

European Chicken Commitment: Enrichment Guide for Broiler Chickens

Introduction

This guide offers a comprehensive review of perching and pecking substrate enrichments that meet the criteria of the European Chicken Commitment (ECC). The guide opens with an overview of the ECC and its enrichment requirements, as well as key recommendations for ECC compliant perching spaces and pecking substrates. The guide then covers the essential characteristics of effective enrichments, the shared welfare benefits of perching spaces and pecking substrates for broiler chickens, and reasons why chickens may show low enrichment use in practice. This guide provides detailed guidance and visual examples of effective forms of perching spaces and pecking substrates in two separate sections. For both types of enrichments, an overview is provided of the ECC requirements and a summary of the scientific evidence demonstrating the value of these enrichments to modern broiler chickens. Supplementary information is provided at the end of this guide on dust bathing materials for broilers, which is not required under the ECC but can offer additional welfare benefits to chickens.

I. What is the European Chicken Commitment (ECC)?

The scientific literature has well-established that chickens are sentient beings that show a range of emotional responses from pain and fear to excitement and curiosity when they can perform highly motivated natural behaviours, such as foraging, perching, and dust bathing.¹ However, how broiler chickens are bred, housed, and slaughtered in today's standard intensive systems means chickens spend their rather short lives experiencing pain, frustration, and poor physical health under barren conditions that severely limit their behavioural opportunities beyond eating, drinking, and sitting.²⁻⁴

With the support of over 30 European non-profit organizations, the European Chicken Commitment (ECC)¹ was created in 2017 as a unified corporate ask to address the most significant welfare issues in broiler production. The ECC criteria are known to improve chicken welfare as evidenced by science and best-case practical examples. Companies signed up to the ECC have committed to provide chickens with more space to live, with natural light and enrichment important for behavioural expression and occupation, to use slower growing breeds with proven welfare outcomes, to ensure humane slaughter without live inversion, and to carry out third-party auditing against those standards by 2026. More than 300 companies across different EU countries and food sectors have signed up to the ECC which is set to benefit millions of broiler chickens each year.

Regarding environmental enrichment, the ECC requires:

- **At least 2 meters of usable perch space per 1,000 birds**
- **At least 2 pecking substrates per 1,000 birds.**

¹ <https://welfarecommitments.com/europeletter/>

Key recommendations for ECC compliant enrichments

Perching spaces

- Slower-growing broilers prefer to perch on fixed, wide, rectangular wood or metal bars with rounded edges and no slope.
- Perching bars should be wide enough to allow the chickens to support their entire foot.
- If perching structures have multiple levels, the angle between the levels should be low.
- Slower growing breeds will occupy platforms more than bar perches. Plastic grid or slatted platforms are recommended to allow birds better grip while using the structures. Suspended platforms can have their height adjusted, providing better access to the chickens throughout their lives.

Pecking substrates

- Effective forms of pecking substrates include bales of substrate, the scattering of food items, vegetative matter, and edible pecking blocks.
- To keep bales intact for longer, the original ties or plastic covering should be kept on the bales. Only a small opening should be made in the plastic to allow birds access. Research suggests firmly pressed straw bales may require less frequent replacement than firmly packed lucerne or loosely packed straw bales.
- A minimum of 2 grams of local, palatable grains should be scattered per day for each chicken in the flock, starting at 15 days of age.
- Vegetative matter should be complex, destructible, and edible bundles of locally available brassicas, vegetables, leaves, grasses, or leafed branches. Vegetative matter should be replaced once consumed, and suspended vegetation should be hung at bird height.
- Edible and destructible pecking blocks, commonly made of forage or grain, should be suspended at bird height, and replaced once consumed.

II. What is an effective enrichment for broiler chickens?

Scientific evidence shows that effective enrichments in commercial broiler farms:

- encourage the expression of species-specific natural behaviours without losing their novelty over time,
- maintain or improve health and physical wellbeing,
- maintain or improve the economics of the production system,
- are practical to employ, and
- add environmental complexity.⁵

The ECC enrichment requirement for perching space and pecking substrates is based on research demonstrating the ability of these enrichments to meet the criteria listed above. When choosing a type of enrichment, it is important to ensure that it is locally available in sufficient quantity and throughout the year.

III. What are the benefits of perching structures & pecking substrates for chickens?

Research shows both perching structures & pecking substrates benefit chicken welfare by:

- **Increasing behavioural expression**
 - Broilers show more natural behaviour, including foraging, investigative pecking, dust bathing, and locomotion, when provided with perches and pecking substrates⁶⁻¹⁵
- **Allowing chickens to be more active.** Broilers show less sitting, and more standing, walking, jumping, dust bathing, preening, stretching, foraging, and exploratory pecking and scratching, which results in:
 - **Better bird mobility & fewer lame birds**^{10,14,16-20}
 - **A reduced incidence of footpad dermatitis (FPD), hock burn, & breast blisters**^{10,21,22}
 - More aeration of the litter thanks to increased bird activity that better maintains its dry & friable condition.

IV. Reasons why chickens may show low enrichment use

Broilers will show low enrichment use in commercial settings if:

1. **The breed lacks the leg strength or cardiovascular fitness to be active and engage with the enrichments.**^{2,3,23-25}
 - Research shows the industry-standard, fast-growing (FG) breeds (e.g., Cobb 500, Ross 308/508, Hubbard Flex) spend significantly more time inactive and sitting, and less time standing, walking, playing, dust bathing, and foraging than slower-growing (SG) breeds.² In addition to having poorer health overall, research has shown flocks of FG chickens show lower behavioral indicators of positive welfare than SG breeds, including more 'stressed/flat' qualitative scores and less enrichment use.³
 - For perching spaces, FG breeds lack the physical ability to jump up and balance on perches, so are only able to use narrow perches until 2 weeks of age and wider platforms until 4-5 weeks of age. However, even when provided with platforms, FG chicken flocks will only spend one quarter of the amount of time perching in comparison to flocks of SG breeds. In contrast, SG chickens are bred for higher welfare outcomes, and use perches and platforms significantly more throughout their lives, illustrating some of the health and mobility issues faced by the current FG breeds.^{2,3,9,24,25}
2. **The enrichment type does not meet the criteria of an effective enrichment (see above).**
 - Non-destructible novel objects, such as CDs, mirrors, or plastic bottle, can be initially attractive to chickens. Broilers can show reduced fear in response to new stressors as long as the objects are continually changed (e.g., every three days) to maintain novelty and avoid adaptation. However, this is not a feasible enrichment strategy for most commercial operations, and since chickens cannot manipulate or consume these novel objects, they will lose interest over time.^{6,26,27}

3. The enrichment is not distributed throughout the barn in a sufficient number and to allow multiple birds to engage with the enrichments.^{15,17,26,28}

- Commercial broiler barns often contain thousands of birds, so distributing the enrichments throughout the barn allows more birds to have the opportunity to engage with and benefit from the enrichments. When straw bales are provided as a pecking substrate, placing the bales throughout the barn allows the fresh, dry straw to be evenly distributed across the barn floor, as the birds' peck and breakdown the bales. This helps to maintain a dry, friable quality of litter throughout the barn.²⁹

V. Perching

To meet the ECC criterion, two metres of perching space per 1,000 chickens should be available through either:

- **Perches** – elevated narrow structures at one or more heights off the ground which birds can grasp with their feet
- **Platforms** – structures providing level elevated space for birds to sit or stand with flat feet at one or more heights^{17,51}

i. What is not considered a perching space under the ECC?

Bales of substrates composed of straw, lucerne, wood shavings, miscanthus, or silage, do not count towards perching space. Although chickens will perch on top of bales of substrate, the ECC classifies this enrichment as pecking substrates rather than perching spaces because the bales might not be permanently available for perching in sufficient quantity.^{3,14} The shape of bales can vary, so there may be limited space on top of bales for more than a single bird to perch. In addition, chickens are highly driven to tear apart these bales with their beaks and feet. Even with plastic wrap coverings, string ties, and frequent replacement, these bales may only remain intact for a short period of time.¹⁵

ii. Modern broilers retain the motivation to perch

Like their junglefowl ancestors, domestic chickens retain the motivation to rest ("roost") and survey their environment off the ground from elevated spaces for protection from predators.^{7-12,17} Research shows modern broilers will begin to perch in the first week of life, with chickens spending the most time perching at 2-5 weeks of age, depending of the breed and type of perching space provided.^{7,8,12,16,21,30} All breeds tend to show increased use of elevated areas during the dark (night) period beginning at 4-5 weeks, which reflects the start of night-time roosting in wild populations of domestic fowl.^{11,12,31,32} Intermediate and slow-growth rate breeds show high daytime perch use and continue to occupy perches throughout their lives at similar levels to laying hens (See figure 3).³³ In contrast, fast-growing breeds show much lower use of perching spaces, and only use platforms at low elevations minimally throughout the day.^{9,11,24,33,34}



Figure 1. Intermediate growth rate broilers perching on a low-sloped rectangular wooden bar perch with rounded edges on a UK farm (Source: Compassion in World Farming).



Figure 2. Slow-growing Norfolk black broilers on an A-frame perch on a UK farm. The perch is composed of rectangular wooden bars with rounded edges at different heights (Source: Norfolk Black Traditional Poultry).

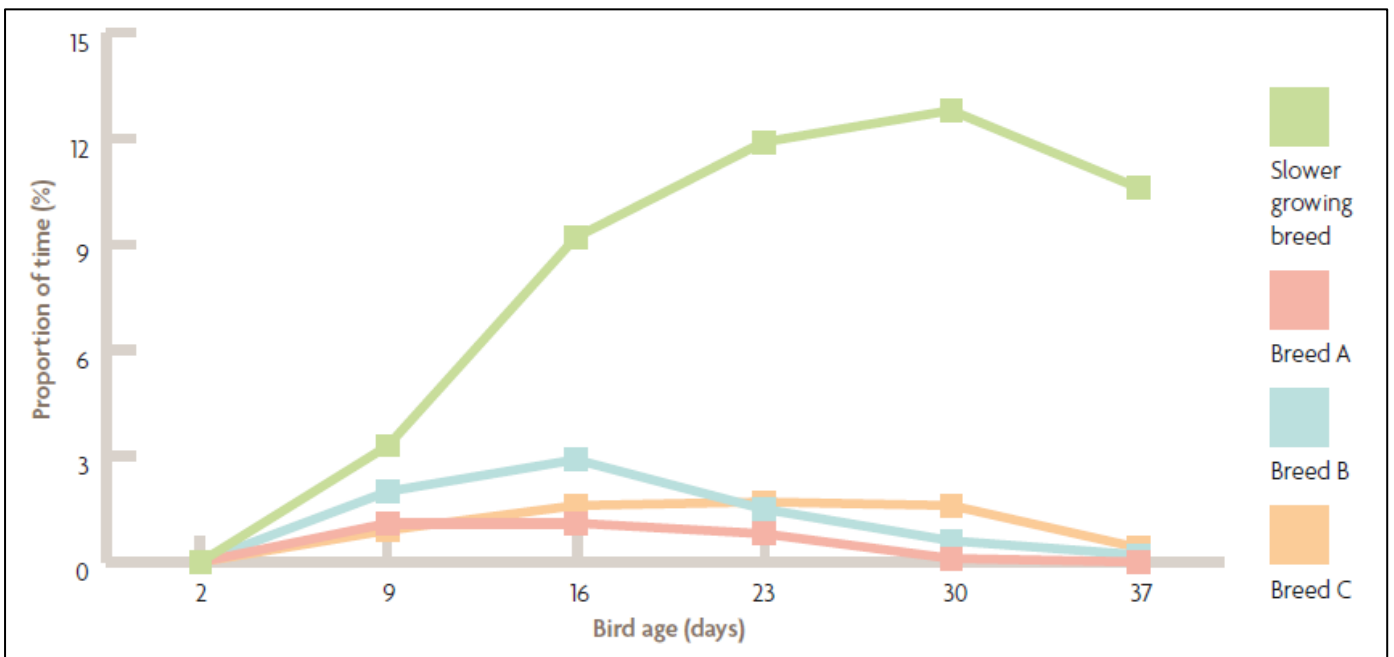


Figure 3. The proportion of daily time spent perching from 2-37 days of age for one slower-growing (SG) breed (Hubbard JA757) and three of the current industry standard faster-growing (FG) breeds: Cobb 500, Ross 308, and Hubbard Flex (Breeds A-C). The perches provided were rectangular wooden bars with rounded edges 20 cm off the litter floor, with 1.3 m of perching space for the fifty birds in each pen of this UK study. The SG birds spent significantly more time perching overall than the FG breeds, with the SG chickens sharply increasing their daily perching from 9 days of age onwards in contrast to all the FG broilers.²

Table 1. Assessment of perching space as an effective environmental enrichment for chickens³⁵

Perching Space for Broiler Chickens	
Benefits	Associated Results
Allows for resting “roosting” off the ground as part of natural anti-predator behaviour^{7-12,17}	Longer resting bouts & less disturbances to resting birds from pushing or trampling ^{7,36}
Encourages a greater amount & variety of movement⁶⁻¹³	Birds have the opportunity to jump, attempt flight, grasp with their digits, and walk up/down ⁶⁻¹³
Provides the opportunity to escape & avoid aggressive birds⁷	Birds are less fearful, so have a reduced risk of piling & smothering ^{17,37-39}
Birds experience a more positive state of welfare²⁸	Birds show more comfort behaviours, including dust bathing, preening, and stretching ²⁸
Better leg health	Fewer birds have obvious gait defects or tibial dyschondroplasia Broilers with perching spaces have wider, more symmetrical leg (tibia) bones ^{10,16,17,20}
Birds spend less time in contact with the litter	Birds show less FPD and have cleaner plumage ^{10,21,22}
Birds are better able to thermoregulate	Birds can get off of the litter for better air flow Perches filled with lower temperature water enhances bird cooling ^{40,41}
Increases available space	Adds vertical space More space available for chickens at the floor level Chickens use the space under perching structures for sheltered resting ¹⁵
Greater dark meat yields	Greater yields of thigh & drumstick meat ⁴²
Better meat & carcass quality	Less drip & cooking loss, and less redness in the breast meat ²² Less thigh meat drip & cooking loss ²² Better footpad condition ^{10,21,22}
No impacts on performance outcomes	No impacts on feed conversion (FCR), mortalities, or body weights ^{10,17,20,34,42-44}
More uniform distribution of birds throughout the house⁴⁵	Improved access to feed & water for all birds in the flock

iii. Guidelines for good perching in commercial broiler farms

The Royal Society for the Prevention of Cruelty (RSPCA) provides standards for good perching spaces (perches & platforms) based on scientific literature and best practice,^{9,11,28,30,50,48} which states:

- a) perch /platform height should be between 10 to 40cm from the floor depending on the size and breed of the chickens
- b) a perching space of 15 to 20cm per bird should be provided
- c) Approximately 20% of birds may choose to perch at any one time (this is important for calculating perch space per bird, i.e., based on 20% usage, 1000 birds will require 40m of perching space to achieve 20cm per bird)

In addition, research shows that chickens use perches and platforms more throughout their lives when they are easier to navigate and include the following design considerations:

1. Adjustable perching heights

- Broilers show higher use of perching spaces that are low enough to allow them to hop on in comparison to higher structures that require ramp(s) to access.⁴⁶
- **The height of perching structures should be adjustable as the birds grow.**^{9,28,30}
 - To enable perch use from the start of life, perching spaces should be provided for chicks at or near ground level and the elevation increased gradually as birds grow to **10-30cm**, depending on the breed. To see improved leg health in commercial flocks, it is fundamental that chickens have perching opportunities they can use before two weeks of age.³⁰
 - The RSPCA recommends that **perching spaces are made highly visible to young chicks** to encourage them to investigate and to start perching, for example by attaching brightly-colored adhesive strips or painting the structures white.⁴⁷

2. Flat perching structures with no or low slope, and low angles between levels

- Broilers prefer to perch on flat structures (0° slope) rather than perches with a 10° or 20° slope. Additionally, chickens show higher perch use when the angle between different levels of the perching structure is lower (12 vs. 42 degrees). The body confirmation of broilers - even intermediate growing strains, makes jumping between perches more difficult for chickens than laying hens.^{15,32,46}



Figure 4. Slow-growing Hubbard JA757 broilers on a Dutch Farm. The A-frame perch has a high slope (~40°) between the different heights of round metal bars.⁵²



Figure 5. Slow-growing Hubbard JA757 broilers on a Dutch Farm. The wooden A-frame perch has a low slope (~20°) between the rectangular bars at different heights.⁴⁹

3. Use of low-sloped grided/slatted ramps to improve access

- Ramps can be used to aid the chickens' access to these enrichments as they age.^{9,28,30} One or more low-sloped ramp(s), made of a grided or slatted material, can increase bird occupancy when attached to higher platforms and perches - especially for older birds. The slope of ramps should be low and gradual to ensure chickens do not have difficulty or experience physical strain while walking or sitting on the ramps.³⁰

4. Design appropriate to breed

While there is an urgent need to move away from faster-growing (FG) breeds to significantly improve broiler welfare, there are instances where producers will start providing enrichment before transitioning to a slower-growing (SG) breed. In that case, it is important to consider that enrichment use varies significantly between FG and SG breeds.

- FG broilers show lower use of perching spaces than intermediate and SG breeds.^{2,11,12,24}
- Intermediate & SG rate breeds cope with narrow perches of varying heights and show a preference for higher perching spaces at night (50 cm vs. 30 or 20 cm platforms). New research suggests slow-growing breeds show higher use of wider platforms than perching bars^{11,48,49}
- **The FG breeds will only use lower (8.5 - 10 cm) raised platforms rather than ramps, perching bars, or higher raised platforms, especially as they age.**^{9,11,30,46}
 - Weaker legs and selection for large breast meat yields has shifted their center of gravity, making it difficult for these FG breeds to balance on narrow perching bars. The weight of FG birds shifts fully onto their feet while gripping the bars. This leads to prolonged pressure on their feet, which may cause pain.
 - In contrast, wider platforms allow the underside of these FG birds to be fully supported, including their large breast muscles before slaughter. Therefore, less pressure is put on their feet while resting on platforms, which is more comfortable for these FG breeds.

Specific to perches, broiler chickens show a preference for:

1. Wide rectangular wooden or metal perches with rounded corners

- Fully round baton perches, such as metal poles or PVC piping, are more difficult for birds to grip with their feet and stabilize themselves. Chickens will perch more on **rectangular bars made of non-slip materials, such as wood or metal, with rounded corners** that allows for better grip while perching. Slow-growing breeds show a preference for rounded wooden perches at 2 weeks of age, and then for rounded metal perches at 6 weeks of age. Rounded corners also ensure there are no sharp edges that could cause foot lesions from perching.^{41,45,47,48,50-52}
- Perches with a **wide, mushroom-shaped top** may better accommodate the broiler's breast muscle tissue and prevent prolonged pressure solely on part of the chest directly in contact with a perching bars, that can result in breast tissue inflammation or lesions and discomfort or pain.^{41,53} However, it is advised that mushroom-shaped perches are made of wood or metal. A recent pilot study showed a slow-growing broiler breed showed the lowest use of plastic perches with a mushroom-shaped or flat top.⁴⁸



Figure 6. Four-week-old slow-growing Hubbard JA757 broilers perching on rectangular wooden bar with rounded edges at a UK facility (Source: RSPCA).

Figure 7. Young broiler chickens perching on low rectangular metal bar with a wide, mushroom-shaped top on an Italian farm (Source: Lubingsystem.com).



Figure 8. Slow-growing Hubbard JA757 broilers on a Dutch Farm with perching structure made of round wooden bars set at two levels. Each perch bar was 1m² providing a total of 6m² of perching space per structure. Three of the perch bars were 20cm above the floor, and the second level had 2 perch bars 40cm off the ground.⁴⁸



Figure 9. Slow-growing Hubbard JA757 broilers on a Dutch Farm with perching structure made of round metal bars set at two levels. Each perch bar was 1m² providing a total of 6m² of perching space per structure. Three of the perch bars were 20cm above the floor, and the second level had 2 perch bars 40cm off the ground.⁴⁸

2. Perches wide enough to support their entire foot

- To encourage high perch use, it is recommended that perching bars for broiler chickens are wide enough to support their entire foot and allow them to remain balanced while perching. The diameter of the perches should allow chickens to curl their feet around the perch, while ensuring their claws do not curl around the bottom of the perch and injure their footpads. The RSPCA recommends 4-6 cm as an optimal perch depth for broiler chickens.^{26,47,50}

3. Fixed perches

- Suspended perches can lead to more failed perching attempts than on fixed bar or A-frames perches as older, heavier birds have more difficulty balancing. It is recommended additional wires are used to secure different levels of the perching structure to enhance its stability.^{30,32}

For hotter climates, higher perch use can enhance the chickens' heat dissipation through the use of:

Cooling perches:

- During hot temperatures ($\geq 28^{\circ}\text{C}$), broilers will show lower levels of perching unless cooling perches are provided. **Cooling perches** have cool water ($\sim 10^{\circ}\text{C}$) flowing through the perching bars, which has been shown to encourage more chickens to perch during higher temperatures. These cool perching bars allow chickens to dissipate a greater amount of body heat while perching. More chickens perching during hotter conditions benefits the entire flock by opening up space on the floor level and improving air flow.^{15,21,40,46}

Grid/slatted platforms:

- Use of plastic grids or slats vs. solid surfaces** for platforms and ramps gives the broilers better grip with their feet while moving, and also when stabilizing themselves while sitting or standing³⁰ Grided platforms allows for better air circulation and heat dissipation for chickens than the use of solid platform surfaces.



Figure 10. When compared to ramps and perching bars, Baillie et al (2018) showed the highest use of suspended platforms by chickens, with 25-74% of the platform occupied by fast-growing Ross 308 broilers on these UK farms. The platform started at ground level for the chicks during their first week, and then was raised by 5 cm each week until it was 20 cm off the ground by week 5.³⁰

Figure 11. Slow-growing Hubbard JA757 broilers on a Dutch farm showed a strong preference to perch on two level platforms than A-frame perches made of metal bars 0.25-0.75 m off the floor. The platform structure was made of six 1m² rigid plastic gridded platforms. One platform was 25 cm high to encourage bird use from an early age, and the remaining five platforms were 50 cm off the floor. The chickens were frequently observed both on top, and underneath, the platforms.⁷¹

VI. Pecking substrates

To meet the ECC criterion, two pecking substrates should be provided per 1,000 chickens.

i. The value of pecking substrates to modern chickens

Although less active than their junglefowl ancestors, modern chickens maintain the drive to forage, through ground pecking and scratching, during daylight hours when offered appropriate enrichments.^{15,49,54-57} Under intensive barren commercial conditions, broiler chickens spend the majority of their time inactive. So, the addition of preferred pecking substrates provides opportunities for chickens to be more mobile by stimulating natural exploratory, foraging, and dust bathing behaviour.^{15,41,49,55,56} This allows chickens to experience a good life beyond only alleviating their suffering. Preferred pecking enrichments provide broilers the opportunities for excitement, play, comfort, interest, confidence, a sense of control, and to take pleasure in their daily lives. When effective, pecking substrates not only increase the expression species-specific natural behaviours, but can benefit the physical health of the chickens, for example by reducing the prevalence of lameness.^{14,18,19}

Table 2. Assessment of pecking substrates as effective environmental enrichments for chickens³⁵

Pecking Substrates for Broiler Chickens	
Benefits	Associated Results
Chickens are more active	Spending less time sitting & standing, and more time standing & walking ^{14,55,56}
Chickens perform more foraging	Provides opportunities for pecking, scratching, ingestion, & general exploration ^{15,49,55,56}
Can stimulate birds to dustbathe	Signifies chickens are experiencing positive welfare ⁴¹
Improves leg health	Chickens have better gait (walking ability) scores Chickens are capable of longer standing bouts ^{14,18,19}
Better litter quality	Increased bird activity helps maintain dry litter Chickens breaking apart wood shavings adds new, dry litter ³⁸

While well-intentioned, not all types of substrates equally benefit the chickens' mental and physical wellbeing. Below is an outline of key features of effective pecking substrate enrichments for broiler chickens based on the available science and examples of best practice:

Key features of effective pecking substrates for commercial broiler farms:

- **Complex structure**
- **Destructible**
- **Hygienic**
- **Changeable**
- **Locally available**
- **Edible, or containing sparsely distributed edible parts.**

At minimum, it should not be dangerous to the birds if ingested.

ii. Most effective pecking substrates

Research has demonstrated the following substrates are beneficial broiler chicken enrichments:

1. Bales of substrates

- Bales of **straw, hay, lucerne (alfalfa), wood shavings, miscanthus (silver grass), or silage** can be provided to encourage broilers flocks to engage in foraging and dust bathing behaviour.

Straw bales:

- Chickens will peck, scratch, and forage in the straw from bales, and also sit on top and next to the bales, which provides a protected resting area for the birds. Studies have shown the addition of straw bales can also improve the leg health of broiler flocks.^{14,18,19}
- Chickens are more active with 1 straw bale/17 m² of floor space, spending more time walking and standing, and less time sitting and resting.¹⁴ Lower densities of straw bales (1 bale/29 m² or 44 m²) are not effective at increasing chicken activity levels on farm.^{18,19} No impact of straw bales has been shown on final body weights, or the number of mortalities or birds culled on large-scale farms.^{18,19}
- The benefits of bales made of substrates other than straw have not been as extensively researched, so current guidance is limited. New research has shown slow-growing Hubbard JA757 broilers peck more at firmly pressed lucerne bales than loosely-packed straw bales or non-pecking food stones.^{48,52} Researchers hypothesize that lucerne could provide a nutritive value for chickens, making it more beneficial as edible enrichment.³⁸ Placing mostly-unpackaged wood shavings bundles in commercial

barns stimulated more foraging, dust bathing, and pecking at the bundles than lucerne bales. An additional benefit of wood shavings bundles is the chickens' pecking breaks down the bundles, which improves litter condition by adding new, dry litter to the floors.³⁸

- When using any substrate bales as enrichment, it is important to consider the size of individual bales and the density provided in barns. Based on the research, substrate bales should be:
 - ~55-76 x 45-55 cm in size (length x width),
 - and/or **approx. 15 kg in weight**
 - **With 1 bale provided per 1000 birds, or ideally at a density of 1 bale/17 m²**, so the full flock can engage with this enrichment and be more active, while also ensuring the floor area occupied by bales does not significantly reduce the available floor space for the chickens.^{14,26} A significant reduction in floor space could harm bird welfare by amplifying the stocking density when the broilers are heavier and less mobile before slaughter.^{15,52}
- To slow the breakdown of substrate bales, it is recommended to keep the bales with their original ties intact. For bales with plastic coverings, a small hole can be cut into the covering to allow birds gradual access to the entire bale.^{49,52,58} A recent Dutch study evaluating different types of substrate bales on broiler farms showed firmly pressed bales did not need to be replaced at all during grow-out. In contrast, loosely pressed straw bales needed to be once, and the firmly pressed lucerne bales were replaced twice during grow-out.⁴⁸



Figure 12. Slow-growing broilers shown investigating and pecking at a straw bale on a UK farm. The majority of the plastic covering on the bale is still intact to slow the bale's breakdown (Source: Compassion in World Farming).

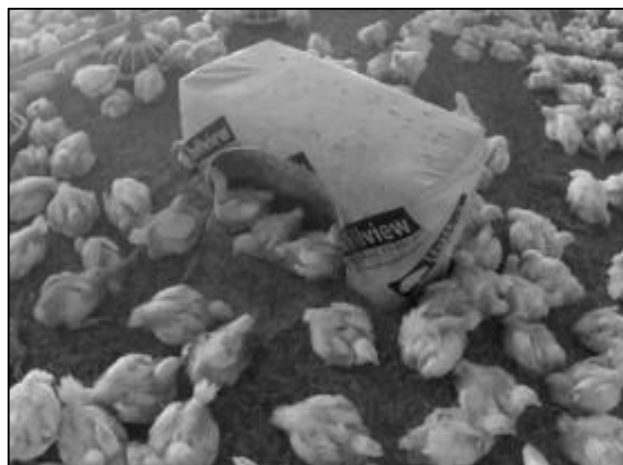


Figure 13. Fast-growing Ross 308 broilers shown investigating and pecking at a 40 cm high short-cut straw bale (80cm long x 40 cm wide) on a UK farm. Bales were placed in the barn on day 10 with the majority of the bale's plastic covering still intact.⁷⁰



Figure 14. Slow-growing Hubbard JA757 broilers on a Dutch farm pecking at 15kg lucerne bales (42 x 55 cm) in wire racks. Racks were first used upside down to allow the young chicks to peck the bales. The bales were replaced once during grow-out after being consumed.⁷¹



Figure 15. Young fast-growing broilers (Ross & Cobb) shown pecking at bundle of wood shavings on a Dutch farm. Only a small hole was cut out of the plastic covering to provide the chickens access but allowing the bales to remain intact for longer.⁴⁹

2. Scattering of food items

- **Feed pellets & whole grains:**

- Scattering of chicken feed pellets in the litter vs. providing it in feeders has been shown to significantly increase broiler foraging and locomotor activity, which decreases the time these chickens spend sitting. However, this feeding strategy is associated with a marked reduction (13%) in broiler body weights at slaughter.⁵⁹
- Studies have shown that scattering whole grains in the litter, in addition to giving the full, regular diet in the feeders, shows little impact on stimulating long-term foraging in broiler chickens.^{20,59-61} However, these studies evaluated the value of whole grains as an enrichment for fast-growing breeds that show low foraging and activity levels overall. Therefore, the welfare benefits of scattered whole grains may only be apparent for slower-growing breeds that are physically capable of ground pecking for this forage.
- Using Beter Leven's framework, which requires slower-growing breeds, it is recommended to:
 - **Scatter a minimum of 2 grams of local, palatable grains per day for each chicken in the flock, starting at 15 days of age.**⁶²
 - To encourage birds to forage, try using whole grains that are more visually distinguishable from the litter, such as unhusked sunflower seeds, dried green split peas, or rice (preferably brown or wild).
- Note: difficulty can arise when auditing to ensure compliance that this type of pecking enrichment is being used on farm. Therefore, it is recommended that farms keep records on grain purchased for scattering.⁶²

3. Vegetative matter (forage & roughage)



- Vegetative matter is used as a pecking enrichment for broilers to provide them with the opportunity to peck and scratch at **complex, destructible, and edible** bundles of locally-available **brassicas, vegetables, leaves, grasses, or leafed branches**. Chickens have shown interest to continue pecking at hanging plant matter; small, suspended bales of forage; or roughage placed in pans on the floor.^{26,28,63}
- The vegetative matter **must be replaced once it is consumed**. Before using a new vegetation, it should be checked if it non-toxic and safe for chickens to consume.
- Vegetation should be suspended, placed in wire racks, or distributed via pans on the ground, as there is a risk of dampening the litter if plants with a higher water content are placed directly on the litter. Any suspended vegetation should be hung at bird height.^{15,28}

Figure 16. Slow-growing broilers shown investigating a suspended corn cob on a UK farm (Source: Alexander Caminada/RSPCA Assured).



Figure 17. Local leafy vegetation suspended in bundles from the ceiling of an open-sided broiler barn in Brazil (Source: Dr Elsio Figueiredo).



Figure 18. Slow-growing broiler chickens investigating and pecking at leafy branches in a rack on floor of a UK farm (Source: Compassion in World Farming).

4. Edible pecking blocks

- Commercial chickens provided with **edible and destructible pecking blocks** are more active overall than flocks without this enrichment. Chickens will direct their pecking to breaking down the blocks, and spend more time foraging in the litter.^{55,56} Research shows both fast and slow growing young broiler chicks first rest around wheat bran blocks, and then their pecking at the blocks increases by 3.2% each day of age in both strains.⁵⁷
- **Grain blocks** are typically composed of an assortment of different whole grains (e.g., wheat, oats) held together with a vegetable-based binder. In contrast, **forage blocks** are formed by compressing dry alfalfa hay or wheat bran in cubes.^{55,63} **Blocks can be suspended with strings or hay nets, or alternatively, placed on the litter.** If chickens are emptying hay nets too quickly, it is recommended to try hay nets with smaller openings or haylage nets.⁶³



Figure 19. Hens pecking at an alfalfa block suspended in cloth netting (Source: Featherwel).



Figure 20. Hens pecking at a suspended hay net filled with hay or straw (Source: Featherwel).

iii. Less effective pecking substrates (NOT RECOMMENDED)

Bundles of String

Other enrichment solutions may also be used to encourage broiler chickens to peck, although less effective than those listed above, such as bundles of string suspended to the feeder lines.

Broiler chickens have been shown to peck at string bundles suspended from the feeder lines (3 – 20 cm off the floor) every ~78 seconds in commercial flocks.⁸ However, the chickens' use of string bundles for pecking is greatly reduced in dimmer areas of the barn.⁶⁴ Bundles of natural string provide a destructible pecking enrichment, allowing broilers to break apart the fibre strands through pecking. Beyond encouraging pecking, the existing research shows no to limited additional welfare benefits of strings as enrichments.^{8,29,65}

- When provided as a pecking substrate, string bundles should be provided:
 - **at bird head height,**
 - **in well-lit areas of the barn** (e.g., on/near feeder lines)
 - String should be provided in **bundles vs. individual strands**, and only **natural fiber** (non-plastic) strings used.^{29,65,66}

iv. Pecking objects of minimal interest (NOT ECC COMPLIANT)

Pecking objects, as opposed to pecking substrates, are non-destructible and non-edible, and therefore present minimal interest for chickens. The ECC requires the provision of pecking substrates, as opposed to pecking objects. Examples of pecking objects, which would not be compliant with the ECC requirement for pecking substrates, are given below:

- **Pecking chains**

Commercial broilers will peck at plastic or (uncoated or colored plastic-coated) metal chains suspended on the feeder lines less frequently than mineral pecking blocks, straw bales, or bundles of wood shavings.^{29,49,65} Beyond encouraging pecking, the existing research shows no to limited additional welfare benefits of chains as enrichments.^{8,29,65}

- **Mineral or Wooden Pecking Blocks**

Across 16 different strains of fast to very slow growing broilers, chickens kept in pens rarely pecked at mineral pecking stones.²⁴ Similarly, providing mineral or other non-food pecking blocks showed no impact on the activity of fast or slow-growing chickens on commercial farms.^{49,52} Chickens likely show little engagement as there is no biological drive to continue to peck at non-food mineral or wooden blocks. Regardless of the level of pecking directed, these items remain relatively intact, so the initial novelty of these blocks wears off quickly after some initial investigatory pecking.

VII. Other types of meaningful indoor enrichments for chickens

Although not required to meet the ECC, adding other forms of enrichment is recommended to enhance the welfare of broiler chickens.

i. Dust Bathing Materials

- Chickens retain their strong natural motivation to dust bathe from red junglefowl. This behavior functions to keep their plumage in good condition and free of parasites.^{34,67} During dust bathing bouts, chickens perform a fixed and complex series of behaviours. Dust bathing starts with the chicken standing and using the feet to litter scratch and rake dust. The bird then squats and uses leg scratching, vertical wing shakes, and rubbing their head on the ground to fully cover their bodies in the dust. Finally, the dust bathing bout ends when the chicken stands up and shakes their feathers to remove any excess dust.³⁴
- Chickens are highly-driven to dust bathe and will perform dust bathing every two days on average when provided the appropriate substrate(s).³⁴ Higher levels of dust bathing in poultry flocks are associated with positive state of welfare, since chickens only have the capacity to perform comfort behaviour when in good health, their basic needs are met, and they are not experiencing negative emotions, such as fear, stress, or pain. When birds are prevented from dust bathing, they show clear signs of frustration.⁶⁸
 - Studies have shown **broiler chickens are most driven to dust bathe in sand, peat moss, & oat hulls** rather than wood shavings or straw pellets.^{34,69}
 - **~1 m² diameter steel rings have been used successfully on commercial farms to contain these preferred substrates (at a depth of ~7.5 cm) to facilitate dust bathing.** Providing these dust-bathing rings with peat moss or oat hulls throughout the barns has been effective at increasing dust bathing and foraging behaviour, reducing bird inactivity, and improving the gait score of broilers at 6 weeks in commercial flocks^{34,70}



Figure 21. A UK broiler chicken farm with several types of enrichments: (straw bales, and 1.1 m² diameter steel rings filled 7.5 cm deep with oat hulls for dust bathing)²⁹

Conclusion

Providing chickens with environmental enrichment, in the form of effective ECC compliant perching spaces and pecking substrates, can greatly benefit the health and welfare of broilers on commercial farms. Research shows slower-growing broilers prefer rectangular perching bars made of wood or metal with rounded edges than fully round perching bars. However, flocks of both faster and slower-growing broiler chickens have been shown to occupy platforms more than perching bars. For pecking substrates, research suggests the most effective enrichments are bales of substrate, the scattering of food items, vegetative matter, and edible pecking blocks. In addition, although not required to meet the ECC, studies have shown providing rings of sand, peat moss, or oat hulls can effectively increase dust bathing and foraging behaviour and improve the welfare of broiler flocks.

References:

1. Marino L. Thinking chickens: a review of cognition, emotion, and behavior in the domestic chicken. *Anim Cogn*. 2017;20(2):127-147. doi:10.1007/s10071-016-1064-4
2. Dixon LM. Slow and steady wins the race: The behaviour and welfare of commercial faster growing broiler breeds compared to a commercial slower growing breed. *PLoS One*. 2020;15(4):1-20. doi:10.1371/journal.pone.0231006
3. Rayner AC, Newberry RC, Vas J, Mullan S. Slow-growing broilers are healthier and express more behavioural indicators of positive welfare. *Sci Rep*. 2020;10(1). doi:10.1038/s41598-020-72198-x
4. Abeyesinghe SM, Chancellor NM, Hernandez Moore D, et al. Associations between behaviour and health outcomes in conventional and slow-growing breeds of broiler chicken. *Animal*. 2021;15(7):100261. doi:10.1016/j.animal.2021.100261
5. van der Weerd HA, Day JEL. A review of environmental enrichment for pigs housed in intensive housing systems. *Appl Anim Behav Sci*. 2009;116(1):1-20. doi:10.1016/j.applanim.2008.08.001
6. Bizeray D, Estevez I, Leterrier C, Faure, J.M. Effects of increasing environmental complexity on the physical activity of broiler chickens. *Appl Anim Behav Sci*. 2002;79(1):27-41. doi:https://doi.org/10.1016/S0168-1591(02)00083-7
7. Ventura BA, Siewerdt F, Estevez I. Access to barrier perches improves behavior repertoire in broilers. *PLoS One*. 2012;7(1). doi:10.1371/journal.pone.0029826
8. Bailie CL, O'Connell NE. The influence of providing perches and string on activity levels, fearfulness and leg health in commercial broiler chickens. *Animal*. 2015;9(4):660-668. doi:10.1017/S1751731114002821
9. Norring M, Kaukonen E, Valros A. The use of perches and platforms by broiler chickens. *Appl Anim Behav Sci*. 2016;184:91-96. doi:10.1016/j.applanim.2016.07.012
10. Ventura BA, Siewerdt F, Estevez I. Effects of barrier perches and density on broiler leg health, fear, and performance. *Poult Sci*. 2010;89(8):1574-1583. doi:10.3382/ps.2009-00576
11. Malchow J, Puppe B, Berk J, Schrader L. Effects of elevated grids on growing male chickens differing in growth performance. *Front Vet Sci*. 2019;6(JUN). doi:10.3389/fvets.2019.00203
12. Malchow J, Berk J, Puppe B, Schrader L. Perches or grids? What do rearing chickens differing in growth performance prefer for roosting? *Poult Sci*. 2019;98(1):29-38. doi:10.3382/ps/pey320
13. de Jong IC, Blaauw XE, van der Eijk JAJ, et al. Providing environmental enrichments affects activity and performance, but not leg health in fast- and slower-growing broiler chickens. *Appl Anim Behav Sci*. 2021;241:105375. doi:10.1016/j.applanim.2021.105375
14. Kells A, Dawkins MS, Borja MC. The Effect of a "Freedom Food" Enrichment on the Behaviour of Broilers on Commercial Farms. *Anim Welf*. 2001;10:347-356.
15. Riber AB, Van De Weerd HA, De Jong IC, Steinfeldt S. Review of environmental enrichment for broiler chickens. *Poult Sci*. 2018;97(2):378-396. doi:10.3382/ps/pex344
16. Kaukonen E, Norring M, Valros A. Perches & elevated platforms in commercial broiler farms: Use & effect on walking ability, incidence of tibial dyschondroplasia & bone mineral content. *Animal*. 2017;11(5):864-871. doi:10.1017/S1751731116002160
17. Baxter M, Richmond A, Lavery U, O'Connell NE. Investigating optimal levels of platform perch provision for windowed broiler housing. 2020. doi:10.1016/j.applanim.2020.104967
18. Bailie CL, O'Connell NE. The effect of level of straw bale provision on the behaviour and leg health of commercial broiler chickens. *Animal*. 2014;8(10):1715-1721. doi:10.1017/S1751731114001529
19. Bailie CL, Ball MEE, O'Connell NE. Influence of the provision of natural light and straw bales on activity levels and leg health in commercial broiler chickens. *animal*. 2013;7(4):618-626. doi:10.1017/s1751731112002108
20. Bizeray D, Estevez I, Leterrier C, Faure JM. Influence of increased environmental complexity on leg condition, performance, and level of fearfulness in broilers. *Poult Sci*. 2002;81(6):767-773. doi:10.1093/ps/81.6.767
21. Zhao JP, Jiao HC, Jiang YB, Song ZG, Wang XJ, Lin H. Cool perches improve the growth performance and welfare status of broiler chickens reared at different stocking densities and high temperatures. *Poult Sci*. 2013;92(8):1962-1971. doi:10.3382/ps.2012-02933
22. Kiyama Z, Küçükylmaz K, Orojpour A. Effects of perch availability on performance, carcass characteristics, and footpad lesions in broilers. *Arch Anim Breed*. 2016;59(1):19-25. doi:10.5194/aab-59-19-2016
23. Bokkers EAM, Koene P. Behaviour of fast- and slow growing broilers to 12 weeks of age and the physical consequences. *Appl Anim Behav Sci*. 2003;81(1):59-72.
24. Dawson LC, Widowski TM, Liu Z, Edwards AM, Torrey S. In pursuit of a better broiler: a comparison of the inactivity, behavior, and enrichment use of fast- and slower growing broiler chickens. *Poult Sci*. 2021;100(12). doi:10.1016/j.psj.2021.101451
25. Baxter M, Richmond A, Lavery U, O'Connell NE. A comparison of fast growing broiler chickens with a slower-growing breed type reared on Higher Welfare commercial farms. *PLoS One*. 2021;16(11 November). doi:10.1371/journal.pone.0259333
26. Global Animal Partnership. *Global Animal Partnership's 5-Step® Animal Welfare Standards for Chickens Raised for Meat v3.2.*; 2020. <https://globalanimalpartnership.org/wp-content/uploads/2020/05/G.A.P.s-Animal-Welfare-Standards-for-Chickens-Raised-for-Meat-v3.2.pdf>.

- Accessed March 14, 2022.
27. Altan O, Seremet C, Bayraktar H. The effects of early environmental enrichment on performance , fear and physiological responses to acute stress of broiler. *ArchGeflügelk.* 2013;77(1):23-28.
 28. Bach MH, Tahamtani FM, Pedersen IJ, Riber AB. Effects of environmental complexity on behaviour in fast-growing broiler chickens. *Appl Anim Behav Sci.* 2019;219. doi:10.1016/j.applanim.2019.104840
 29. Baxter M, O'Connell NE. Does grouping environmental enrichments together affect the way they are used by commercially housed broiler chickens? *Appl Anim Behav Sci.* 2019;210:52-59. doi:10.1016/j.applanim.2018.10.017
 30. Bailie CL, Baxter M, O'Connell NE. Exploring perch provision options for commercial broiler chickens. *Appl Anim Behav Sci.* 2018;200:114-122. doi:10.1016/j.applanim.2017.12.007
 31. Wood-Gush DGM, Duncan IJH. Some behavioural observations on domestic fowl in the wild. *Applied Anim Ethol.* 1976;2(3):255-260. doi:https://doi.org/10.1016/0304-3762(76)90057-2
 32. Sandilands V, Wang CP, Sparks N. Perching behaviour in broiler chickens exposed to two different perch designs. In: *Proceedings of the 50th Congress of the International Society of Applied Ethology.* Edinburgh, UK; 2016:P253.
 33. Bokkers EAM, Koene P. Behaviour of fast- and slow growing broilers to 12 weeks of age and the physical consequences. *Appl Anim Behav Sci.* 2003;81(1):59-72. doi:10.1016/S0168-1591(02)00251-4
 34. Baxter M, Bailie CL, O'Connell NE. An evaluation of potential dustbathing substrates for commercial broiler chickens. *Animal.* 2018;12(9):1933-1941. doi:10.1017/S1751731117003408
 35. Poultry Extension Collaborative (PEC). Modifications to broiler chicken housing to improve animal welfare. *PEC Newsl.* 2020;5(August):1-5. https://www.poultry-welfare-extension.com/uploads/2/5/6/3/25631086/pec_newsletter_vol._5__august_20_.pdf.
 36. Forslind S, Blokhuis HJ, Riber AB. Disturbance of resting behaviour of broilers under different environmental conditions. *Appl Anim Behav Sci.* 2021;242(June):105425. doi:10.1016/j.applanim.2021.105425
 37. Baxter M, Bailie CL, O'Connell NE. Play behaviour, fear responses and activity levels in commercial broiler chickens provided with preferred environmental enrichments. *Animal.* 2019;13(1):171-179. doi:10.1017/S1751731118001118
 38. Tahamtani FM, Pedersen IJ, Toïnon C, Riber AB. Effects of environmental complexity on fearfulness and learning ability in fast growing broiler chickens. *Appl Anim Behav Sci.* 2018;207:49-56. doi:10.1016/j.applanim.2018.04.005
 39. Anderson MG, Campbell AM, Crump A, Arnott G, Newberry RC, Jacobs L. Effect of environmental complexity and stocking density on fear and anxiety in broiler chickens. *Animals.* 2021;11(8):1-16. doi:10.3390/ani11082383
 40. Estevez I, Tablante N, Pettit-Riley RL, Carr L. Use of cool perches by broiler chickens. *Poult Sci.* 2002;81(1):62-69. doi:10.1093/ps/81.1.62
 41. Riber AB, van de Weerd HA, de Jong IC, Steinfeldt S. Review of environmental enrichment for broiler chickens. *Poult Sci.* 2018;97(2):378-396. doi:10.3382/ps/pex344
 42. Nazareno AC, da Silva IJO, Delgado EF, Machado M, Pradella LO. Does environmental enrichment improve performance, morphometry, yield and weight of broiler parts at different ages? *Rev Bras Eng Agric e Ambient.* 2022;26(4):292-298. doi:10.1590/1807-1929/agriambi.v26n4p292-298
 43. Bench CJ, Oryschak MA, Korver DR, Beltranena E. Behaviour, growth performance, foot pad quality, bone density, and carcass traits of broiler chickens reared with barrier perches and fed different dietary crude protein levels. *Can J Anim Sci.* 2017. doi:10.1139/cjas-2015-0202
 44. Akşit M, Kaçamaklı Yardım Z, Yalcın S. Environmental enrichment influences on broiler performance and meat quality: Effect of light source and providing perches. *Eur Poult Sci.* 2017. doi:10.1399/eps.2017.182
 45. Souza da Silva C, de Jong I. Literature update on effective environmental enrichment and light provision in broiler chickens. 2019:Report 1204.
 46. LeVan NF, Estevez I, Stricklin WR. *Use of Horizontal and Angled Perches by Broiler Chickens.* Vol 65.; 2000. www.elsevier.com/locate/applanim. Accessed March 20, 2020.
 47. Royal Society for the Prevention of Cruelty to Animals UK. *RSPCA Welfare Standards for Meat Chickens.*; 2017. <https://science.rspca.org.uk/documents/1494935/9042554/RSPCA+welfare+standards+for+meat+chickens+%288.48+MB%29.pdf/e7f9830d-aa9e-0908-aebd-2b8fbc6262ea?t=1557668435000>.
 48. van der Eijk JAJ, Almekinders TAA, de Jong IC. Rest and activity enrichment use by slower-growing broilers; A pilot study. *Wageningen Livest Res Public Rep.* 2021:5-24.
 49. Berghout J, Roland W, Vollebregt M, Koene M, De Jong I. Towards a safe and sustainable poultry production chain. *South African J Anim Sci.* 2007;37(4):215-220. www.wageningenUR.nl/livestockresearch.
 50. Wiers WJ, Kiezenbrink M, Middlekoop KV. Slow growers are more active. *World Poult.* 2001;17(8):28-29.
 51. European Food Safety Authority (EFSA). Scientific Opinion on welfare aspects of the use of perches for laying hens. *EFSA J.* 2015;13(6):1-70. doi:10.2903/j.efsa.2015.4131
 52. de Jong IC, Van Wijhe-Kiezebrink MC. Use of different types of enrichment in slower growing broilers : a pilot study. 2014:39. <https://edepot.wur.nl/318861>.
 53. Lubing system SRL. Broiler perch systems for floor housing. https://lubingsystem.com/wp-content/uploads/Broiler_Perch_systems_for_Floor_Housing_LUBING.pdf. Accessed July 10, 2022.
 54. Dawkins MS. *Time Budgets in Red Junglefowl as a Baseline for the Assessment of Welfare in Domestic Fowl.*; 1989.
 55. Guy JH, Wright AN. Effect of enrichment with pecka-blocks™ on the behavior and feather condition of commercially-reared broilers. *Br Poult Sci.* 2003;44:29-30.
 56. Bergmann S, Schwarzer A, Wilutzky K, et al. Behavior as welfare indicator for the rearing of broilers in an enriched husbandry environment—A field study. *J Vet Behav Clin Appl Res.* 2017;19:90-101. doi:10.1016/j.jveb.2017.03.003
 57. Bergmann S, Schwarzer A, Wilutzky K, et al. Behavior as welfare indicator for the rearing of broilers in an enriched husbandry environment—A field study. *J Vet Behav Clin Appl Res.* 2017. doi:10.1016/j.jveb.2017.03.003
 58. Global Animal Partnership. *Global Animal Partnership's Better Chicken Project: Broiler Chicken Assessment Protocol v1.0.*; 2021. www.globalanimalpartnership.org/standards/chicken. Accessed March 14, 2022.
 59. Jordan D, Stuhec I, Bessei W. Effect of whole wheat and feed pellets distribution in the litter on broilers' activity and performance. *Arch fuer Gefluegelkd.* 2011;75(2):98-103.
 60. Wood B, Rufener C, Makagon MM, Blatchford RA. The utility of scatter feeding as enrichment: Do broiler chickens engage with scatter-fed items? *Animals.* 2021;11(12):1-10. doi:10.3390/ani11123478
 61. Pichova K, Nordgreen J, Leterrier C, Kostal L, Moe RO. The effects of food-related environmental complexity on litter directed behaviour, fear and exploration of novel stimuli in young broiler chickens. *Appl Anim Behav Sci.* 2016;174:83-89. doi:10.1016/j.applanim.2015.11.007
 62. Stichting Beter Leven keurmerk. Beter Leven broiler chicken -1 star version 5.1.d.d. 01.09.2016. 2016:3-9. <https://beterleven.dierenbescherming.nl/zakelijk/wp-content/uploads/sites/2/2021/07/Broilers-1-star-version-2.1-d.d.-01-09-2016.pdf>.

63. Featherwel. Pecking objects. Feed & Enrichments. <https://www.featherwel.org/featherwel/feedenrichments/peckingobjects.html>.
64. Arnould CD, Bizeray J, Faure M, Leterrier C. Effects of the addition of sand and string to pens on use of space, activity, tarsal angulations, and bone composition in broiler chickens. *Anim Welf.* 2004;13:87-94.
65. de Jong IC, Gunnink H. Effects of a commercial broiler enrichment programme with or without natural light on behaviour and other welfare indicators. *Animal.* 2019;13(2):384-391. doi:10.1017/S1751731118001805
66. Bailie CL, Ijichi C, O'Connell NE. Effects of stocking density and string provision on welfare-related measures in commercial broiler chickens in windowed houses. *Poult Sci.* 2018;97(5):1503-1510. doi:10.3382/ps/pey026
67. Kruigt JP. *Ontogeny of Social Behaviour in Burmese Red Junglefowl (Gallus Gallus Spadiceus Bonnatere)*. Vol 12.; 1964.
68. Vestergaard KS, Skadhauge E, Lawson LG. The stress of not being able to perform dustbathing in laying hens. *Physiol Behav.* 1997;62(2):413-419.
69. Shields SJ, Garner JP, Mench JA. Effect of sand and wood-shavings bedding on the behavior of broiler chickens. *Poult Sci.* 2005;84(12):1816-1824. doi:10.1093/ps/84.12.1816
70. Baxter M, Bailie CL, O'Connell NE. Evaluation of a dustbathing substrate and straw bales as environmental enrichments in commercial broiler housing. *Appl Anim Behav Sci.* 2018;200:78-85. doi:10.1016/j.applanim.2017.11.010
71. de Jong IC, Gunnink H, van Harn J. Wet litter not only induces footpad dermatitis but also reduces overall welfare, technical performance, and carcass yield in broiler chickens. *J Appl Poult Res.* 2014;23(1):51-58. doi:10.3382/japr.2013-00803