak i Hybro G. Temperatura wyższa od zalecanego poziomu standardowego w końcowym okresie odchowu przyczynia się do strat ekonomicznych producenta kurcząt brojlerów oraz wpływa na cechy mięsa decydujące o jego podatności na zakażenia mikrobiologiczne.