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# Effects of environmental enrichment and lack of beak trimming on aspects of health, behaviour and production of commercial turkeys

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## Abstract

*Aim of study*: The purpose of this study was to verify whether the insertion of a pecking object as an environmental enrichment (EE) would be sufficient to prevent the beak trimming (BT) process in turkeys.

*Area of study*: Southern Brazil.

*Material and methods*: A total of 3,116 female turkeys of the Nicholas Super Select line were equally distributed across four treatments in a 2 × 2 factorial scheme with the presence or absence of EE and BT or intact beak. The turkeys were housed at a density of 21 kg/m$^2$ and were followed-up for 62 days until slaughter. Each week, the behaviour of the turkeys, body lesions, and performance indicators such as mortality, feed conversion, feed consumption, and weight were evaluated.

*Main results*: The results regarding injuries and performance showed, in most cases, better results for beak trimmed animals ($p>0.05$). The addition of EE was not effective in reducing the number of injuries in either debeaked or non-debeaked turkeys ($p>0.05$). Injurious pecking of turkeys may result from vigorous investigative pecking.

*Research highlights*: We can conclude that debeaking decreases the number of aggressive injuries in animals, and further research needs to be conducted to search for a possible alternative to EE to avoid BT, reduce injuries, and enhance performance.

**Keywords:** animal welfare; behaviour; injurious pecking; negative interaction; pecking objects.

# Efectos del enriquecimiento ambiental y la falta de recorte del pico en aspectos de salud, comportamiento y producción de pavos comerciales

## Resumen

*Objetivo del estudio*: El propósito de este estudio fue verificar si la inserción de un objeto para picoteo como enriquecimiento ambiental (EA) sería suficiente para prevenir el proceso de recorte del pico (RP) en pavos.

*Área de estudio*: Sur de Brasil.

*Material y métodos:* Un total de 3,116 pavos hembras de la línea Nicholas Super Select fueron distribuidos de manera equitativa en cuatro tratamientos en un esquema factorial 2 × 2, con presencia o ausencia de EA y RP o pico intacto. Los pavos fueron alojados a una densidad de 21 kg/m² y se les realizó un seguimiento durante 62 días hasta el sacrificio. Cada semana se evaluaron el comportamiento de los pavos, las lesiones corporales y los indicadores de rendimiento, como mortalidad, conversión alimenticia, consumo de alimento y peso.

*Resultados principales:* Los resultados sobre lesiones y rendimiento mostraron, en la mayoría de los casos, mejores resultados para los animales con pico recortado ($p>0.05$). La adición de EA no fue efectiva para reducir el número de lesiones en pavos con o sin recorte de pico ($p>0.05$). El picoteo lesionante en pavos puede resultar de un picoteo investigativo vigoroso.

*Aspectos destacados de la investigación:* Podemos concluir que el recorte de pico disminuye el número de lesiones agresivas en los animales, y se necesita realizar más investigaciones para buscar una posible alternativa al EA que evite

el RP, reduzca las lesiones y mejore el rendimiento.

**Palabras clave:** Bienestar animal; comportamiento; picoteo lesionante; interacción negativa; objetos para picoteo.

The translation of the title, abstract, and keywords from the original version in English to Spanish has been generated using OpenAI, ChatGPT GPT-4o mini (2024).

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# Introduction

Scientific literature on the welfare of intensively reared turkeys is scarce compared to other poultry species, despite the growing relevance of turkey production in livestock farming (Erasmus, 2018). Painful procedures are routinely employed in the production of commercial turkeys, such as beak trimming (BT) or debeaking, which can reduce animal welfare (Glatz, 2000). Beak trimming involves reducing the size of the bird's beak to prevent feather-pecking, and eventually cannibalism and food selection (Bastos-Leite et al., 2016).

Activities related to pecking, such as preening, drinking, feeding, foraging, and pecking members of the same species or environment, constitute a large part of the behavioural repertoire of domestic turkeys (Sandilands & Savory, 2008; Dalton et al., 2018). Wild turkeys dedicate 89% of the day to foraging and usually move approximately three kilometers per day, depending on habitat and distance from food and water sources, and communicate through vocalizations, meaning that each sound can be used in different situations (Chamberlain et al., 2020). Hughes and Grigor (1996) reported that female turkeys from 1 to 12 weeks of age spent an average of 6% of their total daily activity time pecking at the plumage and skin of their peers.

When not in wildlife, turkeys change this positive behaviour to agonistic interactions (injurious pecking) with conspecifics, frequently causing serious injuries (Bartels et al., 2020). Debeaking is highly effective in preventing feather pecking and cannibalism and reducing the number of pecked eggs and mortality, but from an animal welfare point of view, this practice is considered an amputation (Laganá et al., 2011; Icken et al., 2017).

Two major welfare issues arise from BT: loss of sensory input due to removal by heat treatment of sensory receptors in the beak, and the potential for acute and chronic pain from severing or heat treatment of nerves (Glatz & Underwood, 2020). The main impact of beak trimming is how the bird uses its beak when it eats, drinks, and pecks in other birds and the environment (Leighton et al., 1985; Grigor et al., 1995; Noble et al., 1997). In this context, there is a need for alternatives to reduce or eliminate painful practices in commercial poultry farming.

Newberry (1995) defined environmental enrichment (EE) as a modification of the environment of captive animals, thereby increasing behavioural possibilities and leading to improvements in biological function. This means that EE is provided with the purpose of 1) increasing the occurrence and range of an animal's normal or species-specific behaviour, 2) preventing the development of abnormal behaviour or reducing its extent and complexity, 3) increasing the positive exploitation of the environment (e.g., the use of an outdoor area), and 4) increasing the animal's ability to handle behavioural and physiological challenges. EE is a possible solution to address the negative impacts of intensive housing and improve animal welfare (Berk et al., 2018; Dennis et al., 2024).

Due to the lack of pecking substrates, animals may redirect their pecking behaviour towards other birds. Injurious pecking is very common in fast-growing strains, especially in turkey broilers, and is a serious cause of poor animal welfare (Martrenchar et al., 2001).

Pecking feathers, along with aggressive encounters, is a major welfare and management concern in intensive turkey farming (Marchewka et al., 2013). Pecking directed at another turkey can be classified as feather pecking or aggressive/injurious pecking (Dalton et al., 2018). Feather pecking is the repeated and forceful pecking, pulling of feathers and/or skin of another turkey, with or without feather removal, which often results in damage to the recipient's plumage and tissues (Savory, 1995; Duggan et al., 2014) and can vary according to severity. Gentle feather pecking is defined as the social and investigative cleaning of another turkey, usually directed at debris in plumage, performed without force and does not harm pecked turkeys (Savory, 1995; Duggan et al., 2014). In contrast, pecking of the head and injurious feather pecking are classified as aggressive pecking, as these behaviours can cause tissue damage and mortality, resulting in a decline in productivity and welfare (Dalton et al., 2013; Duggan et al., 2014).

Injurious pecking is a hostile act that targets the head, neck, and snoods of another turkey (Dalton et al., 2018). The underlying motivation for feather pecking in domestic turkeys is believed to represent redirected ground pecking behaviour under environmentally unstimulated conditions (Dalton et al., 2018). Several studies have shown that the provision of foraging substrates and objects can successfully reduce the damage caused by pecking in groups of domestic turkeys (Crowe & Forbes, 1999; Sherwin et al., 1999a, Sherwin et al., 1999b; Martrenchar et al., 2001).

One hypothesis raised as to why non-aggressive pecking becomes aggressive may be related to incompatibility between the behavioural needs of growing turkeys and the characteristics of the environment (Dalton et al., 2013). It is believed that foraging behaviour on the ground is redirected towards aggressive pecking, but the development and causes are poorly understood and have little supportive literature (Dalton et al., 2013).

Physical restriction and a lack of structural elements in the environment generally do not allow full expression of the behavioural repertoire presented in natural conditions. Whether the expression of the complete behavioural inventory is essential for turkey welfare is still debated among scientists (Bessei et al., 2022).

Research suggests that outbreaks of injurious pecking can be primarily attributed to a lack of suitable environmental features in commercial settings, which hinders the performance of a turkey's normal behavioural repertoire (Dalton et al., 2013). The use of environmental enrichment is one of the alternatives cited by various studies to reduce the occurrence of aggressive pecking behaviours, as this behaviour can be redirected towards objects. Therefore, it can also be used as an alternative for maintaining the beaks of intact turkeys.

Glatz & Underwood (2020) stated that beak trimming should not be used without providing birds with an enriched indoor and outdoor environment. While previous research has provided some insights into the effectiveness of environmental enrichment in reducing injurious pecking in turkeys, one question remains: what are the effects of environmental enrichment on behaviour and performance?

This study aimed to evaluate the use of EE to ensure the welfare of non-debeaked turkeys in commercial systems and whether this affects turkey behaviour. We evaluated performance indicators, such as mortality, weight gain, feed conversion, and percentage of culled animals, and health indicators, such as body lesions, and assessed the behaviour of turkeys.

# Material and methods

## Animals, facilities and management

Turkeys used in this study were handled following the guidelines defined by the 'Guide for Care and Use of Agricultural Animals in Research and Teaching' (FASS, 2020). This study was approved by the Ethics Committee on Animal Use of the School of Animal Science and Food Engineering at the University of São Paulo (approval number: 2669030122).

The experiment was conducted at an experimental farm in southern Brazil latitude S: 27°09'57.00 °and longitude W: 52°37'11.00 °during the autumn of 2022.

The turkeys were housed in a conventional house with 2.5 mm mesh screens, white curtains, and positive pressure, allowing the turkeys to receive natural lighting. Internally, the facility was divided into 76 boxes of 7.6 m² each. The initial stocking density was 5.4 birds/m².

Each pen was supplied with a hanging feeder (Agromarau, Brazil, developed for poultry) and two bell drinkers (Plasson, Brazil, developed for turkeys), providing standard commercial feed and water ad libitum with no difference between treatments and a maximum final stock density of 21 kg/m² at the time of slaughter. The turkeys received four types of feed throughout their lives according to their age and nutritional needs.

All turkeys had access to wood shavings, which provided them with the opportunity to peck and dust bath, and it was kept dry and fluffy throughout the entire research period.

Shortly after hatching at a commercial hatchery, the turkeys were separated by sex, and half of them underwent a beak treatment. Beak trimming (BT) was performed using Nova Tech® infrared laser equipment, removing one-third of the upper beak.

The total number of animals used in the experiment were transported to the farm on the first day of life and randomly distributed among the boxes, following the experimental design. A total of 3,116 female turkeys from the Nicholas Super Select (SS) lineage were housed and divided into a factorial 2 × 2 design with 19 replications in each combination, totaling 779 turkeys per treatment.

The flock remained housed in the boxes until they reached an average slaughter weight of approximately 5 kg/bird at 62 days of age, after which they were slaughtered.

## Study design

The experimental design was completely randomized with a factorial 2 × 2, and the distribution pattern of treatments consisted of debeak or non-debeaked turkeys combined with the presence or absence of EE (PET refillable/reusable bottle). The most common management used in turkey farming in Brazil is beak trimming without EE, and the desired one from an animal welfare perspective is non-debeaked animals with EE (without physical alteration and with an enriched environment).

Half of the turkeys had access to an enriched environment during the experimental period. Refillable/reusable plastic bottles (PET) were considered pecking objects and contained approximately 500 ml of water with blue food-grade dye. They were hung inside each pen in the central area, allowing all turkeys access to the enrichment. In cases of leakage, falling, or puncture, enrichment was replenished. The object was maintained at the eye level of the turkeys and adjusted

as the animals grew, so that the height remained suitable to keep the turkeys interested in the object.

The choice to use simple EE, such as reusable plastic bottles (PET), even though its effectiveness may be limited, was driven by the need for EE to be accepted by farmers in intensive production. This is because it is a readily available material, posing no danger to animal health or a potential entry point for sanitary issues. It is easily replaceable in the case of breakage and does not increase the labour of the producer because it only requires regular height adjustment. Crowe and Forbes (1999) compared different types of environmental enrichment and concluded that perches and objects were more effective than straw and forage (grain scattered on the litter) in reducing the proportion of birds pecked, corroborating that this type of object could be effective as an EE.

## Performance

Weekly weighing of all animals was performed to monitor weight gain and to determine the average weight of the turkeys. Weighing began on the seventh day of housing and was repeated weekly until the end of the experiment. The overall data of the flock were considered for the performance calculations.

Feed conversion was measured weekly by using the ratio of feed consumption to weight gain. The weekly feed intake was obtained by dividing the total amount of feed offered and subtracting the number of leftovers for the evaluation days and the number of animals.

Bird mortality was monitored daily, recorded on spreadsheets, and compiled weekly at the same ages when the turkeys were weighed. The need to euthanize injured animals was also analysed daily, and in cases where elimination was necessary, it was carried out by trained personnel, with the compilation performed weekly on the same dates as the previous parameters.

At 39 days of age, flock equalization was performed, meaning that the number of turkeys was standardized in all boxes to maintain a constant number of feeders and drinkers among the boxes. Surplus animals were randomly allocated to border areas.

The average weight of the flocks was determined by calculating the total weight of the turkeys in each treatment and dividing it by the number of animals allocated to each treatment. No health issues were observed in the flock; consequently, there was no need to medicate the turkeys. To reduce experimental errors, all the measurements were performed by the same team.

## Behaviour

Behavioural observations were conducted weekly in all boxes, starting when the turkeys were 6 days old and repeated when the birds were 12, 20, 26, 33, 40, 47, 54, and 61 days old, during nine weeks.

For each observation day, a scanning session was performed in a random order among the pens. The trained observer remained 1.5 m from the animals to minimize disturbance in the box and ensure that all turkeys could be seen. In each pen, the turkeys were settled for 90 s before starting observations. Initially, the pecking object was assessed by counting the number of turkeys interacting with enrichment. Subsequently, the number of turkeys performing each of the behaviours (Table 1) was counted using scan sampling with a 3-minute interval between each box. The total behaviour in each box must be the number of turkeys. During each observation period of 4 h, each box was evaluated once, considering one treatment replication, totalling 19 replications per treatment per day

**Table 1**. Description of behavioural categories recorded.

| Behaviour | Description |
|---|---|
| Drinking | The turkey is pecking and/or drinking at drinker. |
| Eating | The turkey is pecking and/or eating at feeders. |
| Resting | The turkey is resting on its breast on the ground. |
| Dust Bathing | The turkey is in the lie down position while flicking litter up into its feathers using its wings. |
| Exploring | The turkey pecks at litter with beak and/or scratches at litter with feet, walking or not. |
| Interacting with Environmental Enrichment | The turkey directs its beak at objects within the barn plastic bottle. |
| Injurious Pecking | The turkey directs its beak towards another turkey's feathers/skin while visibly pulling on the feathers and/or skin with its beak. . |
| Gentle Pecking | The turkey directs its beak towards another turkey's feathers while opening and closing its beak on the feathers without any pulling motion. |

(Adapted from Dalton et al., 2018).

of observation. Behaviour was evaluated once per age, starting at 8:00 a.m. each week.

### Injuries

Every day, an observer entered the pen and carefully examined all the birds by walking slowly around the pen. The skin lesions recorded daily were totalled by week and pen at the time of weighing. Each bird was assessed by a qualified person and the number and location of the injuries were documented. The injuries considered were wounds resulting from aggressive feather pecking, observed as plumage damage, loss of feathers, and open injuries with or without blood (Nikolov & Kanakov, 2022). The body areas evaluated were snood, neck, head, tail, and wing. Severely injured turkeys were removed from the pen and treated if recovery was possible. If there was no chance of recovery, the bird was culled and a record of the cull was recorded.

### Lesions in the carcasses

At 62 days of age, the animals were caught by a specialized team in loading turkeys and transported to separate crates by treatment in a dedicated vehicle for turkey transportation.

There is a training program regarding the welfare responsibilities of the turkeys for employees in charge of catching, transporting, and pre-slaughter handling. The catching team has a leader to monitor the process to avoid any occurrences related to improper handling of animals.

Turkeys with health problems, fractures, or injuries that compromised their welfare were excluded. Before transportation, all turkeys received water until loading began, and fasting at the farm was for six hours before loading. The turkeys were caught on their backs, two at a time.

To verify peck injuries, the turkeys were slaughtered and observed on-site at a factory located in southern Brazil. The treatments were slaughtered separately with a three-minute interval between them to maintain traceability and prevent mixing between treatments.

The conscious turkeys were hung by their legs on moving metal hooks connected to a rotating shackle, which transported the turkeys to a stunning tank containing electrified water.

After stunning, the turkeys were subjected to manual bleeding, scalding, and plucking. The carcass quality in turkey was analysed through visual inspection at the exit of the plucking tunnel. At this point, the presence of pecking injuries in turkeys was also examined.

### Statistical analysis

The design was a completely randomized factorial model, including the effects of environmental enrichment (presence or absence/without EE), beak trimming (BT or non-BT), their interaction, and time as repeated measures through the growing period, and pen as a random effect. Each pen was considered as a replicate.

Data were tested for normality using the Kolmogorov–Smirnov test. The performance data showed a normal distribution, and no transformation was needed. Mean comparisons were performed using the Tukey-Kramer test at a significance level of 5%.

For behaviour analysis (daily behaviour, injuries), the assumptions of normality, homoscedasticity, and sphericity were checked ($p>0.05$). Data were arcsine square root transformed to achieve normality ($p<0.05$). We then returned to the real values to present the results. The daily studied behaviour was expressed as the percentage of animals engaged in the activity at the evaluated moment. Injuries were expressed as the average value per week per replication (n=19). Head lesions were detected only once during the experiment and were not considered in the statistics. Mean comparisons were performed using the Tukey-Kramer test at a significance level of 5%.

For carcass injuries, a descriptive analysis was done, and results are expressed as percentage of the total number of carcasses which presented any lesion. The statistical analysis of this study were conducted using SAS software, Version 9.4 (2022). All data are presented as mean ± Standard Error of the mean (SEM).

## Results

### Performance

No effect of debeaking × EE interaction on performance variables, average final weight, percentage of mortality, and culled animals was observed in the female turkeys studied ($p>0.05$; Table 2), but an effect was found for feed conversion ratio and feed consumption ($p<0.05$).

When not debeaked, turkeys presented better FCR when they had access to EE ($p<0.05$), which was explained by less consumption ($p<0.05$). However, debeaked turkeys had a better FCR when they had access to EE ($p<0.05$). When EE was not offered, the FCR was similar between BT and non-BT animals ($p>0.05$) (Table 2).

Analysing isolated factors, for feed consumption, non-debeaked birds consumed more than the debeaked ones ($p<0.05$; 380.17±1.964 kg, 374.36±1.964 kg, respectively). No other effects were observed ($p>0.05$). Although no significant effects were observed on mortality and culling, the main causes of culling were lesions from injurious pecking, heart failure, and other causes.

### Behaviour

An interaction of debeaking × EE was not observed in turkeys' behaviour ($p>0.05$). Debeaking had an effect on gentle pecking and injurious pecking ($p<0.05$; Table 3).

**Table 2**. Performance indicators for turkeys under different environmental enrichment (EE) and debeaking treatments.

| Parameter | Non-debeaked | Debeaked |
|---|---|---|
| Average Final Weight (kg) | | |
| Without EE | 5.01± 0.022 | 4.982± 0.015 |
| With EE | 5.02± 0.024 | 5.00± 0.017 |
| Feed Conversion Ratio (kg/kg) | | |
| Without EE | $1.744^{aA}$± 0.004 | $1.725^{a}$± 0.001 |
| With EE | $1.734^{aB}$± 0.008 | $1.720^{b}$± 0.003 |
| Total Consumption (kg) | | |
| Without EE | $342.68^{aA}$± 18.50 | $336.79^{aA}$± 18.01 |
| With EE | $341.61^{aB}$± 18.49 | $337.04^{aA}$± 18.05 |
| Mortality Rate (%) | | |
| Without EE | 1.61± 0.019 | 1.61± 0.022 |
| With EE | 1.88± 0.026 | 1.21± 0.019 |
| Culled Rate (%) | | |
| Without EE | 1.88± 0.029 | 2.02± 0.027 |
| With EE | 1.75± 0.012 | 2.02± 0.029 |

Means with small letters in the row (Non-debeaked x debeaked) and capital letters in the column (With EE x Without EE) differ significantly ($p<0.05$)

**Table 3**. Frequency of events per week of behaviour in turkeys according to different environmental enrichment (EE) and debeaking treatments.

| Parameter | Non-debeaked | Debeaked |
|---|---|---|
| Exploratory/Walking | | |
| Without EE | 17.41±0.62 | 15.85±0.58 |
| With EE | 17.28±0.74 | 16.43±0.55 |
| Resting | | |
| Without EE | 17.47± 0.66 | 18.29±0.65 |
| With EE | 18.40±0.64 | 18.88±060 |
| Dust Bathing | | |
| Without EE | 0.20±0.045 | 0.14±0.04 |
| With EE | 0.21±0.06 | 0.19±0.04 |
| Eating | | |
| Without EE | 3.86±0.27 | 4.15±0.27 |
| With EE | 3.61±0.23 | 3.97±0.25 |
| Gentle Pecking | | |
| Without EE | $2.35^{a}$±0.13 | $1.82^{b}$±0.13 |
| With EE | $2.35^{a}$±0.16 | $1.73^{b}$±0.11 |
| Injurious Pecking | | |
| Without EE | $0.42^{a}$±0.15 | $0.18^{a}$±0.05 |
| With EE | $0.27^{a}$±0.05 | $0.07^{b}$±0.02 |
| Drinking | | |
| Without EE | $1.68^{a}$±0.15 | $1.06^{b}$±0.11 |
| With EE | $1.17^{b}$±0.11 | $1.34^{b}$±0.13 |
| Interaction with EE | | |
| Without EE | - | - |
| With EE | 1.27±0.13 | 1.26±0.01 |

Means with small letters in the row (Non-debeaked x debeaked) and capital letters in the column (With EE x Without EE) differ significantly ($p<0.05$)

The presence of EE had an isolated effect on exploratory behaviour, with a higher frequency in turkeys with EE access (14.3%) than in those without EE access (12.6%).

When evaluating the behaviour in relation to age, differences were found for all behaviours ($p<0.05$). However, in this study, it was important to understand the differences related to the treatments. In this case, it was found an interaction of age × debeaking × EE for resting, use of EE, injurious pecking, and eating ($p<0.05$; Table 4).

Injurious pecking was higher at 33rd week-old in birds without access to EE ($p<0.05$), even though they were debeaked. The presence of EE did not change injurious pecking during the experimental period ($p>0.05$).

Resting behaviour was lower in the 3rd, 4th, and 5th week-old debeaked turkeys without access to EE ($p<0.05$). The use of EE presented a frequency of 1.27±0.069%/day, despite the debeaking procedure ($p>0.05$), and the use of EE varied over the 9 weeks, reducing and increasing between weeks in a random way ($p<0.05$; Table 4).

Eating behaviour was lower at week 4th, 6th, 8th, and 9th for debeaked turkeys with access to EE ($p<0.05$).

### Injuries

There was an interaction between debeaking and EE ($p<0.05$). Non-debeaked turkeys presented more lesions ($p<0.05$), despite they had access or not to the EE ($p>0.05$; Table 5). The number of lesions was higher during the last two weeks before slaughter in non-debeaked turkeys ($p<0.05$; Table 6).

Debeaking proved to be effective, as the number of injuries was lower ($p<0.05$) in non-debeaking animals (6.7±0.89/week) compared to debeaking at the hatchery (1.38±0.89/week).

Regarding EE, number of injuries was similar between turkeys that had no access to EE (4.2±0.89) and animals that had access to EE (3.9±0.89; $p>0.05$).

The areas most affected by aggressive pecking that resulted in a higher number of lesions in turkeys were the wing, snood, tail, and neck (59.2%, 19.8%, 10.9%, and 10.1%, respectively).

### Lesions at slaughter

At slaughter, the injuries in each treatment group were assessed separately to record the number of damages. The total post-mortem inspection rejection (PMI) showed trends between BT and non-debeaked turkeys and the presence or absence of EE. Of the 2,964 slaughtered turkeys, 66 (2.22%) had carcass injury. Turkeys with intact beaks had more carcass injuries when they had no access to EE (40.9%) compared to the ones with EE access (31.8%). BT turkeys had lower carcass injuries when they had access to EE (10.6%) compared to those without EE (16.7%).

## Discussion

### Performance

Debeaked turkeys showed better performance when evaluating the FCR. This result is likely linked to the beak trimming procedure, as it prevents feed selection in the feeders, highlighting the need for beak trimming in commercial turkey farming for better commercial viability, as feeding is the costliest item in intensive production systems (Sethy et al., 2018). Although it is considered an invasive method that causes pain, and can reduce feed efficiency (Prescott & Bonser, 2004), the turkeys used in this study were beak trimmed on the first day of life in the hatchery, a practice that apparently has less impact on feed intake and weight gain just after the procedure (Leighton et al., 1985). This suggests that less stereotyped behaviour and greater adaptation occur when turkeys are debeaked at a young age; therefore, feed consumption is not affected.

The results of this study are in line with the findings of Noble & Nestor (1997), who found that BT turkeys waste less feed than non-debeaked ones and consequently achieve better feed conversion and lower feed consumption. However, when non-debeaked birds had access to EE, they presented a better FCR. The use of EE can promote a high-welfare environment and promote higher performance (Sherwin et al., 1999a).

In the evaluated groups, the results regarding mortality and the need for culling were not significantly different, which was not expected, as various studies have reported that non-debeaked animals have much higher mortality rates than debeaked animals (Grigor et al., 1995; Nicol, 2018). The turkeys were managed and inspected several times a day by highly trained staff. The attentive monitoring of animals, in combination with the use of EE, may have affected the non-significant difference in mortality and reduced the need for culling between the treatments.

However, even with constant care and the use of EE in the pen, injurious pecking was observed in both trimmed and non-trimmed culled turkeys, and it was not possible to detect the triggering factor for these aggressions, reinforcing that multiple factors trigger abnormal behaviours.

Apart from these results, it must be considered that productivity is not always an indicator of animal welfare, but certain parameters such as decreased mortality rates and the percentage of animals affected by injuries and pathologies may indirectly indicate improvements in terms of welfare. On the other hand, when considering high-performance flocks, this equation becomes more complex.

### Behaviour

Non-aggressive pecking behaviour was more intense in turkeys with intact beaks, as well as injurious pecking behaviour, despite the presence of EE, which aligns with the findings of the study by Busayi et al. (2006), suggesting that harmful feather pecking in turkeys may

**Table 4**. Frequency of turkey behaviour events according to age, environmental enrichment (EE), and debeaking treatments.

| Age/weeks | Behaviour | Non-debeaked | | Debeaked | | SEM |
|---|---|---|---|---|---|---|
| | | Without EE | With EE | Without EE | With EE | |
| 1 | IPE | 0B | 0A | 0B | 0A | 0.135 |
| | RES | 16.42A | 22.84A | 20.89A | 18.57A | 1.765 |
| | IEE | - | 0.26C | - | 0.05B | 0.264 |
| | EAT | 5.68A | 3.63A | 3.21A | 3.89A | 0.693 |
| 2 | IPE | 0.26B | 0.32A | 0B | 0.05A | 0.135 |
| | RES | 18.26A | 15.11A | 15.74A | 16.05A | 1.765 |
| | IEE | - | 2.11AB | - | 2.16A | 0.264 |
| | EAT | 4.26A | 5.00A | 6.89A | 7.31A | 0.693 |
| 3 | IPE | 0.47B | 0.11A | 0.11B | 0.05A | 0.135 |
| | RES | 10.37A | 14.11A | 12.95B | 12.21A | 1.765 |
| | IEE | - | 1.42B | - | 2.00A | 0.264 |
| | EAT | 5.84A | 6.05A | 2.94A | 2.78AB | 0.693 |
| 4 | IPE | 0.11B | 0.11A | 0.16B | 0A | 0.135 |
| | RES | 15.68A | 21.95A | 14.00B | 19.53A | 1.765 |
| | IEE | - | 0.32C | - | 0.05A | 0.264 |
| | EAT | 2.94A | 2.79A | 5.42A | 2.57B | 0.693 |
| 5 | IPE | 1.16A | 1.00A | 0.89A | 0.16A | 0.135 |
| | RES | 15.05A | 17.53A | 13.84B | 18.00A | 1.765 |
| | IEE | - | 1.00B | - | 1.68A | 0.264 |
| | EAT | 5.05A | 3.63A | 3.42A | 3.89A | 0.693 |
| 6 | IPE | 0.47B | 0.53A | 0.05B | 0.16A | 0.135 |
| | RES | 17.05A | 18.89A | 20.63A | 21.74A | 1.765 |
| | IEE | - | 0.42CD | - | 0.63B | 0.264 |
| | EAT | 2.26A | 2.11A | 2.16B | 2.58B | 0.693 |
| 7 | IPE | 0B | 0.11A | 0.32B | 0.05A | 0.135 |
| | RES | 22.32A | 17.00A | 20.95A | 18.05A | 1.765 |
| | IEE | - | 1.84AB | - | 2.16A | 0.264 |
| | EAT | 4.00A | 5.05A | 5.26A | 5.21A | 0.693 |
| 8 | IPE | 0.21B | 0.26A | 0.11B | 0.11A | 0.135 |
| | RES | 20.00A | 18.11A | 24.11A | 21.26A | 1.765 |
| | IEE | - | 3.16A | - | 1.74A | 0.264 |
| | EAT | 3.58A | 3.89A | 3.42A | 2.42B | 0.693 |
| 9 | IPE | 0.05B | 0.05A | 0B | 0A | 0.135 |
| | RES | 18.84A | 17.95A | 18.79A | 21.32A | 1.765 |
| | IEE | - | 0.84B | - | 0.95A | 0.264 |
| | EAT | 2.05A | 2.42A | 1.74B | 1.84B | 0.693 |

Injurious Pecking (IPE), Resting (RES), Interacting with EE (IEE), and Eating (EAT). Means with capital letters in the column differ significantly between ages ($p<0.05$)

**Table 5**. Number of lesions per week in body areas (wing, snood, tail, and neck) according to the introduction of environmental enrichment (EE) objects and the performance of beak trimming.

| | Non-debeaked | Debeaked |
|---|---|---|
| Without EE | 6.9aA | 1.7bA |
| With EE | 6.7aA | 1.1bA |

Means with small letters in the row (Non-debeaked x debeaked) and capital letters in the column (With EE x Without EE) differ significantly ($p<0.05$). SEM=0.73

**Table 6**. Number of lesions per age (weeks) produced by injurious pecking lesions observed in the evaluated body parts (wing, snood, tail, and neck) according to the introduction of environmental enrichment (EE) objects and the performance of beak trimming.

| Age in weeks | Non-debeaked | | Debeaked | |
|---|---|---|---|---|
| | Without EE | With EE | Without EE | With EE |
| 1 | 0 | 3B | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 3B | 1B | 0 | 0 |
| 4 | 8B | 8B | 1 | 2 |
| 5 | 9B | 9B | 6 | 3 |
| 6 | 6B | 5B | 1 | 2 |
| 7 | 8B | 8B | 2 | 0 |
| 8 | 13A | 14A | 4 | 3 |
| 9 | 15A | 12A | 1 | 0 |

Means with capital letters in the column differ between ages significantly ($p<0.05$). SEM=2.5

result from vigorous investigative pecking. However, little is known about the development and relationships among the multiple factors that influence aggressive pecking behaviour in turkeys.

Injurious pecking is a form of aggression that usually follows a social disturbance and is often used to maintain dominance, involving repeated pecks or plucks at the feathers, usually targeting the feathers on the back, tail, base of the tail, and wings. This sometimes includes the removal and consumption of feathers (Dalton et al., 2013). Feather pecking and cannibalism, similar to all forms of harmful pecking in turkeys, are controlled by multiple influences of the environment, diet, and underlying genetic composition (Martrenchar et al., 2001). Stock density, ambience, lighting, diet, and genetic composition variables were the same between the treatments and were not considered in this study. The stocking density used in this study was lower than that used in commercial establishments, yet it was still not sufficient to prevent fights, which is most likely related to social competition.

Environmental enrichment has been suggested to reduce stress and feather pecking, thus leading to an increase in overall flock health (Lindenwald et al., 2021). In this study, EE only altered exploratory behaviour, increasing it when present. Although they are considered strategically important, EE objects should not be seen as the final solution to turkey welfare problems, and if they are not combined with sanitary and nutritional parameters, their benefits may not be observed. Therefore, it is necessary to consider the type of material used, as well as its method of availability, to avoid possible frustration and lead to the belief that EE is not a useful tool for promoting turkey welfare.

## Injuries

Debeaking of commercially raised animals resulted in fewer injuries in the turkeys observed in this study. These results are in line with those of Grigor et al. (1995), who found that all debeaking techniques resulted in significant reduction in injuries due to cannibalism and feather pecking. The adverse effects of beak trimming were minor and short-lived, and were clearly outweighed by the benefits of reducing injuries, as the treatments where the animals underwent BT showed fewer injuries and better FCR results.

The insertion of EE in turkey pens was effective when compared to the injuries and lesions found in the carcasses of turkeys at slaughter with those that did not have access to the tool, confirming the findings of Dalton et al. (2018), which suggests that both feather pecking and cannibalism

occur due to the lack of environmental stimuli in sterile housing and an inherent tendency to peck. Furthermore, although the severity of the lesions was not evaluated, as there was no significant difference in mortality and the need for culling between treatments, it can be assumed that the lesions caused by aggressive pecking were milder and did not provide entry points for other opportunistic agents, although the turkeys still presented with pecking injuries. High rates of carcass condemnation in groups of animals that did not undergo the BT process is common (Glatz & Rodda, 2013), the same result found in the current study.

The area most affected by pecking injuries in this study was the wings, which can be explained by the appearance of ultraviolet (UV) markings on the feathers that are temporally and spatially linked to the initial targets of injuries. Most commercial plants operate under fluorescent or incandescent lighting with minimal UV; therefore, the distorted appearance of emerging feathers in young turkeys may have made them targets for investigative pecking (Dalton et al., 2013; Duggan et al., 2014). Sherwin & Devereux (1999) suggested that the 'unnatural' appearance of these markings under conventional lighting, which emits minimal UV radiation, may attract or prolong the harmful pecking.

Several species of poultry, including domestic turkeys, have the ability for UV vision. This can function as a signal among turkeys, for example, in individual recognition or even in hierarchy organization, which would suggest the presence of visible feather markings under UV radiation. When feathers were viewed under conventional white fluorescent lighting (which emits minimal UV light), the turkeys presented a uniform yellow or white colour according to the stage of feather emergence. However, when viewed under a lamp that emits radiation with peaks in the UV spectrum, distinct fluorescent and non-fluorescent spots were observed in various parts of the body, including wings, tail, thighs, neck, chest, and dorsal surface (Sherwin & Devereux, 1999).

Bartels et al. (2017) observed that in turkey housing systems, providing light covering the long-wave UV spectrum together with EE can help reduce the prevalence of harmful pecking. This aligns with the findings of this study, since the turkeys were under incandescent lighting, which may generate image distortion in turkeys and consequently curiosity, leading an investigative peck to become more aggressive, causing injury to the animals.

The infrared irradiation debeaking procedure proved to be more advantageous than not debeaking the turkeys, resulting in a better feed conversion ratio, less feed consumption, and fewer injuries from injurious pecking, as EE was not effective on non-debeaked turkeys.

Adding only reusable plastic bottles with color liquid as an environmental enrichment tool did not provide the expected result as they caused more injuries to the carcasses, perhaps because it was not the appropriate equipment to be used as the only form of EE and avoiding the beak trimming process. To developed practical solutions, it is suggested that more research must be conducted to clearly understand the development of injurious pecking behaviour. The evaluation of different objects of EE, different breeds of turkeys, and stocking density should be carried out to clarify doubts about the benefits of EE and its impact on both performance results and welfare, as practices involving physical changes should be avoided and even banned in some countries. Providing enriched facilities is recommended, even when birds are beak-trimmed.

**Ethical approval:** This study was approved by the Ethics Committee on Animal Use of the School of Animal Science and Food Engineering at the University of São Paulo (approval number: 2669030122).

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