LEVER

Commercial Cage-Free Egg Production

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Cage-Free Eggs Overview

Eggs today come from two main types of production: caged and cage-free. In caged egg production, hens are kept in enclosed cages where they cannot move freely, and where they eat, drink, excrete and lay eggs all in the same confined space. Conversely cage-free eggs, as the name implies, are laid by hens that live in a non-caged environment—sometimes entirely indoors and sometimes both indoors and outdoors. They can walk freely between the feeding area, laying area, resting area and sand-bathing area, and are able to carry out natural behaviors such as nesting, flying and jumping.

Evolution of Cage-free Egg Trends

Modern egg farming has evolved from backyard free-range farming to pre-industrial farming to intensive farming. Initially, people raised eggs in their own backyards, but due to the breeding environment, natural enemies and other factors, the yield was very low. Later, through genetic improvement, improved feed and water quality and automated egg collection, production capacity increased, with a focus on semi-intensive indoor cage-free production.

Starting in 1960, farms began to use caged rearing to produce eggs with a high degree of mechanization. However in the decades that followed, the level of industrialization sparked concern from animal welfare groups and consumers, who became increasingly conscious of the origins, production method, animal welfare, and health and safety of their food.

In response, the European Commission officially announced in 1999 a 13-year phase-

out of battery cage egg production. The E.U. has also legislated that all eggs on the market must be clearly labeled as to which production system they come from so that consumers can identify and make informed choices. As of 2022, over 50% of eggs produced in the E.U. come from cage-free hens.

In the United States, over the past 15 years a dozen states have passed legislation to ban the production and/or sale of caged eggs in their states. As of 2022, 40% of eggs produced in the U.S. came from cage-free production, which represents a significant and rapid increase from just roughly 5% in 2010. According to the U.S. Farm Bureau, the share of cage-free eggs is expected to reach 64% of total egg production by 2026.

In New Zealand as well as in some Australian provinces, caged egg production has been entirely banned. The South Korean government announced that it intends to ban the use of battery cages, transforming the country's egg production to a fully cage-free system. The Supreme Court of India has recommended to the Indian government that legislation should be introduced to ban caged egg production. Worldwide, more than three dozen countries have banned the use of cage or battery cage egg production.

Cage-free Commitments of Global Food Companies

In recent years an increasing number of major global food brands have made commitment to source only cage-free eggs. As of 2022, more than 2,000 companies worldwide had pledged to source 100% cage-free eggs (including over 60 companies and brands present in Malaysia). These commitments from retailers, restaurants, packaged goods, food service providers, hotels and other food companies typically have a phase in period of several years. Most have pledged to source only cage-free eggs by 2025, while a few have set later deadlines.

Prominent food companies operating in Asia that have made commitments to source

only cage-free eggs include the following:

Retailers: Retailers in Malaysia including Lotus's, Cold Storage, Hero and Markeplace, as well as other retailers in Asia including Aldi, City Shop, City Super, Costco, Legardère, Metro AG, Marks & Spencer, Auchan, RT Mart, and MetroMart.

Restaurant and Cafes: Restaurant and cafe groups active in Malaysia and around Asia including OldTown White Coffee, Benihana, Burger King, Costa Coffee, Delifrance, Dunkin' Donuts, IKEA, Minor Food Group, Papa John's, Peet's Coffee, Pizza Express, Popeyes, Pret a Manger, Shake Shack, Sizzler, Starbucks, Subway, Swensens, The Coffee Club, The Pizza Company, and Tim Horton's among many others.

FMCG: Global FMCG brands active in Malaysia including Barilla, Bimbo, Campbell's Soup, Danone, Ferrero, General Mills, Hershey's, Kraft, McCain Foods, Mondelez International, Nestle, Pepsi, and Unilever.

Food Service: Leading food service companies active in Malaysia including Compass Group and Sodexo.

Hospitality: Malaysia-based hospitality brands including Hatten Group as well as multinational hotel chains such as Accor, Aman Resorts, Best Western, Carnival Cruise Line, Choice Hotels International, Club Med, Deutsche Hotel Group, Four Seasons, Hilton, Hyatt, Intercontinental, Kempinski, Langham, Louvre Hotels Group, MRM Resorts International, Mandarin Oriental, Marriott, Melia, Millennium Hotels, Minor Hotels, Ovolo, Peninsula, Radisson, Waldorf Astoria and Wyndham.

Creating a Large-Scale, High-Yield Cage-Free System

With the number of companies purchasing or committed to purchasing only cage-free eggs increasing, large-scale, high-yield commercial cage-free systems have become increasingly common in Asia as well as in the west. Many major egg producers have converted existing caged production barns to cage-free, and others have built new cage-free barns.

In the transition from caged to cage-free production, egg producers need to choose a system that allows them to address the market shift to cage-free while still producing in large volume at reasonable pricing. At the same time, a system that is compatible with the natural behaviors of hens will be more self-sustainable in maintaining animal health and reducing operating costs. In combining these two most important factors—scale, cost of production, and allowing animals to exhibit natural behaviors—industry experts generally regard the multi-layer cage-free system, also known as the aviary system, as the cage-free egg production method with the highest return on investment.

Multi-Layer Cage-Free Egg System

Multi-layered cage-free egg systems, also know as aviary systems, are the most similar to the natural living environment of hens because they are vertically three-dimensional, like a tree would be in a hen's natural habitat. In a natural setting hens like to scratch, peck, and sand-bathe at the bottom of the tree, then fly up to the branches to perch in a place safe from predators and with some distance from other birds. Aviary systems offer a similar experience.

Multi-layer aviary cage-free egg system
(image courtesy of Big Dutchman)

Multi-layer cage-free systems have been in place in Europe and the United States for many years. The origins of modern multi-layer systems can be traced back to Switzerland in 1980, when Europe was beginning to develop commercial-scale cage-free egg production. The early cage-free systems—single-layer barn rearing or outdoor free-range rearing—did not reach sufficient scale or density of hens to generate a sufficiently low cost of production.

By the 1990s, European countries such as Germany and the Netherlands began to experiment with increasing the density of hens per square meter of barn space through the additional of perches and vertically stacked nesting boxes. These novel approaches evolved into today's multi-layer cage-free systems.

Reducing Management Costs with a Cage-Free Design that Responds to the Natural Behaviors of Laying Hen

There are many equipment producers that manufacture multi-layer cage-free systems today, but all systems are all based on the same principle of encouraging hens to display their natural behaviors. Features that encourage the expression of natural behaviors include the following:

- Bedding is provided at the bottom of the system to provide opportunities for foraging, sandbathing, and scratching (the thickness of the bedding should not exceed 5 cm)
- Nest boxes are provided, either on one tier of the aviary equipment or at the end of each row of equipment
- Water lines are evenly distributed on each tier, with manure strips below, and are adjacent to nest boxes to help ensure hens discover and utilize the nest boxes
- The upper level of the system is equipped with a perch for hens to rest, sleep,

and escape from attacks

- Stepped ramps are provided to connect each floor so hens can move gradually to the top roosting level or to the next box area, reducing injuries
- All floors are separated by wire panels to ensure easy cleaning of the environment, contributing to reduced labor costs

This type of design encourages hens to explore and keeps the flock evenly distributed in the barn. The use of tools like wire mesh and manure strips makes it easy to maintain the environment and air quality at a sanitary condition, thus lowering labor costs. Hens in multi-layer cage-free environments also have a high egg production rate, with few eggs laid on the ground. Large-scale cage-free egg barns maintain 97-98% of the productivity of conventional caged egg production in terms of egg laying rate.

While the capital costs of a multi-layer cage-free system are higher than a single-layer barn cage-free system, the production efficiency is greater and the maintenance cost is relatively low. Because they maximize the use of three-dimensional space, multi-layer systems are also able to accommodate more hens within the same footprint of land. As a result, multi-layer systems are often the more cost-effective long-term choice for producers that can absorb the up-front capital costs.

Operating a Cage-Free Aviary System

To operate a high-yield multi-level cage-free aviary system, several key parameters must be met:

The brooding system and the egg-laying system must be compatible with each other

Due to the three-dimensional nature and complexity of the multi-layer cage-free systems,

One of the two-story cage-free egg barns that have been built in Hainan, China by egg producer Happy Egg. A total of 300,000 layers will be housed at the site.

it is best for hens to learn how to move around the three-dimensional system as chicks. To ensure a smooth transition into the cage-free system, chicks should be trained to find feed, water, and egg-laying areas in a non-caged system. This familiarity with the equipment and enviorment reduces the potential for injuries when hens are moving around or leaping, and is particularly helpful for reducing the rate of keel fractures. Hens that have become familiar with the cage-free system during the brooding period have also been shown to have a high egg production rate once they begin laying.

The environment must allow hens to exhibit their natural behaviors

Hens should have the opportunity to carry out their natural behaviors. An ideal multi-layer cage-free system uses a variety of materials to encourage hens to express their natural instincts for foraging, sandbathing, pecking, scratching,

roosting and similar, while also encouraging them to interact with other hens.

Hens must have a safe and comfortable egg-laying environment

Hens prefer a secluded, dark space away from the flock when laying eggs. Providing nesting areas and nesting materials, and allowing them to imitate natural nesting behaviors. allows hens to lay eggs in a stress-free manner.

Hens must have enough space to live and move freely in

Although multi-story layer systems are designed for intensive farming, providing hens more space to move around can help hens relieve stress and maintain better health. The following space allocations are recommended:

- A maximum density of nine hens per square meter in the system (hens on perches, in nest boxes and similar), and preferably below seven hens per square meter
- A maximum 15 hens per square meter in the floor area
- A minimum height between shelves of 50 cm
- A minimum 2 meters between each row of shelves
- Easy movement between tiers and rows (including ramps, platforms and/or ladder systems)
- Roosting space of at least 15 cm per hen, preferably 22 cm or above
- An enclosed laying area with a comfortable and soft floor, preferably a box that automatically rises up to keep hens out at night to maintain hygiene
- Dry, friable bedding that promotes sandbathing, pecking, and foraging, ideally with more than 560 cm2 of bedding per hen
- More than four different pecking objects or materials per 1,000 hens

In summary, multi-layer cage-free systems combine high productivity with high animal welfare and food safety. In the following chapters we will explore specific management methods for achieving the best results with such systems while also improving animal welfare and environmental control.

Air Quality and Ventilation Control

Air quality is a significant factor that affects the health and productivity of hens. Ventilation is an important component of creating an environment suitable for cage-free egg production.

Hens are relatively metabolically active animals, with hens breathing at a frequency of up to 20-37 times per minute. Hens also have a large amount of air exchange, and require about 740 ml of oxygen per kilogram of body weight per hour, while exhaling about 710 ml of carbon dioxide. Both of these figures are higher than those for other farm animals such as cows and pigs. Consequently, a larger amount of fresh air is needed in the layer house.

Many studies have shown that air quality affects productivity more than any other factor. Good air quality is a necessary prerequisite for hens to exhibit consistent and high egg production capacity over their 90 weeks of life.

In conventional cage systems, the hens have 2-3 times less space per hen than in multi-level cage-free systems. Such high densities cause excessive body temperatures in hens and therefore require more intensive ventilation systems. Even though the density is lower in cage-free systems, it is still necessary to avoid high indoor temperatures, which means that ventilation should not be reduced.

On cage-free farms, hens can move freely, make short flights, and express their natural behaviors such as foraging, scratching and sandbathing. As a result dust, particulate matter and ammonia levels have the potential to increase increase. Since dust acts as a carrier of microorganisms, endotoxins, and other microscopic particles that can pose health risks for both farmworkers and hens if they enter the respiratory system, and ammonia can cause

respiratory irritation or damage, it is important for cage-free producers to use proper environmental controls to maintain good air quality.

Adequate Space with Ideal Ventilation Design

Ideal Air Flow Space

Liu Wen, director of German livestock equipment company Big Dutchman's China division, notes that "Proper distance should be maintained on multi-level cage-free systems—between columns of the system, between each tier of shelves, and between the top of the system and the ceiling to ensure the effectiveness and cost-efficiency of ventilation."

Even Distribution of Air Inlets

To disperse fresh air effectively in cage-free spaces, air inlets above the sidewalls, ceiling inlets or chimneys should be evenly distributed throughout the barn in the areas where hens move around. This fresh air will produce a jet stream that will mix quickly with the original air in the barn to achieve an even distribution of fresh air. The temperature of the fresh air will also slowly approach room temperature whilst removing moisture. It is best to have such airflow cover the entire space as much as possible, so that the heat generated by the hens themselves can be fully utilized.

Ceiling Air Inlets

Ceiling air inlets, or fresh air chimneys, are a popular solution in European cage-free layer farms. In a multi-level system, hens usually gather in the middle of the barn, while their scratching area is closer to the walls on either side. As a result, the heat is usually concentrated in the middle of the barn. To ensure that the fresh air can mix well with the air inside the room, it is best for the fresh air to enter the barn from the middle.

Exhaust stack with optimized air infusion (image courtesy of Big Dutchman)

In buildings with ceiling air inlets, the middle of the roof must be connect with the outdoors. To achieve this, most cage-free layer farms have flat ceilings. In the hot summer months, when it is necessary to switch to tunnel ventilation, a flat ceiling also facilitates the formation of faster air velocities.

Avoiding Too Much Airflow

When air is circulating within the barn it is best to avoid generating too much airflow, which can cause significant temperature changes. Aviary equipment producer Big Dutchman recommends that sidewall air inlets be installed above the highest perching level of the hens. This allows fresh, cool air to flow over the multi-level system, and the hens and hens are not forced to leave their usual roosting or activity areas because of cold airflow entering.

Some variation airflow can allow hens to find a location most comfortable for them. However, too much change in airflow (or any other enivornmental condition) can cause hens to crowd together in one place, increasing aggressive behaviors and the proportion of eggs laid on the ground.

Adjusting Ventilation Conditions with the Seasons

Ventilation conditions can be adjusted with the seasons. During the summer, greater ventilation is needed to remove excess heat and keep the bedding and manure dry. During winter ventilation can be slightly reduced, but not by much, since it is still necessary to bring in the fresh air and remove dust, carbon dioxide and ammonia. It is important to note that it is best to keep external airflow out of the layer house, especially during cold weather.

Han Taixin, vice president of egg processing brand Ovodan Eggs, notes that "Air circulation helps reduce drastic temperature changes in the cage-free laying house, and suitable airflow changes will help hens find their comfort zone. However, it is best for farms to avoid allowing sudden incoming air currents. Such drafts can cause hens to huddle together

due to stress and may also increase their aggressive behaviors, causing unnecessary losses to the farm."

Low Static Pressure

To avoid sudden airflow, low static pressure can be used. In addition to saving companies the cost of hardware amortization, increasing equipment lifespans, improving fan efficiency, and reducing the cost of utilities, the use of low static pressure keeps air flowing evenly in the layer house, allowing air to flow to the floor and helping maintain lower levels of ammonia.

An Australian cage-free layer farm using recirculating fans with water sprays to control air quality (image courtesy of Big Dutchman)

Attention to Air Leakage

In the ventilation system, fans pull out exhaust air from the barn, creating negative pressure. Under such conditions, the fresh air entering the room through the air inlet can be controlled. In order to maintain this condition, the barns must never have gaps in them that could potentially create air leakages, especially during winter. This would hurt the ability to create steady ventilation and temperature control. Manure belts, egg collection systems, equipment that is not used in the winter, windows, doors and similar can all be sources of gaps in the barns. If air intake is not properly controlled, unwanted air tends to fall to the ground quickly (because it is not sufficiently heated). This reduces the ability of the airflow to absorb water vapor, and thereby increases the humidity in the room and the dew point, allowing bedding to become damp.

Installing a chimney with a fan can also help fresh air to be pushed into the heated area below the ceiling in a controlled manner. This allows the hens' own body heat to be fully and evenly utilized by the air stream. When installing exhaust fans, the first 25% - 40% of those fans should ideally be installed along the longer side of the barn and completely covered.

Control of Dust and Particulate Matter on Cage-Free Layer Farms

As noted earlier cage-free hens can move freely around the barn, which can create more dust and particulate matter in the air. However researchers have developed ways to control dust and other particulate matter with technologies of varying cost and effectiveness.

Higher exhaust stacks can dilute the dust emitted out of the barn. Heat exchangers are effective in reducing particulate emissions by allowing electric charge ionization through wire strands on the ceiling. Spraying a combination of tap water, acidic water, soybean oil, and canola oil onto the bedding can also control dust. Some common practices are as follows.

Controlling Bedding Dust With Aerosols

Spraying water or oil directly onto the bedding material helps reduce the dust content. This type of liquid can also change the pH value and convert ammonia to ammonium.

Iowa State University developed the process of adding electrolytic water to bedding materials to help control dust. Electrolytic water takes advantage of the fact that sodium chloride is electrically charged and dissolves in tap water, a method that has been used in the food processing industry for many years. By controlling the amount of sodium chloride in the reactor and the time of electrolysis, slightly acidic water with different concentrations of free chlorine is produced. The free chlorine helps reduce dust and also significantly reduces the production of bacteria and ammonia in the bedding material, as chlorine has antimicrobial effects. The magnitude of the antimicrobial effect depends on the length of time the water is atomized. Controlling the spread of airborne bacteria is a major added benefit of using electrolytic water to manage dust.

Electrolytic water is sprayed through a system of nozzles suspended above the bedding aisle. The amount of water sprayed can be adjusted as the bedding pile size changes. Based on data from trials at Iowa State University and the University of Tennessee, the calculated cost of spraying a 1 cm height of bedding at a spray volume of 125 ml per square meter, including principal costs, ranged from just MYR 0.2-0.5 per hen per year and resulted in a 50% reduction in dust volume.

In hot weather, this type of spray system is one of the best tools to help cool down the hens, as when the water evaporates it takes away some of the heat they produce. Conversely, if the same method is used to control dust during winter, the hens will lose heat and therefore heat needs to be supplemented with appropriate temperature controls.

When using such devices, caution is advised to avoid excessive spraying, as excessive moisture which can cause higher humidity and affect the health of the hens. Using water with

low pH levels may also corrode the equipment in the barn.

Electrostatic Dust Collection

Professor Hongwei Xin, director of the Institute of Agricultural Research at Tennessee Agricultural University, has developed two additional pieces of equipment to help with dust removal that operate based on electrostatic principles: electrostatic air ionizers and an electrostatic air charge system with electrostatic precipitator. Both of these methods control the quality of air by attracting dust particles to the surface of the equipment. The use of such equipment can reduce emissions and improve the air quality for hens and workers. Professor Xin found that such equipment can reduce airborne dust in cage-free layer houses by up to 50%.

Dry Filter

Just like HVAC (heating and air conditioning) systems for homes, the air inside the layer house is filtered when it passes through the air filtration system. Studies have shown that dry air filters can reduce dust levels in cage-free layer houses by approximately 40%. Even using a low-cost method of placing a canvas over the exhaust fan to capture dust and other emissions was shown to reduce dust emissions by about 40% and ammonia emissions by 10% in cage-free layer houses.

Another study at Wageningen University in the Netherlands found that by passing hot exhaust air from inside the layer house through a manure drying tunnel located next to the layer house, particulate matter could be forcefully filtered and removed.

Plant Buffers

Producers can plant shrubs or bushes around the layer house as an additional (and inexpensive) method for reducing dust and ammonia emissions.

Solution Scrubber

A solution scrubber can be used to clean the exhaust gases before they are discharged from the layer house. By cleaning the exhaust gas with a solution, a single-stage scrubber can reduce about 40% of dust and 80% of ammonia. Three-stage scrubbers, as their name suggests, remove dust, odor and ammonia in three stages, reducing 70% of dust and 95% of ammonia. Three-stage scrubbers are extremely effective although expensive.

Control of Ammonia in Bedding Material

The majority of cage-free egg farms use bedding to prevent cysts from developing on the hen's breast from coming in contact with the hard ground, while simultaneously absorbing moisture, breaking down gases, maintaining temperature, and providing space for hens to feed, sandbathe and scratch.

While most indoor cage-free systems are equipped with manure belts, since hens are free to move around some of manure gets excreted onto the bedding. Cage-free farms therefore need to pay particular attention to ammonia control in the bedding area. Aside from that, caged and cage-free layer houses operate in largely the same way when it comes to indoor ammonia control.

Li Zhongwei, General Manager of China cage-free egg producer Weihai Ecological Agriculture, noted that, "As long as the temperature, humidity and ventilation are properly controlled and the bedding is turned and changed regularly, there are typically no problems with high ammonia levels."

It is best to keep ammonia concentration in the layer house below 15 ppm. High ammonia levels can be detected through smell, but for more accurate measurements a sensor can be installed to monitor the level of ammonia in the air at all times.

Humidity control in cage-free layer houses

Humidity is an important factor for controlling air quality. If the air is too humid inside the layer house ammonia may build up in the bedding, impacting hens' health. The temperature difference between the air and the surface of the equipment in the barn also leads to the production of moisture. Conversely, air that is too dry can lead to excessive dust, especially from bedding materials. To solve this, aviary equipment producer Big Dutchman recommends that the relative humidity in cage-free layer houses should ideally be maintained at 40% or slightly higher.

Research by Dr. Hongwei Xin, director of the Institute of Agricultural Research at Tennessee Agricultural University, points out that maintaining the moisture content of bedding at 20-30% is ideal for controlling ammonia levels.

The more surface area that bedding covers, the more it can stay dry and the more effectively the ventilation system will be able to function. Ensuring there is enough space between the equipment for air to properly circulate can also help ensure that bedding has the more opportunity to dry.

Use of Bedding Improvers

Bedding improvers can used alongside the electrolytic water mentioned earlier to lower the pH level of the bedding. Bedding improvers convert ammonia to ammonium and thereby reduce the release of ammonia gas. There are several types of bedding improvers on the market today, including both natural and chemical improvers. Chemical improvers include aluminum sulfate, iron sulfate and sodium bisulfate. Natural additives include zeolite, gypsum, and a combination of diatomaceous earth, calcium bentonite, and citrus acid products.

Thickness of Bedding Material

Research by Dr. Albert Winkel, a livestock and environmental researcher at Wageningen University in the Netherlands, showed that maintaining a bedding depth of about 1 inch (about 2.54 cm) reduced particulate matter and ammonia by 25%. It was shown that adding another 1 inch of bedding upward also increased ammonia and dust by 25 percent. Deeper bedding also encourages birds to nest and to lay eggs on it, increasing the cost of manual egg collection.

Big Dutchman recommends a more feasible bedding thickness of between 0.5 and 2 inches (about 1.25 cm to 5 cm) for cage-free layer houses, although farms can adjust the exact bedding thickness to suit their individual situation. The company also recommends installing scrapers under the cage-free system to regularly scrape and level the bedding so that the thickness of the bedding is not too deep, allowing for better control of ammonia levels.

Reducing Ammonia Production through Feed Formulation

Cage-free hens are more active, have a stronger immune system, and are better able to absorb and digest feed relative to caged hens, so they naturally emit less ammonia. Nevertheless, there are ways for egg companies to reduce ammonia levels still further by adjusting the formulation of the feed used.

Reducing Protein Content in Feed

Most ammonia is produced due to the insufficient digestion of feed, resulting in increased protein in the excrement, which forms into ammonia. By reducing the protein content of feed by 1%, ammonia emissions can be reduced by up to 10%.

Increasing Dietary Fiber Content in Feed

Dietary fiber, such as soy hulls and wheat flour, can increase the frequency of bowel movements and lower pH levels in excrement, which means less active ammonia in the stool.

Adding Supplements to Feed

Adding microecological agents and enzymes such as Bacillus grass, Lactobacillus, Bifidobacterium, Clostridium butyricum, or xylanase and protease to the feed can improve the absorption and conversion of the feed by the digestive system and successfully reduce protein content in the feces, thus reducing the production of ammonia.

Temperature Control in Cage-Free Layer Houses

Laying hens are sensitive to temperature. Rapid air movements and increased ventilation can cause them to lose heat and be impacted by windchlll. To ensure the health of the hens,

Scrapers are installed under the cage-free system to help scrape and control the thickness of the bedding, controlling the ammonia level

cage-free laying houses should use equipment to measure temperature, humidity and wind speed and should also monitor the body temperature of hens.

Installing Sensors in the Layer House

It is worthwhile to install temperature and humidity sensors to accurately measure and control both temperature and relative humidity. The ideal temperature varies depending on the weight and thickness of feathers of the hens and the relative humidity in the barn. With drier air in the barn, more heat is given off by the animal through respiration, increasing the temperature in the barn. Conversely, with humid air in the barn, the hens will produce less heat through respiration, decreasing the temperature in the barn.

Adjusting Layer House Temperature by Controlling Airflow

Greater (and heavier) airflow is needed to remove excess heat and reduce dust concentrations while keeping the bedding dry. This is particularly true during summer months when high temperatures pose a risk of heat stress to the hens.

Airflow can be reduced slightly in colder months when a higher air exchange rate is needed to reduce the CO2 concentration. The recommended CO2 concentration should be below 2,000 ppm. To weaken the standard to 3,000 ppm, the minimum ventilation rate must be at least 1.00 m3/h per layer.

When the weather is cold, the barn temperature can be lower than 20°C/68°F, but it should always be kept above 12C°/54°F. As long as the hens consume enough feed to balance the heat required by their bodies, it will not negatively impact their egg production. Layer houses located in cold regions should consider purchasing additional heaters and keep the barn free of outside air currents, especially during cold weather.

Overall, if the barn environment is comfortable for farm staff then the hens will be comfortable as well.

Bedding Management

Bedding, in the form of material laid on the ground, is often used on cage-free egg farms. This material plays an important role and directly affects production efficiency. Common bedding materials include short-cut straw, wood chips, rice hulls, shavings, sand, and crushed corn cobs. The main functions of bedding are:

- Preventing cysts when the hen's breast rests on hard surfaces
- Absorbing water and keeping manure dry
- Absorbing and moderating gases from decomposing hen manure
- Maintaining temperature in the winter
- Keeping the hens clean
- Hens can forage on bedding, take sand baths (which help maintain optimal feather conditions and improve their ability to regulate body temperature), scratch, increase exercise, and reduce pecking behavior

Weisheng Wang, the founder of Happy Eggs, notes that "Good quality bedding gives hens room to move around when they are not laying eggs and attracts them to move around the barn more, increasing the space utilization of the barn. Poor quality bedding, on the other hand, can bring ammonia blindness and intestinal diseases to the hens."

Maintaining a high quality of bedding can help ensure healthy hens who produce quality eggs.

Enhancing Ventilation

Having enough space airflow can lead to improvements in bedding quality, in addition to other benefits. Big Dutchman recommends that for ideal air circulation in indoor multi-layer cage-free systems, the ceiling should be kept at a distance of about 61 cm from the top of the aviary equipment; the distance between each shelf should be about 50 cm; and the aisles should be at least 100 cm wide.

As mentioned in the previous chapter, ventilation can be adjusted with the seasons. It is also important to avoid the generation of sudden airflow, as cold air drops can cause excessive moisture in the bedding.

In rainy weather, it is important to keep the air in the house fresh and to increase ventilation to avoid water accumulation on the bedding or on equipment. Saturated water vapor in the layer house will be discharged in time through the exhaust fan.

Maintaining the Ideal Thickness of Bedding

The ideal thickness of the bedding will vary based on the density of hens, temperature of the space, humidity of the bedding and other factors. Wang Weisheng, founder of China egg producer Happy Egg, believes the thickness of the bedding should be deep enough for the hens to move around on it and grasp it, but not be so deep that the hens lay eggs on it. The thickness of the bedding can be reduced in summer but should be thickened in the winter. As noted earlier, the recommended range of thickness for bedding is between 0.5 and 2 inches (about 1.25 cm to 5 cm) depending on the above conditions.

To prevent hens from laying eggs on the ground, it is recommended to operate a scraper back and forth in the early morning during the egg laying period. The frequency of scraping can be set according to the individual cleaning schedule of the farm.

Keeping the proper thickness of bedding can reduce dust and ammonia production while avoiding ground eggs (image courtesy of Happy Eggs)

Maintaining the Right Moisture Levels in Bedding

Moisture is one of the most important indicators of bedding quality, and managers should try to prevent bedding from mixing with manure or with moisture in the air. Bedding that is too moist will produce too much ammonia. Conversely, bedding that is excessively dry will cause dust and particulates to enter the air. Both will affect the health of the hens and the farm workers.

Choose a Soft and Absorbent Material

To control humidity, you should ensure bedding is loose fitting, air permeable and water absorbent. It is best to use a mixture of materials and to understand their individual

characteristics. Some of the common better materials and the advantages and disadvantages of each are as follows.

Shavings: Rarer and higher priced than other materials, not used as widely.

- Advantages: Water absorption and degradability is very high
- Disadvantages: Easily contaminated by pesticides and mold, and forms chloramines easier, resulting in the bedding material being spoiled

Straw and wheat straw: The degradation speed is slower than that of shavings, and it generates heat more easily. It is recommended to mix it with shavings at a ratio of 50% shavings to 50% straw. Cut straw before using.

- Advantages: Material is fluffy and absorbent
- Disadvantages: Easily contaminated, thus impacting the health of the hens

Rice husk: If used at all, it is better to mix it with other bedding materials.

- Advantages: Material is easy to apply, spread, rotate and clean
- Disadvantages: It is less absorbent, easily contaminated, and if swallowed by hens can affect their health

Sawdust: Generates significant dust, and is not recommended to use alone.

- Advantages: Can be digested and absorbed
- Disadvantages: Contributes to dust levels inside the barn.

Sand: Sand is usually used on top of concrete in arid climates.

- Advantages: Hens can use sand baths to keep their bodies clean
- Disadvantages: It is important to pay attention to the thickness when adding new sand to ensure it doesn't impact the movement of hens

Keeping Bedding Material Dry

Bedding is prone to producing ammonia and moisture due to the presence of water content within the bedding itself and in hen manure. As mentioned earlier frequent turning and changing of bedding can help keep ammonia levels down, and is a basic requirement for keeping bedding dry.

The manure belt should preferably be placed directly under the perches so that manure does not fall directly onto the ground or onto bedding. If there is not enough space between systems, and there is a high density of hens, manure will pile up, impact ventilation, and result in manure that doesn't dry and that impacts bedding quality.

Farms should adjust the moisture content of the bedding according to the climate. When the climate is dry, water can be sprayed moderately in the layer house to increase the humidity of the bedding (ideally using electrolytic water) and to reduce dust. For humid climates, turning over bedding daily (turning the lower layer of bedding onto the upper layer to dry) is recommended. This is best done once the lights are off and hens are in the layer system, having already finished feeding, in order to avoid stressing them.

During rainy or humid weather is also important to thoroughly disinfect the barn. Spray disinfection is not recommended since it increases the humidity in the hen house. The most ecologically-friendly practice is to sprinkle grass, wood ash or quicklime on the ground and top it off with clean bedding.

Before populating a barn with a new flock of hens, the barn should be decontaminated and covered with new bedding.

Measurement of Humidity Standards

According to a study conducted by Dr. Hongwei Xin, director of the Institute of Agricultural Research at the University of Tennessee, the ideal moisture content for bedding is between 20% and 30%. When moisture content is below 20% dust tends to rise, and when it is above 30% bedding tends to clump and become moldy. Moldy bedding will reduce the resistance of hens to diseases, and can cause mycobacterial pneumonia. Bedding that is already wet or lumpy must be replaced in its entirety, and new bedding must be spread to its original thickness.

Hen Behavior Management

Hens are intelligent, thinking animals that like all animals have a range of natural behaviors that they are compelled to carry out. As egg producers have shifted to cage-free systems and begun to keep up to 100,000 or more cage-free hens in barns, the relationship between farm workers and has had to evolve as well. Having a better understanding of hen behavior, and better responding to hens' natural needs, will help producers increase productivity.

Research shows that hens are much smarter than many people believe. Studies of hens by British and Australian scientists show that hens:

- Demonstrate some math proficiency from an early age, including the ability to perform basic addition and subtraction and even geometry
- Demonstrate a level of self-consciousness and self-control
- Are sensitive to their surroundings (and among the most sensitive of all birds)
- Are able to recognize and distinguish more than one hundred human faces
- Remember people, places, and objects
- Have the mental cognition to predict and plan ahead in order to get more food
- Engage in courtship dances in which roosters attempt to attract female birds
- Use Machiavellian tendencies to manipulate other hens

Hens that are stressed are more likely to exhibit bullying behaviors such as pecking and crowding. The challenge of transitioning to cage-free farming lies in how to properly handle this behavior so production efficiency can be maintained. Mr. Wang Wei-sheng, founder of Happy Eggs, suggests that the operating staff of the farm should learn more about the nature of hens by spending more time with the flocks and reading about the causes of bullying behavior. This knowledge will allow them to make adjustments to the environment and keep flocks healthy, productive and peaceful.

Feather Pecking Behaviors

Pecking is the most common attacking behavior among hens. Hens belong to the same Animalia kingdom order as other birds like turkeys, quails and pheasants: Galliformes. Norwegian zoologist Thorleif Schjelderup-Ebbe discovered in the early 20th century that Galliformes birds share a common social characteristic known as "the pecking order." Hens that rank higher in their social hierarchy (the peking order) are healthier and stronger, and they will try to oust companions lower in the pecking order by pecking at their feathers and anuses. The stress caused by pecking can make hens more susceptible to diseases and epidemics.

Another important characteristic about hens is they do not demonstrate sympathy or a tendency to help when they witness other hens suffering from being pecked. On the contrary, such attacks can drive them to further abuse their weaker companions.

Natural Beak Smoothing

In the past, some cage-free egg producers used beak trimming as a solution for pecking behaviors. However the beaks of hens contain many nerve fibers, so beak trimming causes extreme pain to trimmed hens and perhaps permanent physical and mental damage, leaving

hens more susceptible to diseases and affecting producitivity. Today, veterinarians and responsible producers generally avoid the practice of beak trimming. Many countries in Europe—which has often been the global benchmark in such areas—have expressly banned beak trimming.

A better alternative developed by modern cage-free producers is the "natural beak smoothing method," which allows chicks to gradually round their beaks in a healthy and painless manner. This process involves using a feed back with rough metal at the bottom of it. As the chicks feed their beaks rub against the rough bottom, naturally creating a smooth beak and slowing beak growth.

Studies show that the growth rate of hens' beaks was reduced from the first day that beak smoothing feeding trays were installed. After 14 weeks, most chicks' beaks had a smooth shape. As a result of less problematic pecking, chicks were less likely to experience anxiety, less prone to infection, and their health was more consistent, reducing the mortality rate by 2%. Another benefit of the rounded beaks was the ability to consume more intact feed, thus reducing waste.

The use of natural beak smoothing trays does not increase costs significantly and may increase both operational efficiency and profitability by removing the cost of beak breakage. This type of beak treatment is already being used on farms in the Netherlands, Belgium, China, India and other countries.

Feather Pecking Causes and Solutions

Natural beak smoothing is only one method to prevent feather pecking. Understanding the causes of feather pecking and prescribing the right approach to prevent it is the fundamental solution. Common causes of feather pecking and their corresponding solutions are as follows:

The rough metal surface at the bottom of the feed pan creates a beak grinding effect, which can give the beak a smooth, round shape (image courtesy of Big Dutchman)

Cause of pecking: *High stocking density*

Solutions: *Encourage fuller exploration of the barn*

In nature, all birds need space to express their natural behaviors and hide from predators. In a high-density rearing environment, hens will have to compete with each other to defend their status in the flock, especially for access to feed and drinking water. Without proper management, pecking will almost certainly occur. Mr. Han Tai-xin, Vice Director of China caged and cage-free egg producer Ovodan Foods, shared, "Although the stocking density on cage-free farms is lower than that of caged farms, proper handling and understanding of pecking are still required to prevent reduced egg production."

While high stocking density is inevitable on commercial cage-free laying hen farms, encouraging hens to more fully explore the barn will reduce the actual density by creating a more even distribution of hens, and thereby reduce pecking. In terms of encouraging hens to explore more fully explore the barn, adding bedding to the majority of the barn will lead hens to become familiar with the space and feel comfortable roaming around. Other factos that affect how much of the barn space hens will use are as follows:

- Hens need to feel it is safe to explore, so the hen house should be a confined and stable space that is not affected by external factors such as weather
- Hens should be familiarized with the cage-free system environment during the chick-rearing period to speed up adoption and full use of the barn
- Hens should be able to easily see everything inside the hen house and travel within their range of vision
- Hens should have access to areas for foraging, sandbathing, roosting and hiding. Equipping the house with high perches reduces crowding and is particularly important for more vulnerable hens.

Cause of pecking: *Unbalanced nutrition*

Solution: *Adding proper amounts of amino acids, salt and protein to feed*

Studies have shown that another cause of pecking is a lack of methionine in hens' bodies. Methionine is an essential amino acid for hens, but it cannot be synthesized by their bodies and must be obtained from food. Bird feathers contain an important building element of methionine, sulfur; therefore, hens lacking sulfur in their bodies will peck at the feathers of other hens.

Similarly, salt can be found in the secretions of the preen glands of hens. When hens are low in sodium, they may peck at the preen glands of other hens to incease their salt intake. For flocks already showing pecking behavior, a small amount of salt (about 1.5% - 2%) can be

added to their diet for 3 to 4 days. Be aware that doing this for an extended period can cause salt intoxication, so should be limted and carefully observed.

In addition to amino acids and salt, there should also be sufficient protein in the feed with a focus on balancing amino acids, calcium, phosphorus, and vitamins B2, B6 and B12.

Cause of pecking: *Frequent changes of feed*
Solution: *Feed consistency (ingredients, proportions and amount)*

Studies have found that if a farm makes more than three changes to the feed during the egg-laying period (including even changing the flavor of the same brand of feed), the risk of pecking behavior may increase. Therefore, dietary changes should be minimized. In particular, suddenly changing from a high-protein feed to a low-protein feed should be avoided.

If the feed must be changed, it should be done slowly by increasing the proportion of the new feed in a mixture of both the old and new so that hens gradually adjust to the new formulation. During these dietary change periods, it is also a good idea to provide toys and equipment for hens to peck at, such as hay rolls and hanging discs, to divert their attention from pecking at other hens. Another way to divert their attention and reduce pecking behavior is by mashing granular feed into fine powder.

Cause of pecking: *Uneven growth in flocks*
Solution: E*nsure even growth across the flock and avoid mixing flocks*

As discussed earlier, the health of hens can cause their social status to change. This is especially true during the first 20 weeks of their lives as it is a period of both fast bone development and weight gain. During this period, farm workers must ensure that nutrient intake is evenly distributed among hens. Hens should be weighed regularly to prevent hens

becoming either overweight or underweight. Statistics show that hens that start to lay eggs before their 19th week tend to be more likely to show feather pecking behavior, and those which start egg production before the 20th week have a higher risk of anus pecking.

Farm sshould ensure that the conditions within each flock are the same to ensure the whole flock can "enter and exit the system together." For the same reason, farms should avoid mixing hens from different flocks.

Cause of pecking: *Hens can't fully express their natural behavior*
Solution: *Create an environment encouraging foraging and exploration*

Hens are curious animals who like to explore their environment. When hens can't explore and engage in other natural behaviors, they tend to act out in redirected behaviors such as feather pecking. Creating an environment that encouraging exploration and natural behaviors such as foraging can help prevent pecking.

Even with abundant feed and nutrients, hens still need to express their natural foraging behaviors. A hen that cannot find litter to use or sit on will feel depressed and look for a proxy for foraging behavior, which could manifest as pecking. Spreading clean and fluffy litter in the layer house encourages hens to forage and reduces their stress.

Spreading alfalfa nuggets, corn cobs, carrots, straw, hay, and even ground-up feed onto the litter can further attract hens and incentivize them to forag. These additives also make hens take in more dietary fiber, which is helpful for improving their feather health.

Adding a few small toys to the hen's environment can satisfy their curiosity and motivate them to explore more. Recommended toys include adding small haystacks or hanging shiny or tasseled objects such as old compact discs (though watch out for the sharp edges of broken discs) or shredded paper balls. Hens who forage and explore will be more fully engaged in

their environment and less likely to engage in pecking behavior.

Cause of pecking: *Environmental conditions and stress factors*
Solution: *Maintain stable environmental conditions*

In addition to health conditions, hen stress can also contribute to pecking. Sudden changes in the environment (such as unexpected noise or changes in lighting, temperature, airflow and air quality) can make them feel scared or nervous, causing negative reactions such as pecking. To avoid this problem, managers should try to keep the overall environment of the layer house stable and create an environment where the hens feel safe by:

- Avoiding loud sounds and noises
- Avoiding light leakage or strong light
- Keeping the temperature inside the layer house at a stable level
- Preventing sudden airflow from outside the barn
- Maintaining good air quality

More details about achieving and maintaing these environmental controls are covered elsewhere in this book.

Strangers can also be stressors for hens. As found in the study outlined above, hens are able to recognize and memorize human faces. If farm workers walk around the layer house regularly and frequently interact with the hens, it can reduce stress by increasing hens' familiarity with the workers. If there is staff turnover, try to adopt a progressive approach so that the replacement happens gradually. Strangers should avoid entering the layer house in the evening.

Cause of pecking: *Strong light leading to aggressive behavior*

Solution: *Reduce light intensity*

For hen flocks already showing pecking behavior, dimming the interior lighting can help reduce pecking.

Phillip J. Clauer, a zoological scientist at Penn State University, reported that dimming lighting will make it more difficult for hens to clearly see the wounds and bloodstains on others, thereby reducing their motivation to peck at each other.

Uniform, suitably bright light is one of the effective ways to avoid feather pecking (image courtesy of Happy Egg)

Preventing Piling (Dense Huddling Of Hens)

Hens' lungs are different from humans in that they cannot work autonomously, rather they rely on the movements of the ribs they are attached to. This means a hen must have ample space to move its rib cage in order to be able to draw air into the lungs and force it back out. This biological characteristic leads to a need to maintain appropriate space between hens and their companions.

Whens hens are stressed, excited or scared, they may engage in the so-called piling phenomenon in which they flock tightly together. Sometimes this lasts for just tens of seconds, but at other times it can last up to half an hour or more, resulting in hens' ribs being squeezed and unable to stretch and thereby causing suffocation and death.

This piling phenomenon is roughly the same as the feather pecking behavior covered earlier, and is mainly caused by environmental factors. Hens typically flock together for the following reasons:

- Keeping warm: The temperature is too low, resulting in hens gathering tightly together to keep warm
- Curiosity: Hens like to gather around objects or places that interest and excite them
- Fear: Sudden noise, light, wind, or other environmental instabilities can frighten the hens and cause them to flock together

When piling occurs, farm staff need to record the location at which it took place to be able to solve the problem. Beyond creating environmental stability, there are several ways to address piling behavior. Farms can use these in combination depending on the individual circumstances:

High perches can help prevent piling (image courtesy of Happy Egg)

- **Dry litter**: In addition to keeping the layer house warm in winter, farms should pay attention to litter quality. Replace litter regularly, especially in farms using barn rearing. If hens need to keep warm, they will look for a dry and warm place. If the feathers of other hens are drier and more comfortable than the litter, hens may gather and crowd one another. Hens with poorer health will be crushed. Using dry litter can effectively reduce such behavior.

- **High perches**: If hens are on perches at night there will be no stampede, even if they need to be next to each other for warmth. The space at the highest perch levels is significant, and there is ample fresh air. (Sick hens are usually unwilling to go onto perches, so farm workers should be able to quickly find them and

observe them to provide needed care.)

- **Herd management**: Identify the hens with weaker physiques and feed them separately. Sick hens are more sensitive to environmental conditions such as temperature, light and sound, and are more likely to be trampled by their fellow hens. They are also more likely to spread diseases.

- **Music:** Soothing music can be played in the layer house to calm hens and reduce counteract any sudden noises

- **The importance of brooding:** If hens are exposed to certain objects and sounds in their environment during the brooding period, they will become familiar with them and over time will no longer exhibit excitable or fearful behavior toward them.

Ground Eggs

In addition to reducing pecking and other bullying behavior, reducing floor eggs is another important part of improving production efficiency. While in most cases hens get adapted to the system through early traiining and learn to use egg laying boxes, the following best practices can help ensure they do and can help prevent or reduce the laying of eggs on the ground.

Hens must first develop the habit of entering the system

Hens are highly malleable creatures when it comes to developing habits. Equipment producer Big Dutchman recommends training chicks every day after dusk during the brooding period. A few weeks before entering the egg-laying system, farm workers can dim the lights of the aisles at the end of the day to encourage hens to enter the aviary system. After that, dimming the lights on the lower tier will stimulate hens to move to the upper levels of the

aviary where there is still some light. At that point, all the lights can be turned off.

Once all the lights are off, it's recommended that managers patrol the layer house for a week and move any hens that are still on the ground into the system. After a few times, as the lights dim, the hens will automatically enter the system to rest. At dawn, gradually turn on the lights to stimulate the hens to move down to the nesting areas.

Produers must also ensure that the height of the tiers, including the egg-laying area, are proper. If it is too high the hens will not be willing to jump from the ground into the system, let alone enter the egg-laying area.

Reducing Disturbances During Egg-Laying

Factors that disturb hens during egg-laying, such as loud noises, should be minimized. In the beginning, the vibration and sound of the conveyor belt may cause hens to leave the egg-laying box due to fear. Farm workers can gradually increase the frequency and speed of egg collection so that hens can slowly adapt to the noise and vibration. The conveyor belt should be cleaned regularly to eliminate odors or residues and avoid irritating the hens.

It is also inadvisable to start the feed belt during egg-laying. Feeding should be carried out early in the morning, and it should then be kept quiet during the four-hour peak period of egg-laying before a second feeding is provided. Feed belts and drinking fountains should not be obstacles between hens and egg-laying areas.

Bedding that's too thick can also cause hens to lay floor eggs. Big Dutchman recommends that the bedding should be kept at no more than 2 inches (about 5 cm). Once this thickness is exceeded, the hen will feel too comfortable and may begin laying eggs on it.

The Egg-Laying Area Must Be Attractive to Hens

The habit of birds is to lay eggs in quiet, dark, hidden and comfortable places. After

a hen lays eggs in one place, it will become her exclusive egg-laying site. So creating an attractive egg-laying area is best achieved by making the environment outside the ideal area completely unsuitable for egg-laying. Such an approach can help prevent hens from laying eggs on the ground or in other parts of the aviary system.

Open the egg-laying boxes at least one week (if not more) before hens begin to lay eggs in order to give them enough time to explore and feel comfortable in the boxes. At the peak of egg-laying, ensure that the system is equipped with sufficient egg-laying areas.

Before the flock reaches 30 weeks of age, it's normal to see ground or between-system eggs. When they find ground eggs or eggs in the aviary system's tiers, farm workers should pick up the eggs immediately to prevent other hens from seeing them and replicating the behavior.

Hens prefer to lay their eggs in secluded, dark places. If the design of the laying area is in line with the nature of the hen, ground eggs can be avoided (Image courtesy of Ovodan Eggs)

Chicks exploring the environment in a multi-level brooding system (image courtesy of Big Dutchman)

Chick Rearing for Cage-Free Production

When building a high-rise building, the more stable the foundation the more the building will be able to withstand environmental challenges. The brooding period is akin to the foundation of a house: it is the bedrock for raising safe, healthy hens with high productivity.

Brooding system operators typically focus on environmental controls and providing chicks with a suitable place to grow, including controlling humidity, temperature, ventilation, lighting, cleaning, and disinfection in the layer house as well as controlling for disease, vaccinations, and water intake for chicks. Most of these management behaviors can be assisted by machinery and smart devices. Controls needed in these area are identical whether raising chicks for caged or cage-free production.

In cage-free production, the biggest difference in the chick-rearing stage stems from the importance of providing behavioral training to help chicks become familiar with the cage-free system. Whereas for caged egg production brooding is carried out in cages, for cage-free production brooding must be carried out in cage-free environments that mirror the future conditions that chicks will live in.

In the previous chapter, we discussed the nature and behavior of hens. To reduce management costs brought about by disease and negative behaviors, a large portion of success depends on whether the hens receive appropriate environmental training during the brooding period. This training helps them prepare for living in a cage-free system. In this chapter, we will discuss what brooding techniques can help hens be healthier, thereby improving productivity.

The Brooding System Must Be Compatible with the Egg-Laying System

Hens are fast learners, and it is easy for them to develop habits after being trained, but it is not easy to correct bad habits after they have developed. Wang Weisheng, the founder of China cage-free egg producer Happy Eggs, notes that "Hens are just like humans: all behaviors are best started early."

Consistency between the chick-rearing method and the egg-laying system is particularly critical to cage-free breeding. If the hens will be housed in single-layer barns or in multi-tier aviary systems, it is important that as chicks they be reared in matchinr environments.

Numerous large egg producers have found that raising young hens in traditional caged systems before transferring them to cage-free systems for egg production leads to challenges. This is due to difficulties with adaption caused by the sudden change of systems, including the following:

- Unfamiliarity with the environment and inability to find feed and drinking water, resulting in malnourishment
- Confusion with where and how to move around the system
- Feelings of stress and anxiety, leading to increased sickness
- Delayed egg-laying periods and higher probability of floor eggs
- Hens spending excessive time on the ground or the bottom tier of the system, causing their feces not to fall onto the manure belt, resulting in an increase in ammonia levels

A well-designed chick-rearing system should also use various tools to train the chicks to learn balancing, moving, perching, foraging and sand-bathing within the system.

After living for ten weeks in a brooding system with identical conditions to the egg-laying system they will later be moved into, they are typiacally able to adapt to the egg-laying system within 2-3 days of entering it and calling it home.

Encouraging Chicks to Enter the Aviary Equipment

The first few weeks of training are a critical period for developing good habits and correct behaviors, including training hens to enter and climb the aviary equipment. Managers can gradually elevate the feed and drinking water systems as the chicks grow to encourage them to move upwards and learn how to use perches to roost. Helping hens develop the habit of moving around the avriary system also greatly reduces the rate of ground eggs.

Training To Reduce Stress Behaviors in Chicks During the Brooding Period

Hens are one of the most environmentally sensitive birds. Small changes in the layer house, including sudden noises, airflow, light or unfamiliar faces, may cause stress and negative behaviors.

The role of the brooding period is to make the chicks as accustomed to the various sights and sounds in the environment as possible, which will reduce stress caused by external stimuli. Some companies will play soft music in layer houses to familiarize them with the presence of sound.

The timings of light changes in the brooding hen house should preferably be the same or similar to the timing of light changes in the egg-laying system. This ensures that there is no "jet lag" after the hens arrive in their new home, and they can maintain the same biological clock.

Indoor multi-layer brooding system (image courtesy of Big Dutchman)

When well-trained hens come to the laying hen house, they will be both easier to manage and more productive.

Pay Attention to the Uniformity of Chick Growth

The intake of feed and drinking water for hens is controllable in a caged environment. In a cage-free environment where hens can move around freely there can be increased competition for feed and drinking water, especially during the first 20 weeks. During this period, farm workers should ensure that the nutrient intake is evenly distributed among hens. Hens should be weighed regularly. Maintaining uniformity of hen growth from the chick stage

can help reduce pecking behavior and other negative behaviors covered in the previous chapter.

Progressive Expansion of the Flock's Range of Movement

In order to avoid uneven feeding of the hens in a cage-free environment, it is recommended to raise the chicks in smaller areas for the first 3-6 weeks and prevent them from walking around a lot, or needing to spend a lot of time finding feed and water. Farm staff can gradually expand the range of space and activities available to chicks after 6 weeks. This approach can ensure health and weight gain in chicks and increase their survival rate.

Group Rearing

If there is a significant difference in the growth rate or size of the chicks during the brooding period, they must be raised in groups based on their different sizes. The hens in each small group should be kept even in size so that there is no bullying or feather pecking, with customized care provided to each group.

Entering the Egg-Laying System

Moving chicks into the egg-laying system at the right age is very important for hen health and productivity. The egg-laying cycle generally starts at around 18 weeks. Mr. Han Tai-xin, Vice President of China caged- and cage-free egg producer Ovodan Foods, suggests that hens should be transferred into the egg-laying system at around 16 weeks old. This will allow the hens enough time to regain the weight they lost during the transition period. Becoming adapted to the new environment also helps reduce floor eggs.

It is best for the farm staff to demonstrate moderate changes to the environment, such as adjusting the lighting, feeders, and drinking water positions, to help the hens adapt to their new conditions. Since hens learn quickly, if a farm worker picks up a few chicks and puts their mouths on the drinking fountain or feed belt, other hens will imitate this behavior.

Investments in the brooding system in the early stages will be rewarded with higher productivity and efficiency in cage-free hens.

Lighting Control

Like humans, the life of hens revolves around day and night cycles. However hens are more sensitive to light because their light-receiving process is different from that of humans. Light can pass through not only the eyes of hens but also through the top of the skull, the pineal gland, and the pituitary gland. The pituitary gland causes the hypothalamus to secrete more gonadotrophins to stimulate the secretion of estrogen, which can promote the development of reproductive organs and the formation of reproductive cells. Therefore, the amount of light exposure will lead to different levels of egg production.

Egg producers already formulate their own light cycles to affect the egg-laying time of hens, enhance immunity, and improve food intake and weight uniformity. For cage-free systems, lighting programs have another important purpose: to reduce the bullying behavior of hens, thereby reducing management costs.

Using Light and Dark Controls to Improve Productivity

Mr. Wang Wei-sheng, the founder of China egg producer Happy Eggs, shared that in a multi-tier cage-free system, lighting is a great tool to encourage hens to express natural behaviors and develop good habits. Proper lighting management can reduce operating costs, so overall it is best to keep the lighting of the layer house as stable as possible. That said, some areas should be kept relatively bright or dim depending on their function. During the training period, lighting can also be used as a tool to help chicks and young hens become accustomed to the cage-free system.

Encouraging Hens to Use the System

Lighting is a great tool to foster the desired flow of movement of hens through the barn. For example, a farm worker can use the strength of the lighting to guide hens to specific spaces or activities. The light in the feed and waterline areas can be made brighter to attract hens to feed there so their feces will fall onto the manure belt. Other activity areas, such as scratching and sand bathing areas, should also be brighter than nesting areas. To encourage hens to use perches, farms can also use the method of lighting up the area above the avaiary system to motivate birds to move up naturally and learn to perch.

Avoiding Ground Eggs and Eggs Laid Elsewhere Outside The Nest

When hens are going to lay eggs they tend to look for dim places, in order to ensure safety and comfort. It is therefore recommended to dim the lights in the egg-laying area before the egg-laying period begins. For the same reason, the lights at the bottom of the system should stay bright to prevent hens from laying eggs on the litter or on the ground.

Farm keepers can place photometers in certain areas to better understand the ideal lighting condition to help hens feel comfortable.

Lighting Settings During Cage-free Brooding

During brooding periods, lighting schedules are important because they affect both the nutritional intake and body clock settings of chicks. These can affect how easily chicks enter the cage-free system later. Utrecht University in the Netherlands has conducted research on the operation of cage-free layer houses and recommends that intermittent light and dark cycles—4 hours of light followed by 2 hours of darkness—be provided in the first week after the chicks are born in order to stimulate their eating and resting rhythms and contribute to healthy growth. From the end of the second week onwards, exposure to light should be

gradually reduced, reaching 10 hours of light per day by the end of 7 weeks. After that, the same lighting cycle should be kept through the time chicks enter the egg-production system, and should remain the same thereafter.

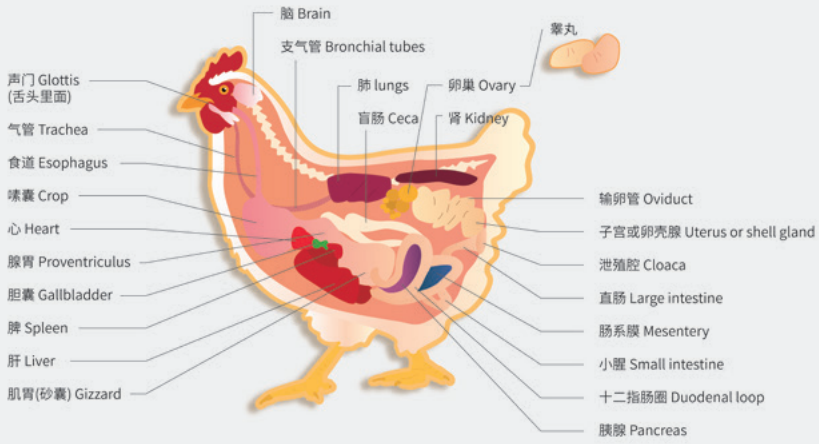
Researchers from Utrecht University also recommend that in a multi-tier cage-free system the lights in the hen house should be gradually turned up in the morning over a time span of 10 minutes, and in the evening the lights should be turned down over a period of 15-30 minutes. Turning the lights on or off instantly can prompt stress behaviors in hens.

The lighting design for brooding can also be fine-tuned depending on the hen strain used, and companies may refer to the breeding manual for the particular strain used.

Intestinal Health

The intestine is an important organ in hens as it has both digestive and immune functions. Hens have no teeth and do not secrete saliva in their mouths; the gastric juices secreted by the stomach are limited and the function of the stomach muscles is solely to grind food. This means that the hen's mouth and stomach have very little ability to absorb nutrients, and hens must therefore rely on their intestines to do so. According to studies, 80% of the digestive activities of hens are completed in the intestine, and more than 90% of the nutrients are absorbed through the intestine.

The intestine is also an important immune organ. 60% to 70% of the immune cells of hens are located in the intestine. The intestinal mucosa, skin, and respiratory mucosa together



form a barrier for hens to defend against external microorganisms and dust. In addition, more than 80% of the metabolites in hens are excreted through the intestine.

Hens that walk around freely will increase their contact with substances in the environment, including feces. The establishment of a routine intestinal health testing and maintenance system is one of the keys to improving efficiency in cage-free laying hens.

Intestinal Diseases Affect Production Efficiency

The intestine assumes a number of important functions in the body of a hen. Once something goes wrong, although clinical symptoms may not appear immediately the health of hens, including egg-laying, will be affected in varioius ways:

- Intestinal problems can slow the development and weight gain of chicks and young hens
- Intestinal damage will directly affect the digestion and nutrient absorption of hens leading to an increase in food intake, ultimately reducing the feed conversion rate
- Intestinal damage leads to weakness, weight loss, and feather loss, which in turn leads to aggressive behaviors
- If the intestinal barrier is damaged, the source of disease can enter other organs via the blood
- The amount of vaccine antibodies decreases rapidly, exposing the hen to various diseases which are not easy to cure
- Intestinal proglems can cause a decline in the egg production rate or a delay or stagnation of production

Causes of Intestinal Disease

Gastrointestinal problems in hens can be caused by several factors. While it can take some time to determine the root cause, doing so can significantly increase productivity. Some of the common root causes are as follows.

Poor Feed and Water Quality

Great attention should be paid to the quality of drinking water given to laying hens. This directly affects their intestinal health. It is recommended that companies pay close attention to the following drinking water quality issues:

- High levels of fluoride, lead, and magnesium in water can cause intestinal damage
- Excessive sodium, potassium and chloride will greatly increase the amount of water that hens drink, resulting in damage and detachment of intestinal mucosa
- Other bacteria that can cause intestinal diseases include Salmonella, Escherichia Coli and mold
- Unclean water supply equipment can form a lysosomal membrane, which releases toxins and germs in the water

If raw feed materials are not properly processed they may also contain harmful substances, pathogenic bacteria or toxins that endanger intestinal health, for example:

- If corn and bran products are not stored properly they produce mycotoxins which destroy the integrity of the intestinal mucosa; this results in an increased chance of necrotizing enteritis, pathogenic bacteria, E. coli, and other harmful bacteria in hens

- Toxins such as gossypol and anti-nutrient factors in miscellaneous meals can

cause intestinal problems if fed to hens

- Animal raw materials, such as meat and bone meal, fish meal and blood meal, may contain toxins and pathogenic bacteria
- The heavy metals in stone powder can be too high, and if added to the feed of young laying hens too quickly can cause intractable diarrhea
- If hens lack vitamin A for a sustained period of time, it may lead to easily damaged intestinal mucosa
- Allowing hens to consume too much high-protein food can increase the burden on the intestines and cause illness

Poor Sanitary Conditions in the Layer House

Coccidia, roundworms, tapeworms and other parasites grow in environments with high temperatures and humidity. If the layer house environment is not well controlled and these parasites are given a suitable growth space, they will destroy the intestinal mucosa of hens and induce necrotizing enteritis.

For environmental management of cage-free layer houses, please refer to the control of temperature, humidity, air quality, and other environmental conditions mentioned in other chapters.

Hen Intestinal Health Test

To observe whether the intestines of hens are healthy, relevant indicators can be collected and recordedincluding weight, food intake, water intake and feed conversion rate. If one of the indicators drops suddenly, there may be a problem with the hens' intestines.

In addition, farm workers can consult with a veterinarian or nutritionist to evaluate a hen's

bone composition, muscle, fat and other physical conditions to determine whether it meets the normal levels for their age group.

Monitor Feces

Whether in a caged or cage-free layer house, it is typical for farm workers to use manure to assess the health of hens. In cage-free environment, farm workers can use several tools to collect feces to monitor the health of hens

If the worker wants to observe fresher manure, they can put flat materials such as cardboard under the target flock before feeding and collect the manure within 30 to 45 minutes. Compared with checking the litter and scraper manure belts, this approach can help farm workers better understand the moisture content in a timely manner, monitoring for atypical texture, undigested feed or abnormal color (the feces of hens with intestinal rotting will present an orange-red color).

Autopsy

If a hen dies, the farm can determine inspection measures based on the specific circumstances.

When examining the intestines, it is best to open from the plain sac into the gastrointestinal tract so that the quality of the lining of each gastrointestinal tract can be observed. It is necessary to pay attention to any obvious lesions or wounds. It is best to look for traces of necrotizing enteritis visible to the naked eye, and at the same time evaluate the changes in the composition of the hen's body. It is worth paying particular attention to the following parts:

- The thin-walled gastrointestinal tract
- Corpus callosum contents

- Gastrointestinal chyme contents and undigested feed (may be wrapped in watery mucus)
- Whether there is orange-red mucus in the intestine
- Whether there any parasites such as tapeworms, roundworms or similar in the intestine near the cloaca

When diagnosing intestinal problems, the following methods and indicators can be used:

- Pathological examinations such as gastrointestinal scratching
- Virus diagnosis
- Flora assessment
- Assessment of the number of oocysts of coccidia and other parasites
- Auxiliary inspections such as feed composition and quality, water quality, nutrient distribution changes, etc

Testing hens that have died from other diseases is also a way to assess intestinal problems. The gastrointestinal tract will degrade rapidly after a hen dies, so changes like these may cause inspectors to mistakenly think there is a problem with the gastrointestinal tract and end up with the wrong diagnosis.

Hen Intestinal Health Intervention Methods

It is best to check hens regularly (and randomly) in the layer house to ensure no changes inside or outside the body have been missed. This can prevent the occurrence and spread of diseases in a timely manner. The following intervention methods can also be used:

- The intestinal microenvironment, composed of different microbial flora, is a key element for ensuring the wellness of intestinal function. When the pH value of the gastrointestinal tract is less than 7, it becomes an environment suitable for the normal activity of intestinal flora. At the same time, it can protect epithelial cells from external germs in the cycle of competition and inhibition. Proper acidification of drinking water can help keep the intestines of hens active.
- When the gastrointestinal flora index is abnormal, probiotics, essential oils and plant-based products can be added to restore the flora.
- If antibiotics are necessary as a last resort, regulations must be considered to ensure that the antibiotics will not have a negative impact on the hens' health.
- If viral enteritis keeps occurring in the hens, virus samples can be extracted from clinical cases and used to make autologous vaccines. Regulations and costs must be considered in this process. If the cost is high, you may find it useful to look for partners to develop and use vaccines together.
- Balance the feed formula to prevent intestinal problems. It is important to pay attention to the ratio of feed and avoid excessive grains and starches, as these will delay digestion and defecation, giving germs more time to reproduce. Some high-quality raw materials, such as soybean meal and corn, help maintain intestinal activity and health. If necessary, mycotoxin adsorbents can be added to the feed in moderation. Care must be taken to ensure hens avoid ingesting toxic substances in their feed, which can cause causing damage to the intestines.

Proper Brooding and Reducing Stress Behaviors

Most of the digestive organs of hens develop early in their growth, so intestinal health needs to be strengthened during the brooding period. If development is delayed due to intestinal infection, it will affect the overall growth rate of hens.

A high-quality diet and avoidance of long periods without food and water is an excellent

way to promote intestinal health. Letting chicks and hens fully express their natural behaviors, especially foraging, will also help the digestive system develop.

The fullness of the crop is an important indicator for evaluating the gastrointestinal health of young chicks. Within 24 hours of entering the barn, most of the chicks will already have a crop about 10mm in size. If the chick's crop is missing or lacking at this time, it is necessary to adjust the diet and management methods as soon as possible.

Stress behaviors caused by overcrowding, environmental changes, noise, strong winds, and similar can also lead to changes in the intestinal environment. It is best to adapt chicks during the brooding period to various situations that may occur in the future in order to reduce their stress responses.

Strengthening Biosafety Management

Enteroviruses such as parvovirus, coronavirus and rotavirus can remain in an active state when they are n hen excrement. They are also disinfectant resistant. In order to effectively reduce pathogenic microorganisms in the layer house, companies must thoroughly clean and disinfect the environment to eliminate conditions that contribute to virus growth.

Drinking Water System Cleaning

In addition to the control of overall environmental conditions, regular cleaning of drinking water systems such as water tanks and water lines is a task where managers should pay special attention. Polluted drinking water systems are hotbeds for the breeding of germs, and they can cause excessive minerals and microorganisms to enter the water. These substances will also combine with vitamins in the water to produce insoluble substances such as biofilms. Contaminated drinking water can cause intestinal flora disorders and diarrhea in hens.

Coccidiosis Control

Coccidiosis is one of the most common diseases that affects the intestinal health and growth efficiency of hens, but many farms underestimate the subclinical infection of coccidiosis. Once subclinical infection of coccidiosis occurs, the damage to the intestinal wall of hens can be catastrophic. Cleaning, disinfecting and biosecurity measures are not completely effective in preventing coccidiosis, but they are important in alleviating early coccidiosis infections. At times it may be necessary to add anti-coccidiosis drugs, based on the specific circumstances (especially prenatal prescriptions), to prevent subclinical coccidiosis infections.

In a cage-free environment, companies need to pay special attention to maintaining the intestinal health of hens from the perspectives of environment, diet, and biosecurity. While complicated, this task has high value considering that the immune strength of hens forms the basis of egg productivity.

Case Studies of Intestinal Microorganisms and Salmonella

Dr. Dawn Koltes of the Department of Animal Sciences at Iowa State University compared the relationship between microorganisms and diseases in the intestines of hens in caged and cage-free environments. Laying hens in a cage-free environment had higher levels of Clostridium and Enterobacterium, which are related to intestinal diseases, but also higher levels of Lactobacillus, which has been identified as an inhibitor of Salmonella enteritis and Salmonella typhimurium.

The European Food Safety Authority conducted the largest-ever study on salmonella in cage and cage-free layer housing, analyzing data from 5,000 farms in 24 countries. The EFSA found that cage-free farms had dramatically lower rates of salmonella contamination compard to caged egg farms, with up to 25 times lower rates of contamination from certain salmonella strains.

Conclusion

In Europe, over the past twenty years the share of cage-free eggs has gone from 10% to over 50% of all eggs produced, and caged egg production will be fully banned by 2027. In the United States, the share of cage-free eggs has increased from 5% to nearly 40% since 2010, and the United Stated Department of Agriculture projects that cage-free eggs will account for 64% of all eggs produced by 2026. In Brazil, the share of cage-free eggs is projected to grow from 5% in 2018 to 20% in 2028. New Zealand and Canada have set timelines for requiring all egg producers to be cage-free, and in Australia over 60% of eggs are cage-free.

In Asia, the shift to cage-free eggs has now begun to speed up as well. Over 100 major regional and international food companies have pledged to source only cage-free eggs in the region within the next several years, including in Malaysia. Large and mid-sized egg producers across mainland China, Taiwan, Korea, Japan, Thailand, the Philippines and Malaysia have implemented or begun to construct large-scale commercial cage-free egg production facilities housing 50,000 to 1,000,000 cage-free laying hens.

Modern commercial cage-free farming is very different from the backyard free-range farming of generations past. It represents an upgrade in animal welfare and food safety, while remaining economical for consumers and having higher profit potential for producers than commodity caged eggs.

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