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# Health Welfare of Laying Hens Reared in Cage and Non-Cage Systems

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ABSTRACT

In this review, the welfare traits related to health status were revealed in laying hens reared in the cage and non-cage systems. In evaluating the health status of hens, infectious diseases, ectoparasites, production diseases, physical injuries, respiratory system diseases caused by air quality, and mortality were discussed. Each production system has specific traits that affect the welfare of the hens. Cage systems are more advantageous and hygienic systems in terms of viral and bacterial infections and ectoparasite transmissions than non-cage systems. However, restriction of movements in the cage disrupts the bone structure. It causes osteoporosis, especially in laying hens with high egg yield. Space limitation in cage systems is seen as a big handicap, especially for natural behaviors. The inability to exhibit natural behaviors causes a negative emotional state, contributing to the development of harmful behaviors such as feather pecking and cannibalism. In non-cage systems, footpad dermatitis, hock and breast burns are more common due to contact with the litter. Increasing environmental complexity in alternative production systems and unexpected conditions in the free-range area (predator attack, poor subsoil, too high platforms, etc.) cause increased bone fractures and injuries. Since there is no litter in the cage systems, the dust and ammonia concentrations are lower, and the respiratory system diseases are less than non-cage systems. Although deaths due to pecking and cannibalism are common in laying hens, the mortality can be kept at low levels with suitable management procedures. In conclusion, infectious disease risks, contact dermatitis, physical injuries, respiratory system diseases, and low mortality in hens reared in the cage system are seen as advantageous in terms of health. However, on the other hand, restriction of natural behaviors makes it difficult for caged hens to maintain their metabolic and mental health.

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## Introduction

Table egg production at the global level has increased by 14.1% in the last 10 years (FAOSTAT, 2020). China, US, India, Mexico, Russia, Japan and Turkey to supply 74% of world egg production and the use of conventional cage systems in these countries is over 90% (IEC, 2016; Mench, 2017). However, egg production in traditional cages is banned in EU countries and switched to the enriched cage and non-cage systems, which are supposed to offer higher welfare standards than traditional cages (Appleby et al., 2003; Weimer et al., 2019). Social concerns about animal welfare have played a significant role in the development of alternative systems at the point of improving the welfare of laying hens in cage systems. However, non-cage systems have increased the risk of diseases, physical injuries, and mortality while improving the behavioral repertoire (EFSA, 2005; Lay et al., 2011).

Welfare is the physically and mentally well-being of the animal in its housing environment. A combination of adequate nutrition, appropriate environment, optimal health, exhibiting normal behavior, and positive mental and emotional status are indicators for good welfare in laying hens (Hartcher and Jones, 2017). Cage systems prevent to display of natural behaviors such as sand-bathing, wing flapping and foraging due to limited cage space. There is generally no welfare problem regarding access to feed and water in all production systems (Shimmura et al., 2010). Closed (barn) systems are more advantageous than open systems in terms of providing suitable environmental conditions since the free-range systems have some problems in terms of lighting, environmental temperature, management of the outdoor area, sustainability of litter quality, and predator threats in the range area (Nicol et al., 2003).

Conventional cage systems have the poorest performance in terms of natural behaviors since they do not have sufficient and suitable area to perform natural behaviors such as nest behavior, dust-bathing and foraging (Weeks and Nicol 2006; Shimmura et al., 2010). The evaluation of animal welfare requires information on all aspects of the animal's health status. Many factors such as viral and bacterial diseases, parasitic load, bone and leg health, behavior, stress, emotional state, nutrition, and genetic structure affect the level of laying hens' welfare (Lay et al., 2011).

Here, we review five main health indicators (infectious and parasitic diseases, production diseases, physical damage, air quality, mortality) related to the health welfare status of laying hens in cage and non-cage systems (Table 1).

**Infectious and Parasitic Diseases**

Prevention and control of diseases and parasites are considered as the basis for animal health (Fraser et al., 2008). Escherichia coli peritonitis, coccidiosis, necrotic enteritis, mycoplasma gallisepticum, calcium depletion-tetany, and infectious bronchitis have been listed as common diseases for poultry (United States Animal Health Association, 2007). Generally, bacterial and viral diseases, coccidiosis, and red mites are more common in non-cage systems than cage systems. (Rodenburg et al., 2008; Fossum et al., 2009; Widowski et al., 2013). Access to the free-range area in laying hens increases the risk of transmitting dangerous infectious diseases such as Avian Influenza, Newcastle, and ectoparasites from wild birds (Lay et al., 2011; Widowski et al., 2013). Also, red mites generally live in the outside environment (Chauve, 1998; Lay et al., 2011; Fraser et al., 2008). Kreienbrock et al. (2003) reported that the incidence of bacterial infection and ectoparasites were found high in non-cage systems and that the use of antibiotics and acaricides was higher in these systems.

Bacterial and protozoan infections such as erysipelas, E. coli, pasteurellosis, and Ascaridia show a considerable increase in laying hens reared in non-cage littered systems compared with cages (Hane et al., 2000; Hafez, 2001; Hafez et al., 2001; Permin et al., 2002; Esquenet et al., 2003); this is because wild birds are a source of many infections for domestic poultry (Halvorson et al., 1982).

Free-range laying hens are very vulnerable to the threats and infectious diseases that may arise from wild birds. However, these risks are lower in layers housed in closed systems such as the cage system. Hens in littered and free-range systems had greater mortality associated with viral disease (lymphoid leukosis, Marek's disease, and Newcastle disease), coccidiosis, and red mites (Dermanyssus gallinae) compared with hens in conventional cages, which are relatively sterile systems, are not suitable environments for ectoparasites (Lay et al., 2011). Therefore, it is understood that the ectoparasitic risk is lower in conventional cage systems than non-cage systems.

Free-range systems increase microbial contamination from soil, direct contact with parasites, and increased risk of infectious disease. It affects the degree to which the environment of the hens is affected by diseases. Health protection practices such as vaccination, disinfection, and biosecurity are standard procedures applied to all housing systems for the minimum disease risk.

**Production Disesaes**

Reproductive disorders such as salpingitis, ovarian obstruction, and prolapse, usually followed by peritonitis and other abdominal changes are often diagnosed during the autopsy of laying hens (EFSA, 2005). Abrahamsson and Tauson (1997) reported that mortality due to salpingitis to be less than 1% in conventional cage systems. Reproductive disorders do not appear to be associated with a particular housing system. Salpingitis and peritonitis may be caused by feather pecking around the cloacal region in non-cage systems (Engström and Schaller, 1993; Ekstrand et al., 1996; Abrahamsson et al., 1998) and laying hens which were not beak trimmed in conventional cages (Michel and Pol, 2001).

The fatty liver Hemorrhagic Syndrome (FLHS) is a typical production disease encountered laying hens in conventional cage systems. According to Peckham (1984), the typical finding of this disease is a decrease in egg yield. Layers are visually healthy and appear to be in good physical form, but there may be a 25-30% increase in body weight. Kaufmann-Bartand Hoop (2009) and Weitzenbürger et al. (2005) reported an increase in fatty liver in cage systems compared with non-cage systems such as littered and free-range.

Table 1. Health parameters and indicators that determine the welfare of laying hens housed in the cage system

| Health classifications | Indicators |
|---|---|
| 1. Infectious and parasitic diseases | Bacterial diseases<br>Viral diseases<br>Ectoparasites |
| 2. Production diseases | Diseases of the reproductive organs<br>Fatty liver Haemorrhagic syndrome (FLHS)<br>Osteoporosis |
| 3. Physical damage | Plumage condition<br>Feather pecking and cannibalism<br>Injuries<br>Foot disorders<br>Bone damages |
| 4. Air quality | Dust<br>Ammonia |
| 5. Mortality | Mortality rates |

Laying hens reared in conventional cages are increasingly susceptible to osteoporosis which a major skeletal health problem resulting from lack of exercise (Whitehead and Fleming, 2000; Jendral et al., 2008). Osteoporosis is widespread in today's commercial laying hens and contributes to approximately 20 to 35% of all mortalities during the egg production cycle in cage system hens (Anderson, 2002). It is generally accepted that the leading cause of bone fragility is the movement restriction in laying hens with high yield (Michel and Huonnic, 2003), although mineral deficiencies in the feed and high egg production primarily lead to a weakening of the leg and wing bones. Increased opportunities for exercise can improve bone strength to a certain extent. Fleming et al. (1994) concluded that hens in conventional cages had poorer bones than non-cage systems.

**Physical Damage**

Feather pecking is one of the most important factors affecting feather condition in laying hens. This behavior creates essential welfare and economic problem in egg production. Laying hens generally prefer littered floor for pecking, stretching, and dust-bathing. Providing access to the litter area may reduce the risk of feather-pecking (EFSA, 2005). If hens can not make dust-bathing, they will have dirtier plumage, less water-proof, and less insulation (Scholz et al., 2014). Thus, dust-bathing improves the plumage condition and welfare status of hens (Widowski and Duncan, 2000); however, laying hens in cage systems does not perform dust-bathing behavior. Foraging is also helped reduce the risk of feather pecking and cannibalism; however, it is impossible in cage systems. Feather pecking damage is relatively slight or does not appear for beak-trimmed hens. Nicol et al. (1999) also reported that increased stocking density accompanied by increased flock size (ranging from 6 to 30 birds/m²) was associated with increased moderate and severe feather pecking and poorer plumage condition. Blokhuis and Van der Haar (1992) concluded that an essential strategy to prevent feather pecking was to offer an adequate substrate, and Nörgaard-Nielsen et al. (1993) also reported that enrichment of the environment could reduce to effect of feather pecking.

Problems such as cannibalism were quite widespread initially, and cannibalism is widely observed in the flocks of non-beak trimmed hens, especially hens housed in cage systems become challenging to manage flock (Amgarten and Mettler, 1989). The mortality rate hens in non-cage systems are generally higher than in caged layers and include mortalities from cannibalism (Appleby et al., 2004). Increasing the feed intake duration may reduce the risk of feather pecking and cannibalism, and it also increases the social time spent with others. Instead of pecking each other's feathers, they peck to feed material (Appleby et al., 2004). Poor ambient conditions such as bright light, poor nutrition, high stocking density, and large group sizes increase the tendency of feather pecking. Cannibalism is also affected by most of the same conditions; however, it is seen more common in non-cage systems than in cages (Mench and Keeling, 2001). High-level feather pecking may result in cloacal cannibalism. It can lead to severe welfare and economic problems in the cage system (Tablante et al., 2000). Beak trimming is an effective way to reduce feather pecking damage (Lay et al., 2011), but from a welfare point of view, beak trimming is a painful management practice (Appleby et al., 2004).

Footpad dermatitis, bumblefoot, hyperkeratosis, and excessive claw growth are common foot problems in laying hens (Lay et al., 2011). Footpads are affected by different environmental factors such as production system, stocking density, litter type and quality, floor and perch design (Tauson and Abrahamsson, 1994) and it is mostly seen in non-cage system hens. High levels of litter moisture and ammonia are the leading causes of dermatitis (Wang et al., 1998). The poor design of the perches used in floor-based systems, accumulation of litter material on the perches, and the high moisture content of the litter can also be associated with the bumblefoot (Tauson and Abrahamsson, 1994; Wang et al., 1998). Hyperkeratotic changes and lesions on the footpad may support bacterial colonization of the toes, potentially leading to the development of secondary infections (Weitzenbürger et al., 2006), which are well-being problems that can cause pain. Hyperkeratosis can be seen in the footpad skin or fingers of hens (Duncan et al., 1992; Weitzenbürger et al., 2006). It is more common laying hens in conventional cage systems than non-cage systems (Abrahamsson and Tauson, 1997) and is a problem that occurs on the footpads or the toes due to long-standing cages or perches caused by excessive pressure (Weitzenbürger et al., 2006). The slope of the cage also contributes to the development of hyperkeratosis in cage systems (Abrahamsson and Tauson, 1995). Foot health is generally better in egg hens housed in conventional and enriched cages than in non-cages (Tauson et al., 1999). However, since conventional cage systems do not have a floor to prevent the growth of the claws, this negatively affects claw health (Taylor and Hurnik, 1996; Abrahamsson and Tauson, 1997).

Laying hens faces various injuries in all types of housing systems. Injuries can be associated with the physical environment or interaction between hens. Feather pecking and cannibalism may sometimes be accidental injuries too. Mortality of hens related to injury can sometimes occur in cage systems; according to Abrahamsson (1996), injury and mortality can prevent well-designed modern cages in good condition. In free-range systems, hens are attacked by predators such as wild birds and animals; eventually, deaths can occur. Löliger et al. (1982) also reported that deaths occurred between 3.8 and 21% by predators.

**Air quality**

General management practices affect air quality, which is closely related to respiratory diseases. Poor air quality can be harmful for animal health, particularly by accumulating aerosolized dust and ammonia (Pedersen et al., 2000). Air quality is a significant determinant of layer hens' welfare, especially in littered intensive systems due to high concentrations of ammonia and dust in the air. High concentrations of ammonia contribute significantly to respiratory tract diseases, and poor air quality also increases the risk of infectious diseases (Fraser et al., 2008). It is reported that the aviary systems have 5-15 times more dust levels than the cage systems (Mårtensson, 1996; Michel, 2004). According to Marthedal (1980), kerato-

conjunctivitis is commonly seen in littered systems. Air quality is also lacking in all littered systems than cages (Michel and Huonnic, 2003; De Reu et al., 2005; Rodenburg et al., 2008). High dust concentrations are also associated with high mortality related to respiratory diseases in laying hens (Guarino et al., 1999).

Amount of aerobic bacteria, aerosolized (particle size: 1-100 μm) and respirable dust particles (particle size: <8.5 μm) were found significantly lower in cage systems than littered systems. These air quality findings may partly explain why laying hens reared in littered systems have more bacterial disease than cages (Lay et al., 2011).

**Mortality**

Mortality observation in laying hens is a widely used tool for assessing welfare in the flocks. The mortality is mainly influenced by the status of beak trimmed or not, lighting, genotype, management, and the differences between housing systems (EFSA, 2005). Increased mortality is usually due to cannibalism or septicemia in laying hens (Tauson et al., 1999). Weitzenburger et al. (2005) stated that 65.5% of total deaths in laying hens occurred due to cannibalism and 37.5% due to enteritis. High mortality is a clear indicator of poor welfare.

Weekly mortality is generally less than 0.1% in a healthy and well-managed hens in conventional cages. Higher mortality associated with viral diseases (lymphoid leukosis, Marek's disease, and Newcastle disease), coccidiosis, and red mites (Dermanyssus gallinae) are commonly seen in littered and free-range system laying hens compared to conventional cages (Lay et al., 2011). Cage systems offer less disease risk and a more hygienic production and are seen more economically than non-cage systems.

Mortality differ among different housing systems in laying hens (Tauson, 2002). Group size and stocking density are essential factors that impact mortality (Nicol et al., 2006). Housing systems with outdoor access constantly are exposed to losses by predators. Many researchers reported that mortality in conventional cages is lower than non-cage and alternative systems (Wahlstrom et al., 1998; Tauson et al., 1999; Michel and Pol, 2001; Jensen, 2003; Michel and Huonnic, 2003; NFU, 2003).

Health welfare status in laying hens according to production systems is summarized in Table 2.

Table 2. Welfare and health status of laying hens in different housing systems

| Welfare Indicators | Conventional cage | Non-cage | Free-range |
|---|---|---|---|
| Mortality | | | |
| Beak trimmed | Low | Moderate | Moderate/High |
| Non-beak trimmed | Low/Moderate | Moderate/High | Moderate/Very high |
| Health | | | |
| Infectious diseases | Low | Low (variable) | Low (very variable) |
| Parasitic diseases | Low | Moderate (variable) | Very high |
| Osteoporosis | Very high | Low | Low |
| Feather pecking in beak trimmed flocks | Low | Moderate | Low |
| Feather pecking in non-beak trimmed flocks | Moderate/High | High | Moderate (variable) |
| Cannibalism in beak trimmed flocks | Low | Moderate (variable) | Moderate |
| Cannibalism in non-beak trimmed flocks | Low/Moderate | Very high (variable) | Moderate (variable) |
| Skeletal quality and foot health | | | |
| Skeletal quality | Low | Low/Moderate | Low/Moderate |
| Foot pad dermatitis/Bumblefoot/Hyperkeratosis | Moderate | Low | Low |
| Claws | Low | High | High |

The use of conventional cages in egg production was banned in 2012 in European Union countries due to the idea that may bring improvements in some welfare traits defined as five freedoms in laying hens. Good nutrition, suitable housing, protection from diseases, exhibiting natural behaviors, and avoidance of management practices that can cause fear and stress are indicators for the good welfare in laying hens. However, it can be seen that no housing system used in egg production can fully supply all welfare criteria ultimately. It is seen as a disadvantage that the cage systems do not allow to exhibiting of natural behaviors. However, welfare criteria such as good nutrition, suitable housing, good health, less fear, and stress are supplied just as non-cage systems. This review deals with the relations between animal health and welfare, and it is seen that the health status of laying hens is generally better in conventional cage systems compared with non-cage systems. If complete welfare is mentioned, a system should fully supply all the welfare criteria. Because the systems currently used are always lacking in welfare, and the desired level of welfare can not be achieved.

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