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Behaviour and welfare concepts in laying hens and their association with housing systems

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ABSTRACT

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The majority of commercial layers in the world is kept in confined cage housing systems where the birds are unable to exhibit their normal behaviours like dust bathing, perching, foraging and nesting etc. The space requirement in battery cage system is much less than the aviary and free range system. Though cage-free systems provide better welfare, there are issues of cannibalism, fracture, spread of diseases, air quality, egg quality and health of the birds. Worldwide there is diffusion in the welfare regulations for both layers and broilers. There is increasing awareness among consumers regarding the origin of their poultry products and simultaneous need to improve the current level of bird welfare by the egg industry. Thus, welfare concepts not only emphasize five freedoms but also have biological, cultural, economic, social, philosophical, emotional, legal, and political dimensions. The degree of free choices made by well informed and educated consumers may play an important role in implementing welfare measures. There is also a need for additional research on economic implications of welfare under different agro climatic conditions. This review will mostly highlight productivity, behavioural restrictions and welfare issues of laying chickens under different farming systems.

Key words: Behaviour, Welfare, Five freedoms, Poultry, Intensive system

INTRODUCTION

Poultry meat and eggs are the most common animal source food consumed at global level through wide diversity of culture, traditions and religion and making them key to food security and nutrition. Presently the world has over 23 billion poultry birds-about three per person on the planet (FAOSTAT, 2016). Within the livestock sector, poultry emerges as the most efficient sub-sector in its use of natural resources and in providing protein to global demand. Poultry production has undergone an enormous expansion and development during last four decades throughout the world. Advances in genetics, nutrition and husbandry have resulted in a phenomenal improvement in the productivity. Consequently, the poultry industry in India has emerged as one of the most dynamic and fastest expanding segment in animal husbandry with an annual growth rate of 6-8% in broiler meat and 5-7% in egg production (Bhanja, 2016).

The majority of commercial layers in the world are kept in confined housing systems with light control, forced ventilation and mechanized feeding. The intensive poultry production systems that aim to maximize profit offer increasingly new technological solutions which facilitate less labour but enhanced productivity. However, these systems do not always meet the natural needs of birds. Now a day, cage rearing system of layer birds is a controversial topic throughout the world due to their comfort, welfare, health, production efficiency and ambiguous behaviours that were expressed by confined birds. The birds are unable to exhibit their full behavioural repertoire due to restriction in their physical environment or by the size of flock relative to their capacity to form stable social relationships. Such problems generally not encountered in meat type birds. The broilers are reared mostly on floor in open sided house for a period of 5-6 weeks only. Hence the welfare issues in broilers are limited to stocking density, metabolic disorders like ascites and sudden death syndrome, breast blisters, hock burns, foot pad lesions etc. which can be minimised through improved management practices.

The traditional housing system of conventional cages is now widely considered to have a negative effect on the welfare of hens. Welfare related aspects have appeared as one of the most challenging issue in the current egg industry. This has created several welfare concerns among the animal lovers. Consumers now more in the origin of their poultry products and most of the people believes that the laying hen industries need to improve the current level of bird welfare. Consequently, consumers' perception of animal welfare can affect the type of the products purchased. This review will enlighten the concept of poultry behaviour and welfare, especially those of egg type chicken and how those affect the poultry production system.

Types of poultry behaviour

As an animal's state can be inferred from its actions, so behaviour served as potential tool that can tell us about the animal health and what the animal's want.

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It is the only non-invasive and non-intrusive methods of welfare assessment. When animal welfare studies were started only behavioural factors related to feeding and reproduction were considered (Gonyou, 1994). Classically, animal welfare has concerned the identification of negative welfare states; of markers of pain and stress, aggression, boredom and abnormal behaviour (Fraser 2008). The state of positive experiences, however, is more difficult to identify. Increasingly, there is also an interest in positive welfare states such as natural behaviours, behavioural needs, preferences, behavioural problems, emotional state, cognitive abilities, etc. The poultry behaviours can be classified as follows.

a. Natural behaviours

The expression of natural behaviour is a frequently used tool used to estimate the welfare of poultry. Among all welfare indicators Linares and Martin (2010) pointed out that the natural behaviour of birds is the most reliable welfare indicator. According to Bracke and Hopster (2006), natural behaviour can be defined as the behaviour animal normally presents when exposed to conditions similar to its natural habitat. Natural behaviours are pleasurable and promote biological functions that are meaningful to the animal's welfare. It is also difficult to identify the limits where the change of behaviour exceeds the range of normal adaptation responses. Some of the natural behaviours have been listed below.

*Dust bathing***:** The bird pecks and scratches the potential dust bathing place, and then sits on a spot and starts to gather loose substrate particles around its body. Several internal and external factors, including light, substrate, presence of parasites, heat, and pleasure, that elicit dust bathing. It is also a mechanism of heat loss by conduction. This sequence of movements, which involves body rotation and leg stretching, may also be considered an exercise. Wall *et al.* (2008) observed that Hy-Line White and Hy-Line Brown layers housed in furnished cages preferred sawdust, and not sand to dust bathe. Hy-Line Brown strain was more aggressive when expressing this behaviour. Pohle and Cheng (2009) and Appleby *et al.* (2002) found that birds prefer litter pecking, resting and preening to sand bathing.

Nesting: This behaviour precedes ovi-position, and the bird searches for an adequate place to lay the egg. Nesting behaviour is an example of natural behaviour with a predominantly internal motivation. It does not depend on the external environment. It involves excessive locomotion and exploratory activities - a special vocalization, called gackel-call produced. Deprived nesting space resulted in egg retention in the eggshell gland (Hughes *et al.*, 1986). In the event of non-availability of nesting space, hen demonstrates its frustration by sitting and not performing any activity.

Foraging: The behaviour of scratching is expressed when the bird scratches the litter with its feet in a backward movement, and pecks the litter in search of food. Higher intensity, duration, and incidence indicate better bird welfare (Bracke and Hopster, 2006). Consequence of the frustration of scratching behaviour is the increase incidence of feather pecking (Haas *et al.*, 2010).

Perching: Normally**,** 25 to 41% of the birds use perches during the day and more than 90% during night (Pohle and Cheng, 2009). However, cages with perches make the birds less active (Matsui *et al.*, 2004).

Comfort behaviours: Wing flapping is often referred to as comfort (stretching) behaviour, and hens also show other comfort-type behaviours that involve wing raising (slight elevation of both wings) and wing stretching (one wing stretched downward). Cages restrict long-distance movement and wing flapping is usually observed when hens are running or flying (Albentosa and Cooper, 2004).

b. Aggressive behaviour

In addition to expressing natural behaviours chickens may also express negative behaviours, detrimental to their welfare when frustrated or frightened. According to Broom (1991), fear is a preparation for danger or a response to a detectable danger. It is associated with freezing behaviour, tonic immobility, escape attempts, aggression, adrenal cortex activity, heart-rate elevation, and effects on meat quality. Cannibalism is a kind of behaviour detrimental to bird welfare, particularly because it causes pain and injuries. It is related to severe feather pecking and some authors believe it is a result of the genetic selection for the improvement of individual performance as opposed to social and natural behaviours.

c. Social behaviour

In some production practices poultry are often grouped into large flocks that are uniform, consisting of similar sized birds in same-sex groups. This reduces sexual activity and allows birds to be more competitive in attaining food. However, groupings of large size may increase aggressive interactions because it is more difficult for the individual to establish a stable dominance hierarchy. Chicken species tend to be social, forming flocks or groups. When space is available the birds will often form sub-groupings, each having an established social order. High population density results in frequent space violation of bird, and dominant-subordinate interactions help to lend stability to the group. For this to occur, birds must recognize individuals and recall social position. Social dominance can produce management problems, especially in high-density systems in which a few dominant individuals may control the feed, water and available space. Mixing of unfamiliar groups or flocks always results in the reestablishment of the dominance order with the associated agonistic interactions. Frequent agonism will result in negative effects on performance.

d. Abnormal behaviour of poultry

The deviation from normal behaviour is generally considered as abnormal behaviour that leads to welfare problems. For welfare assessment it is prerequisite to differentiate between normal and abnormal or disturbed behaviour. There are different approaches to determine normal behaviour. Some authors propose the behaviour of animals in a quasi-natural environment should be the base line (Stolba, 1981). The deviation of the behaviour under commercial husbandry conditions, from the quasi-natural reference system, may be used as measure of welfare problems. Abnormal behaviours are often used as the benchmark of poor housing conditions and the need for environmental enrichment. Untypical behaviour observed in poultry is most clearly described in hens which peck feathers to one another starting with a tail and then from the whole body. Another example is pecking wattles and comb (Caruncle in turkeys), and also eating their own eggs. This is the sign of one of the cannibalism forms and is usually the proof for certain shortages in fodder's composition.These are serious type of abnormal behaviour encountered in birds which once have been developed, often persist even though the causal factors have disappeared. In these cases the occurrence of abnormal behaviours may not reflect the welfare situation at the time of observation. A special problem is the lack of occurrence of behaviours either for the lack of space (wing-flapping), structure (roosting), or lack of eliciting stimuli (flight). The non-occurrence as such may only be considered with regard to welfare if the causes of the effect are known. Although abnormal behaviours often appear to arise from frustrated motivation, they may also be caused by factors that are not directly related to a poor Domestication and changes in the chicken genomeenvironment, such as pathology or neurological predisposition.

Domestication and changes in the chicken genome and behavioural pattern

The primary purpose of domestication was to breed chickens for food and entertainment. However, the selections during domestication process altered the behaviour of the chickens. Molecular studies (Rubin *et al*., 2010) in red jungle fowl (*Gallus gallus*) and Domestic chickens (*Gallus gallusdomesticus*) revealed that Thyroid stimulating hormone receptor (TSHR) was present in Chromosome-5 of the Red Jungle Fowl chicken which is closely related to photoperiodic control of reproduction. However, due to selection for higher egg production there was a change in amino acid glycine to arginine in domestic chicken. This helps in decoupling the photoperiod from reproduction, hence the layer birds are enable to lay eggs throughout the year. In another study Elferink*et al.* (2012) reported that 67 chicken breeds selected for different purposes showed strong evidence of selection at 26 region of chicken genome and some of which contained genes such as Insulin like growth factor-I (IGF-I), skeletal function etc. Study conducted on the behaviour and reproductive success in a small population of domestic chickens released into an un-inhabited island revealed that few behavioural traits like capability for nest site choice and protecting the chicks from predator are lost in modern chickens but was generally observed in the red jungle fowls (Duncan *et al*., 1978). Another notable change seen in many of the modern strains is the loss of broodiness, although many non-commercial strains still possesses the broodiness character and sit on their eggs.

There are other instances where there have been differences in the response criteria of domestic and wild chickens like cockerels crow more than red jungle fowl (Wood-Gush, 1959), lees perching of domestic fowl during day time compared to their red jungle counterpart (Eklund and Jensen, 2011), less fearfulness and response to predator stimuli but increased socialization in modern hens (Campler *et al*., 2009). Even scientific study proved that when red jungle fowl selected for reduced fear character that reduced the foraging tendency (Agnvall *et al*., 2012), normal activity (Eklund and Jensen, 2011) and increased body weight ((Agnvall *et al*., 2014) in red jungle fowls.

Housing systems for layers

In general, layer farmer has the choice of three main housing systems: battery cages - small enclosures with welded wire mesh sloping floors; floor systems - in which the layers are kept on litter and the birds have freedom to move around within the poultry house; and the free range systems - in which the layers also have access to an outdoor run. However, the battery cage is still the most economical way to produce eggs (Horne, 2006). Such housing has also proved to be the best option for disease prevention (Hulzebosch, 2006). Outside the European Union (EU), only Australia and New Zealand have some commercial non-cage systems. In all other countries, farmers mainly keep layers in cage systems. In China, India and South Africa, the non-cage housing refers to non-commercial backyard farming (IEC, 2007) and their contribution to the national egg production is very less. Under floor housing system a layer bird has to be provided with a minimum space of 1100 cm^2, whereas in enriched cages they get 750 cm^2. Before the EU directives, layers in the EU used to get only 550 cm^2 floor space. Presently, in United States of America layers get 430 cm^2 spaces but in other countries including India the hens are kept in cages with space allowances of about 300 to 400 cm^2 which is much lower than the World average of 350 cm^2. Presently the layer farmers using California laying house in India are rearing 4-5 birds in an enclosure of 450X375mm (recommended for 3 birds only) which has attracted the attention of animal welfare society. It is estimated that the production costs of eggs increase significantly when the area per bird in cage

housing is increased from the world level to the enriched cages (750 cm^2), German enriched cages (800 cm^2) or floor systems (1100 cm^2).

For performing most of the natural behaviours, on an average, hens (Hy-Line W-36) required a mean area of 563 (± 8) cm^2 to stand, 1,316 (± 23) cm^2 to turn around, 318 (± 6) cm^2 to lie down, and 1,693 (± 136) cm^2 to wing flap. The mean cage height requirement is 34.8 (± 1.3) cm for standing, 38.6 (± 2.3) cm for turning, and 49.5 (± 1.8) cm for wing flapping. However, space requirements for hens housed in multiple-hen groups in cage or non-cage systems cannot be based simply on information about the space required for local movement by a single hen. It must also incorporate consideration of the tendency of hens in a flock to synchronize their behaviours (Mench and Blatchford, 2014). It is also observed that hens in all housing systems spend a significant proportion of their time standing or lying down (Savory *et al*., 2006). So it is reasonable to provide only one wing flapping space and four standing space in a group of five birds to provide adequate comfort to the birds (Collins *et al*., 2010). Appleby (2004) modelled free movement in furnished cages and showed that larger enclosures provided more free movement space even if each hen was only provided with slightly more space than her body size. Free space opens up in larger enclosures because hens do not use all of the space available to them (Collins *et al*., 2010). This free space permits local freedom of movement for behaviours such as feeding, scratching, stretching, preening and sitting (Appleby, 2004).

With regards to wing spreading it was noted in their study that the maximum recorded value for wingspan (61.7 cm) was smaller for Hy-Line W-36 hens than Hyline's reference value (71.9 cm) for the W-36 wingspan (Mench and Blatchford, 2014). Wing flapping is often referred to as "comfort" (stretching) behaviour, and hens also show other comfort-type behaviours that involve wing raising (slight elevation of both wings) and wing stretching (one wing stretched downward) and these behaviours require less space than wing flapping (Mench and Blatchford, 2014).Spatial requirements for normal comfort behaviour in enriched/furnished cages as per European Union Directive are:

1. A laying hen must have (a) at least 750 cm^2 of cage area per hen, 600 cm^2 of which shall be usable; the height of the cage other than that above the usable area shall be at least 20 cm at every point and no cage shall have a total area that is less than 2000 cm^2; (b) a nest; (c) litter such that pecking and scratching are possible; (d) appropriate perches allowing at least 15 cm per hen
2. Feeder space (cm/hen): 12.1
3. Two nipple drinkers or two cups must be within the reach of each hen

In another study (Zhao *et al*., 2015) recommended that in enriched/furnished cages each laying hen had following spaces

Total available space (cm^2/hen)	: 752
Wire mesh flooring (cm^2/hen)	: 640
Forage area (cm^2/hen)	: 50(scratch pad)
Nest space (cm^2/hen)	: 62
Perch space (cm/hen)	: 15.1
Feeder space (cm/hen)	: 12.1
Nipple drinker (hens per drinker)	: 7.5
Hens per cage or colony unit (CU)	: 60 (per CU)

Behavioural restrictions under different housing systems

Conventional cages inherently restrict hens from expressing highly motivated behaviours for their entire laying period. Behaviours associated with body maintenance (e.g., wing flapping, tail wagging, stretching), locomotion, regulating body temperature are significantly curtailed in conventional cages and lack of load bearing exercise reduces bone strength (Widowski *et al.,* 2013). At high densities, hens suffer plumage damage from rubbing against the cages and lose capacity to regulate body temperature (Greene and Cowan, 2014). On the other hand the enriched cages have a nesting box, perches, scratch area and a dust bathing area. These features provide hens to express internally driven behaviours and results in better health, hygiene and welfare compared to non-cage system (Blatchford *et al*., 2016). However, enriched cages have limited space per hen thus limiting their ability to run or flap their wings. Exercise is significantly restricted. Nesting and perching may also be restricted. Litter inside the cages may be quickly depleted and cause stress to the hens who are excluded from dust bathing by more dominant hens. While some regard enriched cages as an improvement over conventional battery cages, others see little improvement in this housing system (Greene and Cowan, 2014). The birds engage in natural behaviours such as perching and nesting which improves the feather condition and reduces the incidence of feather pecking. The increase in space and locomotion results in greater bone strength in furnishing cages (Regmi *et al*., 2016). Most countries are reporting a lower rate of mortality in enriched cages. But the main drawback with this system is bone weakness - incidences of bone breakage and fracture is more. There is increased incidence of injury and poorly designed perches can cause keel bone deformation and bumble foot. The cracked eggs may promote egg-eating behaviour and eggs laid outside the boxes will require extra effort to collect. Capital cost is expected to be 50 % higher for enriched cages and approximately 70 % higher for colony systems (Horne, 2006) than normal battery cages.

The floor or aviary housing system improves bone strength, plumage and lower levels of hyperkeratosis is

observed in laying birds. This system encourages natural behaviours such as foraging, dust bathing, and comfort behaviours such as stretching wings and wagging tail. However, the negative points with this system are shorter laying periods, lower egg production, higher mortality, higher feed intake, more prone to injuries due to climbing on perches. More incidence of pecking which can result in increased mortality. There is increased numbers of social groups in the houses. There is reduction in air quality in litter based systems, especially increased ammonia causes eye and respiratory tract diseases. Floor system pullets cost an extra 10-15% to rise than cages. Cost of egg production-at least 20% higher than conventional cages and 15% higher than enriched cages (Rodenburg *et al.*, 2008).

Cage-free systems (Free range, FR) provide sufficient space for performance of a full repertoire of locomotor and body-maintenance behaviours. With larger flock sizes (>1,000), incidence of cannibalism and feather pecking can increase, which can be reduced by resorting to beak trimming and/or by reducing the flock size. The opportunity to forage in litter is crucial for hen welfare as the opportunity to forage in litter can reduce the incidence of cannibalism and feather pecking (Greene and Cowan, 2014). But drawbacks with this system are mortality, injurious pecking and bone fractures (Nicol *et al*., 2013; Weeks *et al*., 2016). As litter housing encourages the dust bathing, in a group size of 1000 birds, the hen normally crowded at different times to access to different resources such as dust bathing etc. (Campbell *et al*., 2016). In a typical free range flocks 10% of hen die before end of lay, 42% survivors sustain both fracture and severe pecking, 22% have only fracture, 20% have only pecking while only 12% birds are un-harmed. In comparison, only 4% mortality was recorded in enriched or furnished cage system. These birds are exposed to toxins, wild bird diseases, predators and extreme climatic conditions and have shorter laying periods. Free-range egg production costs, 40% more than in conventional cages and 33 % more than in enriched cages.

Hens prefer to have personal space and where stocking densities are high they will maximise this by spacing themselves out evenly both in cage systems and in colony systems. At lower stocking densities hens may space more randomly or clump according availability of resources such as feed (Albentosa and Cooper, 2004). Rebound levels of wing flapping, tail wagging, and stretching occur when hens are moved to a large space after several weeks of confinement in a small area, with the intensity of rebound of some behaviours being correlated with the duration of confinement, indicating that hens do not fully acclimatize to prolonged, severe spatial restriction (Lay *et al.*, 2011). Other relatively infrequent activities such as dust bathing may be performed more in smaller group sizes.

Time spent for normal activities

Studies conducted at Central Avian Research Institute, Izatnagar revealed that the floor reared layers spent significantly more time in sitting (46.4%), walking (7.2%) and investigating behavior (4.0%) than those reared in California colony cages (38.2, 4.8 and 1.4%) or individual cage (30.9, 1.4 and 1.0%). Whereas, individual cage layers spent more of time in feeding (40.7%) than the colony (26.6%) or floor birds (22.9%). However, time spent for drinking and preening activity was similar in all housing systems. In the colony cages, feather pecking was more frequent, while in caged layers pecking appeared stereotyped in many hens, but at a low frequency. Significantly higher ($p<0.05$) fearful response and time for first peck (response to novel object test) was observed in individual cage layers than the floor and colony birds (Bhadauria *et al.*, 2016a & b). In a study, Anderson (1994) observed that hens reared in floor pens on litter displayed a higher level of fearfulness at the end of the production cycle as compared to caged hens. In other studies it was observed that hens reared in both conventional battery cages (Colson *et al.*, 2006) and furnished cages (Rodenburg, *et al*., 2008) are more fearful than those kept in cage-free housing.

Poultry welfare concepts

The World Organization for Animal Health (OIE) definition of animal welfare refers to how well an animal is able to cope with the conditions in which it lives. It comprises both physical and mental health and includes several aspects such as physical comfort, absence of hunger and disease, possibilities to perform motivated behavior, etc. In 1965, the Brambell Committee in the United Kingdom issued a report advocating that farm animals be ensured Five Freedoms: to turn around, lie down, stand up, stretch, and groom, without restriction of movement (Brambell, 1965). Today, these freedoms have been somewhat expanded and adopted by a wide variety of organizations including the World Health Organization. More recently, some authors support the idea that welfare is mainly or solely dependent on what the animal feels more than its response (Moura *et al.*, 2006). United egg producers has proposed standards for conventional cages and it was based on a literature review focused mainly on mortality, feather quality, stress, and egg production data. Welfare is currently a major requirement for intensive poultry production. In order to understand the welfare regulations and the limits of their application, it is necessary to define specific terms commonly used for explaining the welfare concepts.

The five freedom points: (a) *Freedom to express natural behavior* - highly motivated behaviours in hens are nesting behaviour, perching, foraging (scratching and pecking), dust bathing, etc. (b) *Freedom of not experiencing hunger, thirst and malnutrition* - ready access to fresh water and feed to maintain full health

Welfare principles and criteria as defined by Welfare Quality (FAO, 2011; De Jong and Guemene, 2011)

Welfare principles	Welfare criteria	Measures
Good feeding	1. Absence of prolonged hunger	Criteria measured at Abattoir Drinker
	2. Absence of prolonged thirst	space
Good housing	3. Comfort around resting	Plumage cleanliness, litter quality, dust
	4. Thermal comfort	sheet test Panting, Huddling Stocking
	5. Ease of movement	density
Good health	6. Absence of injuries	Lameness, Hock burn, FPDOn farm
	7. Absence of disease	mortality, culls on farm
	8. Absence of pain induced by management procedures	
Appropriate behaviour	9. Expression of social behaviours	Cover on the range, free range
	10. Expression of other behaviours	Avoidance distance test (ADT)
	11. Good human- animal relationship	Qualitative behavioural assessment
	12. Positive emotional state	

and vigor; no bird has to travel more than 15-25 feet to get feed or water. (c) *Freedom from illnesses, injury or pain* - birds are to be vaccinated at appropriate ages to protect them from a variety of common diseases. In addition, biosecurity measures and other conditions in the farms are to be maintained so as to minimize exposure to other potential disease organisms. (d) *Freedom from discomfort* - birds are to be provided with a shelter with adequate resting area and proper ventilation with provisions for free movement (e) *Freedom of not experiencing fear and distress* - the most common and easiest measure of fear in chickens is by their responses such as attempts to escape, defensive behavior, freezing in place or immobility and vocalization (FAWC, 1979; Thaxton*et al.*, 2014).

Welfare concern with regard to different housing system

Hematological and biochemical parameters: Catecholamine, adrenaline and noradrenaline take part in many metabolic processes. Among other things, they regulate emotions and provide motivation for action (Elenkov and Chrousos, 2006). Housing system has no effect on adrenaline and noradrenaline levels. Significantly higher level of dopamine has been reported in laying hens kept in a battery of cages compared to hens from enriched cages (Pohle and Cheng, 2009).

Plasma corticosterone: Plasma corticosterone concentrations of hens from floor birds were significantly higher than those from cage (Koelkebeck*et al.*, 1986). Free-range poultry is often exposed to adverse thermal and humidity conditions, diseases and parasites, which are also stressors and may cause changes to the blood picture (Akºit*et al.*, 2006). The conventional cage production system appears to induce greater stress in birds compared to furnished cages.

Immune response: Housing conditions affect antibody responses. Birds kept solitary in battery cages, or on a floor provided with litter and perches systems showed significantly higher antibody responses to antigens, than birds kept in the free range system (Van Loon *et al.*, 2004). Shimmura*et al.*, (2009) reported that the immune response was good in the non-cage systems. However, when the floor birds housed in furnished cages there was increased H:L ratio and improved immunological response to antigen presentation and more resistance to experimental infection with salmonella (More *et al.*, 2010).

Mortality: Mortality is higher in laying hens raised on litter based housing compared to furnished cage system (Rodenburg *et al.*, 2008). Organic production system may be a potential cause of health problems (Hegelund *et al.*, 2005) especially to salmonellosis. It is reported that hens in floor systems had the highest prevalence of poor plumage condition, old fractures, emaciation, and abnormal egg calcification. Hens in conventional cages sustained more fractures at depopulation than birds in other systems. Vent pecking was most prevalent in free-range flocks and lowest in furnished cages. Cumulative hen mortality in the enriched cages and conventional cages was slightly lower than the 6%, but in the aviary it doubles.

Skeletal Health: An S-shaped curvature of the keel bone is characteristic of hens with cage layer fatigue (Whitehead and Fleming, 2000). However the problem of osteomalacia is due to the predisposing factors like deficient intake of Ca, P and Vitamin D. Old breaks are of a great concern from a welfare point of view because of chronic pain. The incidence of old keel breaks of hens in non-cage systems ranges from 52 to 73% (Freire *et al.*, 2003; Nicol *et al.*, 2006). Metabolic disorders such as osteoporosis, cage layer fatigue are most likely to be associated with laying hens lacking opportunity for exercise as in conventional cages.

Foot health: The most common foot problems in chickens are footpad dermatitis, bumblefoot, hyperkeratosis, and excessive claw growth. Wet litter conditions and high ammonia content of the litter can cause footpad dermatitis (Wang *et al.*, 1998). A lower incidence of toe pad hyperkeratosis occurs in furnished as compared with conventional cages (Abrahamsson and Tauson, 1997). Hens in conventional and furnished cages have overall better foot health than hens in other systems with access to litter or range (Tauson*et al.*, 2006). Claw health is poor in conventional cages (Taylor and Hurnik, 1996; Abrahamsson and Tauson, 1997).

General infections: Bacterial infections were the most common cause of mortality in birds raised on litter-based systems and included *Erysipelas, Colibacillosis, and Pasteurellosis* (Fossum *et al.*, 2009). Hens raised on litter and free-range also had greater mortality associated with viral disease (Lymphoid Leucosis, Marek's disease, and Newcastle disease), Coccidiosis, and red mites (*Dermanyssusgallinae*) compared with hens raised in conventional cages (Bhanja and Kataria, 2016).

Pest and parasite Load: The survival or reproduction of an ecto-parasite like the red mite is influenced by environmental factors, including temperature, humidity and the construction of fittings. Poultry houses rich in fittings such as roosts, nestsand slatted floors provide better opportunities for mites to reproduce and to infest hens than in conventional laying cages (Maurer *et al.*, 1993). Prevalence of red mites is 4% in conventional cages, 21% in non-cage floor systems (Hoglund *et al.*, 1995).

Indoor air quality: Air quality has been shown to be poorer in litter-based systems (floor housing and aviary) compared with furnished cages (Rodenburg*et al.*, 2008). Aerosolized aerobic bacteria were also significantly higher in litter-based systems compared with furnished cages (Pedersen *et al.*, 2000). Daily mean indoor ammonia concentrations, particulate matter (dust) levels and particulate matter emissions were all highest in the aviary house and lowest in conventional and enriched colony houses. In the aviary house, workers were exposed to significantly higher concentrations of airborne particles and endotoxin.

Food safety and product quality

European Food Safety Authority raised concerns about food safety and quality of egg produced in alternative systems. They noted that the potential for bacterial contamination was higher in systems in which hens laid their eggs in litter material, on the ground, or on nest mats rather than on wire. They concluded that eggs produced in conventional cages still show the best quality from a microbiological point of view. In another study Holt *et al.* (2011) reported that there was no general consensus demonstrating the superiority of one housing situation over another regarding food safety and egg quality. They further argued that many variables interact to make decisions regarding the housing situation that much more difficult to attain. Factors such as climate, hen breed, disease status, rodent and insect load, and age of the facility, etc., all enter into the equation to enhance the complexity of the situation. In a comprehensive study it was observed that housing system type did not influence the rate of egg quality decline through 12 weeks of extended storage. Hens in all three housing systems (Conventional, enriched cages and aviary) were shedding Salmonella spp. at a similar rate; the prevalence of Salmonella spp. on egg shells was very low and did not differ between housing systems. The aviary had higher levels of environmental Campylobacter spp. recovery (drag swab). Salmonella spp. were detected at similar levels of prevalence in the enriched cages and conventional cage production environments, however aviary eggs were more positive (CSER, 2015). Study conducted at our institute also reveals that there was no difference in the quality of the egg produced in cage and floor system of rearing (personal communication). De Reu*et al.* (2005) showed that eggshells from the aviary system are more contaminated with aerobic bacteria compared to those from the cage system (furnished and conventional cages). In another report De Reu*et al.* (2009) found a greater percentage of cracked eggs in furnished cages (7.8%) compared to an alternative production system (4.1%).

Economic aspects associated with different layer housing systems:

Layer in aviary and free-range systems had less efficient feed conversion in comparison to conventional (farm) systems. Even there is no much change in productivity and feed conversion when layer are housed in furnished cages (Valkonen *et al.*, 2008). However, the egg production from conventional cage layers was higher than in alternative systems such as aviary, floor management or free-range system (Tauson *et al.*, 1999). Switching to floor system egg production expected to increase variable costs by an average of 12% and total costs by 26%. Free-range production was considered to be most expensive alternative, with total costs 45% higher than conventional cages (Mench *et al.*, 2011). Aviary had average operating costs 23% higher and average total costs about 36% higher compared with the conventional house. On the other hand enriched housing system had average operating costs only about 4% higher compared to the conventional house, but total costs were 13% higher than for the conventional house (Mathews and Summer, 2015). The EU directive (1999/74/EC) has significantly affected the egg production (9.9 billion to 5.0 billion) in EU countries. There was a reduction of the laying hen flock from 35.7 million to 19.6 million birds or by 45.1 %. There was a loss of 12,300 jobs and additional imports of another 4.9 billion eggs.

Welfare issues in backyard poultry: In the village environment, birds are mainly indigenous breeds, which are generally better able to cope with the natural environment than those breeds that have undergone extensive genetic selection for production traits. However, disease transmission is high in backyard poultry systems, often resulting in low productivity and high mortality. Newcastle disease is one of the most problematic and widespread diseases in both village and intensive production systems. Vaccines have been developed, but not all farmers have access to them, and vaccinating free-ranging poultry can be a challenge (FAO, 2011). Another challenge facing small-scale poultry producers in developing countries is the availability of appropriate nutrition. Many smallholder farmers and their families have limited food, and are thus unable to provide feed for their small scavenging chicken flocks. Poultry frequently also lack access to a source of clean and cool water. This is a welfare concern for the poultry and for the people rearing them, as productivity will be low. In hot climates, birds may have difficulty staying cool if natural or artificial shelter is not provided, as all chickens are derived from jungle-living birds and they actively seek shade. Most of these welfare issues can be addressed by improved veterinary care and nutrition and the provision of simple facilities such as clean drinking-water and shade.

CONCLUSION

The welfare of laying hens in modern intensive production units is now well recognized to be a problem. At the same time there has been a move towards more welfare-friendly housing systems. Welfare concepts not only emphasize the five freedoms but also have biological, cultural, economic, social, philosophical, emotional, legal, and political dimensions. The degree of free choices made by well informed and educated consumers may play an important role in implementing welfare measures. Many past research finding showed that, there are many different characteristics of the housing systems which affect directly or indirectly the welfare of laying hens. In general, laying performance of chicken not only depends on where the hens are kept, but also many of other factors. When we analyse the cause and effect relations between the housing systems and welfare, it becomes obvious that none of these systems are ideal but we have to opt the kind of housing system that provide feasibility of production as well as economics of rearing under different agro climatic conditions.

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