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REVİEW ARTICLE

# Develeopment of Sensory Organs and Its Effects on Growth in Chicks

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**Abstract**

Recently, alterations in poultry farming have been much more than other branches of agriculture. This case also achieves a great deal of success in terms of efficiency. Increasing productivity in broiler production is one of the most important issue and researches are increasing day by day. Both during incubation and after hatching, applications are aimed at increasing productivity, growth and development. In this study, the development of sensory organs in chicks and the effects of the applications through sensory organs are emphasized. Especially in recent years, studies on odor, colour and light have been increasing. In the chick sex posed to some applications during incubation, the effects of these applications after hatching have been observed in most studies. To increase these effects positively, more intensive research should be conducted and positive developments should be recorded in broiler production. Broiler development and growth occurs with feed consumption. The earlier the chicks are fed and the more feed is eaten during growth, the more production occurs at slaughter age. For this reason, the importance of the senses in terms of their effect on the feeding behavior is discussed in this study.

## Introduction

The increase in the world population, climate changes due to global warming and pandemic diseases affecting many regions have brought the importance of plant and animal production, which is necessary for a healthy and balanced nutrition of people, to the agenda. Due to the global changes that have occurred for many years, researchers have worked on sustainable agriculture and livestock policies (Ordu and Zengin, 2020). Accordingly, developments in poultry farming are also quite high. Livestock is one of the sub-branches of the agricultural sector and provides raw materials to different industries. Animal husbandry is crucial for societies because it provides basic nutrients (Er and Özçelik, 2016). Main animal products (eggs, milk and meat) constitute the main protein sources that people should take for a balanced and healthy life (Ordu and Zengin, 2020). Poultry was domesticated about 8000 years ago (Webster, 2002). This is a great development for humanity and has had a significant impact on meeting people's protein requirements. Since its first domestication, chicken has been bred for meat and eggs, and recently much effort has been done to increase chicken production and yield. There are many studies on increasing feed consumption. Today, poultry farming, particularly egg and meat poultry, has become the most intensive animal production area with significant capacity increase (Nkukwana, 2018; Sarıca *et al.*, 2018; Sheldon, 2000; Waarst *et al.*, 2015). Although almost all of the chicken meat and eggs are obtained from the intensive production in our country, there is a demand for poultry products obtained from traditional production for various reasons (Sarıca *et al.*, 2020).

Chicken is reared in intensive conditions, either as flock in the hen house or in groups in cages. There is an increasing interest in the social behavior of these animals to encourage more effective flock management and to get more efficiency from them (Göger, 1994). Additionally, chicken density in the poultry is one of the important factors affecting the yield. To generate more income in broiler enterprises both in Türkiye and other countries, the density of poultry is frequently exceeded and problems may occur (Teke *et al.*, 2019).

Early studies on chick behavior focused on identifying which behaviors were instinctive and which were acquired behavior. In one study, chicks showed instinctively grooming and scratching on the ground between day one and day three after hatching (Göger and Yenice, 2018). Studies have shown that chicks instinctively fear stinging insects but try catching flies (Krause *et al.*, 2006). In another study (Thomas *et al.*, 1998); one day old chicks were exposed to the smell of feathers, faeces, sawdust and feed and it was investigated whether these odors effected the chicks. It has been observed that chicks exposed to fecal odor exhibit a more headshaking behavior than the others (Thomas *et al.*, 1998). Sneddon *et al.* (1998) studied on the scent of strawberry, applied to the shells of the hatched eggs, and the behavior of the chicks after hatching. They observed that the chicks spent more time on the strawberry scented litter than the normal litter in the hen, and this was significant. In a study conducted, at the 20th day of the embryo, chicks exposed to odors containing amyl acetate and dichloroethane in various concentrations were observed to wake up by shaking their heads and making a clap-like sound with their beaks (Tolhurst and Vince, 1976). In chicks, the senses other than the sense of taste are highly developed and directly affect the behavior of chicks such as hatching, finding, and consuming feed. In many studies, it has been determined that the chick inside the egg hears the sound of the chicken and the chick easily finds its own mother after hatching (Edgar *et al.*, 2015). However, some sounds are known to trigger hatching (Vince 1968b, a; Vince *et al.*, 1984; White, 1984; Rumpf and Tzschentke, 2010; Sleigh and Casey, 2014; Tong *et al.*, 2015). The ability to distinguish colors in chicken is highly developed. Their development is supported by periodically using lights of different wavelengths (Classen, 2003). Chicks can easily select the bait by touching the bait with their beaks or they try to recognize a foreign object with their beaks (Kutlu, 2015; Göger *et al.*, 2018). Although it is thought that the sense of smell is not developed in chicks, it has been observed that this sense has developed considerably in recent studies and applications have been made to increase feed consumption, particularly in broilers.

The determining factors in the selection of feed in chicken; taste and smell of feed, visual cues, learning ability, nutritional needs and social interaction (Forbes, 1995). Research on visual discrimination has revealed that chicken can distinguish objects through their shapes (Göger and Yenice, 2018). Portella *et al.* (1988) reported that broilers prefer larger particles with increasing age. It is also reported that the location of the feed in the cage is a visual factor for feed separation (Kutlu, 1993). It has been reported that chickens generally prefer brightly colored feeds, especially pink and red, and that color is a strong cue for chickens in learning about preference and hatred (Forbes and Covasa, 1995; Çadırcı, 2014). It has been reported that the taste and smell of the feed have an important role on the selection of the feed, but has a secondary importance compared to the visual reagents during the feed selection as a result of the few taste receptors in the tongue and palate of the birds (Kutlu, 1993).

**Sensory Organs in Chicks**

All senses are used to recognize feed and a loss of one sense results in loss of the ability to select and digest. While mammals depend primarily on taste in recognizing feed, birds use appearance and quickly learn to combine the metabolic consequences of feed eaten with the sensory characteristics of a feed (Forbes and Covasa, 1995). For this reason, the sense of sight is one of the most important sense organs for feed consumption in poultry. After the eggs are placed in appropriate incubation conditions, a third layer, the mesoderm, develops in the space between the endoderm and ectoderm layers in a short time. These three layers form the basic structure of different organs and tissues of the chick during embryo development (Elibol, 2009). Elibol (2009) reports that the eye socket and ear canal begin to form at the 24th hour of the embryo, the nose and wings are formed on the 3rd day, the eyes are colored, and the beak takes its normal shape on the 6th day of incubation. The sense of hearing emerges at the 12th day of the embryo (Cohen and Fermin, 1978; Hirokawa, 1978; Rebillard and Pujol, 1983; Whitehead and Morest,1985a, b).

**Sense of Taste**

In chicken, taste sensitivity is different for specific taste stimuli (Liu *et al.*, 2018). Taste is important in guiding nutritive choices and motivating food intake and the sensory organs for taste are the taste buds, that transduce gustatory stimuli into neural signals (Liu *et al.*, 2018). Nevertheless, the study conducted by Tuncel *et al.*, (1995) state that feed taste is not an important factor that can affect the feed consumption of chickens, they can change their feed preferences by effecting sense of taste. Although it was stated in the previous studies on taste that the development of taste sense in birds very low, studies carried out in recent years also reveal that chickens have a better taste system and the sense of taste develops more than previously estimates. Mammals have a more developed taste system than poultry. Because of birds have less taste receptors than mammals there is a

broad consensus that birds have a lower taste than mammals (Liu *et al.*, 2018). According to Berkhoudt (1985) and Shi and Zhang (2005), the number of taste receptors are 5-12 in daily chicks, 24 in chickens, 6974 in humans and 17000 in rabbits. It is supported by some studies that the number of taste receptors varies between 240-360 depending on the chicken breed (Ganchrow and Ganchrow, 1985; Kudo *et al.*, 2010). Chickens can distinguish bitter, sweet, salty and sour tastes from each other to a certain extent (Kare and Mason 1986; McKeegan, 2004; Forbes 2010). Gentle (1972) reported that chickens respond even to low-concentration stimuli of hydrochloric acid and acetic acid. Accordingly, recent findings in chicken taste buds and taste sensation indicating that the chicken taste organ is better developed than previously thought and can serve as an ideal system for multidisciplinary studies including organogenesis, regenerative medicine, feeding and nutritional choices (Liu *et al.*, 2018). Taste sensitivity for specific taste qualities may be altered under certain conditions (Liu *et al.*, 2018).

**Sense of Hearing**

The sense of hearing in chicks is well developed. The inner ear is a complex three-dimensional structure that contains the auditory and vestibular sensory organs, which are the first step in the transduction of sound, balance and motion stimuli (Neves *et al.*, 2013). A mature inner ear is a complex labyrinth containing multiple sensory organs and nonsensory structures in a fixed configuration, and any perturbation in the structure of the labyrinth will undoubtedly lead to functional deficits (Wu *et al.*, 1998). It has been observed in studies that the chick embryo begins to hear on the 12th day of incubation (Cohen and Fermin, 1978; Hirokawa, 1978; Rebillard and Pujol, 1983; Whitehead and Morest, 1985a, b). There is some evidence of incubation period interactions between chicken and embryo. One day before the chick hatches, the hen and chick begin to communicate vocally, and this communication increases as the hatching time approaches. It has been observed that the cackling sound of chickens reduces the danger warning. Studies showed that the newly hatched chicks ran toward the box containing a chicken and several chicks, despite they did not see any chicks or chickens. Although chicks may recognize their own hens in different ways, hearing is one of the important factors. The chicks could find their own hens in the dark room even when the own broody hen was replaced with another one. When the brooding was hidden in different ways, the chicks somehow managed to reach their own hens (Edgar *et al.*, 2015). There have been studies on the reactions of chicks to hearing behavior during hatching and after hatching. Making a “clicking” sound or making a hatching sound artificially at certain times during the hatching affects the hatching time and hatching distribution (Vince 1968b, a; Vince *et al.*, 1984; Rumpf and Tzschentke, 2010; Sleigh and Casey, 2014; Tong *et al.*, 2015). Additionally, if the eggs are kept touching each other in the hatching basket, it is stated that the hatching occurs earlier than those that do not touch each other (Vince, 1973). In a study, it was stated that different sound waves triggered the output (White, 1984). Similarly, Veterans *et al.*, (1998) stated that giving an electronic click sound during the hatching period accelerates chick hatching and hatching is completed early.

**Sense of Sight**

The sense of sight in chickens is relatively better developed compared to other living things. Manipulation of light intensity is an important management tool affecting broiler production and well being (Deep *et al.*, 2010). Lighting is a powerful exogenous factor in control of many physiological and behavioral processes, and light may be the most crucial of all environmental factors to birds (Olanrewaju *et al.*, 2006). The ratio of the eyes on both sides of the head is quite large compared to other living things. They have a viewing angle of 300 degrees. Apart from the ability to distinguish colors, the visual abilities of winged and humans are quite different from each other (Lewis and Morris, 2000). For poultry, light is an essensial part of the sense of sight, both as visual acuity and color discrimination (Manser, 1996). It is also stated in many studies that lighting provides significant improvements in body weight gain in broiler farming. In the first week, sufficient light should be provided in order for the chicks to find the feeder and drinker easily, to learn their place, to stimulate their feeding and drinking behavior and to ensure their activities in the first days, and then it should be reduced (Sarıca and Erensayın, 2009). Light wavelength strongly influences broiler behavior. The human eye can perceive a very narrow region between 400 and 700 nm wavelengths on the scale called electromagnetic spectrum, which is used to describe electromagnetic waves (North and Bell, 1990; Prescott and Wathes, 1999). However, Prescott and Wathes (1999) reported that unlike humans, birds can detect wavelengths up to 360 nm, Holden (1983) 350, Hogsette *et al.* (1997) and Prescott and Wathes (1999a) up to 320 nm. The wavelength (λmax) of human eye is most sensitive up to 555 nm, while that the chicken eye is 562 nm (Lewis and Morris, 2000). There is a superiority in favor of birds in terms of sensitivity to short (400–500 nm) and long (600–700 nm) wavelengths (Prescott and Wathes, 1999). Generally, bright light intensity encourages increased activity, while lower light intensity may cause cannibalism (Olanrewaju *et al.*, 2006).

**Effects of Light Wavelength on Chick Development**

Wavelenght, intensity, species and location of light play an important role in chick development and performance. Currently broilers are grown under low

light intensity, usually under green or blue light (Rierson, 2011). In the early stages of development, short wavelengths (blue, green) stimulate rapid development, whereas long wavelengths (orange, red) accelerate development and sexual maturity when approaching sexual maturity (Classen, 2003). Many studies show that broilers reared under blue or green light weigh more than those reared under red or white light (Cao *et al.*, 2008; Rozenboim *et al.*, 1999; Halevy *et al.*, 1998; Wabeck and Skoglund, 1974). Chicks exposed to purple or green (415 or 560 nm) light grow better than those exposed to red (>635 nm) or white light (<635 nm) (Foss *et al.*, 1972; Wabeck and Skoglund, 1974; Rozenboim *et al.*, 1999b).

Recent studies have shown that the wavelength or color of light affects the behavior (Manser, 1996), welfare (Manser, 1996; Classen, 2003) and performance (Prayitno *et al.*, 1997; Rozenboim *et al.*, 1999a, 1999b; Classen, 2003) of the birds. Lewis and Morris, (2000) reported that there is a negative interaction between body weight and light wavelength approximately 530–750 nm in broilers, and a decrease of around 50 g in body weight for every 100 nm increase in wavelength. Lein *et al.* (2008) stated that broilers had better weight gain and performance under dim light intensity. This is also supported by previous research (Quentin *et al.*, 2005; Blatchford *et al.*, 2009) that broilers reared under dim light are less active and thus have better body weight gain. Numerous studies have been conducted on the effect of light wavelength on broiler performance (Kondra, 1961). Researchers have often compared white light with blue, red, and green light. Green and blue light is believed to perform better due to their calming effect on broilers (Prayito *et al.*, 1997). It has been reported that short wavelengths (400– 450 nm) generally improve growth and feed efficiency (North and Bell, 1990, Prayitno *et al.*, 1997). Wabeck and Skoglund (1974) found that blue (470 nm) and green (530 nm) light provides the best feed usage in broilers. Similarly, Rozenboim *et al.* (1999a) reported that broilers reared in green (560 nm) light benefited better from feed compared to those reared in white, blue (480 nm) and red (660 nm) light. Smith and Philips (1959) found that broilers reared with green light benefited better from feed than those reared with blue, red and orange light.

**Feed Preference of Chicks Under Different Color Light**

Rierson (2011) conducted a study investigating the feed preference of broilers under different colors of light. The experiment was carried out with 40 newly hatched Cobb500 male chicks. In the 3.05 m x 1.62 m hen house, 4 feed boxes of 40.5 x 40.5 cm dimensions were placed aside and each box was illuminated with a different color light. The trial lasted 6 weeks; chicks were given powder feed under 4 different colors of light between 1 and 3 weeks, powder and pellet feed under 4 different colors between 4-6 weeks. Blue, green, red and white lights were used as light colors. Rierson (2011) stated that between the 1st and 3rd weeks, the chicks showed a preference for white light and did not prefer to consume feed under blue light. He observed that a small number of chicks were unstable between 1 and 3 weeks. At 4 and 6 weeks, the chicks were found to show a preference for pelleted feed and white light. They did not consume powder feed under green and blue light. Red remained the second color choice as in the first 3 weeks and the number of unstable animals was higher than at weeks 1 to 3. Heshmatollah (2007) discovered that when chickens are given different light intensities, their choices become difficult, but they prefer green light over red, orange, or yellow. The authors also concluded that broiler chicks prefer orange dyed feed at low light levels, but prefer green dyed feed at high light levels. In a study by Rierson (2011) that investigated broiler preferences for different color feeds under different color lights, it was observed that chicks under blue light showed a high preference for red dyed feed. They showed a greater preference for green feed under yellow light and very few chicks were unstable under yellow light. It has been observed that chicks under green light do not prefer blue feed, and the most unstable chicks are those under green light.

**Effect of Light Intensity on Broiler Chicks**

Prayitno *et al.* (1997) conducted a study on the effect of light color and intensity on behavior and leg problems in broilers. When the red light intensity increases; the time spent on sitting, walking, drinking water, wing stretching and aggressive behavior increased, and the number of chicks showing wing stretching and aggressive behavior increased as the blue light intensity increased. When the red light intensity increases; the time spent on napping, sleeping and pecking decreased, but when the blue light intensity increased, the time spent on these behaviors did not decrease. Prayitno *et al.* (1997) did not find a significant difference between light intensities and light colors in terms of live weight at the end of the experiment. However, they found that body weight gain was higher in blue light than in red light. Feed consumption and feed conversion ratios were the same in all 3 groups. Similar results were obtained with the aforementioned previous studies. Deep *et al.* (2010) conducted a trial on the effects of 4 different light intensities (1 lx, 10 lx, 20 lx and 40 lx) on feed consumption and body weight gain in broilers. In the measurements made on days 0, 7, 14 and 35, it was observed that the body weight gain was not affected by the light intensity. Deep *et al.* (2010) found that the feed efficiency of the animals exposed to 1lx light on the 7th and 14th days was lower than the other groups. According to other studies, it was found that light intensity did not affect feed consumption and feed efficiency (Skoglund and Palmer, 1962; Newberry *et*

*al.*, 1988; Kristensen *et al.*, 2006; Lien *et al.*, 2007; Blatchford *et al.*, 2009).

Many studies have been conducted to investigate the effects of light on performance in birds. In particular, studies on light wavelength are quite numerous and the positive effect of wavelength on feed consumption in broilers has been supported by many researchers. Although the light color does not affect the feed consumption much, it has been stated that the chicks prefer white light more. It can be thought that the chicks prefer the bait because they see it better under white light. In studies with light intensity, it has been determined in many studies that light intensity does not have an effect on feed consumption and feed efficiency.

**Sense of Touch**

Poultry has a developed sense of touch. In newly hatched chicks, the behaviors of straightening their wings and rubbing on the litter are observed. These behaviors may be an indication of how developed their sense of touch is. The sense of touch is of great importance during the intake of feeds. The beak, which replaces teeth and lips in poultry, is an organ that easily takes up grain feeds, especially on hard ground (Kutlu, 2015). Poultry touch with their beak to recognize an object and try to understand what it is. Chickens become aggressive toward chickens that are later joined to a cage or cage where a social hierarchical order is established. Chickens in a flock need to get to know each other for social order to occur. This ability enables them to recognize only those chickens in the social order and to peck those in their subgroup (Göger *et al.*, 2018). It has been reported that the feed used is powder or pellet, which is a distinguishing feature for chickens and broilers prefer larger particles as age progresses (Portella *et al.* 1988). Feather trimming behavior is quite common in poultry. Since feathers play an important role in water and air insulation, Delius (1988) reports that the bird's aim is to make each feather function better by trimming its feathers with its beak. Clayton *et al.* (1991) argue that feather trimming behavior in poultry reflects a co-evolution between chickens and living parasites. Studies show the importance of beaks for chicks, trying to recognize objects by touching them, choosing feeds and helping them to find and consume the appropriate feed.

**Sense of Smell**

The olfactory systems (or sense of smell) has received greater study in birds than other specialized chemical senses (McKeegan, 2004). The role of olfaction on feed intake, as indicator for appetite in chickens, is still unclear (Te Pas *et al.*, 2020). Chickens can detect and respond to a wide range of olfactory stimulants (McKeegan, 2004). When the articles belong to 25–30 years ago are examined, it is stated that the sense of smell does not develop in poultry. However, according to recent articles on the sense of smell have shown that the smell of chicks is not so bad.

The number of olfactory receptors is 283 in chicks, 396 in humans, 1130 in mice, and 1948 in elephants (Araneda *et al.*, 2000; Niimura *et al.*, 2014). Smells may be repulsive to or attractive to animals. In a study conducted with 7-day-old chicks, it was observed that the chicks avoided cat odor (Fluck *et al.*, 1996). Likewise, the smell of blood is also repulsive by the chicks. In a study conducted with blood, it was observed that chicks showed blood avoidance behavior, and chicks that were presented with blood and red dye of the same color were visually similar, showed a direct fear reaction when approached the smell of blood, and did not give a negative reaction to the red dye (Jones *et al.*, 1979; Fluck *et al.*, 1996). Chickens raised in a vanilla-scented environment gave fewer fear signals when exposed to the familiar scent of vanilla when moved to another location (Jones *et al.*, 2002).

**Early Exposure to Odor**

It is widely known from many studies that animals remember the stimuli they were exposed to before birth/hatching. Chickens show various behavioral responses to many artificial and natural odors (Bang and Wenzel, 1985; Wenzel, 1987; Jones and Roper, 1997). Chicks learn odors even after hatching and remember being exposed to the same odor before hatching (Burne and Rogers, 1995; Minguez, 1997), thus avoiding predators (Fluck *et al.*, 1996), learning to feed (Gentle, 1985; Marples *et al.*, 1996) and avoiding harmful substances (Guilford *et al.*, 1987; Burne and Rogers, 1997; Marples *et al.*, 1997).

In the experiment conducted by Sneddon (1998), the exposure of the eggs to strawberry odor between the 15th and 20th days of incubation caused the chicks to spend more time in the strawberry-scented litter. When the taste preferences of the same chicks were investigated, no significant difference was found between strawberry and tasteless water in terms of consumption. In a study by Bertin *et al.* (2010) the eggs were exposed to two different concentrations of orange oil and natural vanilla blend odor during incubation. In the test, in which two forms of known feed with and without smell are presented; the group exposed to high concentration odor preferred odorless bait and this was found to be significant. The group exposed to low concentrations spent more time consuming scented feed.

**Exposure to Odors After Hatching**

Burne and Rogers (1996) developed a simple method for measuring chicks' responses to odors. Taking the advantage of day-old chicks' tendency to

stare at brightly colored objects, the authors recorded the chicks' responses to plastic beads paired with various fragrances. Observed headshaking and pecking behavior varied at different concentrations of odorants. Porter *et al.* (1999) conducted a study investigating the reactions of chicks to odors after hatching. During the application, the cotton tip of the ear swab was dipped in the scent of strawberry, orange and an odorless ear swab was used for control. It was observed that sleeping chicks shake their heads and bang their beaks together when exposed to the odor. Awake chicks did not show such reactions when exposed to the same odor. In another study by the same researchers (Porter *et al.*, 1999) demonstrate that the behavior of chicks exposed to 3 different scents (mint, lavender, orange) was observed by squeezing the scent from the side of their beaks while they were sleeping. Looking at the test results, it was found that the chicks exposed to the three other stimuli showed different reactions compared to the control group. Chicks showed the highest response to the smell of mint and this reaction was found to be significant. In the study carried out by Porter et al (1999) the chicks reacted the most to the smell of mint. Studies on smell have shown that when chicks are exposed to certain odors before they hatch, they remember those odors and these odors affect some behaviors after hatching. After hatching, chicks respond differently to different odors.

## Discussion and Conclusion

Today, behavior has become a science. Knowing the important behavioral characteristics of chickens provides great convenience to for producers in the practices related to their care. The complex behavioral responses of chickens to alterations in the physical and sociological environment should be taken into account by the producers. Regarding to rearing healthy chickens, applications starting from the embryo period are of great importance. Recently, studies on the development of sensory organs in animals have been increasing. Until 25–30 years ago, there was not much research on the development of sensory organs in chicks; however, in recent years, the tendency toward this issue has increased and there are many studies on the development of sensory organs in chicks and their effects in chick performance and behavior. These studies are conducted with day-old chicks, as well as before the chick hatches. Particularly, the senses of hearing, sight and touch are highly developed; it is known that research on the sense of smell is increasing. The practices that the chicks are exposed to during and after hatching has many effects in terms of development and growth. In many studies, it has been observed that sensory organs in chicks have a significant effect on chick behavior and growth. In particular, the effects of the applications exposed during incubation on the chick during the period after hatching have been at significant levels.

Variables such as smells familiar to chicks, light colors and intensities that affect their behavior, sounds in the environment, and feed form affect feed consumption; behavior, growth and development of chicks. However, it is necessary to increase the number of studies on these subject and to contribute to increasing the benefits of broiler production in Türkiye.

## Author contributions

All authors contributed equally to the study.

## Conflicts of interest

The author declare no conflicts of interest.

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