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Impact of Bill Trimming on Duck Health and Welfare - A Review

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Abstract: Cannibalism has become a serious problem in the poultry industry especially in ducks. Understanding and controlling cannibalism is a crucial to duck production and welfare. Cannibalism causes detrimental effects on welfare, physiology, and immunology resulting in abnormalities and impaired production performance of ducks. Furthermore, the negative impact of cannibalism on ducks welfare has recently attracted increasing public awareness and concern. Much information has been published on the effects of cannibalism on production performance and physiological responses in ducks. In contrast, our knowledge of basic mechanisms associated to the reported effects, as well as related to duck welfare exposed to cannibalism is in fact scarce. Several managerial strategies have been conducted to counteract the deleterious effects of cannibalism in poultry, including bill trimming. Bill trimming is used as a method of reducing the damage to feathers and skin caused by injurious pecking in ducks. However, bill trimming also causes some welfare issues as trimming the beak results in pain and sensory loss. This review presents the deleterious effects of beak trimming on beak morphology and structure, physiological conditions, and production performance of ducks.

Keywords: Ducks, Cannibalism, Bill Trimming, Health, Welfare.

INTRODUCTION

The global poultry sector has undergone a series of structural changes during the last two decades making it one of the fastest-growing livestock sectors. The poultry industry has witnessed modern production technology, genetic improvements, better bio-security measures and improved disease control and prevention. As the world progresses towards increased urbanization and higher incomes, developed as well as developing countries offer opportunities for poultry producers to capitalize on these positive trends (Kumar *et al.*, 2022).

In 2020, global poultry meat output is expected to increase by 2.6 percent to 137 million tons (FAO, 2020). Consumers' efforts to replace bovine and pig meat with alternatives are mostly to blame for the anticipated increase in production. Because of its relative cost, consumers appear to have connected to poultry, resulting in cascade impacts throughout the poultry value chain, from production to export. Lower food service sales, purposeful production limitations, and disease outbreaks, on the other hand, have slowed the rate of production increase in 2020, approximately halving the rate in 2019 (FAO, 2020).

Globally, ducks are concentrated mostly in Asian countries with top four duck producing countries in the world are China, Vietnam, Bangladesh and Indonesia are located in this continent. Asian countries keep a large portion of ducks (88.1%) followed by Europe (7.7%), Americas (2.3%), Africa (1.7%) and Oceania (0.1%) in the year 2017 (Ismoyowati & Sumarmono, 2019).

The other significant contributing countries of world duck population are Myanmar, India, Thailand and Malaysia of Asia, Russian Federation and France of Europe. The domination of Asia in duck production is mainly due to the food habits of the people. For communities of China, Hong Kong, Japan, Korea and South-East Asia, duck is an important item in their food. In the same time, duck egg is also an essential protein source in some Asian countries. In India, Indonesia and Philippines ducks are mainly kept for egg production and not for meat supply. Also, France is an important country in Europe that has a sizeable number of ducks since long time. Ducks occupy an important place in French cuisines as special products like foie grass and fattened breast muscle are a delicacy (FAO, 2020).

The total duck meat produced in the world as per the latest data available in the FAO for the year 2017 is 4460.23 million kilograms. Of this, 84.18 % (3754.42 million kilograms) was produced in Asia. China is the key producer of duck meat in the world. With more than 3112.67 kilograms, China contributes a major share of 69.78 % duck meat production in the world and contributes 82.91 % to the Asia's duck meat production. France occupied second place in duck meat production in 2017. Ducks in France and in other European countries are reared specifically for meat

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purpose and hence, they are heavier breeds (Jalaludeen & Churchilz, 2019).

In duck-producing countries, cannibalism is one of the most important inhibiting factors to duck production. Cannibalism is known to impair the welfare, performance, productivity and health of the ducks by reducing feed intake, decreasing nutrient utilization, inducing skin injury, pain and death (Rodenburg *et al.*, 2013). Many factors can stimulate outbreaks of cannibalism in ducks, including lack of foraging opportunities; nutritional imbalances, light intensity, genetics, and group size **(**Ahmed, 2022). Besides, improving environmental management, nutritional strategies have been developed to partially alleviate the negative impacts of cannibalism in birds, including feeding diet with addition of salts, vitamins and minerals in diets (Nicol, 2018). Recently, bill trimming has been implemented in poultry to counteract the negative effects of cannibalism and feather pecking (Dennis *et al.*, 2009). Bill trimming is dialectical because of its potential to cause injury and pain. In poultry, a considerable of physiological and behavioral evidence can be found demonstrating the presence of neuromas in the bill. This review aimed at elucidating the impact of bill trimming on health and welfare of ducks. To prepare the review, we conducted a literature search with focus on the effect of bill trimming on poultry (laying hens, broiler, and quail) especially ducks using the following criteria: (1) peer-reviewed journal articles in English were included; (2) chapters in an edited book were selectively involved; (3) studies on hens and quail were selectively included to verify and/or support the data on ducks. The key words used during literature search included cannibalism, bill trimming, ducks, health, welfare.

Impact of Cannibalism and Feather Pecking on Poultry Industry

Feather-pecking is a non-aggressive activity in which birds peck at or pull off the feathers of conspecifics. There are various types of feather-pecking, including mild and severe (Martin & Beaugrand, 2014). Forceful pecking and pulling of feathers, as well as the removal and ingestion of pulled feathers, are all symptoms of severe feather-pecking. It is typically harmful in nature, causing feather damage, feather loss, sores, pain, and even cannibalistic pecking and death in some cases (Rodenburg *et al.*, 2013).

Severe feather-pecking is intense, but it's not the same as aggressive pecking, which is linked to social behavior and the development and maintenance of dominance in social hierarchies. Aggressive pecking is usually directed at the head and does not usually cause plumage damage to the rest of the body (Gilani *et al.*, 2013).

Gentle feather-pecking is the practice of pecking at the plumage of other birds without using excessive force and without removing any feathers. It does little or no damage, and the receiver rarely reacts negatively, such as vocalizations or a retaliatory peck. Gentle feather-pecking has been demonstrated to be a natural habit that contributes to social exploration (Riedstra & Groothuis, 2002).

Due to increased energy demands of denuded birds and higher mortalities due to cannibalism, severe feather-pecking has a negative economic impact (Rodenburg *et al.*, 2013). The inhibition of foraging behaviors such as ground pecking or a lack of environmental stimulation was positively linked with feather pecking in a several studies (Dixon *et al.*, 2010; & Gilani *et al.*, 2013).

Feather pecking and cannibalism are both harmful and painful behaviors that can result in the death of birds, resulting in economic losses. As a result, duck producers typically cut their birds' beak and claws within the first three weeks of life (Hester & Shea-Moore, 2003). Feather-pecking is poorly understood due to its multifaceted nature, and it is mostly handled by remedial techniques such as bill-trimming and reduced lighting (Petek & Mckinstry, 2010), which aim to alleviate the problem but do not address the primary cause of the behavior (Gilani *et al.*, 2013). Furthermore, bill-trimming is a difficult issue that has its own set of issues, including acute and chronic pain (Petek & Mckinstry, 2010).

BILL TRIMMING

Bill trimming is the removal of approximately one-quarter to one-third of the upper beak, or both upper and lower beak of a bird (Hughes *et al.*, 2019). Bill trimming is performed as part of an overall strategy to reduce peck injuries and death when raising groups of poultry. Bill trimming may be performed on many species including laying hens, turkeys, ducks, and quail. Bill trimming is acutely painful, as nociceptors are present in the tip of the beak. There are several different methods of bill trimming, which can be classified into four major groups: mechanical, hot-blade, electrical and infra-red (American Veterinary Medical Association, 2010).

Moreover, bill trimming can be defined as removal of the sharp upper and lower mandible tips of the beak, it is a widespread management practice designed to reduce the degree of damage inflicted if one bird pecks at the feathers or skin of another (Nicol, 2018). However, beak trimming also causes some welfare issues as trimming the beak results in pain and sensory loss (Riber & Hinrichsen, 2017).

Furthermore, Dennis *et al.* (2009) defined the bill trimming as a technique consists of partial amputation of the upper and lower part of the beak. It is used in commercial poultry farms, broilers matrices, ducks and turkeys (Fournier *et al.*, 2015).

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Another method used in bill trimming is the conventional hot blade debeaking, it is an invasive method, which causes stress and pain, resulting in bird suffering, thus being a reason for resistance to its use. However, it is used in most farms with the objective of improving productive performance (Dennis *et al.*, 2009).

Causes of Bill Trimming

Bill trimming is a common husbandry operation used in poultry production around the world, including the United States, to avoid feather pecking and cannibalism (United Egg Producers, 2004). Bill clipping is a common husbandry process used on laying hens, broiler breeders, turkeys, and ducks in the poultry industry. Moreover, beak cutting is used to prevent or minimize interbird pecking, aggressiveness, and cannibalism. Beak clipping, like most invasive husbandry practices, has sparked a lot of discussion and research from the standpoint of animal welfare (Farm Animal Welfare Council, 2007).

Furthermore, layers when stressed show aggressive pecking, which leads to cannibalism and consequently an increase in mortality, lower egg production and decrease in egg quality. The fact that the birds are debeaked and the type of debeaking affects the zootechnical indexes and the quality of the eggs makes the technique used to be extremely important (Mertens *et al.*, 2009; Dennis & Cheng, 2010; & Vieira- Filho *et al.*, 2016).

In the same time, birds use their beaks for a variety of functions, including hatching, feed selection and intake, as well as for defense and attack. However, in commercial production systems, some of these functionalities need to be inhibited, since it is undesirable for the bird to select feed or peck eggs and/ or other birds. Therefore, widespread beak trimming was recommended, particularly for intensive production systems (Kuenzel, 2015).

Several studies have revealed the potential harmful effects of bill trimming on health and welfare of birds Table (1).

Table 1. Examples of bill trimming effects on health and welfare of ducks

Parameter	Effect of Bill Trimming	Reference
Bill related behavior	spend more time performing passive behaviors, such as resting and standing	Duncan *et al.* (1989); & Cunningham *et al.* (1992)
Guarding behaviors	tucking the bill under the wing	Eskeland (1981); Craig & Lee, (1990); Kuo *et al.* (1991); Cunning-ham *et al.* (1992); & Gentle *et al.* (1997)
Performance	decreased body weight	Laganá *et al.* (2011); Na-Lampang (2012); Marchant-Forde & Cheng (2010); & Angevaare *et al.* (2012)
Stress markers	higher plasma corticosterone higher H/L ratio non-significant effect on glucose	Voslarova *et al.* (2013); El-Kazaz (2015); Sengul *et al.* (2015); Voslarova *et al.* (2013); & Chloupek *et al.* (2009)
Beak morphology	severe abnormalities neuromas in the beak	Kajlich *et al.* (2016) Eskeland (1981); Gentle (1986); Gentle *et al.* (1990, 1991); & Cheng (2005).

Effect of Bill Trimming on Duck Health

Stress is described as a condition in an animal that results from the action of one or more stressors that may be of either external or internal origin; whether a stressor can be considered as harmful depends on the way an organism was able to cope with a threatening situation as it regained homeostasis. Furthermore, it could be classified into mental, physical or mixed (Von Borell, 2001).

The inflammatory process and the stress that is generated after the bill trimming start physiological changes, among which there is an increase in the secretion of corticosterone, this hormone secreted under stress and in cases of occurrence of pain and inflammation (Cheng & Muir, 2007). It is also involved in the process of maintenance of organic homoeostasis, bringing behavior changes and alterations to the metabolism of carbohydrates, proteins, and lipids (Davis *et al.*, 2004).

In the same time, visible wounds and necrotic beak tissue were still visible 2 to 3 weeks after hot blade bill trimming, with upper mandibles healing more quickly than lower ones, according to a visual assessment of wound-healing rates (Marchant- Forde *et al.*, 2008).

Moreover, the nature and level of tissue damage sustained are strongly related to the amount of pain experienced by an organism following tissue trauma. The beak of a duck is a sophisticated, functioning, and well-innervated organ with numerous sensitive mechanoreceptors, thermoreceptors, and nociceptors (Cheng *et al.*, 2005; & Gustafson *et al.*, 2007c). Multiple parameters, including the proportion of the beak tissue removed, determine the relative effect of beak trimming on bird well-being (Cheng, 2005).

During beak trimming, the branches of the trigeminal nerve that innervates the beak are damaged.

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Neuromas develop at the tip of the beak as part of the normal healing process, and later regress. When severe beak-trimming methods are employed, neuromas with sensory corpuscles and nociceptors may persist and exhibit ectopic activity and spontaneous discharges that cause pain (Crespo & Shivaprasad, 2003).

Effect of Bill Trimming on Duck Behavior

Beak trimming results in reductions in growth rate and substantial changes in bird behavior including reduced feed intake, time spent pecking, pecking force and activity (Janczak & Riber, 2015). Moreover, Nicol *et al.* (2013) discovered that non-trimmed birds engaged in much more aggressive pecking and exploratory activity than trimmed birds. In comparison to undamaged birds, bill-trimmed birds demonstrated fewer pecking, threatening, and avoidance behaviors (Nicol *et al.*, 2013). Beak trimming is also associated with improved plumage condition in adult birds (Nicol, 2018).

Elshafaei *et al.* (2017) revealed that bill trimming by scissor efficiently reduced aggressive pecking behavior without affecting welfare and production performance. Meanwhile, trimming by hot blade efficiently reduced aggressive pecking without affecting welfare but significantly reduced body weight. In the same time, beak trimming reduced activities such as feeding and drinking (Marchant-Forde *et al.*, 2008; & Dennis & Cheng, 2010).

In the same time, Gustafson *et al.* (2007a and b) found that bill trimming with a hot blade, scissor, or hot searing reduced ingestive behavior in the first week after trimming, the difference faded one week later. Different ways of bill trimming had no effect on the behavior of floor pecking. Also, trim ducks spent significantly less time engaging in bill-related behaviors (preening, feeding, drinking, and exploratory pecking) and more time resting than non-trim ducks. These differences disappeared by 1 week post-trim. There was evidence of feather pecking in the trim pens, but feather pecking and skin damage were more extensive in the non-trim pens.

Furthermore, on days 3 post trim, there was a significant difference between treatments in bill-related and resting behaviors, with trim birds resting more and performing fewer bill-related behaviors. However, by 6 days post trim, there were no significant differences in behavior between treatments. The performance of bill-related behaviors increased significantly with time in the trim birds while resting decreased significantly with time in the trim birds. No other behavior categories changed significantly over time. The difference in change over time between non-trim and trim birds was significant for bill-related behaviors and resting (Gustafson *et al.*, 2007a and b).

Also, according to Araujo (1997), bill trimming lowered feeding time and frequency, as well as drinking frequency in bill trimmed pullets, when compared to non-trimmed ones. On the other hand, Glatz (2005) found that cutting the beaks of layers at the age of 18 weeks enhanced their productivity and physical condition. Moreover, Gentle & Mckeegan (2007) found non-significant effect of bill trimming on ingestive behavior of broiler chickens immediately after bill trimming and even after 6 weeks. The practice of beak trimming in poultry caused discomfort and tension, particularly when done aggressively, and this has an impact on feed consumption in the days after the beak trimming, particularly due to heightened sensitivity resulting from the wound that is made by the process (Gentle, 2011).

Previous studies showed that bird behaviors were significantly affected for a short time by bill trimming, and bill trimming resulted in a reduction in feeding, preening, and other bill-related activities of layer chicks (Marchant-Forde *et al.*, 2008). However, there was no long-term effect of bill trimming on laying hens behaviors (Schwean-Lardner *et al.*, 2016).

EFFECT OF BILL TRIMMING ON DUCK PERFORMANCE

Effect of Bill Trimming Stress on Body Weight and Body Weight Gain of Ducks

Decreased poultry performance is generally considered a sensitive indication of stress. Significant stressors, including stress associated with bill trimming either on the day of hatching or at older ages, are well known to decrease the growth rate in broiler breeders (Henderson *et al.*, 2009).

Moreover, Laganá *et al.* (2011); & Na-Lampang (2012) found that bill trimmed bird by hot blade had significant decreased body weight compared to controls. In contrast, Guesdon *et al.* (2006) found that hot blade bill trimming method enhanced body weight gain of laying hens compared to control birds. On the other hand, Sengul *et al.* (2015) reported that live weights, carcass weights, and carcass percentage of large white turkeys unaffected by beak trimming. Beak trimming may impair early body weight of birds (Marchant-Forde & Cheng, 2010; & Angevaare *et al.*, 2012).

Furthermore, Gustafson *et al.* (2007a) found that mean body weight differed over weeks between non trim and trim ducks. Post hoc tests attributed that trim ducks being lighter than non-trim ducks when weighed at the end of the week in which they were trimmed, however, there were no significant treatment differences in weight during other weeks. Similarly, the non-trim and trim ducks also differed in weight gain. The trim ducks showed a lower weight gain than non-trim ducks during the week in which they were

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trimmed. The difference in weight gain between the treatments in the first week post-trim was significant; however, there were no significant weight gain differences between treatments during other weeks (Gustafson *et al.*, 2007a).

Also, previous studies have reported that birds had lower body weight after bill trimming (Gentle & McKeegan, 2007; & Schwean-Lardner *et al.*, 2016) and this decrease in body weight can persist for a short time or several weeks, even to several months, depending on the age at trimming, the severity of trimming, feed form, and individual characteristics (Davis *et al.*, 2004; Marchant-Forde *et al.*, 2008; & Onbaşılar *et al.*, 2009).

Effect of Bill Trimming on Feed Intake and Feed Conversion Ratio of Ducks

Previous study stated that feed consumption and feed conversion ratio of birds with untrimmed beaks were significantly higher than beak-trimmed birds (Honaker & Ruszler, 2004; Marchant-Forde *et al.*, 2008; & Marchant-Forde & Cheng, 2010).

Also, feed intake and growth are significant indices used in the literature to assess the impact of various stresses on bird well-being including beak clipping. The most common finding after bill trimming is that moderate trimming reduced feed intake and subsequent growth of Single Comb White Leghorn hens (Davis *et al.*, 2004). Moreover, Marchant-Forde *et al.* (2008) reported that feed intake was also reduced for 3 to 4 weeks in layer chicks trimmed at 1 day of hatch compared to non-trimmed birds.

Moreover, changes in feed intake after bill trimming in poultry, regardless of the trimming method or bird age, have been linked to an increase in the presence of pain and discomfort produced by tissue, neuron, and or sensory receptor injury (Cheng, 2005).

In general, changes in feed intake after bill trimming, independently of the method applied or bird age at the time of beak trimming, indicate lack of motivation to search for food as a result of the pain or discomfort caused by the tissue damage and nerve injury, as well as to the mechanical difficulty to apprehend feed pellets due anatomical changes in the beak shape and loss of sensation (Marchant-Forde & Cheng, 2010).

Effect of Bill Trimming on Duck Mortality

The birds can support the bill-trimming by using effective procedures and adequately performed techniques. There was not a single duckling that died because of the trial in a study performed by Martin & Beaugrand (2014). Also, there is clear evidence that bill trimming can reduce laying hens mortality in both cage and non-cage systems (Weeks *et al.*, 2016).

Moreover, Laganá *et al.* (2011) found that Japanese quails submitted to debeaking compared to non-debeaked birds showed a decrease in mortality rate. A meta-analysis of mortality data from 801 beak-trimmed and 228 intact-beak flocks of laying hens housed between 2006 and 2012 showed significantly (but not dramatically) lower mortality in beak-trimmed versus intact flocks at 40 weeks (Weeks *et al.*, 2016). This model accounted for factors such as bird age, breed, flock size, and housing system are the best estimate to date of the effectiveness of bill trimming as a management practice (Nicol, 2018).

Effect of bill trimming on carcass traits, organ weight and meat quality of ducks

Li *et al.* (2020) found that carcass trait and some indices of meat quality and organ percentages of broiler breeders were not impacted by beak trimming. He found that, there was no difference in carcass traits among the trimmed and non-trimmed birds and there was no difference in the liver, gizzard, and proventriculus percentages among the trimmed and non-trimmed birds.

Moreover, Sengul *et al.* (2015) found that bill trimming had no significant effect on live weights, carcass weights, carcass percentage, the carcass components (breast, thigh, ridge, wing and neck) and their percentages in whole carcass, liver, gizzard and abdominal fat weights of large white turkeys. However, some characteristics such as carcass percentage, ridge, breast, liver and gizzard, live weight, carcass weight, parts of carcass percentage, edible yields and abdominal were significantly affected. Furthermore, no significant changes were observed in the relative weight of all digestive organs evaluated in layer pullets exposed to bill trimming, this indicates that laser bill trimming does not increase feed intake, and therefore, does not compromise digestive organ development of layer pullets (Petrolli *et al.*, 2017).

Also, Marchant-Forde *et al.* (2008) found no significant differences in relative weights of liver, heart, spleen, or adrenal gland between trimmed and non-trimmed laying chicks. In the same time, Onbaşılar *et al.* (2009) found that liver and spleen percentages of laying hens were not influenced by bill trimming age.

Effect of Bill Trimming on Blood Stress Indicator in Ducks

Effect of Bill Trimming on Hetrophile Lymphocyte Ratio

Heterophils are part of natural and cellular defense against any microbial infections, and lymphocytes are types of leucocyte that interfere with the development of antibodies and cell immunity to produce a particular immune response (Wigley, 2013). Any increase in heterophil/lymphocyte ratio (H/L ratio) would lead to an elevated secretion of corticosterone,

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leading to reduced antibody titer and suppression of immunity (Rouhalamini & Salarmoini, 2014).

The heterophil-to-lymphocyte (H/L) ratio has proved to be a valuable measurement in stress-related research in birds (Post *et al.,* 2003). Increases in heterophil to lymphocyte ratios caused by heteropilia have been reported to be an indicator of chronic stress (Davis *et al.,* 2000). Also, El-Kazaz (2015) found that the hetrophile lymphocyte ratio in bill-trimmed quails was considerably greater than in non-trimmed birds.

However, Elshafaei *et al.* (2017) revealed non-significant differences among different methods of bill trimming than non-trimmed Muscovy ducklings in hetrophile lymphocyte ratio. As non-trimmed pheasants were handled similar to ones exposed to bill trimming, Voslarova *et al.* (2013) did not find any change in H/L ratio. These results agreed with Dennis *et al.* (2009) who found non-significant differences in hetrophile lymphocyte ratio between trimmed and non-trimmed laying hens.

Effect of Bill Trimming on Corticosterone Level

Stressors activate the sympathetic adrenomedullary (SAM) and hypothalamic-pituitary-adrenal (HPA) axes (Osti *et al.,* 2017). Integration of the hypothalamic-pituitary-adrenal system stimulates the hypothalamus to produce corticotrophin releasing factor, which causes the pituitary gland to release adrenocorticotropic hormone (ACTH) (Jones & Henderson, 2013). The presence of ACTH in the bloodstream stimulates the adrenals to secrete corticosterone (Mohammed *et al.,* 2021).

The inflammatory process and stress that occurs as a result of bill trimming cause physiological changes, including an increase in corticosterone release, a hormone that is secreted during stress and in cases of pain and inflammation (Cheng & Muir, 2007).

Moreover, Voslarova *et al.* (2013) reported that, bill-trimmed pheasants exhibited higher plasma corticosterone concentrations in comparison with non-trimmed birds. Increased corticosterone levels in the blood have a deleterious impact on food intake and the release of peptides involved in eating (Liu *et al.,* 2012). These responses to trimming can be partially mitigated by the administration of known or putative analgesics (Janczak & Riber, 2015). Analgesic drugs cannot be used outside the laboratory context to manage bird pain in commercial settings, but these laboratory procedures provide important support for the inference that the changes seen in response to bill trimming are indicative of pain (Nicol, 2018).

Effect of Bill Trimming on Glucose Level

Virden *et al.* (2009) explained that stress stimulates the neurogenic system, so the hypothalamus releases corticotrophin releasing factor (CRF), which in turn stimulates the anterior pituitary to produce adrenocorticotropic hormone (ACTH). Adrenocorticotropic hormone secretion makes adrenal cortex tissue cells to proliferate and secrete glucocorticoid hormones that play an important role in accelerating gluconeogenesis, the process of forming new sugars from non-glycogen compounds. Glucocorticoids hydrolyze proteins (gluconeogenesis) and convert them to amino acids or fats, which are then transported to the liver. In the liver, amino acids or fatty acids are converted into glucose, which increases blood glucose levels (Lalonde *et al.,* 2021).

According to Hazelwood (2000), glucose is the main carbohydrate metabolite that is used as an energy source by most of the body's cells for various physiological and biochemical processes. It is maintained in a constant level through gluco-regulation mechanisms that are regulated by several metabolic hormones such as insulin, glucagon, pancreatic polypeptide, corticosterone, and thyroxin. According to Fayed *et al.* (2012), glucose level is one of the main physiological markers that may be utilized to assess the health and welfare of birds.

Sengul *et al.* (2015) reported that, plasma triglyceride and glucose levels in large white turkeys were all unaffected by bill trimming. Also, Voslarova *et al.* (2013) found no significant changes in plasma glucose concentrations between trimmed and non-trimmed pheasants. Furthermore, Chloupek *et al.* (2009) found no changes in glucose concentrations between trimmed and non-trimmed pheasants.

Effect of Bill Trimming on Beak Morphology

Beak treatment alters beak shape, either intentionally through treatment protocol or unintentionally through tissue regrowth (Marchant-Forde *et al.,* 2008). Altered beak morphologies such as shovel beaks (bottom beak longer than top) as well as beaks with a crack (visible crack on the top and/or bottom beak) or bubble (blister-like formation under the tissue of the beak tip) are significantly less common in infrared bill trimmed white leghorn hens as compared with hot blade bill trimming ones (Carruthers *et al.,* 2012). Beaks that have any detectable difference between the top and bottom have been classified as “severe abnormalities” and may be a welfare concern (Kajlich *et al.,* 2016).

Moreover, beak shape may has important implications for laying hens’ production and welfare as it has been suggested that elongation of the bottom beak relative to the top beak (shovel beak) may alter the bird's ability to pick up feed particles (Struthers *et al.,* 2020). Also, Prescott & Bonser (2004) reported that hens with shovel beaks had reduced feeding ability, meaning they were less successful at grasping and ingesting pellets when they were presented as a thin, single layer. In the same time, Glatz (2003) found that

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laying hens with short upper beaks resulting from hot blade beak trimming had lower feed intake over a 7 week period, but there were no differences in the consumption of different feed particle sizes between birds with long and short upper beaks, suggesting that beak shape does not impact the birds ability to consume different sizes of feed particles.

More recently, Struthers *et al.* (2019) studied the effect of beak shape on the productivity of infrared beak–treated laying hens and found no differences in feed intake during rearing between birds with a shovel beak compared with birds with untreated beaks. However, McKeegan & Philbey (2012) found no evidence of neuroma formation or abnormal nerve growth up to 50 week post-infra-red bill trimming in laying hens suggesting that infra-red bill trimming did not result in chronic pain.

Moreover, an average length of 0.51 cm, or 21.1% of the total bill length from nares to tip, was removed from the upper bill of the trim ducks at 3 weeks old. By 6 weeks post-trim the upper bill was only 11.9% shorter than the lower bill. At this age the healed bill stump had a smooth surface and was covered by epithelium. Visual inspection showed no signs of tumors or other external abnormalities in trim bills (Gustafson *et al.*, 2007c).

The results of the microscopic analysis of the bills showed that non trim bill sections contained many more nerve fibers than did the trim bills. Within the portion of the bill stump nearest the wound site of trim, the layer of connective tissue became much wider and had an irregular orientation, which is characteristic of scar tissue. The trim bill sections were also completely lacking blood vessels, which were numerous in the non-trim bill sections. Since there was very little nerve regrowth into the bill stump, there was no evidence of neuroma formation (Gustafson *et al.*, 2007c).

Cannibalism has recently become a serious issue to the poultry production especially ducks in most duck producing countries. Cannibalism can impair production performance, welfare, physiology and immunology of ducks. Bill trimming seems to be useful in ameliorating the destructive effects of cannibalism on feathers and skin caused by injurious pecking in ducks, however, it also causes some welfare issues as trimming the beak results in pain and sensory loss. Finally, it is important to mention that intervention strategies to deal with cannibalism in ducks have been the focus of many published studies, which apply different approaches, including environmental management (such as facilities design, lighting, etc.), nutritional manipulation (i.e., diet formulation according to the metabolic condition of the birds), as well as dietary supplementation of feed additives in the diet (e.g., prebiotics, synbiotics, probiotics, vitamins, minerals, etc.). Nevertheless, effectiveness of most of the interventions has been variable or inconsistent. More recently, innovative approaches have been explored, including genetic selection of breeds with reduced aggression. However, these potential opportunities, although promising (particularly, for duck industry), still need further research and study.

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