

THE EFFECT OF MODIFICATION OF INCUBATION FACTORS ON THE QUALITY OF BROILER CHICKENS MEAT

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Abstract: Embryonic stage of development, in conditions of intensive broiler production, is a period in which the dynamics of postnatal development and the productive performance can be affected significantly. Green monochromatic light and thermal conditioning are the most commonly used treatments that have given satisfactory results in postnatal development. The aim of this study was to examine the effect of these treatments on meat quality of broiler chickens. Our study is based on the four experimental groups (control and three different treatments). Each group was incubated in separate incubator with 80 eggs, with controlled incubation parameters (temperature, humidity, ventilation). The control group was incubated under standard conditions (37.8 °C, without light). The first treatment consisted of thermal conditioning (raising the temperature to 39,8 °C for 3 h on 16th, 17th and 18th day of incubation). Another treatment consisted of lighting a green monochrome light (diffused LED lighting intensity of 0.1 W/m²) from 5th until 14th day of incubation, in the intermittent mode (15 min. light, 15 min. darkness), and from 15th day of incubation under constant light regime. The third treatment was a combination of first two treatments, with the temperature and lighting changed by these regimes. Our results indicate a significantly higher average body weight, protein content in meat, and less progressive loss of moisture (drip loss) in all treated groups. The applied treatments had no effect on mortality, conversion, or the content of fat and ash in meat. The results also indicate a significant synergistic effects achieved by the simultaneous application of both treatments.

Key words: incubation factors, heavy hybrids chickens, meat quality

Introduction

There are several ways to affect, during embryonic development, the stimulation of muscle growth, and thereby the production of meat. The literature describes methods for achieving these results based on the application of

monochromatic green light and thermal conditioning (temperature increase during the incubation in certain critical stages) during embryonic development or in early postnatal development (*Halevy et al., 2006*).

Light can affect muscle tissue directly or indirectly. Direct effect is reflected in the penetration of monochromatic green light through the egg shell and affecting the muscle tissue directly. Alternatively, light can affect the myogenesis indirectly through the endocrine system or through extra cellular mitogens produced in adjacent tissues. Light energy can reach the hypothalamus directly through the skull and soft tissues (*Lewis and Morris, 2000*).

Increased expression of mRNA (messenger ribonucleic acid) for receptors for growth hormone was detected in satellite cells, derived from the chickens that were treated with a green monochrome light (*Halevy et al., 1998*). Growth hormone has been marked as a mitogen of satellite cells, regulating the number of receptors on these cells by positive feedback (*Sadowwski et al., 2001*). Indirect effects of growth hormone on the muscle tissue can be achieved through triiodothyronine. High levels of growth hormone in the circulation, before hatching, affects the increased thyroxine monodeiodination in triiodothyronine in the liver of birds (*Darras et al., 1990*).

Studies suggest that thermal conditioning at an early age, leads to temporary halt in growth that is followed with increased compensatory growth. This process leads to the body and breast muscle weight gain in treated broiler chickens in compare to the control group, at a later age (*Yahav, 2000*). Recent studies show that this treatment has a stimulatory effect on the growth of skeletal muscle through the stimulation of proliferation of satellite cells and their accelerated differentiation (*Halevy et al., 2001*).

The main mediator of responses of satellite cells, exposure to moderately increased temperature, are locally produced growth factors, primarily those produced in the muscles themselves. This is indicated by increased expression of IGF-1 (insulin-like growth factor 1) protein in breast muscle of chickens subjected to such treatment, with an accompanying proliferation of satellite cells. It is proved that IGF-1 stimulates proliferation of primary satellite cells in chicken (*Halevy et al., 2001*).

Based on data from the literature, we set the research goal to determine the influence of the monochromatic green light and thermal conditioning, and their combined action, during embryonic development, on the meat quality of the broilers chickens. In addition to this we wanted to give a general assessment of the justification of their use in commercial broiler production.

Materials and Methods

For this trial we have used the fertilized eggs of heavy hybrid "Ross 308", originating from parent flock at the age of 54 weeks. The average egg weight was 66.5 g, while egg weight ranged from 63.5 g to 69 g.

Temperature was regulated using an electronic thermostat "Thermoregulator ET-01" producers "Pro-Electric", Novi Sad, Serbia. Monochromatic green light was achieved using LED (light emitting diode) lighting, using "JCDR LED 18" (1.2 W 10000-12000 mcd) light source, manufactured by "Vito Industrial Limited, Zhuhai, China. Light intensity and homogeneity of light were controlled with luxmetr "Peak Teck 5025", produced by "Peak Technologies, LLC." Old Columbia Rd., Columbia, USA.

The experimental groups (Eg) were formed according to the following principles:

EgA was the control group that was incubated under standard conditions (constant temperature of 37.9 °C, without light, with relative humidity and ventilation that were adapted to the respective stages of embryonic development);

EgB was incubated under standard conditions until the 15th day of embryonic development. During 16th, 17th and 18th day of the embryonic development the temperature was increased by 1.5 °C for 3 hours (from 09:00 h to 12:00 h). From 19th day until the end of incubation, the incubation factors were identical as in the EgA.

EgC was incubated under standard conditions until 5th day of embryonic development. From 6th to 15th day of embryonic development it was subjected to the influence of monochromatic green light (wavelengths from 450 to 550 nm and intensity 0.1 W / m²) under intermittent regimen of 15 minutes of light and 15 minutes of darkness. After that period, from 16th day of incubation, until the end of the embryonic development the light was constant.

EgD was a combination of experimental treatments EgB and EgC.

After hatching, drying and rest for 24 hours, broiler chickens were packed into transport boxes, separated on experimental groups and transferred to the experimental farm of Faculty of Agriculture in Novi Sad "Pustara" in Temerin. Chickens were vaccinated using a regular vaccination program and throughout the trial were under constant veterinary supervision. During the production cycle the broilers were fed ad libitum in three phases using a complete feed mixture (CFM) adjusted for their age.

The measurement of body weight was carried out using the scales "Mettler K5", produced by "E. Mettler", Zurich, Switzerland. The moisture content in meat samples was determined by drying at 105 °C to constant weight. The percentage of protein in meat was determined by Kjeldahl method. The percentage of fat in meat was determined by Soxhlet method. Ash content in meat was determined by annealing, or heating the sample at 500 °C. The progressive loss of moisture from the breast muscles ("Drip loss") was determined by measuring the weight of the samples of breast muscles before and after storage at +4 °C for 24 and 48 hours, as described in Perić *et al.* (2009).

The degree of statistical significance between groups was performed by analysis of variance (ANOVA) and Student's t-test, for the significance level of

95% 95% ($p < 0,05$) and 99% ($p < 0,01$). The calculation was performed using PC and *Microsoft Excel 2003*.

Results and Discussion

The results related to the basic production parameters (body weight, mortality and conversion) are shown in Table 1.

Table 1 Basic production parameters

Parameter	EgA	EgB	EgC	EgD
Body weight (g)	2089 ^{b,c,d}	2243 ^a	2222 ^a	2272 ^a
Mortality (%)	3,0	2,0	3,0	2,0
Conversion	1,911	1,887	1,908	1,906

^{a,b,c,d} – statistically significant difference ($p < 0,05$)

^{A,B,C,D} – statistically very significant difference ($p < 0,01$)

Monochromatic green light shows the stimulating effect on growth and this effect can be expected in the embryonic stage of development (*Rosenboom et al., 2004*). Thermal conditioning results in increased body weight (*Yahav, 2000*). Application of light of different wavelengths had no effect on conversion and mortality (*Wabeck and Skoglund, 1974*). Our study showed a statistically significantly higher body weight in all treated groups than in the control group, and no impact on mortality and conversion. The main parameters of meat quality (dry matter content, chemical composition and progressive loss of moisture) are shown in Table 2

Table 2 Meat quality parameters

Parameter	OgA	OgB	OgC	OgA
Dry matter content (%)	27,74 ^{B,C,D}	30,17 ^A	30,17 ^A	30,94 ^A
Protein content (%)	18,70 ^{B,C,D}	19,94 ^A	19,45 ^A	19,56 ^A
Lipid content (%)	2,05	2,24	1,88	1,96
Ash content (%)	1,02	1,04	1,05	1,03
Progressive loss of moisture after 24 h (%)	1,88 ^{b,c,d}	1,11 ^a	1,26 ^a	1,20 ^a
Progressive loss of moisture after 48 h (%)	1,97 ^{b,c,D}	1,43 ^a	1,56 ^{a,D}	1,36 ^{A,C}

^{a,b,c,d} – statistically significant difference ($p < 0,05$)

^{A,B,C,D} – statistically very significant difference ($p < 0,01$)

Alvarado and Owens (2006) report that the percentage of protein in muscle tissue of broilers was 19.14%. *Lesiów (2006)* finds that the total fat content in muscle tissue varies considerably from 1,58 % to 6,65 %. *Ristic et al. (2007)* reported that the percentage of ash in broiler meat makes an average of 1.2% by weight fresh meat after slaughter.

The results show that all treated experimental groups had statistically significantly higher dry matter content and lower moisture content in muscle, in compared to the control experimental group. These results indicate that the treatment, which influenced the increase in total body weight, acting on account of higher dry matter content and not on account of higher moisture content in meat. The increase in the percentage of dry matter in the meat generally can result with the increase or decrease its nutritional value, depending on whether it is achieved at the expense of increasing the total content of protein or fat as the main nutrients. Our results indicate that the percentage of protein was significantly higher in all treated groups compared to the control group, and ranged above 19%, while in the control group it was below this value. In addition, our results indicate the absence of statistically significant differences between all experimental groups in the lipid and ash content in meat.

The progressive loss of moisture is an important indicator of meat quality, since the weight loss increases during the technological process of cooling. This moisture loss is greatest in the early days, so it is common that it is expressed as the percentage mass loss after 24 and 48 hours of cooling. The moisture loss is related primarily to the loss of free water that is free in the cell or the extra cellular space. Our results show, unequivocally, the beneficial effect of the treatments on the progressive loss of moisture from the meat after 24 hours and 48 hours of cooling.

Conclusion

All the applied treatments show significant results in increasing body weight, without affecting mortality and conversion. Treatments have a significant impact on the increase of dry matter in the meat which is a result of increasing the percentage of total proteins, while treatments have no effect on fat and ash content in meat. All treatments have a significant effect on reducing the progressive loss of moisture from the meat.

Based on these results we can conclude that it is reasonable to use treatments that are based on the modification of incubation factors, and that there is a possibility that they can be successfully implemented in commercial broiler production.

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Uticaj modifikovanih inkubacionih faktora na kvalitet mesa brojlera

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Rezime

Faza embrionalnog razvoja u uslovima intenzivne brojlerske proizvodnje je period koji značajno utiče na postnatalni razvoj i proizvodne performance. Zelena monohromatska svetlost i temperaturni uslovi su najčešće upotrebljavani tretmani koji daju zadovoljavajuće rezultate u postnatalnom razvoju. Cilj ovog rada je ispitivanje uticaja ovih tretmana na kvalitet mesa brojlera.

Naša istraživanja su bazirana na četiri eksperimentalne grupe (kontrola i tri različita tretmana). Svaka grupa je inkubirana u odvojenom inkubatoru sa 80 jaja, sa kontrolisanim inkubacionim periodima (temperatura, vlažnost, ventilacija). Kontrolna grupa je inkubirana pod standardnim uslovima (37.8 °C, bez svetla). Prvi tretman se odnosio na temperaturne uslove (povećanja temperature tokom 3 h do 39,8°C, 16., 17., 18. dana inkubacije). Drugi tretman je uključivao upotrebu zelene monohromatske svetlosti (difuzne LED svetlosti intenziteta 0.1 W/m²) od 5. do 14. dana inkubacije, u naizmeničnim intervalima (15 min svetla, 15 min mraka), i od 15. dana inkubacije konstantan svetlosni režim. Treći tretman je bio kombinacija prva dva tretmana sa temperaturnim i svetlosnim izmenama u datim režimima.

Naši rezultati ukazuju na značajno veće prosečne telesne mase, sadržaj proteina u mesu i manje progresivan gubitak vlage (drip loss) u svim tretmanima. Primenjeni tretmani nisu imali efekta na mortalitet, konverziju hrane i sadržaj mast i pepela u mesu. Rezultati takođe ukazuju na značajne sinergističke efekte koji su postignuti simultanom aplikacijom oba tretmana.

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