A Literature Review of Broiler Chicken Welfare, Husbandry, and Assessment
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Literature surrounding key aspects of broiler chicken husbandry and its relation to animal welfare are reviewed, for the context of broiler chicken farming in Indonesia. This review focuses on husbandry of commercially grown broiler chickens on farm, including light systems, litter substrates, lameness, contact dermatitis, heat stress and climate control. Common assessment methods of broiler chicken welfare are also reviewed. Key broiler welfare issues in Indonesia are likely to be heat stress, lameness, and contact dermatitis, and these may result in reduced productivity. Considering photoperiod and reviewing litter substrate management could be economical and practical ways to improve welfare. Foot pad dermatitis and lameness are useful indicators of broiler welfare, and the high market demand for chicken feet in Asia could serve as an incentive to improve broiler welfare and chicken foot quality in the region.

**Keywords**

Asia, Assessment, Broiler, Chicken, Husbandry, Indonesia, Welfare.

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Introduction

Animal welfare and application in Asia

Early animal welfare was based on the Five Freedoms, developed in the United Kingdom by the Brambell committee in 1965 as a framework on which to base regulations regarding husbandry of production animals (Fernandes et al. 2021; Webster 2016). Although the Five Freedoms provide a basis for animal welfare, there have since been significant developments in the methods to assess and measure animal welfare, and to what standards we consider welfare to be ‘good’. Definitions of animal welfare must incorporate the physical and mental health of the animal, as well as the interaction of the animal and its environment (Carenzi and Verga 2009). Animal welfare has progressed from being focused on the absence of negative states, to including positive states too (Rayner et al. 2020). Welfare is a continuum, and the state of an animals’ welfare depends on the individual’s experience and perception (Carenzi and Verga 2009). Many definitions of animal welfare exist, including Fraser and Broom’s (1997) definition ‘The state of an animal as it attempts to cope with its environment’, and more recently, Fernandes et al. (2021) ‘A transient state within an animal that relates to what the animal experiences’. The importance of considering animal welfare is formalised in the Treaty of Amsterdam (1997), which acknowledges animal sentience and the need for animal welfare legislation regarding production animals. This is supported by the Cambridge Declaration on Consciousness (2012), which states that all mammals, birds, and many other creatures are conscious beings and have the capacity for consciousness, and therefore suffering. The European Union (EU) sets out minimum standards for animal management in member states (Falaise 2019), however, many countries outside of the EU have limited or no animal welfare legislation.

Culture, religion, economics, and climate are all factors which influence a country’s perspective of animal welfare, and people from European countries are generally more
concerned with animal welfare than those from Asia (Phillips et al. 2012). In Asia in general, animal welfare legislation and regulation are still under development (Murray, Ashley, and Kolesar 2014) and fall behind countries regulated by the EU (Sinclair et al. 2017). There have been multiple incidents where welfare concerns between countries have affected international trade of animal products. For example, Australia implemented a temporary ban on live cattle exports to Indonesia due to recorded animal cruelty at slaughter (BBC 2011), resulting in major economic and animal losses (Phillips 2005). There are also consumer concerns within Europe that imported meat is grown to a lower standard compared to European regulations (Eurogroup for Animals n.d.). Sinclair et al. (2017) suggest that to improve animal welfare in Asian countries, an approach tailored to local audiences and climate will be most effective. Efforts to improve animal welfare in Asia include the Regional Animal Welfare Strategy – Asia, the Far East and Oceania (RAWS), a programme developed by the Australian government and supported by the World Health Organisation (OIE). There is a current (2023) shift in the animal welfare environment to focus on improving standards of animal welfare in Asia and improve biosecurity, including a range of grants available specifically focused on farm animal welfare in Asia, from Compassion in World Farming, World Animal Protection, Animals for Asia Coalition, Universities Federation for Animal Welfare and others. These initiatives demonstrate a focus on and provide opportunities to research, campaign and improve animal welfare in Asian countries.

Indonesia is a member of the RAWS programme. Relevant legislation in Indonesia include Law No. 18 of 2009 Concerning Livestock Husbandry and Animal Health, and Regulation No. 95 of 2012 Concerning Veterinary Public Health and Animal Welfare. These mainly focus on animal health and welfare to ensure human health, food safety, and to prevent torture and misuse of animals. Animal welfare is referred to in the legislation where the Five Freedoms
are stated in *Regulation no. 95 of 2012*, regarding all vertebrate animals and invertebrates that can feel pain.

The World Animal Protection (WAP) Index rates countries regarding their recognition and legislation of animal sentience and prevention of cruelty to animals in a score of several factors from A (best) to G (poor). Indonesia in the WAP Index was given an overall score of E (World Animal Protection 2020), because Indonesia does not have an animal welfare strategy, and awareness of animal welfare among animal production farmers is lacking.

In 2018, the Indonesian government prohibited the use of antibiotic growth promoters as supplements in animal feed in an amendment under *Law no. 18 of 2009*, which also included other restrictions on the use of antimicrobials. Antimicrobials are used to reduce disease, when antimicrobial usage is restricted, an alternative is to improve animal welfare and management to prevent disease instead (Dawkins 2017). Assessment of livestock facilities, and routine inspections are necessary to ensure that legislation are adhered to.

In many areas of Asia, pork is the leading product in the meat industry, e.g. in China (Statista 2023) and Vietnam (Hanh et al. 2019), however, Indonesia is a predominantly Muslim country which restricts the consumption of pork, and chicken is the most consumed meat product there (excluding fish)(Statistics Indonesia 2023). The chicken farming system in Indonesia has similarities to the system in Malaysia, where many farmers are contracted to grow chickens by vertical integrator companies (Baluch et al. 2017), and birds are usually harvested when they reach around 2 kg at 30-33 days. Baluch et al. (2017) suggest that the industry in Malaysia has overly prioritised business interests of growth and profit, and the focus on consumer concerns, health, animal welfare and environmental safety is compromised. Similar concerns may also apply to the industry in Indonesia.
Good animal husbandry and consideration of animal welfare can reduce suffering and premature mortality of chickens, increase production, and improve meat quality (Dawkins 2017). Good animal welfare can also reduce disease and decrease the need for antimicrobials (Benincasa et al. 2020; Fernandes et al. 2021; Sinclair, Fryer, and Phillips 2019), which reduces potential for anti-microbial resistance (Dawkins 2017; Albernaz-Gonçalves, Olmos Antillón, and Hötzel 2022), a serious global issue threatening public health throughout the world. Animal welfare can be assessed using a combination of resource-based, animal-based, behavioural and health indicators, and can be improved by modifying animal management or husbandry practices (BenSassi et al. 2019; De Jong et al. 2016; Rowe, Dawkins, and Gebhardt-Henrich 2019). This literature review of broiler chicken husbandry and welfare has focused on the context of Asia, and specifically Indonesia, where information was available.

**Broiler Chickens**

**Chicken Farming**

Raising chickens which have been selectively bred for high muscle deposition for meat, to varying extents from fast growing to slow growing breeds, is known as broiler chicken farming. Broiler chicken farming is by far the largest terrestrial animal production industry in the world, with roughly 70 billion broiler chickens slaughtered every year (Mench et al. 2021). The demand for chicken meat worldwide is expected to increase, particularly in developing countries (Mottet and Tempio 2017). Due to such high demand, production systems have been intensified to be as efficient and productive as possible, often at the cost of the chicken’s health and welfare (Azarpajouh et al. 2022). Although the health of a flock is crucial to the success of broiler farming, in large intensive systems the monetary value of a single chicken is very low (Rowe, Dawkins, and Gebhardt-Henrich 2019), which sometimes
makes it difficult and impractical for the farmer to be concerned with every individual
animal’s welfare. However, all broiler chicken farmers have a moral responsibility to be
concerned with the welfare of the animals under their care (Appleby, Olsson, and Galindo
2018; de Olde and Valentinov 2019; Fraser 1999; Frey and Pirscher 2018).

Artificial Selection, Physiology and Welfare

Broiler chickens have been selectively bred for generations, with selection for conventional
broilers focused on a small range of traits including faster and bigger muscle growth for meat
production. There is a range of breeds of broiler chickens, from fast growing breeds which
can reach the target weight of 1.5-3 kg in around 30 days, to slower growing breeds which
reach the same weight in a longer period, up to 70 or 80 days (Torrey et al. 2021). The
selection process has led to broiler chickens being genetically predisposed to health and
welfare issues, including but not limited to, cardiovascular diseases resulting in an increase in
sudden death syndrome and ascites (Zhang, Schmidt, and Lamont 2018), contact dermatitis
(Ask 2010), leg disorders (Shim et al. 2012), and low locomotor activity (Hartcher and Lum
2020). In a study comparing fast (Ross 308) and slow growing (Hubbard Redbro) strains
under the same commercial conditions, Baxter et al., (2021) recorded that slower growing
strains were healthier, had lower mortality and lower culling rate with fewer carcass
downgrades. However, slower growing chickens were harvested on average 5.5 days later
than the fast-growing chickens, and at a lower weight.

Artificial selection for fast growth of broiler chickens has resulted in significant changes to
the body conformation of the animal. Comparisons of broiler chickens from 1957 to 1991
showed a 450% increase in body weight at 42 days of age (Havenstein, Ferket, and Qureshi
2003). It is demonstrated that 85- 90% of this increase can be attributed to selective breeding,
and 10-15% as a result of nutritional developments (Akbas et al. 2009; Havenstein, Ferket,
Selection for conventional, fast-growing broiler chickens has focused on increased pectoral muscle mass (i.e. breast meat) and a heavier body weight that is achieved more quickly. Rapid weight gain results in juvenile broiler chickens carrying a heavy weight on immature bone structure compared to their ancestors, for example, junglefowl at the same age. Paxton et al., (2010) discuss how juvenile junglefowl depend more on larger medial rotators muscle group (rotating part of the hip muscle) for stability, which transitions to a dependence on using abductor muscles (hip muscles which pull the leg sideways away from the body) more for stability into maturity. Broiler chickens develop these muscles at different rates, with abductor muscles growing faster than expected, comparable to adult junglefowl.

Physiological measures show that broilers also have less pelvic limb muscle which affects the amount of support at the hip joint (Paxton et al. 2010). Larger abductors and medial rotators were found in the hips of the broiler chickens, whereas junglefowl had longer contracting muscles. The results of these changes in combination with fast growth for heavier body weight at a younger age have reduced the walking ability of broiler chickens compared to junglefowl (Paxton et al. 2010).

Several common leg deformities have been recorded in broiler chickens, including valgus or varus angulation (Figure 1), otherwise known as twisted leg deformity; the severity of this condition is measured in the tibia-metatarsus angle (Shim et al. 2012; Van Der Pol 2017). Tibial dyschondroplasia bone lesions, where a mass of cartilage forms at the proximal end of the tibia have also been documented in broiler chickens. Shim et al. (2012) found that occurrence valgus or varus angulation (where the leg bones angle inwards or outwards, respectively) and incidents of tibial dyschondroplasia bone lesions were higher in fast growing broiler chicken strains than slow growing strains. One study investigated the differences in walking ability between genetic strains of broiler chickens on different litter systems, the authors revealed that male chickens were more likely to have valgus or varus
angular deformities and femoral degenerative joint lesions than females, and deformities were more likely to occur on new litter than re-used litter (Paz et al. 2013). Twisted leg problems are heritable, and therefore selective breeding of chickens without this problem could reduce the prevalence and increase health and welfare (Akbas et al. 2009; Shim et al. 2012; Le Bihan-Duval, Beaumont, and Colleau 1996; Tang et al. 2020; Guo et al. 2019). The cortical bone (the dense outer layer of bones) of broiler chickens are highly porous, which may also predispose broiler chickens to bone deformities (Shim et al. 2012). Deformities can result in poor walking ability, or lameness, in broiler chickens, which itself is a severe welfare concern and can lead to other issues such as restricted ability to reach feed and water or avoid danger (Berg and Butterworth 2021).

Figure 1. Diagrams of broiler chicken from rear view of normal posture, varus deformity in both legs and valgus deformity in both legs (sourced with permission from Van Der Pol, 2017).

Fast-growing broiler strains are also genetically predisposed to cardiac disturbances, with past reports of prevalence of up to 17% having cardiac arrhythmia (irregular heartbeat) at 44 days old (Olkowski and Classen 1998), to more recent studies reporting 0.5-4% (Crespo and Shivaprasad 2013). Heart rate and consequent blood flow of fast-growing broilers is significantly lower than in slow-growing broilers, and this can also be a precursor to broilers developing ascites, with links to thyroid dysfunction (Olkowski 2007). Chronic heart-pump failure is a major cause of ascites and Sudden Death Syndrome in broiler chickens, and selection of chickens for better cardiac function would be one way to mitigate this (Zhang, Schmidt, and Lamont 2018). As well as cardiovascular problems, a range of other welfare issues have resulted from artificial selection of broiler chickens. Hartcher and Lum (2020)
review broiler chickens’ predisposition to musculoskeletal disorders, leg weakness and compromised walking ability in further detail.

The above health and welfare issues are a direct result of breed selection, however other welfare problems are indirectly related to breed selection, for example leg pain from the above disorders which leads to increased time spent lying and prolonged contact with litter, which can increase contact dermatitis.

Chicken Behaviour

Modern chickens were domesticated from wild jungle fowl native to Asia, and despite decades of selective breeding, many behavioural adaptations from wild ancestors persist. Although the physical characteristics of chickens have changed a great deal from domestication and selective breeding, the cognitive potential of chickens has not (Garnham and Løvlie 2018). The motivation for chickens to perform their natural behaviours is strong, and where the ability to perform natural behaviours is limited due to environmental constrictions, this can result in the expression of these behaviours in adapted ways that can be detrimental to their health and welfare. For example, without litter to forage in, broiler chickens on slatted floors pecked at feed more and gained weight more quickly, resulting in birds over the target weight (Chuppava, Visscher, and Kamphues 2018).

In a detailed review of chicken behaviour and cognition, Garnham and Løvlie (2018) describe studies which show chickens (both domestic and junglefowl) have advanced and sophisticated cognitive abilities. Studies show that chickens can show self-control (Abeyesinghe et al. 2005) and have the ability for empathy (Edgar et al. 2015; Marino 2017). This increases the complexity of providing for animal welfare in production systems, because chickens are adapted to a social, complex, and constantly changing environment. Ferreira, Guesdon, and
Calandreau (2021) identify the importance of understanding chicken cognition when considering chicken welfare in a modern commercial setting. For example, how cognition relates to reduced range use in free-range production systems; preference conditioning tests showed individual differences between low ranging and high ranging birds. The chickens’ association with conspecifics and food to different areas of their environment also influenced their ranging (Ferreira et al. 2019). Outcomes of the preference conditioning tests show that increasing association of the outdoor range with feed could encourage low ranging birds to use the outdoor range more frequently (Ferreira, Guesdon, and Calandreau 2021; Ferreira et al. 2019).

The primary behaviour of junglefowl is foraging, which is pecking and scratching at the ground: free-living junglefowl were observed to spend 66% of observations pecking at the ground, and 34% of observations scratching at the ground (Dawkins 1989). Foraging is the primary method of appetitive food seeking for chickens and entails constant movement, by scratching and pecking at the ground to uncover sources of food (Schütz and Jensen 2001). Other highly motivated behaviours, although they take up a relatively small proportion of time, include preening, where chickens use their beaks to clean and oil their feathers, (Murillo et al. 2020), and dust bathing, where chickens lay in dry soil or other dry substrate which they toss into their feathers, which also serves to remove parasites, remove excess oils in the feathers and maintain feather quality and skin health (Mench, de Jong, and Butterworth 2021). Strong motivation persists for perching on branches or artificial perches, particularly at night, which is key for predator avoidance (Bailie, Baxter, and O’Connell 2018). This may also have a role in social systems, where dominant chickens prove their status by holding priority roost or sleeping positions, as has been described in free-living chickens (Gottier, 2012), and perching behaviour has been associated with social structure in laying hens (Cordiner and Savory 2001).
There has been more research investigating cognition and behavioural problems in layer hens than broiler chickens, likely because of the higher prevalence of behavioural problems that influence production of layer hens, such as cannibalism and feather pecking, and their longer lifespan. However, recent studies have used judgement bias tests to assess the affective states of broiler chickens in enriched environments, and at different stocking densities (Anderson et al. 2021; Lourenco-Silva et al. 2023). Broiler chickens were able to learn the judgement bias test and showed the ability to demonstrate optimistic responses. The authors highlight that if broiler chickens are deficient in perching, dustbathing or foraging, they may experience negative affective states (Anderson et al. 2021). The intrinsic need and motivation to fulfil these behaviours persists, and opportunities should be provided for chickens to express these behaviours, even in intensive systems.

**Welfare and Husbandry**

The welfare issues that affect broiler chickens have been well documented in European research (Hartcher and Lum 2020; de Jong and Butterworth 2021). Many of the issues have arisen over time due to selective breeding and intensification of farming practices. In a study assessing welfare of 168 broiler flocks across different farming systems, Gocsik et al. (2016) found that important factors contributing to broiler welfare were breed, stocking density and length of dark period. Fast growing chicken strains are usually kept at densities of between 30 to 40 kg/m², and up to 44 kg/m² for heavier target weight birds, depending on the local conditions and regulations (de Jong et al. 2012; Mench, de Jong, and Butterworth 2021).

Some argue that although space is an important consideration, welfare may be more dependent on the way the space is used and the environment managed, rather than focusing on the complexities of how much space there is available, which changes as the birds grow (Dawkins 2018; Estevez 2007). Producers are unlikely to be interested in reducing stocking
density of birds for welfare reasons, due to the clear economic advantage of raising more
chickens in the same space. This review does not provide further details on the welfare
impacts of stocking density of broiler chickens, but focuses on how the space and
environment is managed, and amendments to husbandry which farmers may be more likely to
apply on farm.

**Light Systems**

One aspect of broiler chicken farming which can influence the welfare, behaviour, health, and
production of broiler chickens is the light system provided (Alvino, Archer, and Mench
2009). The light spectrum, intensity, photoperiod, and source of light presented impact on
chickens’ behaviour, welfare, and productivity. In closed house, intensive systems, which
rarely use natural lighting, these factors are wholly dependent on the farmer.

Birds are tetrachromatic, which means they have four colour photoreceptors in the eye
(Remonato Franco et al. 2022), whereas humans are trichromatic, with just three colour
photoreceptors. This means that the light spectrum or colour provided has significant impacts
on broiler chickens that we, as trichromats, may be unaware of (Deep et al. 2012; Lewis and
Morris 2000). Many bird species including poultry have feathers which reflect ultraviolet
wavelengths (Sherwin and Devereux 2010). Chickens can see ultraviolet light, which is not
provided by fluorescent and incandescent bulbs, whereas Light Emitting Diodes (LED) can
provide the ultraviolet light spectrum. Providing chickens access to ultraviolet light has been
shown to improve feather condition, gait score, and reduce fear responses, all of which
improve welfare (James et al. 2018). Although further research is necessary to fully
understand the effects of ultraviolet light on chickens and production, this could be a simple
and effective way to improve broiler chicken welfare.
Other wavelengths of light have also been shown to affect bird behaviour and productivity. Birds raised under green or white light had increased activity and time spent walking compared to birds under blue light at 33 to 34 days of age, which spent more time inactive (Remonato Franco et al. 2022). Hesham et al. (2018) found that broiler chickens were more active under red light, with increased wing flapping and aggression, whereas feeding and resting increased under blue light, and birds showed more preening and dust bathing behaviour under green light. They concluded that although the light colour did not significantly affect the welfare parameters measured, birds raised under blue light were observed to have better welfare from reduced fear and stress levels. Mohamed et al. (2014) also found significant benefits to production when blue light was used during pre-slaughter handling and transportation, with significant increases in final body weight and reduced weight loss during transport of broilers kept under blue light for the last two weeks of growth. This shows potential benefits for both animal welfare and production due to the apparent calming and fear reducing effects, blue light could be used at stressful and fear-inducing times during chickens’ lives, such as during collection, transport, and during shackling at slaughter to reduce stress (Adamczuk et al. 2014; Mohamed, Eltholth, and El-Saidy 2014). Other research has investigated providing green and red strobe light and music for enrichment on commercial farms, the results showed that both music and light stimulated the chickens, however it was unclear if the experience was beneficial or stressful for the chickens (Jacob et al. 2022). Further research into the application of coloured lights on commercial farms would be beneficial. Chickens absorb light through their skulls, as well as their eyes, therefore light intensity is also an important consideration in broiler farming (Mench, de Jong, and Butterworth 2021). Light intensity is usually monitored in lux (L), or foot-candles, based on human sensitivity to light, however a chicken correlated measure of light, named Clux, can be used to determine
how chickens perceive light (Remonato Franco et al. 2022; Prescott, Wathes, and Jarvis 2003). Clux can take into account light intensity and wavelength from a chicken’s perspective, using the sensitivity curve of chickens, because when different light colours are tested at the same lux, chickens will see the intensities differently, due to the interaction between colour and intensity (Hy-Line International 2017). However, L is more commonly reported. In Europe, chickens must be raised under lighting of a minimum of 20 L, whereas in the United States of America broiler chickens are commonly raised under 5 L (Aldridge et al. 2022). Different lighting intensities have been shown to affect broiler chicken time budgets and behaviour. Under 5 L light intensity, chickens foraged and preened less than at 50 or 200 L (Alvino, Archer, and Mench 2009), and light intensity of less than 5 L can cause damage to the eye including diseases which can lead to blindness (Olanrewaju et al. 2006). Prescott and Wathes (2010) found that chickens prefer to feed under brighter light intensities, and providing brighter light intensity during photoperiods is important so that chickens can distinguish between light and dark periods and maintain a circadian rhythm (Alvino et al. 2009).

Photoperiod, or numbers of light and dark hours, has a significant effect on broiler chicken behaviour, welfare and productivity (Schwean-Lardner, Fancher, and Classen 2012). In European legislation birds must have at least six dark hours per 24 hour period, however in other countries this differs, and systems that use 24 hour lights on are common (Onbaşılar et al. 2007). Schwean-Lardner, Fancher, and Classen (2012) report that mortality increased with day-length (number of light hours) and showed that feed conversion ratio was most efficient under the shortest day-length, although smaller amounts of feed were consumed. Whereas, body weights were highest under 17 and 20 hours of light, compared with 14 and 23 hours of light. Observing the effects of day-length on health parameters saw health improve with decreasing day length (Schwean-Lardner et al. 2013), including ocular weight, gait scores and
footpad lesions. This research demonstrates that photoperiod must be considered to optimise animal welfare and productivity. Research has also shown that increased scotoperiod, or number of dark hours, to four dark hours from hatch to the first 7 days could have beneficial effects on the immunity and growth of broiler chickens, without adverse effects on feeding and performance (Magee et al. 2022). These studies also suggest, if implemented on a large scale, there could be economical benefits from reduced electrical usage from increasing dark periods (Onbaşlar et al. 2007).

The effects of different lighting systems during incubation of chicken eggs have also been tested, and there are mixed reports on how light during incubation affects hatch rate, embryonic development, and quality of chicks (Li et al. 2021a). Eggs are commonly incubated under dark conditions, however, Li et al. (2021a) found that incubating eggs under different colour lights (including white, blue and red) compared with a dark control, showed minimal differences in embryonic development, and light colour during incubation did not affect final weight or other growth parameters of the chickens (Li et al. 2021b). Yameen et al. (2020) investigated three light periods during incubation, including 24 hours darkness, 12 hour intermittent light/dark periods, and 24 hours light. The authors found that any amount of light during incubation increased early embryonic mortality compared to the dark trial, however hatchability was higher in the intermittent light trial compared to the dark trial (Yameen et al. 2020). In another study, Archer (2017) found that exposure to white and red light on an intermittent 12 hour light/dark schedule, providing 250 lux at egg level during incubation improved broiler welfare post-hatch by reducing fear and stress compared to dark incubation. Fear was measured using tests of isolation and tonic immobility, and stress was measured assessing physical asymmetry and blood tests, where increased corticosterone and reduced serotonin indicated increased stress, thus poorer welfare (Archer 2017). Commercial
implementation of light exposure during incubation would be a low-cost measure that could improve welfare of broiler chickens post-hatch.

**Litter Substrates**

Litter material and litter management in a broiler house can have significant effects on the health, welfare, and productivity of broiler chickens, as well as the sustainability of the farm system (de Jong et al. 2012). Litter substrate is key for managing ammonia levels, dust, and moisture in a chicken house. High ammonia in litter is caused by faecal matter, water spillage, humidity, and other factors leading to high moisture and bacterial activity in the litter, which can cause hock burns and footpad dermatitis, as well as breast blisters for the chickens (de Jong et al. 2012). Diarra et al. (2021) describe the key factors of litter substrate; it should be absorbent as well as be able to evaporate moisture into the environment, have a low moisture content, be free from dust and other contaminants, have low thermal conductivity and not compact down.

Substrates used in broiler farming include wood shavings, sawdust, straw or hay, sand, rice hulls, and peanut hulls, among others (Diarra et al. 2021). Regional availability and cost of materials play a role in the choice of substrate used on a farm (Davis et al. 2010), and some materials, particularly wood shavings, sawdust, and sand, are also in high demand for other industries (Diarra et al. 2021). Litter substrate has been shown to have a significant impact on broiler chicken welfare. The most important factors of substrate regarding broiler welfare include the levels of ammonia and litter moisture, compacting or caking characteristics, and the ability for the substrate to promote natural chicken behaviours, such as dust bathing (Shields et al. 2004).
The way in which the material is presented and managed is important. Particle size, litter depth, texture and source of the material affects how the substrate performs (Diarra et al. 2021). The use of deep litter systems in tropical conditions (such as Indonesia and other parts of Asia) could contribute to heat-stress in broiler chickens, and other welfare issues. It has been shown that litter ammonia increases in warm and wet conditions (Cruz García-González and Del Mar Delgado 2007), and wet litter can have a significant negative effect on broiler health and welfare regarding footpad dermatitis (de Jong et al. 2012). Re-using litter over chicken cycles is a common practice, however in some cases this has been shown to increase footpad dermatitis, thereby reducing animal welfare (Paz et al. 2013). The choice of litter material in re-use systems can greatly affect the health and welfare of the chickens, with some materials improving chicken health with re-use and some decreasing health with re-use (Xavier et al. 2010). On first use, rice hulls resulted in the best foot health out of the materials tested (Brachiaria grass, corncob, rich hulls, and sawdust), however the re-use of rice hulls significantly increased footpad dermatitis, decreasing health and welfare with re-use (Xavier et al. 2010). Rice hulls are a commonly used substrate in Asia, with a low price and wide availability, and can be made into compost after use. Most commonly, whole rice hulls are used, however ground rice hulls and rice hull ash have also been tested (Veltmann, Gardner, and Linton 1984). Rice hull ash is produced when rice hulls are burned at the rice mill for energy and to reduce bulk when transporting and disposing of rice hulls in North America. Rich hull ash is a good potential litter substrate, with no adverse effects on performance or litter fertiliser value compared with pine shavings and a 50/50 mixture of pine shavings and rice hull ash (Chamblee and Yeatman 2003), although effects of ingestion should be assessed. The effect of rice hull ash on broiler welfare and behavioural indicators have not yet been assessed but may have potential as an alternative to whole rice hulls in Asia.
Differences in the prevalence of lameness on different flooring systems have not been thoroughly tested. When compared to chickens raised on slats or in cages, those raised on litter systems had higher incidences of hock-burn and footpad lesions, however hock-joint arthritis was higher on slatted floors than on litter (Çavuşoğlu et al. 2018). In the same study, chickens raised on slats and slats with litter had higher average body weight gain compared to those on deep litter systems, which may have contributed to higher hock-joint arthritis. One welfare challenge for broiler chickens is lameness (Kestin et al., 2001; Weeks et al., 2000). Lameness can be associated with wet litter (Granquist et al. 2019; de Jong, Gunnink, and Van Harn 2014), because of increased infection in the leg via lesions from footpad dermatitis, which increases on wet litter (Shepherd and Fairchild 2010). Litter systems allow exhibition of natural behaviours, such as dust bathing and foraging, however deep litter systems could contribute to lameness and poor gait scores due to offering lower resistance when force is applied (i.e. being soft to walk on and providing less support than hard ground). Using a deep litter system may increase lameness compared to a system which offers more resistance for the chickens to walk on, for example slats or a shallow litter system, however (to the authors knowledge) this has not been investigated.

Lameness

Lameness, or the inability to walk normally, affects a significant proportion of broiler chickens, particularly towards the end of their growing period; prevalence of 19% of a flock with a gait score of three or more was recorded by Granquist et al. (2019), from 50 commercial broiler farms in Norway. Increased lameness has been associated with lower slaughter weights, increased mortality, and increased condemnations (carcasses deemed unfit for consumption), therefore results in economic losses (Granquist et al. 2019; Yang et al. 2023).
The genetic selection for fast growth rate combined with the heavy liveweight of broiler chickens has been shown to be the main contributor to lameness (Kestin et al. 2001). However, other contributing factors to lameness include infections (Butterworth 1999), age, genetics, housing, husbandry, and nutrition (Bradshaw, Kirkden, and Broom 2002). There is an association between first week mortality rates and subsequent lameness in the flock (Kittelsen et al. 2017), and walking ability decreases with age generally in fast-growing strains (Rasmussen, Erasmus, and Riber 2022). Many incidences of lameness appear to be a result of abnormally heavy weights on immature joints and bones (Kestin et al., 2001), however in some severe cases, birds may be underweight for their age, due to inability to stand or move between feeders and drinkers (Berg and Butterworth 2021). Lameness is commonly assessed in research using the Bristol Gait Score, a 6-point score from 0-5, described by Kestin et al. (1992). However, there are some recent initiatives to predict lameness using technology (de Alencar Nääs et al. 2021; Sandilands et al. 2011).

Lameness scores of three and above have been demonstrated to be painful in broiler chickens, because when given anti-pain medication such as Metamizole, lame chickens’ walking and gait score improved significantly (Nääs et al. 2009). As well as pain, an obvious welfare issue, lameness reduces welfare (Kestin et al., 1992) by increasing discomfort and reducing the ability to express normal behaviours, and fear may increase with the inability to escape a perceived danger (Granquist et al. 2019). In severe cases, lameness limits access to food and water (Berg and Butterworth 2021). However, Weeks et al. (2000) found that time spent feeding was not affected by lameness, but feeding behaviour was affected. Lame birds spent up to 50% of feeding time eating whilst laying down, and number of feeding bouts was reduced, although total feeding time was not affected (Weeks et al. 2000). To the author’s knowledge, there has not been any research on the effect that sitting whilst eating has on
chickens’ digestion, although this may cause an additional source of discomfort, because healthy animals would ordinarily eat whilst standing. Weeks et al. (2000) also showed that chickens with severe lameness had altered overall time budgets, with lameness affecting non-essential behaviours, such as preening, as well as decreasing time spent standing, and increasing time spent lying (Weeks et al. 2000). Increased lying causes prolonged contact with litter, which can increase skin lesions, particularly if the litter is of poor quality (Freeman et al. 2020).

Contact Dermatitis and Cellulitis

Footpad dermatitis (FPD), hock burns and breast blisters are lesions that develop on the skin of the footpad and toes, hock joint or breast, and are caused by contact dermatitis (Freeman et al. 2020). The most important factor contributing to contact dermatitis is litter quality, with wet litter causing an increase in FPD (Shepherd and Fairchild 2010; Wilcox, Patterson, and Cheng 2009; Xavier et al. 2010). Keeping litter dry by choosing the correct material and proper management is key in reducing contact dermatitis, however other factors such as age, sex, water intake and nutrition also play a role in maintaining litter quality and therefore contact dermatitis (Freeman et al. 2020).

There is some evidence to suggest that litter depth can also affect prevalence of FPD; Ekstrand et al. (1997) found that in a study of 101 farms, FPD significantly increased with greater litter depth, irrelevant of litter material (out of pine wood shavings, straw, or a mixture of different materials). The most successful litter for reducing FPD was pine wood shavings (Ekstrand, Algers, and Svedberg 1997), and Freeman et al. (2020) found pine wood shavings to be most effective when replaced every four days. In flocks with contact dermatitis, replacing wood shavings every four days could also be used as a remedial treatment to improve the condition, although may prove impractical and expensive on commercial size
farms. Freeman et al. (2020) showed that provision of iodine mats in some areas of the chicken house were not useful at reducing incidences of or providing remedial treatment for contact dermatitis, likely because of increased moisture on the foot. As well as litter quality, age, and body weight also affect FPD (Haslam et al. 2007). However, there are inconsistencies in the literature of the factors influencing contact dermatitis, with differences between studies over time and in different countries (Haslam et al. 2007). This is likely because many reports are based on FPD scores at slaughter of birds from several commercial farms, therefore many husbandry and environmental factors cannot be controlled for or analysed. Apart from effect of litter quality, research has not yet determined if the farm and its specific management and husbandry factors determine the occurrence of FPD, or to what extent FPD is also influenced by other uncontrollable or difficult to control factors, such as outside temperature and humidity, genetics, or other stresses; although de Jong et al., (2022) begin to look at how consistent different farming systems are regarding welfare.

FPD can be determined visually using a 5-point score from 0-4, as is used in the Welfare Quality (2009) broiler assessment protocol, which can either take place on farm or at slaughter. However, other methods of detecting FPD include automatic detection using a camera at the slaughter line, or thermal imaging (Wilcox et al., 2009). Jacob et al. (2016) found that as the severity of FPD increases, the skin temperature on and around the lesion on the foot decreases due to necrosis, and this can be detected using thermal imaging.

In Asia there is a large market for chicken feet, also known as chicken paws, or phoenix claws; this demand is demonstrated by imports of tonnes of chicken feet from the rest of the world to Asia, for example from America to China (Cang 2020; Jacob et al. 2016. It has been estimated that the market in chicken feet is now the third most economically important part of the chicken, after breasts and wings (Jacob et al. 2016; Shepherd and Fairchild 2010).
Chicken feet with blemishes due to FPD are sold at a lower rate (Shepherd and Fairchild 2010; Xavier et al. 2010), and therefore the incidence of FPD can be economically detrimental. The huge market for clean chicken feet should be a major incentive for producers to reduce incidences of FPD and carcass downgrading due to FPD, for both economic and animal welfare reasons, and is particularly relevant to Asia.

Litter substrate and quality have also been determined to be important in reduction of cellulitis. Cellulitis is a thickening and yellowing of the skin in the abdominal region, and is usually observed at meat inspection after slaughter. Cellulitis is a major cause of condemnation of broiler carcasses worldwide, and therefore this issue is economically important (Schulze Bernd et al. 2020). Cellulitis is caused by scratches on the skin, where *Escherichia coli* then enters deeper layers of the skin and causes the discolouration and skin thickening. Cellulitis may be more common in summer months, or in warm weather (Part et al. 2016), and contributing factors are litter quality, feeding regime, which may increase scratching between chickens at feeders, and stress (Schulze Bernd et al. 2020). As incidences of cellulitis are usually determined after slaughter, there are no studies observing the effect of cellulitis on broiler chicken behaviour, however more scratches and worse feather condition, which are underlying causes of cellulitis, indicate reduced welfare.

Heat Stress and Climate Control

Healthy body temperature of broiler chickens is within the range of 40.6 to 41.7 degrees Celsius (°C), and the optimal ambient temperatures, or thermoneutral zone, to rear chickens to reach full growth potential is between 18-24°C (post-brooding period) (Olanrewaju et al. 2010). Broiler chickens raised under higher temperatures are susceptible to heat-stress, and broiler chickens in tropical climates rarely meet their breed growth potential due average
ambient temperatures being above the thermoneutral zone for most of the time (Kpomasse et al. 2021). Hot chickens expend energy in thermoregulation, such as panting, which reduces the efficiency of feed conversion, and this results in major profit losses (Olanrewaju et al. 2010). McLean et al. (2002) found that chickens which were recorded panting also ate less, although growth rate was not affected, and females panted more and from a younger age.

In a detailed study of acid-based homeostasis and thermoregulation, chickens were raised from 21 days at differing temperatures of 26.7, 21.1, and 15.6 °C. Chickens raised at the highest temperature had significantly decreased body weight, high-density lipoprotein, and total protein in blood at 56 days old, but had significantly increased rectal temperature, cholesterol, and triglycerides, compared with the two other temperature trials (Olanrewaju et al. 2010). Birds raised in higher temperatures had higher respiratory rates, to dissipate heat by evaporation through panting. Panting decreases the carbon dioxide levels in the birds, resulting in changes to kidney function, and altering the acid-base balance of the bird, or respiratory alkalosis. The loss of fluids through evaporation in panting also affects fluid make-up and can increase acidification of the blood (Olanrewaju et al. 2010). The study concluded that chickens raised under lower ambient temperatures were healthier and had higher body weights than those raised under high temperatures.

Exposure to temperatures over 30 °C can result in severe heat stress for broiler chickens (Saracila et al. 2021). This issue is becoming more of a concern with the impacts of global warming, alongside selection for fast growth of broiler chickens, which has resulted in poor heat tolerance. Heat stress can cause oxidative stress which causes biological damage and can result in disease such as gut inflammation (Wang et al., 2018), this in turn can affect meat quality in regards to oxidative stability, and has ramifications for food quality and safety (Fellenberg and Speisky 2006). Furthermore, oxidative stress causes an inflammatory response in the body cells, which further exacerbates the oxidative stress (Saracila et al.
Research has investigated nutritional supplements which could help to reduce the effects of heat stress on production and meat quality (Fellenberg and Speisky 2006; Saracila et al. 2021) such as electrolyte salts (Borges et al. 2003). Borges et al. (2003) aimed to find the optimal combination of electrolyte balance, water intake and litter moisture for commercial success. Supplementing feed with salts to increase Dietary Electrolyte Balance (DEB, including sodium (Na), chlorine (Cl), or sodium chloride (NaCl) and potassium (K)) under different temperatures revealed that increasing DEB also increased feed and water intake, and increased body weights, as well as lowered body temperature (Borges et al. 2003). However, the increased water intake resulted in increased litter moisture, which caused difficulties with litter management. Drinking water temperature and water intake are important for regulation of body temperature (Borges et al. 2003; Abdel-Moneim et al. 2021), and in hot climates drinking water should be cooled where possible (Cobb-Vantress 2021; Abioja et al. 2011). Other research has investigated different methods to reduce heat stress in boiler chickens, including amino acids, natural antioxidants, minerals, electrolytes, phytobiotics, probiotics, fat and protein, feed restriction, feed form and others, with varying success (Abdel-Moneim et al. 2021).

Heat stress is also an important factor while transporting chickens in tropical climates. Abidin et al. (2022) found that pre-transport water sprays reduced cortisol in male broilers, and appeared to be beneficial for their welfare during transport in hot humid conditions. Further research is needed to fully assess the effect of animal husbandry and management practices on heat stress in countries most affected, such as in the hot and humid tropics (Kpomasse et al. 2021). Shahzad et al. (2021) provide useful descriptions and graphics demonstrating the effect of high humidity and temperature on heat stress in broiler chickens (Figure 2).
Precision Livestock Farming (PLF) is a method of using technology to increase the productivity of farming, and often uses indoor climate control systems which aim to provide the optimal climate for efficient growth of livestock (Costantino, Fabrizio, and Calvet 2021). This aims to keep the temperature and humidity within the animals’ thermal neutral zone, and reduces the effect of extreme outdoor climate on livestock growth, either using heating or cooling systems where necessary. Evaporative cooling systems have been developed to control temperature and humidity, and therefore dew point, in hot climates (Shahzad et al. 2021). These systems aim to ensure animals put their energy into growth, as opposed to thermoregulation. Climate control systems also aim to regulate indoor air quality (IAQ), by removing toxic gasses such as ammonia (NH$_3$) or carbon dioxide (CO$_2$) by air exchange mechanisms. Climate control not only has benefits for the animals, but also has been shown to reduce respiratory problems in farm workers, due to better air quality (Costantino, Fabrizio, and Calvet 2021). Climate control systems also have the potential to increase food security, particularly in developing countries. Costantino et al. (2021) demonstrate the importance of climate control systems for the future of livestock farming, as global warming increases the prevalence of heat stress in livestock, which contributes to food insecurity and is of particular concern for hotter countries such as Indonesia.

Climate control systems in closed broiler houses in hot climates must be tested for their effectiveness. Muharlien et al. (2020) investigated the difference between closed bamboo chicken houses with fans (with wall curtains but no cooler pads) compared with open sided bamboo houses. They found that there were no significant differences in air temperature and
humidity between the houses, only a difference in air velocity due to fans in the closed house system. However, they did find that chickens in the closed house system were more productive, which may have been due to better air quality from higher wind speed and air exchange, although that was not discussed in the paper (Muharlien et al. 2020). To the authors knowledge, research has not yet investigated the influence of different aspects of climate control, for example how wind speed affects broiler behaviour.

Welfare Assessment

Parameters for assessment

The parameters for assessing broiler welfare range from resource to animal-based measures. Resource-based measures focus on provisions and the quality of the environment which is in control of the farmer. This includes the access to feed and water, measured by the number of drinkers and feeders; litter substrate, temperature, air quality, and stocking density, among others. Resource-based measures assess potential for animal welfare, whereas animal-based measures allow further insight into how the animal is managing with the environment and provide a direct observation of the welfare of the animal. Several ‘iceberg indicators’ of animal-based measures for broiler chicken welfare have been shown to be useful for assessing welfare in a recent report by the European Food Safety Association, Table 1 (Nielsen et al. 2023).

Table 1. Iceberg indicators for welfare assessment of broiler chickens, modified from Nielsen et al. 2023.
<table>
<thead>
<tr>
<th>Walking ability</th>
<th>Various assessments have been developed, however the most common and accepted as verified measure of welfare is the six-point (0-5) gait score (Kestin et al. 1992). Chickens scored as 0 are agile and able to walk completely normally, and a score of 5 is where the chicken is incapable of walking.</th>
<th>100 individual chickens per flock are scored, 10 chickens from 10 locations in the house.</th>
<th>In instances where chickens score 4 or 5 in the gait score, it is deemed that their welfare is compromised and they are unlikely to recover, therefore it is recommended they are culled to prevent unnecessary suffering (Butterworth and Haslam 2009; Berg and Butterworth 2021).</th>
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<tr>
<td>Feather and body cleanliness</td>
<td>The Welfare Quality (2009) broiler chicken welfare assessment measures the cleanliness of a bird’s feathers, particularly on the ventral part of the body, using a four-point score from 0-3, where 0 is completely clean and 3 is very soiled.</td>
<td>100 birds should be scored from different locations in the house, and different birds from those tested for walking ability. This measure can be assessed on farm or at slaughter.</td>
<td>The feather condition of broiler chickens is essential for thermal regulation, preening as a comfort behaviour and dirty plumage can be a sign of gastro-enteric disease or poor litter quality. Dirtier chickens with scores of 2 and 3 have poorer welfare.</td>
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<tr>
<td>Lethargy</td>
<td>Defined as sitting motionless with head drooped or standing with eyes closed, not responding to any stimuli (different from decreased activity towards the end of the growing period, where birds still respond to stimuli). A binary yes/no measure.</td>
<td>The total number of chickens counted in the chicken house showing lethargy are counted.</td>
<td>Lethargy can be a sign of heat-stress, cold-stress, and gastro-enteric disorders, and is a clinical sign of illness or extreme discomfort, therefore the welfare of these birds is compromised. The more birds showing lethargy equates to poorer welfare of the flock, although acceptable levels of lethargy in a flock have not been published.</td>
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<td>Mortality Rate</td>
<td>Birds found dead and culled due to health or welfare issues over a certain period of the cycle.</td>
<td>Percentage of total flock within a specific time frame, usually first week, first two weeks, or complete cycle.</td>
<td>Mortality and cull rates can be a sign of disease, predation stress, or heat-stress. If more birds are found dead, or more birds are culled during the growing period, this is an indication of poorer welfare of the</td>
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flock. 2-3% mortality (including culls) is expected or accepted in a European flock slaughtered at 35-36 days (Raj and Berg 2021).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description and Scoring Guide</th>
<th>Total Birds Assessed</th>
<th>Observations</th>
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<tr>
<td>Hock-burns</td>
<td>The Welfare Quality (2009) assessment provides a visual scoring guide of 0-4, where 0 is normal hock joints without and lesions, and 4 is severe lesions on the hock joint of the chicken.</td>
<td>100 birds per flock, 10 birds from 10 different areas of the house should be assessed, this can be done at the same time on the same birds as the cleanliness score.</td>
<td>Hock burns are a type of painful and inflamed skin dermatitis, usually caused by poor litter quality and decreased activity, resulting in more contact time with litter. Chickens with higher hock burn scores have poorer welfare. Prevalence of hock burn from 0-7% have been reported (Berg 2004).</td>
</tr>
<tr>
<td>Footpad Dermatitis</td>
<td>The Welfare Quality (2009) assessment provides a visual scoring guide five-point scale (0-4), where 0 is a</td>
<td>A sample of 100 birds, 10 birds from 10 different locations in the chicken house,</td>
<td>Footpad dermatitis are painful lesions on the skin of the foot and toes of chickens. These lesions increase with</td>
</tr>
<tr>
<td>Heat stress</td>
<td>Heat stress can be determined non-invasively by observing the number of birds showing panting (breathing through open beak), lethargy (as above) and wings held away from the body.</td>
<td>If there are birds observed panting, 100 birds should be visually assessed from a distance to determine the number of birds panting out of 100 birds counted.</td>
<td>Panting occurs when birds are experiencing heat stress, panting is a validated measure of heat stress in broiler chickens. More birds panting indicates poorer welfare of the flock. An acceptable level of panting in a flock has not been described (to the authors knowledge), and prevalence will be influenced by climate and time of day.</td>
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</table>

- Clean foot without lesions, and 4 is lesions on a large proportion of the foot and toes. Should be assessed. This can be assessed at the same time on the same chickens as the cleanliness and hock burn scores. Poor litter quality and pathogens. Higher scores of footpad dermatitis and the more birds affected shows poorer welfare of the birds. Levels of footpad dermatitis at 5-10% of the flock have been described (Berg 2004).
**Welfare Assurance**

Farm animal welfare assessment is common in European countries, and assessments can be for the purpose of regulation, assurance schemes, or research (de Jong and Butterworth 2021). Many countries have minimum standards of animal welfare, for example regulations of maximum stocking densities, which is enforced by government inspection on farm and at slaughter. In some countries, farmers can also join assurance schemes with higher welfare standards, which allows farmers to sell their products at a premium, e.g. Red Tractor scheme\(^1\) in the UK, Global Animal Partnership\(^2\) in North America, SPCA\(^3\) in New Zealand. The Red Tractor Standard is the most common assurance certificate in the UK, which provides a minimum standard of housing, management, and welfare, mainly using resource-based measures for assessment (Mullan, Stuijfzand, and Butterworth 2021).

Assurance schemes were developed in the 1980s in the UK to boost consumer confidence in livestock farming and food safety, at a time when these issues were a major concern for the public. Lewis et al. (2008) provide a background to the development of farm assurance schemes in the UK, they found that the main driver of these schemes at the time was consumer demand for safe, high standard products. However, the uptake of farm assurance schemes in some European countries can be low for two reasons, firstly where national legislation for farming practices is already of a high standard, consumers are less concerned with schemes for higher welfare products because there is already trust in the national...
The second reason is that, in lower income European countries, consumer values differ, and there is more concern for quantity rather than quality of farm products (Lewis et al. 2008). However, standards have been improving generally across all European countries, in part due to EU-wide legislation on the welfare of farm animals in Council Directive (2007) 2007/43/EC, on the minimum rules for the protection of chickens kept for meat production.

In Asia, farm animal welfare assurance schemes are less developed, however there is a movement towards higher welfare standards in some areas. Farm animal welfare assurance schemes have been described in Korea (Cheon et al. 2021) and Taiwan (Yang and Hong 2019). Reportedly, supermarket giant Carrefour in Taiwan only accepts cage free eggs (The Poultry Site, n.d.) and there is a higher animal welfare scheme in Taiwan. Yang and Hong (2019) found that the main drivers for higher welfare products in Taiwan were food safety and healthiness. They found that people with higher income, higher level of education, and females, were more likely to pay an increased price for a higher animal welfare product.

Standards, motivations, and priorities as well as climate, resources, and supply chains differ greatly across the world, therefore national scale investigations into animal welfare, the benefits of assurance schemes and consumer demand, or potential for these schemes to succeed in individual countries is necessary, albeit difficult where farm animal welfare research is uncommon.

**Welfare Assessment for Research**

The Welfare Quality (2009) (WQ) broiler assessment protocol is commonly used to assess animal welfare for research purposes. It was developed along with other farm animal welfare assessments from the Welfare Quality Network\(^4\), including cattle, pig, and layer hen welfare assessments. The WQ broiler assessment provides a protocol with resource-based,

\(^4\) http://www.welfarequality.net/en-us/home/
environmental, and animal-based measures (some included in Table 1), as well as a scoring system to give a numerical outcome. The WQ assessment has been shown to be suitable to assess broiler welfare in Europe, however there are some WQ assessment parameters which have not been assessed, or the validity has been questioned. Some stakeholders suggest that the Welfare Quality assessment is too time consuming (de Jong et al. 2016), estimated to take between 3-4 hours to assess one flock of chickens. de Jong et al. (2016) also report that the final scoring calculation system could be improved to ensure it can differentiate between flocks on similar farms. However, the assessment protocols evolve and change with input from scientists (Welfare Quality Network, 2018), and there have been suggested changes to make the assessment shorter whilst keeping validity (de Jong et al. 2016).

WQ is one of the first welfare assessments to include animal-based measures (de Jong and Butterworth 2021), including the touch test as a measure of fear. Tests of fear can be impacted by lameness of the flock, and the touch test (Vasdal et al. 2018), along with fear of novel objects and the stationary person test of fear (Rasmussen, Erasmus, and Riber 2022) are not scientifically validated measures of broiler welfare. Assessment of breast blisters on live chickens is also difficult to measure; in one study, researchers were unable to accurately assess breast blisters on farm, due to obstruction of feather coverage, and reported it is easier and more reliable to assess breast blisters at slaughter after feathers are removed (Tuyttens et al. 2015).

Although developed in Europe, WQ assessment parameters have been used in farms around the world. Hanh et al. (2019) used parameters from WQ assessment to assess broiler welfare on farms in Vietnam. Hanh et al. (2019) found that fast-growing breeds such as Ross 308 had a higher percentage of lameness compared to the slow-growing Ho x Luong Phuong breed. They also found that birds raised with outside access had better welfare compared to those raised indoors, measured by reduced cleanliness and walking ability, and increased hock burn.
and footpad dermatitis of chickens raised indoors. They concluded that management improvements are needed to improve the welfare of indoor raised broiler chickens in Vietnam. The WQ assessment was also used to compare farms in Brazil that export to the EU with farms in Belgium. Despite having a lower standard of animal welfare legislation in Brazil, the outcome found that welfare was better on the farms in Brazil compared to in Belgium (Tuyttens et al. 2015). This may have been influenced by farm selection, as the selected farms in Brazil were exporting to other countries and may have higher standards than those catering for the domestic market. Research has also shown that people from a variety of cultures and countries can be trained to reliably assess of gait scoring in a consistent way (Butterworth et al. 2007). Overall, previous research demonstrates that the WQ assessment is sensitive enough to differentiate between welfare in different farming systems.

Another assessment is the transect method of assessing animal welfare, which derives from ecological research, and has been adapted to assess broiler chicken welfare (Marchewka et al. 2013; BenSassi, Averós, and Estevez 2019). This method entails walking straight lines through a chicken house and measuring obvious signs of poor welfare of the chickens directly in front of the assessor. This includes recording chickens which are immobile, dirty, showing signs of pain or dead. When using the transect method it is essential that different areas of the chicken house are represented, because research has shown that injured, sick or immobile birds are more likely to be at the edges or close to walls in a chicken house (BenSassi, Averós, and Estevez 2019), however this is not always the case (Marchewka et al. 2013). A calculation of the total flock is then used to assess the total welfare score of the flock. There is also a smartphone application, IWatch-Broiler (BenSassi et al. 2019), which can be used to record data quickly and easily. This is a relatively quick assessment method and requires minimal training. This would be suitable for farmers to use, so they can quantitatively assess
their flocks and make husbandry adjustments accordingly and quickly, to benefit the current flock in terms of welfare and production. The transect method has been shown to be a robust and simple method of assessing broiler welfare on commercial farms (BenSassi, Averós, and Estevez 2019).

The assessment of welfare has historically focussed on reducing negative states of welfare, for example in the Five Freedoms, however more recently there is increasing research into how it is possible to provide and assess positive states of welfare. To make positive welfare assessment a reality, some authors suggest that because there are not validated, practical on-farm tests to measure positive emotional states, resource-based measures should first be validated. For example, using cognitive bias tests to observe if a resource does induce a positive state, and then these resources can be used as a practical method to assess positive welfare on farms (Rowe and Mullan 2022). Further research is needed to include assessment of positive welfare on broiler farms.

Conclusion

The development of the chicken industry via artificial selection for fast growth and heavy weight, to the intensive housing systems, have led to a myriad of welfare issues for broiler chickens, some of these issues lead to reduced production and food safety concerns. Consequently, there has been a wealth of research into broiler chicken welfare to determine the effects of various housing aspects, including lighting, climate control, and litter substrate, and the impact these have on chicken health and welfare measures. Much of the research on broiler chicken welfare has taken place in Europe, with limited investigation into broiler welfare in Asia, where the climate, resources and views on animal welfare differ greatly to those in Europe. In the tropics, the hot and humid climate limits the growth of broiler chickens, due to heat intolerance. The effects of different aspects of climate control and
substrate use have not been fully investigated as to how the reduce the issue of heat stress in chickens in situ. One of the key considerations in broiler husbandry is management of litter substrate, and this could be a good starting point for broiler flocks in Asia. To maintain good quality litter, temperature, humidity, feed and water must be well regulated by good management. Good litter quality has been shown to reduce footpad dermatitis and other contact dermatitis, which can also reduce incidence of lameness. Good quality litter also allows chickens to keep clean and exhibit natural behaviours, essential components of good welfare. Additionally, better quality of chicken feet, from reduced incidences of footpad dermatitis, will add value to chickens in the growing Asian chicken feet market. Improving these welfare factors can result in lower mortality, culling and condemnations at slaughter, therefore it is also economically sensible to aim to improve these welfare factors.

Reviewed here are some of the key aspects of broiler chicken welfare and husbandry, and how they can be assessed. This literature review provides the background for a research project on broiler chicken welfare on Indonesian farms, which aims to assess the welfare of broiler chickens in Indonesia in general and, where necessary, develop practical and economic solutions to improve animal welfare.

Declaration of Interest

The authors have no conflict of interest regarding this research.

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