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Epigenetic adaptation applications in Poultry

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Abstract
Epigenetic adaptation practices are defined as regulations that change gene expression in the cell independent of the DNA sequence. Gene expression levels of stress environmental factors such as nutrition, light wavelength, temperature and sound are improved by epigenetic adaptations. These improvements are not passed on to future generations. Epigenetic applications are adaptations such as the lighting in different colors, hot-cold shock, different sound wavelengths and feeding in poultry during the embryonic development period. Thanks to the thermal stress and environmental manipulations performed during embryonic periods, it is ensured that it gains the ability to adapt in the hypothalamus-pituitary-thyroid and hypothalamus-pituitary-adrenal axes. Poultry can perceive colors in the 350-700 nm wavelength range. Long wavelengths reach the hypothalamus much faster than short wavelengths. These light wavelength applications affect efficiency and performance. In the embryonic period, the structure of the auditory brain such as papilla, cochlea, nucleus magnocellularis, anteroventral cochlear nucleus, nucleus angularis, dorsal cochlear nucleus, nucleus laminaris, medial superior olive, optic tectum, superior colliculus develops. The auditory perception of the sound applied in this period is ensured, when it is heard later, the auditory recognition of the emergence by the activation of the auditory nerve fibers. These adaptations provide the ability to cope with the thermal stress encountered in adulthood. In this study, information is given about the effects of environmental factors such as temperature, light and sound wavelength on the epigenome and the transmission mechanisms and relationships of these effects across generations.

Keywords: Epigenetic Adaptation, Embryonic Period, Light Wavelength Applications, Different Temperature Applications, Sound Wavelength Applications

1. Introduction

Epigenetic adaptation applications; It causes phenotypic variations in gene expression that are not caused by changes in the DNA sequence but are inherited. Epigenetic adaptation practices are adaptations gained by affecting the gene expression of various environmental effects such as sound, temperature, lighting, nutrition during the embryonic development period (Tzschentke *et al.* 2004, Tzschentke and Basta, 2002, Tzschentke *et al.* 2004). These adaptations cause changes in the cellular dimension; It does not cause any changes in the DNA sequence. In the embryonic period, epigenetic adaptation practices are widely used in farm animals to eliminate the negative effects caused by environmental factors. In this way, it is ensured that lines with desired properties are obtained in accordance with environmental conditions. In this study, it is aimed to give information about the effects of environmental factors such as temperature, light and sound wavelength on the epigenome and the intergenerational transmission mechanisms and relationships of these effects.

1.1 Epigenetic adaptation applications

1.1.1 Epigenetic adaptation relations with applications of different wavelengths of light

In poultry breeding, light intensity shows different effects depending on the light source, lighting period and light wavelength. Light wavelength in poultry; It is an important environmental factor affecting behavior, yield performance and health; Therefore, artificial lighting (light duration and light intensity) is widely used to improve the reproductive performance of modern poultry laying hens (Er *et al.*, 2007). When the light wavelength ranges are examined, the wavelengths of purple in the range of 380-435 nm, blue in the range of 435-500 nm, green in the range of 501-565 nm, yellow in the range of 565-600 nm, orange in the range of 600-630 nm, red in the range of 630-780 nm takes color. Depending on the light wavelength, the stimulation of the hypothalamus changes.

Since the retina structure of poultry is different from that of humans, their response to light color is also different from humans. While poultry can perceive colors in the 350-700 nm wavelength range, humans are sensitive to light in the 450-650 nm range. If poultry are animals, long wavelengths reach the hypothalamus more than short wavelengths (Andrews and Zimmerman 1990) [4]. For example, long wavelengths reach the hypothalamus 36 times faster in ducks and 80-120 times faster in quail than short wavelengths. The common feature of humans and birds is that they are both sensitive to wavelengths between 545-575 nm (Cao *et al*.2008) [6].

1.1.2 Epigenetic adaptation relations with applications of different different heat

When the body temperature of poultry is examined, it is seen that it changes between 40.5-41.5 ºC (Yahav, 2004) [43]. This temperature varies depending on age, gender, race, physiological conditions. During the growing period, temperature reserves are generally between 15-28 C.With this temperature increase, the balance between body temperature and heat released from the body deteriorates (Etches *et al*., 1995) [10]. As a result, it is exposed to thermal stress. (Etches *et al*., 1995) [10]. The ability to adapt to this thermal strain is called thermotolerance (Yahav, 2009) [44]. Depending on the increase in temperature and humidity, body weight gain, carcass quality, growth, mortality, chick quality, feed consumption and conversion rate are affected (Yahav and Hurwitz, 1996; Yalçın *et al*., 2001; Yahav, 2009; Yalçın *et al*, 2009) [45, 44. 47]. In addition, in studies on thermal stress adaptation in poultry, heat application is performed above optimum conditions in early and late embryonic periods. Thanks to the environmental manipulations applied in the embryonic period with this thermal stress, it provides the ability to adapt in the hypothalamus-pituitary-thyroid and hypothalamus-pituitary-adrenal axes (Decuypere ve Bruggeman, 2007; Uni ve Yahav, 2010; Yahav ve Plavnik, 1999; Yahav ve McMurtry, 2001; Yahav ve Tzschentke, 2006; De Basilio ve ark., 2001; Yahav ve ark., 2005; Uni ve Yahav, 2010 [38]) [8, 38, 46, 7, 38].

1.1.3 Epigenetic adaptation relations with applications of different sound wavelengths

While sound stimulation of approximately 2,200 Hz is made in the embryonic period in poultry; It is known that the highest application rate is between 2,600 and 5,000 Hz in the period after incubation. (Jones ve Jones 2000, 2001, 1995a, b; Manley ve ark.1991; Plontke ve ark.1999; Warchol ve Dallas 1990) [18, 19, 16, 17, 23, 41]. It is stated in the studies that nerve fibers to detect auditory stimuli at these intervals begin to form on the 10th day of the embryonic period (Jhaveri and Morest, 1982a; 1982b) [14, 15]. When the prototypical anatomy of poultry is examined in this process, the papilla, cochlea, nucleus magnocellularis, anteroventral cochlear nucleus, nucleus angularis, dorsal cochlear nucleus, nucleus laminates, medial superior olive, optic tectum, superior colliculus form the structure of the auditory brain (Romand and Marty, 1975; Ryan and Woolf, 1992) [25, 29]. In various studies, it is stated that vocal stimulation in the embryonic period is rapid in early auditory development in the postnatal period (Romand & Marty, 1975; Ryan & Woolf, 1992; Cantt 1998; Werner & Gray, 1998) [25, 29, 5, 42]. Synaptic activity is recorded in response to the electrical stimulation of afferent axons shortly after the axonal input of the sound stimuli through dendrites (Jackson *et al*. 1982). It is known that in poultry, the ability to perceive and respond to the normal intensity of sound auditory on the 12th and 14th days of the embryo (Jackson and Rubel 1978; Saunders *et al*. 1973; Jones *et al*., 2006) [13, 30, 34]. It had observed that auditory perceived sounds are recognized auditory spontaneously with the activation of auditory nerve fibers when heard later (Shatz 1990, 1994) [31, 32].

2. Epigenetic adaptation studies

2.1 Some studies on epigenetic adaptation relations with different wavelengths of light applications

During the embryonic period, Pyrzak *et al*. (1987) [24] examined the effects of red, blue and green light applications. In the study, Pyrzak *et al*. (1987) [24] red light application increases the number of eggs; They stated that in the green light application, they observed that the eggshell quality was better. Rozenboim *et al*. (1999) [27], in their study, applying green light in the early stages of the broiler fattening period; They reported that it positively affected the yield characteristics. On the other hand, blue light application compensatory growth was observed towards the end of the fattening period. Rozenboim *et al*. In another study conducted by (2004), broiler chickens examined seven experimental groups. In the study, they have argued that green light increases development in broilers at early ages, while blue light increases growth. Rozenboim *et al*. In a similar study by (2013), it was reported that greener color applications encourage the growth of chicks at an early age, and transition to a different light environment at 10 and 20 days of age is more effective on growth. In addition, the study results showed that opsin receptors, which perceive the green color, which is very active at hatch, at the age of 9 days; It has been suggested that it results from being suppressed by opsins that detect red color. Er *et al*. (2007) examined the effect of different light wavelengths on the Hy-Brown line between 19 and 52 weeks. In the study, they used blue (B), green (G) and light-emitting diode lamps, red (R) light, as well as incandescent light (W). All light sources equated to a light intensity of 15 lx and stated that they applied for 16 hours a day. They had concluded that different wavelengths of light affected egg quality, and that egg weight in white light (61.1 g) was statistically significantly ($P < 0.05$) greater in red light (59.2 g) during the trial phase. As a result, in the red light application, egg weight is less than in other light applications, egg length and egg width had shortened in the blue light application and egg width in the red light application is shorter with age; They had reported that green light application improved egg quality. In a study by Wabeck and Skoglund (1973) [40], they had applied blue and green light. In the study, they had stated that blue and green light application had higher live weight gain in broiler chickens. They also had observed that feed conversion rate and mortality were not affected. Stating that had blue and green light application accelerates the development of poultry, Halevy *et al*. (1998) [12] stated the number of muscle satellite cells (new cells) depending on the light wavelength.

2.2 Some studies on epigenetic adaptation relations with different heat applications

Birgül and Alkan (2015) [1], who applied high heat in the early and late stages of embryonic development during the incubation period in broilers, examined the effect on live weight. They had applied optimum incubation conditions (37.5 o C temperature and 55% humidity) to the control group eggs during the development period up to 19 days in the experiment. In their study, ın the early (8-10th days) and late embryonic (16-18th days) periods of the incubation, they had applied to the eggs for 3 hours a day (12.00-15.00), 41 o C temperature and 65% humidity. At the end of the study, it had stated that the chicks in the heat-treated group in the late embryonic period had the highest live weight (1569.30 ± 21.21g). In another study, they had examined the effects of 36 ° C (Low), 37.5 ° C (Control) and 39 ° C (High) heat strain on the growth rate, feed consumption and metabolism in the embryonic period (Molita ve ark. 2016). At the end of the study, they had observed that exposure to high temperature during late embryonic development enabled it to adapt to heat tolerance. In a similar study, Almeida *et al*. (2016) [3] had examined the effects of different (36 ° C, 37.5 ° C, 39 ° C) thermal applications in the embryonic period. In the study, they stated that they had found the average chick weight in the order of heat treatment as 48.50 g, 48.94 g, 48.98 g, respectively. At the end of the study, they had determined that different degrees of heat application during the embryonic period did not affect chick weight and quality. Zaboli *et al*. (2017) had observed the effects of chronic heat (39.5 ° C and 65% humidity for 1-7 days 12 hours, standard conditions 7-16 days, 36 to 38 ° C for 24 hours for the last 3-5 days) application. Zaboli *et al*. (2017) had stated in their study that the had applied Heat application induced thermotolerance by modification of physiological parameters, especially in the first week of chronic heat application and during the development of the thermal regulation system.

2.3 Some studies on epigenetic adaptation relations with different sound wavelength applications

Tong *et al*. (2018) [35], who applied the species-specific voice for 15 minutes per hour from the 10th day of the embryonic period, examined the relationship between the control group. When the findings obtained in the study were examined, it was estimated that the sounds played on the 10th and 19th days of the incubation did not have a statistically significant effect on the growth characteristics, but the late embryonic deaths were higher (P <0.01). Türkyılmaz (2006) [36] investigated the relationship between mother voice, music and control group in her study on Japanese quails (Coturnix coturnix Japonica). In the study, stimulation times in incubation had reported as 392.32, 388.24 and 383.51 hours, respectively.Türkyılmaz (2006) [36] had stated that sound stimuli are statistically significant (P<0.001) according to the results of the study. In addition, 66 of the 120 chicks used in the behavioral test conducted in the study had found to orient the mother's voice and 35 of them to the music voice. They had concluded that the orientation times to the sound source were 115.94, 127.32 and 119.09 seconds, respectively. Regarding the sound frequency application, Demırbas and Kubanc (2018) [9], who made 3 different applications (500 Hz, 600 Hz and 400Hz), used the lowest 1/16 and the highest 2/16 value for the egg damage/egg ratio of these groups in the group where 600 Hz (Hertz) had applied. They determined that.Timothy *et al*. (2006) [34] had examined how sound frequencies are affected by early or late stimulation in the embryonic period. In the study, they had stated that incubation did not give a response to the 12th and 16th sound stimuli. In another study, Alıldı *et al*. (2002) examined the effects of instrument sounds. According to the results of the study, they had stated that the immunoreactivity higher in the group in which the species-specific sound was applied, but there was no statistically significant difference.In addition, in the study, it was stated that the auditory stimulation of vocal applications in the nuclei in the embryonic period increased the synaptic protein expression pattern. Foushee *et al*. (2002), in the last 48 hours of incubation, Japanese quails had stimulated a species-specific sound (gray animal) at a magnitude of 65 decibels for 10 minutes/hour. In the results of the study, Foushee *et al*. (2002) had stated that groups with sound stimulation in the embryonic period are more sensitive to sound than the control group. In another study, it was stated that the sound application was started at 433 hours and the earliest time interval for the stimulation sound was 176 ms, and the appropriate time intervals for the stimulation were 134 ms and 380 ms. In the results of the study, it was found that all groups were hatched the earliest and there was no decrease in hatcheries, while Veterány *et al*. (2005) [39] has been observed by. Veterány *et al*. (2005) [39] had examined the effect of using synthetic voice during incubation in chickens of the Hampshire breed. In their study, they had used an electronic sound generator for stimulation with a power of 1250 mV and a time interval of 134 ms, 176 ms, 210 ms and 380 ms. In Trial 1, they had examined the effect of sound stimulation on egg weight and hatch, the effect on hatching in the 2nd trial, and the changes on hatching in the 3rd trial. Rumpf and Tzschentke (2010) [22] examined the effects of acoustic sound applications in the embryonic period in their study. They had stated that acoustic sound applications increase the movements and clicking sounds of the embryo inside the egg.

3. Conclusions

When the studies conducted were examined, it was observed that epigenetic adaptation applications gained adaptation ability in the hypothalamus-pituitary-thyroid and hypothalamus-pituitary-adrenal axes thanks to the thermal stress and environmental manipulations performed in the embryonic periods. It has been reported that long wavelengths reach the hypothalamus in poultry animals (350-700 nm) exposed to different colors of light than short wavelengths. In the embryonic period, studies have shown that it improves the structure of the auditory brain such as papilla, cochlea, nucleus magnocellularis, anteroventral cochlear nucleus, nucleus angularis, dorsal cochlear nucleus, superior colliculus, nucleus laminates, medial superior olive, optic tectum. It has determined that the auditory perception of various sound stimuli in the embryonic period and then the activation of the auditory nerve fibers when it was heard, the auditory recognition was achieved spontaneously. As a result, it was found that epigenetic adaptation practices show various variations in the embryonic period; It is also stated that it has effects on efficiency and performance in later periods.

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