WHITE PAPER ON THE FAILURE OF CAGE-FREE HOUSING SYSTEMS TO REDUCE OVERALL HEN SUFFERING

PEOPLE FOR THE ETHICAL TREATMENT OF ANIMALS

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Executive Summary

The time has come to acknowledge that the well-intentioned move to compel the egg industry to switch from traditional battery cages to alternative cage-free housing systems has failed to achieve more than minimal improvements in hen welfare and, in some cases, can create distinct or worse welfare problems than the caged systems they replaced. This transition and the marketing of cage-free options have left consumers with a false impression of "happy" hens who can perform a full range of natural behaviors. Despite marketing claims, stocking density, poor building design, and flock size in industrial cage-free systems limit high-quality expression of a full range of natural behaviors, such as the ability to stretch and preen wings, roost, scratch, peck, forage, dust-bathe, socialize, and more. Cage-free certifications and labels mislead consumers into believing that cage-free hens behave like hens in their natural environments. The egg industry encourages and profits from this fiction, which is perpetuated through deceptive humane labeling, promoted in studies that respond to industry concerns to increase productivity and profit, and legitimized by animal welfare organizations that secure corporate cage-free commitments.

Cage-free housing cannot achieve good animal welfare because it exists within a larger industrial system that exploits hens and causes them great suffering at every stage of their lives. It simply removes battery cages but transforms the same factory farm shed into one large cage. Cage-free environments involve most of the same abuses found in conventional housing, such as permanently damaging the sensitive tips of hens' beaks by searing or burning them off with a blade or infrared light and inducing molting to maximize a hen's egg production. It similarly depends on the cruelties of industrial hatchery and genetic selection to maximize production and exploit hens' bodies to their biological limits and beyond.

In artificially lit and severely crowded non-cage housing, where space allowances can prevent the average hen from turning around freely and spreading her wings or traveling to another section of a barn without bumping into or infringing on the space of another hen, pecking is the one natural behavior that remains after the pecking order has fallen to pieces.

Cage-free confinement also introduces welfare problems that are worse than in caged systems, such as increased immunosuppression and chronic respiratory infections and skin lesions caused by ammonia-saturated air, wet loose litter, and higher levels of pathogenic particulate matter. This dust is disturbed by mass movement, dustbathing, and pecking on open flooring, increasing the risk of barn fires in addition to widespread contagion and, consequently, the mass killing of infected flocks due to heatstroke and suffocation from the standard industry practice of ventilation shutdown (VSD/VSD+). Uncaged hens are vulnerable to higher rates of injurious, severe, and cannibalistic feather, toe, and cloacal pecking, leading to chronic pain, infection, loss of the ability to regulate body heat, cannibalism, and even death.

In flocks numbering in the tens of thousands, each hen is provided with only between 1 and 1.5 square feet of floor space. This confinement, combined with large flock sizes, breeds aggression and resource competition. Hens' natural behavioral synchronization leads to piling and suffocation. Debilitating keel-bone fractures and breaks often occur when hens fall or are pushed or jostled by other hens from perches and nest boxes. Competition for next boxes causes piling and even death from suffocation due to smothering. As a result of resource competition, hens in cage-free systems lay a portion of their roughly 300 eggs per year on the floor. These hens will never brood or experience motherhood. When a new generation of hens is hatched in mechanized incubators, they are born without the presence of their mothers, which deprives the chicks of learning vocalizations that would help them manage fear and stress responses throughout their lives. These motherless chicks are once again traumatized by being separated from the chicks they imprinted on at a hatchery when they are roughly loaded and transported to egg factories. This dystopian cycle of chronic stress, frustration, pain, suffering, aggression, and death by cannibalism, disease, and slaughter repeats with each generation of chicks born into the egg industry, whether destined for a battery cage or a cage-free facility.

Confining hens to battery cages was always ethically untenable, but so was the alternative presented by cage-free campaigns; neither option should be supported or promoted. Instead, anyone who believes hens' suffering is unacceptable should commit to supporting efforts to eliminate their exploitation for eggs in the first place.

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Introduction

In the 1830s, selectively bred hens laid between 50 and 175 eggs each year. From the 1860s to the 1890s, especially in the U.S., a new group of commercial breeders began selecting for traits such as high productivity and rapid growth.[1] It was during this period that the concept of the "laying hen" emerged. This construction reduced the chicken to her reproductive traits and eventually restricted her behavior, weakened her musculoskeletal system, prevented hens from experiencing positive affective states, and introduced chronic stress.[2,3]

Over the past century, hens' average egg production doubled from 150 eggs per hen in the 1930s[4] to 301 in 2024.[5] Their ancestor, the red jungle fowl (*Gallus gallus*), laid only about 10 to 15 eggs per year. Today's genetically selected hens (*Gallus gallus domesticus*) reach sexual maturity earlier and can produce over 350 eggs annually.[6] In 2024, U.S. table egg production totaled 93.1 billion. Per capita egg consumption has increased 15% over the past 20 years, from 255 in 2004 to 273 in 2024.[7]

Based on the 2022 Census of Agriculture data published by the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service and the U.S. Environmental Protection Agency's (EPA) definitions of concentrated animal feeding operations (CAFOs), an estimated 98% of "egg-laying" hens in the U.S. live on factory farms.[8] Of the 240,530 egg factories in the U.S. included in the 2022 census, 347 operations housed 75,000 or more hens, which accounted for more than 75% of the total hen population. Another 23% are housed in operations with up to 75,000 hens.[9]

The United Egg Producers' (UEP) certified cage-free requirements for indoor floor space are one hen per 1 square foot (144 square inches) in indoor housing systems that provide hens with access to vertical space. In single-level, all-litter floor systems, the density is one hen per 1.5 square feet (216 square inches) of usable floor space.[10]

As of August 1, 2025, the total number of "layers" in the U.S. was 362 million, of which 297 million produced table or market-type eggs.[11] As of September 1, 2025, the estimated U.S. non-organic commercial cage-free table egg flock was 116.6 million, 38.7% of the current U.S. table egg flock. The ratio of caged to cage-free "layers" is 55/45.[12]

Ten U.S. states have laws requiring that cage-free systems replace traditional cages or prohibiting the sale of eggs from caged hens, effectively creating a cage-free market in those states.[13] Yet these are not the states where most hens are raised on factory farms.[14] The USDA's Agricultural Marketing Service estimates that 76% of U.S. hens need to be in cage-free production by 2026 to meet projected consumer demand.[15]

Bare wire cages or "battery cages" offered industry benefits such as lower food conversion ratios, reduced disease risk without litter, and better egg quality.[16] Although caging was once thought to be unnatural, irrational, or doomed to fail, the testing of prolonged caging of hens in smaller groups to improve hen health, survivability, and egg production was justified under the guise of protection against weather, predators, and disease.[17] However, the significant welfare issues of cages gained public attention after Ruth Harrison's 1964 book *Animal Machines* exposed the problems in intensive factory farm systems. Over the following 40 years, research into cage welfare increased, public awareness grew, and governments began banning battery cages, starting with Switzerland in 1992, well ahead of the European Union's (EU) 1999 phase-out, which was completed in 2012.[18,19]

Scientific research on hen social stress and welfare increased after the publication of Harrison's book and then the British government's 1965 Brambell Report. Founded in 1967, Compassion in World Farming (CIWF) lobbied against industrial farming and battery cages but was largely ignored.[20] Despite clear evidence from animal welfare scientists of the many shortcomings, including both obvious and subtle effects on hen well-being, such as disruptions in social behavior and stocking densities, hen stress behaviors, injuries from living environment designs and social interactions, and skeletal weaknesses, factory farms became the main method for raising animals for profit.[21,22,23]

Cage-free multi-tiered aviary systems are usually open-plan setups with an open floor, litter, nest boxes, and elevated areas.[24] Aviary-style barns have rows of equipment running the length of the facility, containing nest boxes, feeders, waterers, open-wire floors, and perches. There is typically a manure belt running between each layer of the equipment and a scratch area between rows. The layout and design can vary greatly. Some systems have doors on the rows of equipment that can be closed to contain the birds, whereas others do not restrict them.[25]

Like conventional cage systems, most non-cage systems feature tiered structures to create vertical space within indoor barn houses instead of additional flooring space. Eggs packed in USDA grade-marked consumer packages labeled as cage-free are "laid by hens [who] are able to roam vertically and horizontally in indoor houses and have access to fresh food and water." In addition, "They must allow hens to exhibit natural behaviors and include enrichments such as scratch areas, perches and nests. Hens must have access to litter, protection from predators and be able to move in a barn in a manner that promotes bird welfare."[26] Cage-free housing systems are highly variable due to different management practices, labeling schemes, and welfare certifications, which can lead to discrepancies in how birds are managed across these systems.[27] Various selection pressures have molded current domesticated hen strains, including greater egg production, egg quality, feed efficiency, longevity, and behavior.[28]

The Problem of Cage-Free Housing Systems

The increased complexity of managing cage-free systems has led to significant challenges in achieving or surpassing cage welfare standards. Welfare in cage-free systems varies considerably and depends on the steep learning curve in management, genetic selection, welfare research, and the design and maintenance of a wide variety of housing environments.[29] No single factory farm housing system is ideal from the perspective of a hen's welfare.[30] Although environmental complexity increases hens' behavioral repertoire, it also increases the risk of infectious disease outbreaks. Non-cage confinement can create opportunities for the stressed hens to express behaviors that are harmful to their well-being.

Although cage-free systems have been praised by some animal welfare organizations as a significant improvement in hen welfare and a preferable alternative to battery cages, cage-free systems shift—rather than eliminate—welfare burdens, improving some welfare outcomes while worsening others. Hens in cage-free systems are comparatively more immunocompromised because they breathe in high levels of pathogenic dust, ammonia, and particulate matter. The accumulation of dust and feathers in electrical systems contributes to a high incidence of barn fires. Cage-free hens have higher rates of injury, particularly keel bone fractures and injurious pecking. They are more likely to develop hypocalcemia (below normal levels of calcium in the blood), and high stocking densities lead to an increased risk of contracting bird flu (HPAI), which invariably leads to cruel mass slaughter methods.

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The shift to cage-free systems has created economic opportunities for the egg industry. Welfare studies that focus on floor laying and pecking help egg producers address productivity and profit losses associated with the shift to cage-free systems.[31] Cage-free labels allow the egg industry to charge a premium while signaling to consumers that these "specialty" eggs are laid by "happy" hens and, therefore, acceptable for kind people to buy. The industry clearly demonstrated this marketing approach in a recent comprehensive report on transitioning to cage-free systems, funded by UEP, the Food Industry Association, the Food Marketing Institute Foundation, and the United Egg Association. The report states that cage-free marketing offers an opportunity for an industry "reset" in how consumers and the animal activist community perceive the industry.[32,33] Cage-free welfare assurances mask the failure of this approach to meaningfully reduce overall hen suffering. Instead, "cage-free" functions as an industry tool to stabilize and expand markets and support overall industry growth.

To understand the cruelty of confinement in cage-free egg factories, it is essential to examine the nature of chickens, including their complex social structures, biological rhythms, preferences for behavioral symmetry, and intrinsic motivations, and then to compare all these aspects with findings from welfare studies. Scientific literature shows no evidence that the cognitive abilities and complex behaviors of highly selected breeds of chickens in industrial farming differ significantly from those of their wild ancestors.[34] We must also recognize that the idea of the "laying hen" is an industry invention that masks breeding practices designed to maximize egg-laying rates across housing systems. Cage-free labels fail completely to address the cruelty of industrial hatcheries that kill male chicks and replace "spent" hens from cage and non-cage systems with chicks whose sensitive beak tips have been removed and who are deprived of critical social and emotional learning opportunities from their mothers and older chickens.

Analysis

PART I: THE EFFECTS OF TOXICITY AND PATHOGENIC DISEASE ON THE BODIES AND BEHAVIOR OF HENS

A. Pecking, Foraging, and Dustbathing in Pathogenic Dust and Wet Litter

Cage-free housing systems are primarily indoor systems with limited or no outdoor access. Certified cage-free guidelines from the UEP address only indoor housing components.[35] The large amount of feed, litter, and excrement—combined with dustbathing and foraging behavior and increased bird movement in alternative systems—leads to higher concentrations of bacteria and fungi in the air and increased levels of dust.[36,37] According to the American Veterinary Medical Association (AVMA), the daily average indoor ammonia (NH_3) levels, dust, and particulate matter emissions were all higher in cage-free aviaries than in systems with cages.[38] Studies show that birds can detect ammonia in the air and prefer to avoid it. When given a choice, they prefer fresh air over air with between 25 ppm (a recommended upper-boundary limit set for human safety rather than animal welfare) and 45 ppm ammonia and perform significantly more foraging, preening, and resting behaviors in fresh air.[39]

Particulate matter $(PM)_{10}$ levels in cage-free housing can be up to 1,000 times higher than in ambient air.[40] High dust levels have been associated with more severe pulmonary lesions, typical of chronic bronchitis, in cage-free birds.[41] The most profound effects of ammonia, a colorless, highly irritant alkaline gas,[42] from decomposing manure and "poultry dust" from feathers and skin, dried manure, feed, and litter material, are respiratory irritation and conjunctivitis. The saturated dust in cage-free barns carries toxins and disease organisms.[43] Inhalation also causes painful skin conditions as well as pulmonary congestion, swelling, hemorrhages, and blindness.[44] When ammonia interacts with the epithelial cells of the trachea, it causes lesions. The loss of tracheal cilia, tiny hair-like structures that prevent pathogens from entering the respiratory system, reduces the effectiveness of the respiratory system's innate immune response.[45] PM_{10} is a regulated air pollutant under the Clean Air Act that also impacts the health of workers in egg factories.[46,47,48] When ventilated into the surrounding air, fine particulate matter that forms in the air from ammonia emissions can affect public health.[49,50]

Birds have innate needs to peck, forage, and explore their environment. Modern strains of hens can spend around 40% of the day in foraging activities.[51] It has been claimed that pecking substrate (material specifically provided for foraging and stimulation) spread on the floor acts as "enrichment" that fulfills these needs, preventing frustration and encouraging natural behaviors. Yet the same loose litter scattered on the floor of barns that is said to allow hens to scratch, dust-bathe, and forage plays a role in ammonia control by absorbing feces and moisture.

Immunological data suggest that floor pens may lead to compromised immune systems. Not all commercial housing systems include foraging materials designed to encourage exploratory behavior (e.g., straw bales, pecking blocks, scattered grains, or turf mats), leading to a lack of enrichment and frustration expressed by feather pecking.[52]

Cage-free housing systems, whether single-tiered or multi-tiered, which allow for horizontal movement, are characterized by a litter or "floor" area. Typically, the feed and water are provided over wire flooring.[53] Scattered litter like dry wood shavings, sawdust, shredded papers, corn cob, straw, rice and peanut hulls, gypsum, or sand helps absorb moisture from excrement, provides a surface for dustbathing, improves air quality, and lowers ammonia levels.[54] However, wet litter can cause problems like footpad dermatitis and hock burns at the joints that are crucial for a bird's mobility. If foot lesions become infected, a painful foot inflammation called bumblefoot can develop. Hens may also develop foot issues from standing on wire, leading to hyperkeratosis (a thickening of the foot pad) and cracks that can become inflamed or infected.[55]

In addition to skeletal disorders, the prevalence of foot problems, such as footpad dermatitis (FPD), also varies between housing systems. FPD is an inflammation of the plantar surface of hens' footpads, mostly studied in broiler chickens, but it can also affect laying hens. Footpad dermatitis often results from wet litter and is thus commonly linked to litter-based housing systems. This lesion can develop into arthritis, frequently spreading to upper joints, which increases the severity of lameness and reduces feed intake, leading to slow, chronic debilitation.[56]

B. Biological Rhythms in Artificially Lit Barns

Light significantly influences many aspects of avian biology, physiology, and behavior. Lighting is of particular interest to researchers because it benefits producers economically, as light can influence feed consumption and growth rate.[57] The "management" of lighting—such as hours of light, light wavelengths, or light distribution—has been used to speed up embryo development, to promote skeletal growth and weight gain through exposure to constant light, and to try to regulate the circadian rhythm of bird species, most of which are diurnal and naturally experience changes in light intensity related to daily, lunar, or seasonal cycles. Sleep "disruption" has also been observed.[58] As hens have been bred for unnaturally high performance, the temperature and light are controlled to eliminate major seasonal variations.[59] Since hens depend on light to stimulate the hormonal activity on which egg formation depends,[60] UEP guidelines mandate a lighting period of no greater than 18 continuous hours in closed barns[61] to simulate the longest days of summer.

In indoor systems, hens are raised under artificial lighting that may provide unusual photoperiods or low levels of illumination to enhance productivity and reduce cannibalism. This can affect the

birds' eye structure (eye enlargement) and potentially negatively impact their ability to perform normal behaviors.[62] The hours of lighting, light wavelengths, and light distribution affect circadian activity as well as hen aggression and space usage, which can lead to piling (overcrowding), smothering, and high losses of hens.[63]

C. Cage-Free but Confined: Stocking Densities and Their Effect on Hen Welfare

Chickens distinguish between members of their social group, indicating that they recognize each individual. Chickens can also keep track of their pecking order and recognize who is a part of the group and who is not.[64] For both the red jungle fowl and wild or free-ranging domestic chickens, social groups consist of one dominant male, one dominant female, lower-ranking chickens of both sexes, and chicks.[65] Each chicken understands his or her place in the social hierarchy, recognizing the faces and ranks of over a hundred other birds.[66] In high stocking densities, stable hierarchies based on individual recognition cannot form.

Animal management practices are designed to maximize profit by cramming as many animals into facilities as can profitably be made to fit. The result is an assembly-line mentality that disregards animal interests and treats each animal as an industrial input rather than a sentient individual.[67] High stocking densities restrict the space available to each hen. The social environment presents challenges due to the large group size, which can lead to competition for resources like food, water, and nests; feather pecking; cannibalism; and excessive aggression.[68] One study found that stocking density influenced every behavior examined. Birds in high-density barns perform fewer comfort behaviors and are more likely to participate in pecking and piling behaviors compared to those in low-density barns.[69] Behavior restrictions can also occur in non-cage systems due to management issues like high stocking density.[70]

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While increased indoor space may promote some hen behaviors linked to better well-being, such as walking, stretching, perching, and dustbathing, it can also lead to harmful behaviors like feather pecking and aggression due to the rise in social interactions among the hens within the group.[71] One study measuring the isolated movement of a single hen shows that 1 square foot of space prevents the average hen from turning around freely, and even 1.5 square feet does not allow her to spread her wings fully. It also does not account for the space that hens may need for longer movements to access resources like food, water, perches, and nest boxes.[72]

Within a group, hens tend to synchronize behaviors such as dustbathing, foraging, egg laying, and perching. When most birds are engaged in the same activity at the same time, it can result in uneven distributions of birds across a housing system. Depending on the availability of resources like feeders, perches, and nest boxes, it can lead to either increased or decreased competition and stress due to conflicts.[73] Dense "clustering," or crowding of hens mainly along walls, in corners, and at entrances, can result in smothering and high mortality.[74,75]

In non-cage housing systems, with stocking densities of more than 10,000 birds in a single barn, there is increased risk and incidence of feather pecking and cannibalism. With such large numbers, a subgroup of birds has poor welfare due to bullying from others, which prevents them from feeding and increases their fear of other birds.[76,77] One study estimated that the minimum surface area needed to avoid negative welfare effects from aggression and injurious pecking in a group size larger than 30 is 80 m^2 per bird (approximately 860 square feet). Barren environments and a lack of elevated structures are hazards because they limit the options for targeted birds to escape or hide.[78]

D. The HPAI Outbreak and Mass Killing Through Heatstroke and Suffocation

Litter-floor aviary housing systems and increased bird movement within them increase the risk of contracting and spreading infectious diseases.[79] Bird health can also be negatively affected in non-cage systems by an elevated risk of bacterial and fungal infections spreading among birds.[80] Large flock sizes, such as those housing 100,000 or more hens in a single barn, and overcrowding increase the risk of spreading disease, including the highly pathogenic avian influenza (HPAI) virus.[81]

The current HPAI outbreak is the largest and most costly animal health crisis in U.S. history.[82] Since 2022, it has affected more than 182.9 million birds.[83] In the first 10 months of 2025, HPAI in commercial table egg layer flocks led to the mass killing of more than 41 million birds. Of these, 60% of hens (24,651,320) were in cages and 40% (16,750,480) were cage-free.[84] According to an April 2025 congressional report, which included USDA Animal and Plant Health Inspection Service (APHIS) data, "table-egg-laying" hen flocks account for approximately 75% of the total domestic poultry loss.[85]

The H5N1 strain of HPAI has a mortality rate in birds of nearly 100%.[86] Under current APHIS policy, affected flocks must be depopulated within 24 to 48 hours of presumptive HPAI diagnosis. Large facilities often exceed the 48-hour deadline, typically by one to two weeks.[87] Infected birds show symptoms ranging from clinical signs of depression, apathy, lethargy, listlessness, huddling together with ruffled feathers, cyanosis of combs and waddles (bluish discoloration due to poor oxygenation), and brain, head, and face edema or swelling to tremors, gross lesions, and necrosis in the brain, pancreas, liver, and spleen.[88,89,90]

As of January 2025, APHIS had disbursed approximately $1.46 billion in indemnity payments and other compensation linked to the H5N1 outbreak. Of this sum, $1.138 billion was paid for the value of culled birds and eggs (second spending site), the majority of which went to a handful of top producers.[91,92]

Mass killing or "depopulation" through VSD+ (ventilation shutdown plus heat, CO_2, or heat and CO_2) involves sealing off the airflow in barns, turning off the fans, and raising the temperature. Body heat from the flock raises the temperature, increasing the latent temperature in the house until animals die from hyperthermia, which leads to heatstroke and suffocation that may result from any combination of excessive temperature, excessive CO_2 in relation to oxygen, or toxic gases from slurry or manure below the barn. This process lasts for hours or even days due to factors such as the age and size of a barn, the insulation, the ventilation system, the number and size of the animals, and the ability to adequately seal fans, louvres, doors, and windows.[93] Chickens experiencing hyperthermia will demonstrate thermal panting to reduce their core body temperature, causing an excessive loss of CO_2, supplemented by rapid fluttering of the gular (throat), which can precipitate beak opening and closing, raising heads, and defecation with abundant loss of water.[94]

One recent study cites that the utilization of AVMA preferred depopulation methods—water-based foam generators, water-based foam nozzles, whole-house gassing, partial-house gassing, containerized gassing, cervical dislocation, mechanically assisted cervical dislocation, and captive-bolt guns[95]—may not always be feasible in cage-free systems due to the complicated structure of the building, size, resource availability, and concerns for worker safety. Additionally, carcass removal after mass depopulation in cage-free systems may be challenging due to the onset of rigor mortis, as hens have been observed grasping onto the metal structure with their feet.[96]

The same dust that harms hen health and acts as a vector for microorganisms and toxins also contributes to deadly barn fires. UEP cage-free guidelines address the "high incidence of electrical fires" caused by the buildup of dust and feathers in an electrical system, which is "the leading cause of layer barn fires … followed by heaters, human error, and spontaneous

combustion."[97] From 2022 to 2024, 98% of the 2.53 million farmed animals burned alive in barn fires were poultry, mainly hens in egg factories. Because official data on barn fires is limited due to a lack of consistent reporting requirements for farmers and fire departments, these are conservative estimates. The Animal Welfare Institute warns that until fire prevention and suppression measures are mandated across the sector, hundreds of thousands of animals will burn to death or die from smoke inhalation each year. In most cases where a cause was reported, the culprit was a malfunctioning or improperly used heating device or another electrical issue.[98]

PART II: THE NEW PECKING ORDER: REDIRECTED AGGRESSION, PECKING, AND CANNIBALISM

A. Foraging, Feeding, and Preening Without a Beak Tip

One of a hen's most vital sensory organs is her beak. With many nerve endings and a highly specialized, sensitive tip, the beak helps chickens make precise distinctions between objects they touch. Chickens also use their beaks to grasp and manipulate objects when eating, nesting, exploring, drinking, and preening. Since they use their beaks as tools to establish their social rank and defend themselves, the tips of chicks' beaks are removed while birds are still at a hatchery. Because of the beak's sensitivity, damage to it causes intense pain.[99]

The industry practice of beak "trimming," routinely conducted to reduce the prevalence and severity of injurious or cannibalistic pecking, offers clear economic benefits to producers. However, beak trimming (either with a hot blade or infrared methods) raises welfare concerns because it is painful and causes the beak to lose function and fail to give sensory feedback to hens.[100] Birds with the tips of their sensitive beaks removed tend to become more withdrawn and less active, engage in less pecking behavior, eat less, and grow more slowly than untrimmed birds. These changes are mainly due to sensory deprivation.[101] Both trimming by infrared or hot blade methods cause pain and can impair beak-related activities, such as eating, drinking, and removal of ectoparasites. For these reasons, several EU countries have banned or omitted beak "treatment."[102]

B. Injurious Pecking, Feather Loss, and Cloacal Cannibalism

In nature, chickens spend much of their time foraging and pecking. They respond emotionally to both the events they go through and those they anticipate. For example, chickens expecting a negative, neutral, or positive event display emotions that show their comfort or concern with what is about to happen.[103] In chronic psychological stress and fear response conditions, redirected feather and vent pecking is a major welfare problem in cage-free egg factories.

Frustrated, despondent, and stressed birds redirect their foraging behavior to the feathers of others around them.[104] When management is not tuned to behavioral programming in cage-free systems, there is a greater risk of injurious pecking developing.[105] One study maintains that aggressive pecking levels do not differ between housing systems. Surprisingly, mortality, feather pecking, and body wounds also showed no differences between systems.[106]

Injurious pecking is a serious concern for hen welfare in cage-free systems.[107] It describes damaging bird-to-bird pecking that results in feather damage, skin wounds, or tissue injury. It includes severe feather pecking (SFP), cloacal (vent) pecking, toe pecking, and aggressive pecking at the comb, head, or neck of other hens.[108] SFP, which causes feather loss, places hens at risk of cannibalistic pecking. In one study, parasitic infestation was significantly linked to plumage damage. Bacterial infections can also be related to poor feather coverage and skin injuries.[109] SFP, in which feathers

are damaged or removed, has been reported to affect over 50% of layer flocks in various European countries.[110] Hens with severe feather loss are more susceptible to skin injury,[111] impairing a bird's ability to regulate her body temperature and potentially leading to higher mortality.[112]

Injurious pecking that may progress to cannibalism remains one of the biggest animal welfare and economic challenges for non-cage housing systems.[113] The odds of flocks showing vent pecking or cannibalism increased with the rate of SFP. Vent pecking was more likely to be observed in housing with more and/or longer "pop-holes" (small openings or exits in buildings where hens can move between the inside of a barn and the outside) and where feed was scattered on the floor. Providing more aerial perch length, or perches > 0.5 m in height, was associated with an increased risk of vent pecking, which has implications for the impact of feeding management on feather pecking in hens in cage-free egg factories.[114]

Feather pecking is related to the time birds spend on feed intake and foraging.[115] Poor feather coverage not only can be painful because of direct skin exposure to potential trauma but also affects insulation, leading to greater heat loss and discomfort, making it another valuable welfare indicator. Feather loss in the cloacal region is often correlated with cannibalism in "laying" hens.[116]

Feather pecking involves birds pecking, pulling out, and sometimes eating the feathers of other birds. Researchers estimate that feather pecking occurs in 80% to 94% of cage-free flocks in the U.S. Behaviors like aggressive pecking, vent pecking, and cannibalism are categorized separately from feather pecking. Aggressive pecking is usually related to how birds establish social hierarchies and dominance. Vent pecking targets the rear of a bird and can lead to serious issues like "pick out," in which internal organs are removed, or even cannibalism among birds.[117]

Cloacal or "vent" cannibalism can be a major source of mortality in hen flocks. Cloacal or vent prolapse refers to the prolapse of the cloacal or vent area, sometimes associated with straining during laying or the passing of large eggs. The tissue becomes exposed and is at risk of damage and infection. Immediately after laying, the mucous membrane in the cloaca may be exposed for a while, presenting to other hens "an interesting fleshy and shining object to peck."[118] One study of commercial non-cage farms concluded that vent cannibalism, reduced feather cover, keel bone deformation, and beak abnormalities were the most frequent lesions, observed in ≥40% of hens. Other common lesions were cloacal prolapse (30.5%), footpad dermatitis (24.3%), and septicemia (23.1%).[119]

C. Roosting: Artificial Perches and Fractured Keel Bones

Perching is a natural predator-avoidance behavior. In natural environments, flock members live on a home range during their breeding season. Within that range, they have regular roosting sites that include the lofty branches of trees.[120] While bone strength is said to improve in non-cage systems,

issues with weak bones and fractures persist across all housing types. Artificially lit cage-free housing raises risks such as keel bone fractures from collisions and injuries when hens miss perches.[121] Between 9% and 21% of flights in cage-free aviary systems end in failed landings.[122] Bone fractures occur when hens fall or sustain injuries during flight by striking objects such as perches, feeders, drinkers, or nest boxes within a shed.[123]

Keel bone fractures (KBF) are a main welfare cost in cage-free systems, with incidence rates ranging between 85% and 97%. Keel bone damage occurs in up to 95% of hens in non-cage housing. KBF can lead to extensive pain and movement restriction and potentially be a cause of death.[124,125] Keel deviations and fractures have multiple causes and risk factors. Broad influences include genetics, nutrition, and housing. Specific risks may include external trauma, such as prolonged pressure on the keel and collisions as well as internal trauma, like the egg-laying process and vigorous wing flapping.[126] The ossification (the process of forming or hardening bone tissue) of the caudal part of the keel bone is not complete before birds reach 35 to 40 weeks old. After the onset of lay, studies have shown that there is a significant load on the immature bones, including the keel, with regards to positioning of the egg, calcium ion mobilization for the egg shell, and ossification of the immature keel bone.[127]

Damage to the keel bone significantly affects the growth, production, and behavior of hens and results in acute and prolonged suffering. Hens with keel bone disorders (e.g., wounds, soft tissue damage, fractures, and deviations)[128] are more likely to have impaired mobility, which leads to lower feed intake, reduced egg production, and poor eggshell quality. These hens may fail to reach nests, increasing the number of floor eggs and the risk of microbial contamination of eggs. The effective use of perches may also be limited in hens with severe keel bone damage. Hens with keel bone disorders may experience severe pain and discomfort, resulting in hormonal and hematological changes. Impaired mobility can cause hens to spend more time lying on litter on barn floors, increasing the risk of feather damage, bumblefoot, footpad dermatitis, and breast blisters.[129]

PART III: GENETIC SELECTION, ARTIFICIAL NESTS, AND MOTHERLESS HATCHING

A. Laying Rate, Musculoskeletal Degeneration, and Reproductive Disease

Laying rate, which equals the number of eggs laid divided by the number of days of the recording period, is the trait that has the highest economic weight in breeding programs for hens in egg factories.[130] In an ideal scenario for the egg industry, mature hens would produce one good-quality egg per day.[131] Commercial hens now lay about 320 eggs over a period of 70 to 80 weeks, with goals for 500 eggs in roughly 100 weeks.[132] Several viral pathogens that can impact the birds' health or induce reversible or irreversible lesions in the female reproductive organs adversely interfere with the egg industry's desired target.[133] Genetic selection leading to higher productivity induces chronic stress.[134] Selecting and managing hens for high egg production contributes to a high rate of skeletal disorders, especially susceptibility to long bone fractures and keel bone damage.[135] Today's laying hens have been selectively bred to produce an unnatural and unhealthy number of eggs, requiring significant amounts of calcium to produce egg shells[136] that deplete them of vital nutrients. Hens kept in cage-free environments are likely to develop hypocalcemia (low calcium levels in the blood).[137] For some breeds, the stress on their reproductive system is often fatal.[138]

Recurrent causes of hen mortality in egg factories include bacterial or parasitic infections and issues related to egg laying, such as salpingitis (severe infection, inflammation, and swelling of the oviduct or fallopian tubes), salpingo peritonitis (the spread of *Escherichia (E.) coli* and caseating exudate or "cheese-like," coagulated substance from ruptured ovarian follicles to the peritoneal or abdominal cavity), egg yolk peritonitis (when yolk and shell material enters the abdominal cavity instead of the oviduct), and egg impaction (when a hen cannot pass an egg from her oviduct).[139,140,141] Hens with salpingitis show an inflamed oviduct that is frequently distended, thin-walled, and filled with laminated (layered), malodorous egg concrements or hard masses.[142] Hens frequently suffer from uterine prolapse because of the constant laying of eggs, a painful condition caused by the uterus being pushed out of the body.[143]

Forced molting practices, particularly in the U.S., extend the productive lifespan of hens from 75 to 85 weeks of age to 110 weeks or longer. According to UEP cage-free guidelines, induced molting "rejuvenate[s] hens' reproductive cycle" by reducing the average flock weight by up to 25%.[144] During molting, usually between weeks 60 to 65 (just over a year), producers provide low-nutrient feed and reduce the lighting period for a short time, which stops egg production and leads to loss of primary feathers.[145] These methods disrupt the physiology of hens.[146] While molting naturally occurs in autumn for hens, forcing molting can cause significant stress and weaken their immune systems, making them more prone to infections. Inducing molting cycles boosts egg production at a profitable rate by making hens lay eggs at a faster rate than they would naturally and is designed to limit the cost of replacing "spent" hens with younger ones.[147]

B. Laying in Plastic Nests: Roosting Behavior, Resource Competition, and Floor Eggs

Hens have an innate need to perform pre-laying (nest-building) behaviors and prefer a separate, enclosed nest site, which they will work hard to access as oviposition (the act of laying, or the release of the egg from the ovary) approaches. Access to a nest site is a top priority for laying hens, preferred over food at this time. Foraging to build the nest is a behavioral need.[148] A hen nearing oviposition may inspect 25 or more different potential nesting sites and enter several before finally choosing one in which to lay her egg.[149]

UEP cage-free guidelines call for "dedicated nests." For community nests, UEP specifies a minimum of 9 square feet of nest space per 100 hens. For individual nest boxes, UEP requires at least one nest for every five hens. Flooring substrates that promote nesting behavior include AstroTurf, rubber mats, plastic nest pads, snap-on plastic inserts, straw, or hay.[150] Automatic egg-collection nest boxes often feature a rubber (plastic) nest floor mat or artificial turf.[151] Cage-free aviaries claim to provide nest boxes to meet this need and ensure efficient collection of clean, undamaged eggs. But hen preferences, stocking densities, and resource competition compromise their ability to lay their eggs in a nest.[152]

Nest site attractiveness and social facilitation (a phenomenon in which one hen's nesting behavior encourages others to do the same), combined with the hens' internal biological rhythm—driving them to lay eggs mainly in the morning—can cause overcrowding if there aren't enough nests to accommodate all hens nesting simultaneously. Nests are typically not provided to allow simultaneous use by all hens, resulting in competition that leads to crowding in the nests and can increase the risk of heat stress and smothering, aggressive pecking that promotes the outbreak of cannibalism, and mislaid eggs in litter. The percentage of "floor eggs" varies greatly but may be between 10% and 80%, although this laying behavior is believed to decrease with age and experience. When eggs are laid in designated nest areas, the system is designed so that the eggs will roll onto the egg belt, which both removes hens' access to their eggs and transports them for processing.[153] A recent solution offered to optimize nest use in order to prevent egg soiling and breakage is selecting hens with no preference for particular nests, essentially breeding this innate drive out of hens and selecting traits to reduce the laying duration and also help reduce the occupancy rate in the nests.[154]

C. Hatching the Next Generation: The Effect of a Motherless Industry on Behavioral Programming

Chickens have at least one key trait of "empathy": the capacity to be influenced by and share another's emotional state. For social species like chickens, living in groups offers several benefits, including the chance to learn by watching others. This kind of learning through observation (called "social learning") allows social groups to pass down learned behaviors through generations.[155] Chickens have more than 30 types of vocalizations to distinguish between threats from land or air.

Before they hatch, a mother hen teaches some of these sounds to her chicks. As she softly clucks while sitting on her eggs, her chicks chirp back to her and to each other from inside their shells.[156] Pre-hatching communication, natural brooding, and maternal care and influence help guide the chick's behavior, facilitate behavioral synchronicity and the synchronization of ultradian rhythms (active and inactive periods), and buffer the chicks' response to stressors.[157]

In industrial hatcheries that supply cage and cage-free systems alike, the separation of the mother hen from her chicks long before the eggs even hatch makes behaviors and emotional experiences related to empathy, transmission, or even learning impossible.[158] A lack of brooding can increase the risk of group stress in commercial hens. Under natural conditions, young chicks imprint on their mother, learning her features and forming a strong attachment. When chicks are raised commercially without a mother, they become somewhat attached to each other, although these bonds are often broken when chicks are transported from a hatchery to a rearing farm. The transfer from a rearing farm to a "laying system" typically occurs just before the onset of lay, when birds are 15 to 18 weeks of age, but earlier transfer is possible.[159]

Based on the hypothesis of environmental matching or predictive adaptive response, the way embryos respond to their environment during development prepares them to handle the same conditions after birth. If the environment remains consistent after birth, the prenatal developmental responses would be adaptive. However, if there is a mismatch between the predicted and actual postnatal environment, these responses could be maladaptive. In chickens, behavioral programming starts in the embryonic stage. Studies on the effects of stressors on hens and their offspring show that the parental early life environment prepares the chicks to cope with stressful conditions. These findings support the idea of transgenerational behavioral programming effects in chickens, suggesting that hens' chronic inability to cope with stress and behave aggressively is a cyclical issue that reproduces itself.[160,161]

Recommendations

A hen in a cage-free egg factory is a shell of her former pre-industrial self. The welfare science community's evidence of cage-free hen suffering goes far beyond the idea that artificially designed environments limit chickens' ability to express a full range of natural behaviors. Not only do hens endure unnecessary pain, they also continue to suffer and become weaker as time goes on.

Hens in cage-free systems face most of the same cruelties as hens in cages. A review of cage-free studies reveals welfare issues that are either marginally improved, unchanged, or, in some respects, even worsened. Many of the touted improvements, such as transitioning to cage-free housing, are undermined and replaced by new problems caused by the cage-free system, including higher rates of injurious pecking and cannibalism; respiratory, pulmonary, and skin lesions and infections from ammonia-rich, pathogenic dust; and increased risk of disease outbreaks and mass killings. Cage-free environments entrench and magnify other harms, such as keel bone fractures and the high incidence of fires caused by dust composed of feathers, feed, and loose litter that accumulate in electrical systems.

Efforts should be intensified to study and implement effective methods of shifting our current food culture as well as strengthening access to and increasing the daily consumption of animal-free foods by making animal-free options the default.

Regrettably, the Welfare Footprint Institute's conclusions about the reduction in cumulative pain from switching to cage-free systems are highly questionable and deeply flawed. Its 2021 study narrowly focuses on daylight hours during a hen's laying cycle, ignoring life before about 16 to 20 weeks of age.[162] The main quantitative analysis excludes the experiences of "breeder" hens, chicks, and juvenile hens in industrial hatcheries; the pre-laying phase; and the killing of male chicks, along with other factors that greatly affect a hen's quality of life, such as footpad dermatitis, high ammonia levels, and mortality from barn fires and mass killing methods such as VSD/VSD+, which are not modeled in the comparative analysis of housing systems. The Welfare Footprint

Institute's methods and highly influential findings cannot serve as an adequate foundation for guiding industry and advocacy recommendations.

Non-cage housing is not a "big-win, small-loss" tradeoff. All egg factories, including cage-free ones, systematize the disablement of hens, leading to debilitating injuries, chronic pain, and even death. Hens' mental lives are altered from an industrial hatchery to a factory floor under commercial conditions of hatching without a mother, mutilations of their sensitive beaks, overcrowding, and other traumas and stressors.

Cage-free assurances falsely foster a consumer illusion that "cage-free" equals "cruelty-free." Yet when consumers seek to make an ethical choice and purchase cage-free eggs, they still receive eggs produced on factory farms. Cage-free promises betray consumers concerned about animal welfare, animal protection organizations that offer false hopes of meaningful industry reform, and, most importantly, the millions of hens who are cruelly exploited.

The future of the egg industry will likely be shaped by the growing influence of multinational retailers in setting standards for producers and by changing consumer preferences and perceptions.[163] Undercover investigations and research—both industry-funded and independent—reveal that "cage-free" claims are misleading at best and fraudulent at worst. Instead of focusing only on eliminating specific cruel conditions like caging and breeding genetically compromised hens to better adapt them to cage-free systems, an honest, comprehensive review of the entire effort would lead to its rejection.

Cage-free eggs maintain the status quo by supporting animal-based consumer habits, boosting the reputation of factory farms, and extending animal suffering. The transition to cage-free systems began with good intentions to reduce the suffering that is apparent in the battery cage system. However, it has become a disservice and a way of perpetuating cruelty by luring kind consumers into continuing to buy eggs that they would otherwise have stopped consuming. The industry is using the endorsement of animal welfare organizations to actively target people who are reducing or attempting to reduce their intake of animal-derived foods.

The cage-free strategy should be reformulated to weaken rather than strengthen the industry. Instead of concentrating on strategies within factory farms, such as participating in regulatory discussions, improving certification standards, or guiding welfare investments in cage-free systems and breed standards, we call for a mass effort to shift away from their use. This must be embraced by everyone who believes hens' suffering is unacceptable. Caging hens is abhorrent, as is the alternative; neither should be used or celebrated.

Funding should instead promote research, innovation, and market access for food technology that is completely free of animal testing and support the rapidly growing animal-free food markets both domestically and globally, which would lead to a welcome reduction of the climate footprint within the agricultural sector (see Appendix). Efforts should be intensified to study and implement effective methods of shifting our current food culture as well as strengthening access to and increasing the daily consumption of animal-free foods by making animal-free options the default. Additionally, support for consumer education campaigns should be strengthened to inform consumers about the lack of a necessity to eat eggs, the health benefits of not eating eggs, and the alternatives to egg consumption.

Appendix

Because cage-free marketing influences consumer attitudes and behaviors, many people who would otherwise avoid eggs are not doing so. Animal advocacy groups, however, are uniquely positioned to provide guidance and influence consumer habits, especially as more ethics- and climate-minded consumers seek transparency.

Studies show that the term "cage-free" can mislead consumers, who often overestimate the welfare benefits and environmental sustainability of cage-free systems. A 2023 study, partly funded by the UEP, the United Egg Association, and the Food Industry Association, examined consumer understanding of "cage-free" and found confusion and misconceptions about different production systems. Many believe cage-free is healthier and has a lower environmental impact than conventional methods. Most also see cage-free production as better for animal mortality rates. Over half of the consumers in the sample are unaware of upcoming retailer commitments, although many support such pledges. Respondents view "caged" production more negatively than "conventional," highlighting the importance of framing, messaging, and marketing. Consumers tend to experience a "halo effect" with regard to cage-free eggs, associating animal welfare with environmental benefits. However, according to the study authors, research shows otherwise—cage-free systems require more resources,[164] worsening environmental burdens. A 2023 Data for Progress survey found that many consumers were confused and often misled by egg marketing using labels like "Farm Fresh," believing the hens were not confined in cages.[165] The results of a 2024 study showed consumer confusion about egg labels, with the main finding being that respondents struggled to differentiate various animal welfare labels.[166]

Animal-free foods have the lowest environmental impact and the greatest potential to address the climate catastrophe. One comprehensive study performed a full life cycle assessment using producer data from 40 food products, including eggs, that make up 90% of global protein and calorie consumption across 38,700 farms in 119 countries. Since meat, aquaculture, eggs, and dairy account for roughly 83% of the world's farmland and 56% to 58% of food-related emissions, despite providing only 37% of our protein and 18% of our calories, the researchers emphasize the importance of significantly changing how food's environmental impacts are communicated to consumers. The study highlights that transitioning from current diets to a diet excluding animal-derived foods would provide transformative environmental benefits beyond what producers can achieve: a 76% reduction in food's land use, a 49% reduction in food's greenhouse gas emissions, a 50% decrease in acidification, a 49% decline in eutrophication (the process whereby bodies of water become overly enriched with nutrients from animal waste and other sources, leading to harmful algal blooms, oxygen depletion, and dead zones), and a 19% decrease in scarcity-weighted (i.e., adjusted for local water scarcity) freshwater withdrawals.[167]

Studies show that consumers are increasingly willing to try animal-free options. According to August 2025 survey data from the Meat Demand Monitor, which is partially funded by the Beef Checkoff Program and the Pork Checkoff, 10% of respondents identified as "Flexitarian/Semi-Vegetarian," and a combined 7% identified as either "Vegan Vegetarian or Vegetarian."[168] The Sentience Institute's 2021 Animals, Food, and Technology report reveals that most respondents (74.6%) feel some discomfort with the animal farming industry and that 91.8% of respondents believe animals have roughly the same capacity to experience pain as humans. In addition, 64.9% believe humans should eat fewer animal-derived foods, 54.3% consider animal farming one of the most important social issues today, and 38.8% support banning animal farming altogether. Half are trying to reduce their own consumption, and 34.5% say they are open to trying to eat vegetarian or vegan in the coming years.[169]

U.S. vegan markets are booming, confirming high demand and continued momentum leading to rapid growth. The U.S. plant-based eggs market is projected to achieve $627.1 million, with a compound annual growth rate (CAGR) of 25.9% from 2025 until 2034.[170] According to the Good Food Institute's 2020 State of the Industry report, the U.S. retail plant-based food market grew 27.1%, almost twice the rate of the total retail food market, to just over $7 billion. U.S. retail sales of plant-based meat reached $1.4 billion in 2020, a 45% increase over the prior year.[171] The U.S. vegan dessert market reached $2.9 billion in 2022 and is projected to reach up to $5.8 billion by 2030. The market is expected to grow at a CAGR of 9.1% from 2024 to 2031.[172]

U.S. trends mirror the global rise of the vegan market. The global vegan food market was valued at $19.93 billion in 2024. Looking ahead, IMARC Group forecasts the market to reach $42.09 billion by 2033, growing at a CAGR of 8.66% from 2025 to 2033. North America currently leads the market.[173] Other forecasts project the global vegan market to reach around $55.42 billion by 2034, accelerating at a CAGR of 10.63% from 2025 to 2034.[174] The global vegan eggs market was valued at $1.5 billion in 2022 and is projected to reach $4.5 billion by 2030, growing at a CAGR of 14.8% during the forecast period from 2024 to 2031.[175] The global plant-based eggs market was valued at $194.6 million in 2024 and is estimated to grow at a CAGR of 24.3% from 2025 to 2034 to achieve $1.5 billion in 2034. The plant-based eggs market from liquid segment held a 56.9% market share in 2024, amounting to $110.7 million, with projected growth at a 24.9% CAGR until 2034. The plant-based scrambled eggs segment will capture $629.9 million and demonstrate a CAGR of 27.9% by 2034.[176] In 2024, the global vegan chocolate market was estimated at approximately $1.38 billion, and under a scenario forecast for the vegan chocolate confectionery segment, it's anticipated to reach about $2.73 billion by 2033, reflecting a CAGR of around 14.5% from 2025 through 2033.[177] In 2025, the global vegan yogurt market is valued at $7.5 billion and is expected to grow at a CAGR of 5.3%, reaching over $12 billion by 2035.[178]

Global grocery store chain Lidl has exceeded its 400% sales target for its own-label meat-free products and plant-based milk by 2025, achieving a 694% increase.[179] Meat juggernaut JBS launched a new plant-based company, hailed as a "new leader in European plant-based food."[180] People in the U.K. consumed less meat at home in 2022 than at any point since records began in the 1970s.[181] In March 2024, British multinational grocery retailer Tesco reported rising volume demand for meat-free ingredients and whole cuts, with fish alternatives up by 100% versus last year over the last three months, tofu and tempeh up by around 20%, plant-based steaks and chicken breasts up by 20%, and meat-free burgers up by 10%.[182] Demand for vegan food at U.K. quick-service restaurants like Leon, Subway, Gail's, Wasabi, Yo!, and Wenzel's increased by 56% in 2024, while vegetarian orders were up 64%.[183] Katherine Bagshawe, U.K. food and coffee director at Pret a Manger, stated in February 2024 that vegetarian and vegan products made up a third of the chain's main meal sales.[184] French bakery manufacturer Bridor stated that the number of people adding plant-based products to their diets continues to grow every year, with 39% of global consumers saying they find the vegan claim appealing when buying baked goods.[185] Gruppo Tonazzo, a major Italian meat company that has sold meat for five generations, has decided to stop selling meat to focus solely on plant-based foods for ethical reasons. The company will now concentrate on Kioene, a meat-free brand.[186]

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