EUROGROUP FOR ANIMALS

OPTIMISING LAYING HEN WELFARE IN CAGE-FREE SYSTEMS

Working towards a smooth transition in European egg production

Based on a technical report by AgraCEAS Consulting

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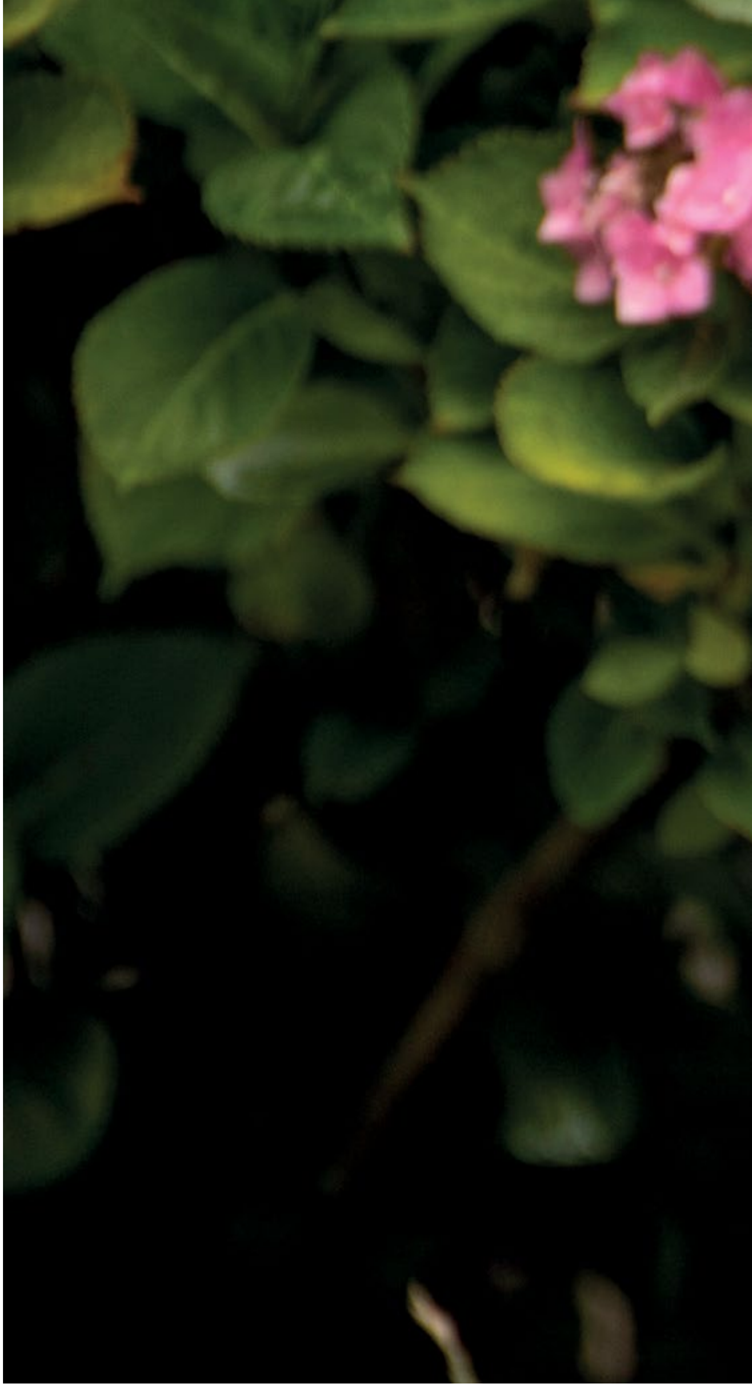
FOREWORD



The EU "Laying Hen Directive" (Council Directive 1999/74/EC), entered into force in December 2013, introduced a ban on conventional battery cages, while still allowing the use of 'enriched-cages'. The use of enriched cages varies per EU member state, with some having heavily invested in these systems, and others having moved more decisively towards cage-free systems. However, in recent times major retailers and food businesses have committed to only source their eggs and egg products from cage-free producers, and this by 2025 or earlier. Some EU member states have also recently introduced or announced legislative bans on the use of cages in the egg industry.

While the transition away from caged to cage-free systems is a positive step for the welfare of laying hens, the design and management of cage-free housing have an important impact on animal welfare and need to be taken into account when managing the transition. Although it is acknowledged that some behavioural needs of laying hens, such as dust-bathing, foraging, and proper nesting can only be satisfied in cage-free systems, poorly designed and poorly managed cage-free systems can neutralise such positive effects on animal welfare. As with any industrial farming system, a proper design of the facilities and adequate management practices are essential to provide high levels of animal welfare.

The recent failure of the “enriched cage” to satisfy evolving perceptions on the ethical treatment of animals clearly shows that **cage-free systems should be fit for purpose and fit for the future**. Animal welfare and animal health go hand in hand and have a major impact on the productivity and economic viability of egg production. In this perspective, ensuring animal welfare can help producers secure all the economic benefits arising from improved hen welfare.

The main aim of this document is to highlight aspects of cage-free egg production that require special attention to protect animal welfare, and gives some recommendations that can be useful for policy makers and industry stakeholders for maximising the welfare of laying hens in cage-free systems.

After a brief description of the rearing and housing systems present in the EU, this document describes important aspects of laying hen welfare and presents recommendations that can ensure the future resilience of the sector in terms of scientific evidence and societal expectations. The environmental and public health impacts of cage-free systems are also briefly discussed, together with potential mitigation strategies that can improve the overall sustainability of all cage-free systems.

The last section of the document provides basic information on the egg production chain in the EU and is followed by three case studies of interesting and innovative systems (Rondeel, Plantation, and Kipster).

RECOMMENDATIONS

- **Do not use "combi" systems** as an alternative to enriched cages*
- **Keep enough clear space** around feeders and drinkers; hens should have *ad libitum* access and equal availability to feeders/drinkers.
- Give hens the **possibility to forage for feed**.
- **Add insoluble fibre to the diet** to help prevent injurious feather pecking.
- Give laying hens **continuous periods of natural light and darkness** (i.e., 8 continuous hours of darkness).
- **Use controlled ventilation and heating systems** to maintain air quality and adequate temperature; the use of manure belts improves air quality.
- **Provide laying hens with enriched and attractive functional areas**, for example outdoor areas, well maintained scratch areas, and/or covered verandas.
- **Equip outdoor areas with vegetation** or other shade and protection from predators to make them are attractive for hens.
- **Pay special attention to perch and nest box design**, as well as the quality of nesting materials.
- **Familiarise pullets in the rearing phase** with the conditions they will encounter in the laying phase. This will help prevent problems in the laying phase.
- **Maintain litter quality throughout the laying period.** This is fundamental to ensure foraging and to prevent frustration and injurious feather pecking.
- **Provide suitable environmental enrichments**, particularly those that are edible and/or destructible (such as scattered grains or straw bales), in sufficient quantity.
- **Ensure a high level of hygiene and cleanliness.**
- **Respect biosecurity measures.**
- **Take a proactive approach** to preventing injurious pecking behaviour.
- **Consider reducing stocking density.**
- **Manage mortality** by reducing external and internal parasites and preventing injuries (e.g., improve perch design and positioning, use ramps to prevent fractures).
- **Inspect the birds at least 2-3 times a day**, and make sure they are handled in a competent and careful manner by trained and educated staff.

* Combination systems (aka "combi" cages) **are inadequate from an animal welfare point of view** and should not be considered an acceptable alternative to enriched cages. See also section 3.2.4.

1.

SOCIETAL EXPECTATIONS ON ANIMAL WELFARE AND EGG PRODUCTION

In recent years, European citizens have become increasingly aware of health, animal welfare, and environmental issues. Consequently, consumers in the EU market are demanding "sustainable" food, i.e., healthy items (including eggs) that also abide by higher animal welfare standards.

A 2016 survey conducted by the EU on the attitude of European citizens towards animal welfare (Special Eurobarometer, 442) indicates that **an absolute majority of Europeans (94%) regards as important the protection of farmed animals (including laying hens) welfare**. In Sweden, Finland and Portugal almost all respondents (99%) reported they consider farmed animal welfare to be important. Even at the lower end, in Hungary, Croatia, Poland, Slovakia and Bulgaria, the percentage of respondents considering animal welfare important was 86-88%.

The increased sensitivity of European citizens towards farmed animal welfare issues can be seen when comparing the 2007 (Special Eurobarometer, 229) and 2016 Eurobarometer's results: between 2006 and 2015, in nine Member States there was an increase of 5% in the proportion of respondents who believe the welfare of farmed animals should be better protected.

In terms of purchase choices, less than half of European consumers (47%) think there is sufficient choice of animal welfare-friendly food products in shops and supermarkets (+9% compared to 2006). Most respondents (59%) indicate a higher willingness-to-pay for improved animal welfare, particularly in Sweden, Luxembourg, and the Netherlands.

More specifically, with regards to the Europeans' attitude towards the welfare of laying hens, two recent studies suggest that consumers differentiate between different production systems and can express relevant preferences. These studies provide an indication that **consumers may consider free-range production to be particularly relevant for animal welfare**.

A study carried out in Poland (Zakowska-Biemans & Tekien, 2017) concluded that consumers:

- Clearly differentiate between barn vs. free range farming systems and have a strong preference for systems providing outdoor access to laying hens;
- Have a preference for free range eggs over organic ones (also determined by price considerations), despite the legally guaranteed benefits of organic farming in terms of animal welfare; thus free-range claims are more likely to generate market prospects than organic claims.

Similarly, a survey carried out in the UK indicated that according to consumers:

- Hens in free-range systems are "happier" (74.2%)
- Outdoor access and fresh air are the most important factors to ensure high animal welfare standards (Petterson, 2016).

Europeans are in favour of high animal welfare standards and are willing to pay more for high welfare products. This is driving major food businesses and retailers to commit to use only cage-free shell eggs, in most cases by 2025 at the latest. These include retailers such as Tesco in the UK and Central Europe, Camst in Italy, Monoprix and Carrefour in France, international food catering services such as Sodexo and Compass Group, and food multinationals such as Nestlé (CIWF, 2016a, 2017a).

Some EU member states and regions have even introduced legislative bans on cages in egg production. Austria will ban enriched cages from 2019, Wallonia and the Netherlands from 2021 (the Netherlands will still allow the so called "colony cages[1]"), Germany from 2025. Farmers who switched to enriched cages to comply with EU legislation will have to make further investments to meet changed demands. In some countries, this will involve a substantial proportion of the industry. This is the case, for instance, of several Eastern European countries, but also of Spain (87.8% enriched caged production) and France (64.8%).

The current shift away from cages is the result of a demand from civil society to improve animal welfare that is also backed by scientific evidence. Studies show that only cage-free systems can offer laying hens the possibility to express their full behavioural repertoire (Nicol et al., 2017; EFSA, 2005). However, it is also recognised that the specific features and management of all cage-free rearing and housing systems play a fundamental role in determining the welfare of laying hens.

There is a risk that the welcome but rapid shift we are witnessing towards cage-free systems will place such economic pressure on farmers that it may result in the adoption of sub-optimal solutions in terms of animal welfare. Producers are currently discussing ways to diversify the offer, and in particular barn eggs are likely to replace eggs from enriched cages in forming the bulk of the "value line" (or cheapest) production (Puybasset, 2018), although acceptability of barn eggs for the general public differs by country (FarmingUK, 2017). Some farmers may be attracted by solutions that can maximise production while keeping costs low, but that can be suboptimal from the point of view of animal welfare.

The impending demise of enriched cages in the EU shows that there are intrinsic risks associated with massively adopting certain systems without considering the evolution of consumer preferences, scientific evidence, and shifts in societal expectations concerning the rearing of animals for food. For these reasons, **the ongoing transition away from cages must be accompanied by the enactment of good practices**. This will benefit animals, who will enjoy better lives; consumers, who will be able to trust the market; and, last but not least, producers, who will adopt systems that are animal welfare friendly, economically viable, and resilient towards future trends.

With the expected success of the European Citizens' Initiative "End The Cage Age", it is plausible that the rearing of hens (and any other farmed animal species) in cages will be banned across the EU in the not so distant future. In that case, policy makers and producers must be enabled to guide a smooth transition towards higher welfare cage-free systems. The second European Union Reference Centre for Animal Welfare, dedicated to poultry, will be a valuable asset in assisting this transition. Producers will need to be guided in optimising the choice of breeds, housing and management to address some existing challenges, such as keel bone damage, mortality, and injurious feather pecking in cage-free housing systems. Meanwhile, the present document identifies some good practices that can be useful for producers when transitioning away from caged eggs.

[1] These are larger cages that typically contain 40 to 80 birds each.

2.
CAGE-FREE REARING AND HOUSING SYSTEMS

2.1
ALTERNATIVE REARING SYSTEMS

European legislation sets down rules for three (cage-free) alternative rearing systems, namely barn, free-range, and organic. Rearing systems are indicated by law on each individual shell egg and on the packaging of shell eggs, according to a code system defined in Commission Regulation No. 589/2008. The relevant legal provisions for alternative systems are set down in several pieces of EU Legislation, as explained in more detail below.

BARN

BARN SYSTEMS at a glance

- **Main features:** cage-free system allowing hens to freely move around within a building.
- **Stocking density: maximum 9 birds/m²** of usable area.
- **Minimum indoor space:** 1,100 cm²
- **Minimum outdoor space:** 0
- **Flock size:** can range from hundreds (small-scale production) to tens of thousands (large-scale production).
- **Minimum requirements:** the system should satisfy the conditions listed in **Art. 4 of Directive 1999/74/EC**.

EXAMPLES OF HOUSING SYSTEMS FOR BARN PRODUCTION ARE:

- **Flat deck system:** similar to a multi-tier system but developed on one level.
- **Multi-tier system:** hens can freely move between several (up to four – 3 floors plus ground floor) levels.

Barns are alternative rearing systems for laying hens that do not make use of cages and must provide (Art.4 of Council Directive 1999/74/EC):

- A maximum stocking density of 9 laying hens per m² usable area;
- Either linear feeders providing at least 10cm of access per hen, or circular feeders providing at least 4cm per hen;
- Either continuous drinking troughs providing 2.5cm of access per hen, or circular drinking troughs providing 1 cm per hen.
- Either one nest every seven hens, or 1m² of nest space for max. 120 hens (common nest);
- Adequate perches, providing minimum 15cm per hen;
- 250 cm² of littered area per hen, which must be a third of the ground surface;
- Equal access to drinking and feeding facilities (applicable to multi-tier systems)

If access to an outdoor range is provided, pop-holes must have a width of 40cm by 35cm height with 2 m available per 1,000 hens.

FREE-RANGE

FREE-RANGE SYSTEMS at a glance

- **Main features:** hens have access to outdoor areas for foraging, pecking and scratching.
- **Stocking density:** 2,500 birds/HA of ground available.
- **Minimum indoor space:** 1,100 cm^2
- **Minimum outdoor space:** 4 m^2
- **Flock size:** can range from hundreds (small-scale production) to tens of thousands (large-scale production).
- Minimum requirements: should satisfy the conditions listed in Art. 4 of Directive 1999/74/EC and Annex II of Regulation (EC) No 589/2008.

EXAMPLES OF FREE-RANGE SYSTEMS:

- **Multi-tier or flat deck systems**, as per above but with free-range access
- **Fixed or Mobile sheds:** the sheds are like aviaries. However, they are moveable and hens have access to pasture too.

Free-range systems are further regulated by **Annex II of Regulation (EC) No 589/2008**, according to which, to be considered *free range*:

- Hens must have continuous daytime access to open-air runs, which can be restricted only for a limited period of time in the morning;
- Open-air runs must be mainly covered with vegetation and not be used for other purposes;
- Open-air runs must not extend beyond a radius of 150m from the nearest pop-hole of the building, or 350m where appropriate shelters are provided in accordance with the Hens Directive.

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ORGANIC

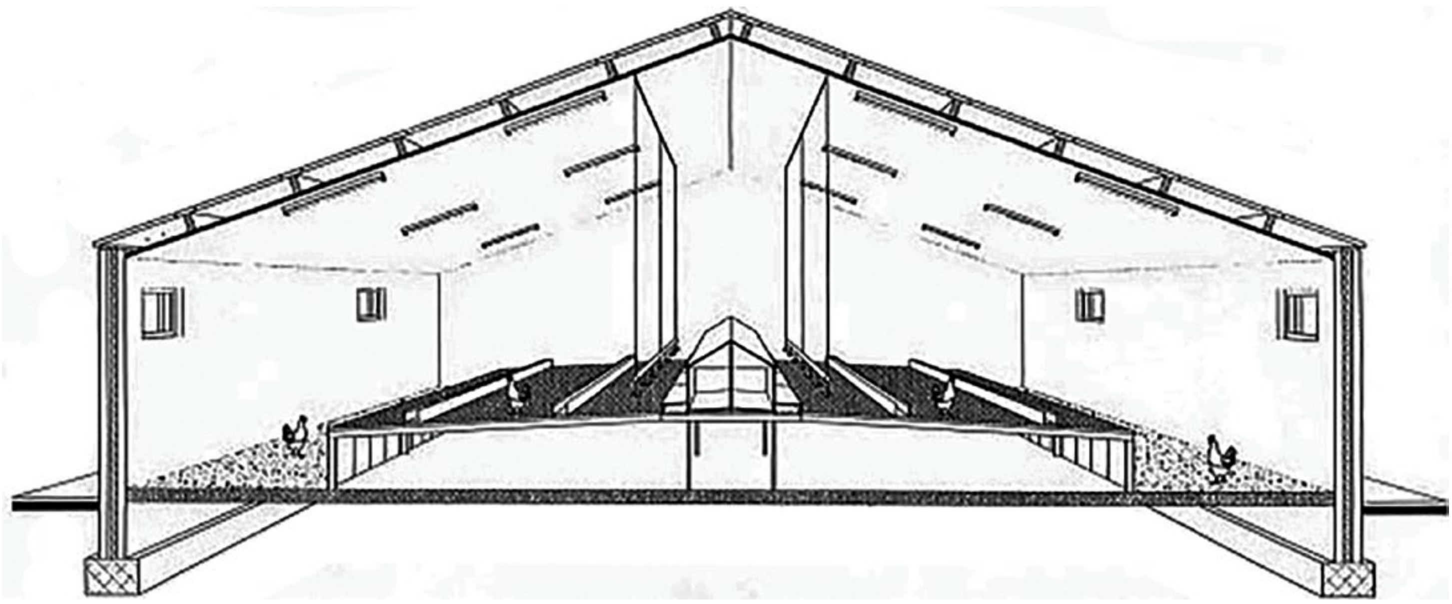
ORGANIC SYSTEMS at a glance

- **Main features:** Hens can freely roam in the outside areas.
- **Stocking density:** 6 birds/m^2 of usable area
- **Minimum indoor space:** 1,660 cm^2
- **Minimum outdoor space:** 4 m^2
- **Flock size:** ideal for smaller flocks (200-2,000 hens)
- **Minimum requirements:** should satisfy the conditions listed in Art. 12 and Annex III of Regulation (EC) No 889/2008.
- **Examples of organic housing systems:**
  - **Multi-tier or flat deck systems**, as per above but complying with organic requirements.
  - **Fixed or mobile sheds**, as per above but complying with organic requirements.

The specific rules for **organic rearing systems** are set down in **Article 12** and **Annex III of Regulation (EC) No 889/2008 on organic production**, according to which *organic eggs* must be produced on farms where:

- At least one third of the floor is solid and covered with litter material
- A large part of the floor area is available for the collection of bird droppings
- Appropriate perches (18 cm/bird) are provided
- Exit/entry pop-holes of a size adequate for the birds are provided
- Maximum 3,000 laying hens are housed per compartment
- All birds should have easy access to an open-air area through pop holes (with a combined length of 4m for every 100m^2 of available housing area).

Example of a flat deck barn system (used with permission from www.laywel.eu)



2.2 HOUSING SYSTEMS

Alternative rearing systems can have different types of housing. **Table 2-1** sets out the most common housing systems for laying hens across the EU and how they are used in the different rearing systems.

The characteristics of the different types of cage-free housing systems are described in more detail below.

SINGLE-TIER/FLAT DECK/ FLOOR HOUSING SYSTEM

Flat-deck systems typically have only one tier and are the simplest form of barn housing for laying hens. Flock sizes in single-tier systems can range from hundreds to tens of thousands of hens. Their structure and design can vary, however they all have some characteristics in common:

- At least one third of the **floor** must be solid and covered with litter (LayWel, 2006). Most commonly, there is a central raised area (the tier) with a slatted floor on which feeders, nests and perches are placed (Nicol et al., 2017).

Table 2-1: Mapping of cage-free housing for laying hens by rearing system

Housing type	Rearing system		
	Barn	Free-range	Organic
Single (flat deck)/Multi-tier	✔		
Single (flat deck)/Multi-tier with outdoor access	✔	✔	✔
Combination (“combi”)*	✔**		
Mobile sheds		✔	✔

Source: AgraCEAS based on literature review

* A combination system can theoretically be used for free range or organic production if the doors are left open and there is outdoor access. In reality this rarely seems to happen as it is not particularly attractive to use the system in this manner.

** Turns into cage system, when doors are closed.

- A **manure pit or a manure removal system** is normally placed underneath the central raised slatted area.

- The **nest boxes** are usually placed over the slatted floor. Nest boxes are usually covered with an artificial grass bottom or litter and eggs can be collected automatically or manually. Nests can be individual or for groups of hens.

- **Perches** are usually placed in A-frames on the slatted floor (LayWel, 2006) or suspended from the ceiling.

The roaming area in flat deck housing systems, especially if equipped with covered verandas, allows hens **to move around and express a range of normal behaviours** (e.g. flap their wings, stretch, fly and dust bathe).

MULTI-TIER/AVIARY SYSTEM

Aviaries or multi-tier systems are housing systems in which hens can move freely between several tiers (maximum four according to EU legislation; Windhorst, 2017). Aviaries are available in many different designs, and their main characteristic is that they **maximise use of the vertical space** in the barn. Perches, feeders, drinkers, and nest boxes are usually provided on several tiers, with their exact position depending on the aviary design.

The presence of well-designed ramps or approach perches facilitates access to these resources for laying hens as well as movement between tiers. According to Art. 4 of Directive 1999/74/EC, aviary systems can have a maximum of four levels allowing with free movement between levels. However, reportedly the Competent Authorities in some member states allow “stacked” aviary systems whereby up to three 4-tier aviaries are stacked upon each other and separated by layers of concrete, thus effectively forming 12-tier structures (ANDA Animales, personal communication).

As for any other barn system, the maximum allowed stocking density in aviaries is 9 birds/m^2 of usable area. Although the flock size can range from hundreds (small-scale production) to tens of thousands (large-scale production), aviaries are typically used for large-scale barn egg production, also in consideration of their high set-up costs.

Well-designed aviary systems should enable hens to perform important behaviours, and namely:

- Perching and roosting on aerial perches;

- Performing nest seeking and egg-laying behaviours in collective nests;

- Using feed and water lines;

- Pecking, scratching and dust-bathing when on the ground littered area.

If properly designed to facilitate access to resources and avoid overcrowding, and if group sizes are not too big (i.e. maximum 6,000 hens and ideally under 4,000), the complex, multi-layered nature of aviaries can provide a stimulating environment for hens.

Flat deck systems and aviaries can be equipped with **covered verandas** (also sometimes called “winter gardens”). These are covered areas adjacent to the main barn, which offer natural light and are accessed via pop-holes. Verandas provide birds with additional space to dust-bathe in litter, forage if enrichments are provided, and enjoy natural light and, often, fresh air (CIWF, 2012a).

Additionally, these areas are useful, particularly for hens kept in free-range systems, if the birds have to be confined indoors for prolonged periods, for instance because of an outbreak of avian influenza. The surface of covered verandas is not normally included in the calculation of the floor space available to the hens as verandas are accessible only during the daytime (CIWF, 2012a).

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Example of a covered veranda.

MOBILE SHEDS

Mobile sheds are a **housing system most frequently used for smaller free-range flocks (typically 200 – 2,000 hens) and in organic egg production**. They function like fully equipped "polytunnels" on skids or wheels and use natural ventilation, with an internal layout similar to flat-deck (single tier) housing systems (Nicol et al., 2017). The main feature of these systems is the suspended slatted flooring. Mobile poultry houses are regularly rotated among different fields or pastures.

This can contribute to keeping the animals healthy, for instance by reducing parasite load (CIWF, 2016b). On the other hand, factors such as good ventilation and temperature control, as well as cleaning and disinfection of the poultry houses, are of particular importance in these systems to maximise animal welfare[2]. In contrast to static barns connected to the sewage system, the potentially contaminated wastewater is sometimes directly carried into the soil (Giersberg et al, 2017).

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Example of a mobile shed.

ABOUT COMBINATION ('COMBI')/ CONVERTIBLE HOUSING SYSTEMS

Combination ("combi") housing systems combine the characteristics of aviaries and conventional cages. These are typically multi-tiered structures with doors on each tier. Hens can freely move around only when the doors are open. When the doors of the tiers are closed, a combi system becomes to all effects an enriched cage, with a comparable a stocking density.

In the EU, companies like Big Dutchman (Germany) and Farmer Automatic (Germany) are manufacturers of combi cages (Alonzo, 2016). Combi systems can sometimes be considered attractive by producers who want to be able switch from cage-free to conventional eggs depending on market demand. However, the combi system **cannot be considered a suitable cage-free system from the perspective of animal welfare**, because closing doors routinely can enhance negative behaviours as hens are constantly switching from an aviary environment to close confinement. **When the doors are closed, hens are deprived of key features and resources that encourage natural behaviours** such as nesting and scratching, because the equipment of these systems when used as enriched cages can be unsatisfactory from an animal welfare perspective. Furthermore, the process of transfer from the aviary environment to the caged system can cause frustration in the animals (CIWF, 2017b). For all these reasons, combi systems won't be discussed in any more detail here.

[2] https://www.proof.net.au/Mobile-Hen-Housing

3.

OPTIMISING LAYING HEN WELFARE IN CAGE-FREE SYSTEMS

CIWF (2012b; based on extensive existing work by Fraser and Broom, 1990) identifies three key components of animal welfare:

- **Physical well-being**, defined as the extent to which an animal's biological processes can cope with their environment.
- **Mental well-being**, defined as an animal's emotions and how they feel.
- **Natural living**, defined as the extent to which an animal lives and behaves as it would in the wild.

These three components are deeply interconnected: ill health is one of the components of poor welfare and can even lead to death; but also stress and frustration, or the impossibility to carry out important natural behaviours can lead to poor welfare, and ultimately worsen health status via changes in immune function.

An overview of the main aspects influencing the welfare of laying hens, based on desk research is presented in **Table 3-1**. The section that follows presents a more detailed description of each area with some general recommendations on how to manage risks and improve animal welfare.

In addition to the issues outlined above, there are also the following animal welfare issues to consider outside the egg-production phase:

- **Management of male chicks** – chicks are sexed after hatching. The current standard industry practice is to immediately kill day old male chicks, normally through exposure to gas or through maceration.

- **Rearing system for pullets** – the characteristics of the housing system used for rearing pullets may differ from the one used during the laying stage of a hen. This can cause permanent behavioural and/ or physical problems (fearfulness, injurious pecking, frustration).

- **Catching, handling, and transport** – at the end-of-lay, hens are caught and transported to slaughterhouses. The travel time is typically longer for hens than for broilers as specialist slaughterhouses are required for this and they are fewer in number (FCEC, 2012).

- **Slaughter** – in most Member States hens are shackled upside down and stunned in an electrical waterbath prior to slaughter.

Recommendations for these phases are described in section 4.

Table 3-1: Main aspects influencing the welfare of laying hens

Issue	Comments
Feed and water	**Quality and accessibility of feed and water** (number, shape, position, functioning of feeding and drinking places, space around these resources, presence of competition , etc.)
Physical characteristics of the environment	These characteristics include, among others, **lighting regimes**, **climate/temperature**. **Litter and manure management** plays a role in some of these factors.
Freedom to choose among different functional areas	The **availability, accessibility and attractiveness of outdoor areas or covered verandas and scratch areas,** the design of **perches** and **nesting areas** and the **quality of the nesting and litter materials**. The possibility to **fly** up in aviaries (design dependent).
Enrichments/ possibility to perform natural and comfort behaviours	The extent to which the availability & quality of resources allows behaviours such as **foraging**, **pecking**, **dust-bathing**, **perching**, **resting**, **wing flapping**, and preening.
Health	• **Injurious pecking** and **beak trimming**, **plumage condition** • Bone **fractures** and osteoporosis • **Internal and external parasites** (mites, coccidia, worms) • Bacterial and viral **diseases** • Foot disorders • General hygiene
Handling and stockmanship	**Training** of the operators, frequency and quality of **flock inspections**, as well as the type of **handling** of birds by staff e.g. during inspections, catching, loading, etc. have a direct impact on animal welfare.
Stocking density	Insufficient space may result in overcrowding, **competition** for resources, lack of rest.

Sources: AgraCEAS based on various including CIWF, AssureWel, LEI Wageningen, GAP, Beter Leven.

3.1 MEASURING ANIMAL WELFARE OUTCOMES

The choice of a given rearing and housing system, and the provision of certain resources to laying hens are *per se* insufficient to guarantee animal welfare. Ultimately, laying hen welfare must be assessed on the animals themselves (EFSA, 2015). Typically, animal welfare assessment protocols measure several dimensions, and namely: the resources provided (space, enrichments, etc.), the management (e.g. beak trimming, vaccination programmes), and several parameters on the animals (such as normal behaviour, health, emotional state).

There are different protocols for measuring and benchmarking laying hen welfare on farm across rearing and housing systems[3]. Policy makers and farmers alike can get expert advice from research institutions or consortia and/or animal welfare organisations on these assessment protocols. In some countries, it is possible for farmers to participate in farm assurance schemes incorporating such animal welfare assessments, and to sell their products (in this case, eggs) with labels that are clearly identifiable by consumers[4].

[3] Examples of this are AssureWel, Welfare Quality®, and the RSPCA assessment protocols.

[4] Examples are Beter Leven in the Netherlands, RSPCA Assured in the UK, Für Mehr Tierschutz in Germany, etc.

Higher welfare systems generally require clear space around feeders and drinkers; ad libitum access and equal availability across feeders/drinkers; and the possibility to forage for feed.

Adding insoluble fibre to the diet can help prevent injurious feather pecking.

3.2
FEED AND WATER

Welfare impacts of **feed and water** comprise the following main elements: suitability, quantity, and accessibility. Of the three, accessibility can be influenced by the design of the housing system, whereas suitability and quantity are factors determined by management. **Laying hens should have ad libitum access to adequate feed and water.** Access to feed and water can be facilitated by splitting hens into groups.

Feed composition can affect health parameters, particularly the occurrence of injurious feather pecking. **Inadequate fiber or amino acid content in the diet can lead to severe feather pecking, so fiber supplementation may be required** (Nicol et al., 2017). Scattering grains and fibrous feed on the ground gives hens the opportunity to complement their diets while also spending time foraging. Adding insoluble grit to the diet can also contribute to a healthy digestive system.

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Laying hens should be given continuous periods of natural light and darkness (typically 8 continuous hours of darkness)

Ventilation and heating systems should be used to achieve specific parameters for air quality and temperature

The installation and use of manure belts can improve air quality parameters

3.3 PHYSICAL CHARACTERISTICS OF THE ENVIRONMENT

The following environmental parameters have a direct impact on animal health and welfare, as well as on productivity:

- Lighting regime
- Temperature and humidity
- Air quality

The Laying Hen Directive states that the lighting pattern for laying hens must "include an adequate uninterrupted period of darkness lasting, by way of indication, about one third of the day, so that the hens may rest". Higher welfare schemes typically mandate minimum continuous periods and levels of (natural) **light** alternated with these minimum continuous periods of **darkness** (RSPCA, 2017; KAT[5]). This is because while daylight encourages certain active behaviours, a sufficient period of uninterrupted darkness is needed for resting. Systems with outdoor access or covered verandas can help ensure exposure to natural daylight.

Temperature and humidity are important for the thermal comfort of laying hens as well as for air quality. Hens are comfortable between 18 and 27 degrees Celsius (Wageningen UR, 2004), with a thermo-neutral zone (in which they are very comfortable) for healthy animals between 20-25 degrees Celsius (Nicol et al., 2017). **Adequate ventilation** (either natural or forced) is essential to ensure that excessive heat, odours, and humidity are removed from the hen house. **Heating** should be used in colder climates, as below 10 degrees Celsius hens start suffering from cold stress (ibid.). These considerations also apply to mobile sheds used in small-scale free-range or organic farming systems, which should additionally ensure good insulation (DEFRA, undated).

Air quality (presence of dust, endotoxins from bacteria, ammonia, etc.) influences not only animal health, but also the environmental impact of the farm and the health of operators (see Section 6). Aviary systems with belt removal of manure often manage to maintain better air quality[6] compared to systems with manure pits as in most single deck housing. However, depending on outside temperature, maintaining good air quality parameters can be problematic irrespective of housing system (Nicol et al., 2017).

5 http://bit.ly/2BE6TRT; criteria developed in collaboration with the Deutscher Tierschutzbund.

6 The parameters of ventilation systems are not normally specified in higher welfare schemes, but targets for air quality parameters (e.g. ammonia -generally 20ppm; dust – generally 10mg per m^3; and in some cases, carbon dioxide and carbon monoxide, are).

3.4
FREEDOM TO CHOOSE AMONG DIFFERENT FUNCTIONAL AREAS

Different functional areas that can be offered to laying hens include: outdoor areas, scratch areas – which may be provided in covered verandas or within the main house – and areas for nesting and resting within the hen house. The possibility to choose between different environments can promote natural behaviours, which can in turn reduce the risk of developing abnormal behaviours.

Outdoor access year round is beneficial for several reasons. Firstly, ranges encourage foraging, thus reduce the incidence of feather pecking (Lambton et al, 2010). In addition, foraging is a way for hens to complement their diet with sources of food found on the range (insects, etc.; FeatherWel, undated). **Covered verandas** can be used as a contingency option to provide hens with extra space and foraging opportunities even when strict housing orders are in place due to disease outbreaks (e.g., highly pathogenic avian influenza).

Access to outdoor areas at an early age allows exposure to endemic diseases, which can be beneficial in the long term as it is thought to lead to stronger immunity in hens later in life (CIWF, 2010). **Hens are more likely to use outdoor ranges if shade is provided (especially in warmer climates), as well as protection from predators.** Cover may be natural (trees, shrubs, crops) or artificial when suitably designed (e.g. shade nets; AssureWel, undated). Additionally, hens are attracted by the presence of other animals, so having ruminants such as alpacas or llamas grazing on the range can encourage hens to use it (FeatherWel, undated).

The outdoor range is accessed through **pop-holes**, whose position, number, and design should entice hens to go outside. The most important characteristics are an easy access to the outside area, and the visible proximity of a shelter (vegetation cover, or artificial; FeatherWel, undated). The size of the pop-holes seems to be of lesser importance (Harlander-Mathauscheck et al., 2005).

Good maintenance of the range when hens have outdoor access is essential for their health and welfare, and includes:

- Maintenance/drainage of the areas, particularly around the pop-holes, to prevent the formation of puddles or heavily poached areas (which discourage use and can be a source of disease)
- Pasture rotation and regular maintenance of grassy areas to reduce parasitic load (FeatherWel, undated)

Inside the hen house, well-designed, secluded **nest boxes** can reduce pre-laying stress for hens and promote nest-building behaviours (Struelens et al., 2008). The positioning of nest boxes in the hen house

can influence the use of other resources such as outdoor areas[7]. The presence of nesting materials, besides making nest boxes more attractive for hens, reduces the proportion of floor eggs (Nicol et al., 2017). Some farm assurance schemes have specific requirements for the accessibility[8] of nesting areas and/or nest boxes (1 for every 5 or 6 hens e.g. RSPCA and GAP all levels, respectively).

Perch design is very important for hen health and welfare. For this reason, the basic characteristics of perches for laying hens are defined in EU legislation and some farm assurance schemes have introduced further specifications[9]. There is also a recent EFSA opinion (2015) specifically dedicated to the effects of perch design on animal welfare. For more information, see also section 3.6.2.

It is beneficial for laying hens to have access to suitably equipped, enriched and attractive functional areas, for example outdoor areas, well maintained scratch areas, or covered verandas.

Well-maintained outdoor areas provided with vegetation or other shade and protection from predators are attractive for hens and can contribute to good health.

The design and maintenance of the different functional areas influence their use. Perch and nest design, as well as the quality of nesting materials are important to maximise health and welfare benefits.

Familiarising pullets in the rearing phase with the conditions they will encounter in the laying phase can maximise use of resources and reduce abnormal behaviours.

Finally, the propensity of laying hens to explore and make use of available resources is also influenced by their familiarity with these resources. Hence the importance of the pullet rearing phase, which should ensure exposure to the facilities and equipment that the birds will encounter later in the laying phase. The availability of litter for foraging in the rearing stage contributes to reducing the incidence of injurious pecking behaviour in the laying phase (Nicol et al., 2017; see also section 3.6.3).

[7] Pettersson et al. (2017) found that birds roosting on the far side of an aviary system (further from pop-holes leading to the range) were less likely to use the range the following day.

[8] E.g. GAP levels 3, 4 and 5 foresee that pop-holes are at least big enough for two hens to pass; sufficient in number (precise definition depending on the number of sides of the house on which pop-holes are found); and that the entrance not be muddy.

[9] Directive 1999/74/EC mandates 15cm of perch space per hen; higher welfare schemes are typically more specific, in terms of perch design, e.g. the proportion of this perch space which is raised (Beter Leven 3*). See also RSPCA welfare standards which recently included very detailed requirements re perch position.

3.5
ENRICHMENTS

The freedom to choose among different environments provides stimulation as well as the opportunity to perform natural behaviours for which laying hens are highly motivated. Among these behaviours, *foraging* plays an important role, although resting, perching, pecking and nesting also rank high (Nicol et al., 2017).

Litter quality is essential to keep hens in good health and encourage foraging as well as dust-bathing. Maintaining litter in good condition, namely dry and friable, throughout the laying period has been defined as "the single most important enrichment [...] to reduce the risk of feather pecking (FeatherWel, undated)". This can be achieved by regular raking and forking, rotavating, and topping up as required. If the litter becomes capped (matted, compact) it should be removed and replaced, and the underlying causes investigated (ibid.).

Maintaining litter quality throughout the laying period is fundamental to ensure foraging and to prevent frustration and injurious feather pecking.

Laying hens benefit from the provision of suitable environmental enrichments, particularly those that are edible and/or destructible (such as scattered grains or straw bales), in sufficient quantity, and appropriate for the specific functional area.

Enrichments can be introduced to further encourage natural behaviours, particularly in the indoor environment. Such enrichments include **straw bales**, **pecking blocks**, suitable hanging items (e.g. edible or destructible), **grain** and **grubs**. Higher welfare schemes typically require at least two forms of suitable environmental enrichment inside housing. For instance, scattered grains and bales are compulsory to obtain the 3-star Beter Leven label. Enrichments need to be provided in sufficient quantity for all birds to be able to access them.

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Ramps can facilitate movement between different tiers of an aviary system.

3.6 SELECTED HEALTH ASPECTS

Cage-free systems present definite advantages in terms of animal welfare but do require careful housing design and specific management strategies to maximise the health benefits for hens. Some aspects that should be taken into account when switching to non-cage systems are discussed below.

3.6.1 Immune function

The strength of a hen's immune systems depends on various factors, among others the bird breed and feeding. **Hens kept in non-cage systems have a strong immune function.** In particular, systems that offer access to the outdoors from a young age can boost immunity through exposure to endemic diseases (Nicol et al., 2017). Immune function can also be boosted by feed supplementation with some types of probiotics that promote gut health (ibid.).

3.6.2 Keel bone damage

Laying hens now can produce 300 eggs/year, compared to 115 eggs/year in the 1930s. **The major metabolic requirements in terms of calcium mobilisation from the bones to produce all these eggs make laying hens susceptible to bone fragility and fractures** (FAWC, 2010).

The **layout and design of perches plays a role in the incidence of keel bone fractures**. Laying hens are motivated to perch, especially during darkness periods (Nicol et al., 2017). Besides satisfying a behavioural requirement, freedom of movement and access to perches can improve bone strength (Nicol et al., 2017), a clear advantage over more restrictive systems (CIWF, 2012b). In the presence of perches, hens appear to be calmer and less likely to pile and smother (e.g., during catching). However, the greater movement of birds may result in more fractures due to collisions with hard objects. The keel bone is particularly susceptible to damage/deformation, with the pressure applied to it during perching and landings a notable risk.

Perch placement and design can play an important role in reducing the incidence of keel bone damage. Research results show that collisions with equipment or other hens and inaccurate landings, particularly in aviary systems with several tiers, are the main causes for keel bone fractures, and the higher the hens can go, the more severe the fractures (Lay, 2011). Perches should be arranged so that birds can move easily between them and the other equipment, thereby reducing the risk of collisions and subsequent bruising and/or other damage[10]. To further reduce the risk of fractures, producers should consider a careful design of housing including ramps to facilitate movement between different tiers, and the influence of genetic selection on bone strength (CIWF, 2016a; Sandilands and Schrader, 2014; Widowski, 2016). According to one recent review study (Nicol et al., 2017) "*Systems that incorporate **soft-perches** i.e. metal or wooden perches covered with approximately 3 mm thickness of soft polyurethane and/ or **ramps** or 'stepped' slats are (...) preferable, and this is an active research area.*"

Fractures due to osteoporosis (bone fragility due to calcium depletion) frequently occur during catching at the end of the laying period, and in this phase it's

[10] The RSPCA standard for laying hens provides very detailed specifications on this aspect. See https://bit.ly/2P6dlV9


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Perch design plays an important role in laying hen health and welfare.

Laying hens tend to have fragile bones due to high productivity

The keel bone is particularly susceptible to fractures

Housing and perch design (provision of ramps, soft and well positioned perches) can reduce collisions and failed landings and thus reduce the risk of keel bone fractures. Genetic selection can also improve bone strength

Handling of end-of-lay hens should be gentle to avoid fractures during depopulation

important that stockpersons handle the animals with care (see also Section 4.2). Once again, house design and the layout of the equipment play an important role in facilitating removal of the hens. Perches and other facilities should be easy to remove or winch up out of the way prior to catching (DEFRA, undated).

3.6.3 Injurious pecking and cannibalism

Injurious pecking is the most common form of abnormal behaviour in laying hens and one of the leading causes of mortality in cage-free systems.[11] It stems from redirected foraging and pecking that can be co-triggered by stress and an imbalanced diet composition (e.g. insufficient fibre). It can be directed at other hens' feathers (feather pecking) and/or vents (vent pecking) and, when severe, it is a very serious animal health and welfare issue. Sometimes injurious feather pecking (IFP) can lead to vent pecking (Nicol et al., 2017) and cannibalism. This behaviour has a multifactorial origin: factors relating to the pullet rearing phase, genetic line, housing system and management, diet composition, opportunity to forage and health status can all play a role in determining its occurrence.

The **presence of feather pecking in a flock should be verified by regularly assessing plumage condition and cover**. Although loss of plumage cover can also be an indication of abrasion against structural elements of the housing, this specific type of abrasion is more frequent in cages than in cage-free systems (Nicol et al., 2017). Methods to assess feather cover and specific advice on how to improve it have been published, for instance, by AssureWel[12] and FeatherWel[13].

11 https://bit.ly/2KABbrd

12 AssureWel project (http://www.assurewel.org/)

13 FeatherWel https://bit.ly/2PZ0MQL

The most common strategy to manage the risk of IFP is **beak trimming**, the ablation of the terminal part of the beak in young chicks. Beak trimming does not prevent the occurrence of injurious pecking, but it mitigates its negative effects. However, beak trimming is a painful mutilation causing both acute pain and potentially also chronic pain after the procedure; it leads to a loss of normal function; and causes a loss of integrity of the animal (CIWF, 2009). The vast majority of higher welfare standards either ban beak trimming or require that it be performed within the first days of the bird's life and using infrared equipment (e.g. RSPCA) rather than a hot blade; however, to this day no painless method for beak trimming is commercially available. Note that hens with intact beaks are able to reduce lice and mite infestations by preening, whereas trimmed beaks prevent this behaviour (Nicol et al., 2017).

As set out by CIWF (2009) and DEFRA (2005), and implemented by several farms in e.g. Germany, the Netherlands and the UK (CIWF, 2010), there are strategies to help prevent or control injurious feather pecking and cannibalism.

Strategies to manage injurious pecking behaviour without beak trimming include:

- The use of breeds/strains of birds with lower propensity to peck
- The use of feed which is high in insoluble fibre (which has been shown to prevent IFP and cannibalism) in a form which is time consuming to eat (thus satisfying the pecking instinct)
- Offering opportunities for foraging, including sufficient good quality litter and environmental enrichment
- Provision of resting and refuge areas so resting and active birds can be separate
- Preferential use of nipple drinkers
- Division of the flock into smaller groups
- Well-designed and managed ranging areas
- Preventing and/or treating red mite infestations
- Minimising changes in housing and management between the pullet rearing and the laying periods
- Effective health management

* Higher welfare schemes generally advocate maximum group sizes in the range of 2,000 (GAP levels 4 and 5) to 6,000 birds (*Beter leven* 3*).

** E.g. see http://bit.ly/2QbrsOq

3.6.4 Foot disorders

Foot disorders in non-cage systems are primarily due to contact with wet litter and inappropriate perches. Wet litter can lead to hyperkeratosis and, eventually, painful infections (e.g., bumblefoot). Hence the importance of ensuring that the litter is clean, friable, and dry. According to the EFSA (2015), perch characteristics can influence the incidence of footpad dermatitis (especially bumblefoot) in laying hens, and namely: height, material, shape, and diameter. The same features can also influence claw and toe damage. To reduce the risk of injury and infection, the EFSA (2015) recommends the use of perches made (or wrapped with) soft materials to improve grip; additionally, perches with a square section and 3-6cm wide are recommended over perches with a round section as they prevent balancing movements, which improves foot health. However, consideration should also be given to the possibility of proper cleaning and disinfection (see also Section 3.6.6.).

3.6.5 Infectious and parasitic diseases

With all its advantages, **cage-free housing results in exposure to a wide range of pathogens**, both viral and bacterial, particularly in free-range flocks. Avian influenza is of concern in this context during periods of outbreaks among wild birds, although mitigation strategies are possible. Reducing contact with wild birds (especially waterfowl), foxes, and other potential vectors can play a major role in limiting exposure to highly pathogenic diseases circulating in the environment (CIWF, 2016a).

Options for ensuring this include:

- avoiding a high spatial concentration of poultry farms in the same area;
- avoiding the genetic similarity of hens in an area;
- the possibility to cover the outdoor range if necessary, the absence of ponds/water sources and/or the provision of a suitably designed covered veranda that can allow birds to be housed during times of higher external disease risk without losing all the benefits that these facilities offer.

Feed should not be stored or made available in range areas. In all systems, suitable biosecurity measures must be in place to prevent infectious disease outbreaks, and good hygiene measures can help to prevent disease from entering a holding.

The presence of **internal** (coccidia, worms) and **external parasites** (red mites, lice) causes severe animal health and welfare issues and even death, especially when infestations are severe. Red mite infestations can lead to injurious feather pecking. Hen houses can be regularly treated against red mites and both hens and eggs should be regularly checked for signs of infestation. It is useful for producers to agree a flock health monitoring programme with their veterinarian and adopt strategies to prevent and/or control these infestations[14]. In mobile systems, the possibility to move mobile sheds between different areas also within the same production round helps avoid the build-up of parasites in one area (CIWF, 2016a).

3.6.6 Hygiene

In terms of general hygiene, **the regular cleaning and disinfecting of fittings** such as nest boxes, maintenance of litter and range areas, and regulation of temperature and ventilation, are important to help safeguard the hens' health and welfare. The ability to roam outside, the provision of litter, and access to nests have several advantages but may negatively affect dust levels inside the hen house and ultimately the cleanliness of hens. Strategies can be put in place to mitigate these risks: for instance, sloped entrances (e.g. using old slats, sloped concrete or stones) with drainage around pop-holes can help reduce the dirt carried into hen houses on birds' feet which can have an impact on litter quality (CIWF, 2016a).

[14] See https://bit.ly/2SgjErc. This is also a requirement of the RSPCA standard for laying hens.

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3.7
HANDLING AND STOCKMANSHIP

The main elements of management can be considered to be: daily flock management; handling; and dealing with health issues. **Stockmanship is essential to help to ensure animal health and welfare and its importance cannot be stressed enough** (DEFRA, 2001). Stockpersons should be trained to correctly and calmly handle the animals and to recognise signs of decreased welfare. This requires an understanding of normal and abnormal behaviour. While the housing system may facilitate the ease of inspection, routine management practices are fundamentally independent of the housing system.

Hens should be visually inspected at least two or three times a day with suitable records kept, including mortality

Stockpersons must be sufficiently trained to identify and deal with health issues

Birds should be calmly and carefully handled

3.8
STOCKING RATE

Stocking rate is defined as the number of birds allowed or present per unit area (Nicol et al., 2017). In the case of laying hens, EU legislation defines a maximum number of birds per unit area that depends on the rearing system. Levels of aggression and injurious pecking behaviour and, in some cases, layer performance can be influenced by stocking rates (Huo et al, 2016; Kang et al, 2016).

This is because laying hens have the tendency to carry out specific behaviours, such as feeding, or dust-bathing all together at the same time (Collins et al., 2010). Some authors have reported an increased risk of damp litter and plumage damage at higher stocking densities, and higher levels of corticosterone, a stress hormone (Kang et al., 2016; Steenfeldt and Nielsen, 2015). Management factors appear to be important in mitigating the risk of injurious feather pecking and aggression if these behaviours are determined by stocking rates (Zimmerman et al., 2006).

Some higher welfare standards mandate maximum stocking densities that are lower than the maximum prescribed by EU legislation (e.g., 6.7 birds/m^2 for Beter Leven 3 stars[15]; outside the EU, 7.15 birds per m^2 for Global Animal partnership steps 1 and 2 (Global Animal Partnership, 2017); 6.2 birds per m^2 for AGW Animal Welfare Approved). The German label "Für mehr Tierschutz" (standard and premium) allows a maximum stocking density of 7 birds/m^2, but as the mandatory veranda cannot be taken into account for the calculation of available surface, the real stocking density is approximately 5.5 birds/m^2. LEI Wageningen calculated that husbandry systems should not exceed 4.5/m^2 if birds are to be provided the opportunity to perform their full behavioural repertoire (Wageningen UR project team Houden van Hennen, 2004).

Decreasing stocking densities compared to the maximum allowed legal standards can be beneficial for animal welfare. Management factors are also very important.

[15] See https://beterleven.dierenbescherming.nl/zakelijk/english-info

4.
RECOMMENDATIONS FOR SPECIAL STAGES OF A LAYING HEN'S LIFE

4.1
PULLET REARING PHASE

A pullet is a young laying hen, normally reared at a rearing site different from the main laying site, typically until the age of around 16 weeks. After this period, pullets are transferred to the laying farm in preparation for the start of the laying, three to four weeks later. Pullets can also be reared on the same farm where they will spend their lives as laying hens, and this can have beneficial effects on their welfare, since they do not need to be caught and transported and they are already familiar with the management on the farm.

The welfare of pullets is not covered by minimum EU legal standards. However, **the way pullets are reared has a lasting impact on their future welfare**, i.e., on their potential to express a range of normal behaviours when they become adults. Ideally, the birds should be reared in the same type of systems in which they will eventually spend their lives as laying hens, to make the transition from rear to lay less complicated and stressful (CIWF, 2012a). More specifically, drinker, feeder and perch types, litter type and quality, slats and facilities on different levels, lights and feeder timing, as well as temperature in rear and lay environments should match, as concluded by the AssureWel Project on animal welfare (Assurewel Project, undated). Ensuring that pullets have access to the same activities and resources in the pullet farm as on the lay farm can maximise the benefits of these for hens during the laying stage.

CIWF (2016) sets out some **good practices in terms of rearing pullets**, in accordance with RSPCA welfare standards for pullets (RSPCA, 2016), which include the provision of the following features:

- **A raised slatted area**, to help pullets to learn to move around the hen house without injury (including the risk of feather pecking) while they are young and light, and their bones are stronger. Furthermore, access to a raised area allows the distribution of the birds on a wider surface, thus preventing frustration and competition for resources.
- **Appropriate perches**, with a minimum provision of 6 cm/bird, to increase bone strength and thus reduce the risk of fractures (Assurewel, 2014).
- **Nest boxes** can be used during the latter stages of pullet rearing. This helps to train the bird to use a nest box and reduce the number of eggs laid on the floor, which can in turn have a positive financial impact on the farm business.
- **Dark brooders**, i.e. horizontal heating elements, surrounded with curtains to darken the area. They are useful to create a dark and warm place for pullets to rest and hide from exploring birds that might peck them. Dark brooders are associated with a reduction of feather pecking, cannibalism and fear (Riber and Guzman, 2016).
- **Access to outdoors (pullets destined for free range systems)**, no later than 12 weeks of age, to make pullets less fearful when moved to outside areas (CIWF, 2016a).

CIWF (2016) indicates that it is important to monitor the birds to avoid an early or late onset of lay, which may respectively result in a higher risk of feather pecking and vent pecking or problems with prolapse. In this regard, it is of foremost importance to:

- Weigh a sample of birds regularly from the day of arrival on the laying farm, and
- Avoid mixing birds from different rearing groups when putting pullets into the laying shed.

Finally, it is beneficial to transport the pullet to the laying farm at an early age as this provides more time for adjustment. As noted above, ensuring similarities between the two environments can also limit the scale of adjustment required (Assurewel Project, undated).

4.2 CATCHING HENS AT END OF LAY

The catching of end-of-lay hens is the first stage of the depopulation and slaughter process, which typically occurs when hens are between 60 and 80 weeks old. Traditionally this has involved staff catching hens by hand and carrying them inverted to transport modules, with several hens held at a time. This not only causes pain and distress to the hens, with a high risk of traumatic fractures, but it can also be arduous for the catching staff[16].

There are measures that can be taken to both minimise the risk of stress and fractures, and facilitate the catching process. These are laid out below (RSPCA, 2017; Eyes on Animals, 2018; Humane Slaughter Association, 2011):

- **The distance from transport to loading should be minimised.** Ideally, loading should take place inside the building; and in this context, the possibility to load inside the hen house should be foreseen when designing new installations. For existing installations or smaller installations where loading inside the building is not possible, an accessible and sheltered concrete area outside the building should be designated for this purpose.
- **Access doors should be sufficiently wide** if loading is to take place outside the building.
- **The facilities provided to hens should remain the same until depopulation.** For example, water should be available until depopulation. It is a legal requirement that free-range birds have access to the range up to and including the day prior to depopulation. This continuity of the provision of facilities, as well as providing hens with the necessary welfare, will not create unnecessary agitation prior to catching which could make the process more difficult.
- **Low light or green/blue light should be used during catching.** This will minimise the fear reactions of birds. Alternatively, a period when hens are naturally roosting may be chosen for the time of depopulation for the same reason.
- **A depopulation plan should exist,** and a team leader should be assigned to ensure it is correctly followed.

[16] As a general note, care should be taken when catching hens during all stages of their life; but the case of end-of-lay hens is particularly important due to their fragility.

Catching end of lay hens with the Swedish method.

- **Staff should be suitably trained (with proof to attest the training completed) and employ welfare friendly practices.** More specifically these include:
  - Catchers working in teams of at least two: one person catching the hens, and the other opening and closing crates.
  - Hens should be caught using the Swedish method, whereby up to two hens at a time are caught upright and subsequently held upright around both the chest and wings (note: the birds should not be held by the wings).
  - Minimising the number of birds that are carried at any one time (with the Swedish method, for example, only two hens are carried at a time).
  - Loading carefully; ensuring crates are stable and chickens are upright in crates; and not overloading crates.

In addition to these practices for the more traditional system of catching end-of-lay hens, some efforts to develop alternative systems have also been made. The most notable was developed within the EU-funded Hennovation project[17]. The project developed a pilot method initially designed for catching end-of-lay hens from inside hen houses equipped with enriched cages (Elson and Weeks, 2017). It used trolleys with fully swivelable wheels that can be placed in the aisles in front of the cages. Each trolley holds four drawers and the system is designed to dock seamlessly with existing transport modules. Key advantages of using this system included:

- Improved wellbeing of hens and catching team; notably catchers appeared to have a lighter workload
- Reductions in injured and dead hens on arrival at the slaughterhouse
- A time to load hens similar to traditional catching methods, but with potential to improve on this as catcher experience of the new method developed.

While not initially designed for cage-free systems, the catching method developed by Hennovation may also work in cage-free environments, albeit with some adaptations.

[17] The project ran from January 2015 – August 2017.

4.3
TRANSPORT AND SLAUGHTER OF HENS AT END OF LAY

Transport and slaughter are the last stages of a laying hen's life. The slaughter process is stressful for all animals, and this is no different in the case of end-of-lay hens. The limited availability of facilities intended for the slaughter of end-of-lay hens can add a specific challenge.

The best practice would be the slaughter of laying hens on farm, using a suitable slaughter facility or mobile slaughter unit. This practice sidesteps the challenges surrounding the transport of hens at end of lay.

If on-farm slaughter is not possible, transport to a suitable facility is required. The following measures are good practices for transport:

- **Shortest duration possible.** Higher welfare standards often limit the transport duration. Limits vary between standards; 3-4 hours is common, though some standards allow up to 8 hours.

- **Suitable temperature.** In hotter climates or periods of the year, forced ventilation or even fully conditioned trucks can assist with maintaining a suitable temperature; as can transporting the birds during the cooler period of the day. The upper and lower temperature limits for transporting broiler chickens indicated by EFSA (2011) are 5 to 24/25 degrees Celsius, but the EFSA had also recommended establishing thermal limits for the transport of laying hens and end-of-lay hens because of their specific physiological characteristics.

With regards to slaughter, laying hens are typically inverted, shackled and stunned using electrical water-bath stunning. Slaughter through the use of controlled atmosphere stunning (CAS) is commonly considered to be less aversive as it avoids the need for shackling and live inversion, and it has a higher success rate. Research to improve stunning and slaughter methods is ongoing.

4.4
ALTERNATIVES TO THE KILLING OF DAY OLD MALE CHICKS

Chicks are typically sexed after hatching, with the males killed using gas or maceration methods. This occurs as the males are considered to have insufficient economic value; notably they do not provide enough meat to be used as broilers. In this context, it should be noted that there is generally a negative correlation between fattening and laying performance.

The main approaches investigated to avoid this are (Amir Aslan, 2014; Krautwald-Junghanns, 2018; Damme, 2015):

- **Influencing the sexing ratio.** There has been some experimental success in influencing the sexing ratio through the introduction, for instance, of feed restriction (i.e. limits on access to feed during certain periods), although this may negatively affect animal welfare.

- **Sex determination prior to hatching.** Methods for determining sex prior to hatching have been developed. The main challenge is that methods need to be rapid, cost-efficient, and highly precise to be used on a large scale. The three main methods developed are based on: (1) identification by cutting a small hole in the shell and using infra-red light to determine the gender; (2) more recently, a less invasive method using near infrared and fluorescence has been found, which leaves the inner egg shell membrane intact and improves chick welfare and hatching rates (Galli et al., 2018); (3) identification through extraction of

fluid from the shell and chemical testing (this method is not accepted widely because it is carried out on the 8th or 9th day of incubation, when the chick's ability to suffer *in ovo* cannot be completely ruled out[18]).

- **Creating economic uses for males of layer lines.** This is currently perceived as being difficult due to the negative correlation between fattening and laying performance noted above. Dual-purpose breeds exist, but they tend to have lower egg and meat yield rates. However, the Kipster farm sells meat from male chicks thanks to an agreement with Lidl Netherlands[19], and as research continues, it is possible that male layers will become increasingly attractive for fattening, especially via the selection of more economically interesting dual-purpose chickens through cross breeding of broiler and layer lines.

While the approaches above are not yet fully ready for large-scale usage, some of them are close and some egg producers are preparing to use them in the near future. For example, United Egg Producers in the US has committed to ending the practice of killing day-old male chicks by 2020 (Wired Magazine, 2014).

In addition to these more scientific methods under investigation, a more traditional method can be used to reduce the number of day old chicks that are killed. Some male chicks can be kept in laying systems as cockerels. They have the advantages of being good guards (and hence protect hens against birds of prey). Flocks of laying hens with cockerels may also be calmer/ show less signs of fearfulness. Some systems therefore foresee 1 cockerel for around every 25 hens (CIWF, 2009).

[18] Source: Deutscher Tierschutzbund, personal communication

[19] See https://bit.ly/2BAYVsl

5.
ECONOMIC ASPECTS OF CAGE-FREE EGG PRODUCTION

5.1
KEY FIGURES

In 2016, the European Union accounted for around 15% of global eggs production (**Figure 5.1**). According to the European Commission, the production of eggs in the EU has steadily increased between 2012 and 2016. In 2016, around 7.7 million tonnes (mt) of eggs were produced in the EU, compared to 7.5 mt in 2012. Projections from 2016 expect the sector to further grow in 2017 and 2018[20].

In 2016, 73% of EU egg production was concentrated in 7 countries, with France as the top producer (**Figure 5.2**). Egg production in cage-free systems is led by Germany, the Netherlands, and the UK, holding together 58% of the total number of laying hens kept in cage-free systems (**Figure 5.3**); it is still limited in Poland, Spain and France.

In particular, as shown in **Table 5-1**:

- Germany is by far the top user of cage-free systems, accounting for one third of EU barn and organic eggs;
- The UK is the top producer of free-range eggs, accounting for 41% of the European free-range production.

Official data from the EU from 2012 to 2017 show that the number of laying hens reared is increasing; at the same time **cage-free rearing systems are constantly gaining ground at the expense of enriched cages (Figure 5.4)**, although as we have seen the relative proportion of enriched cages vs. non-cage (alternative) systems varies widely by country.

[20] 2017 and 2018 figures had not been released as of October 2018.

Figure 5.1: World production of eggs (2016)

Source: AgraCEAS based on FAOStat

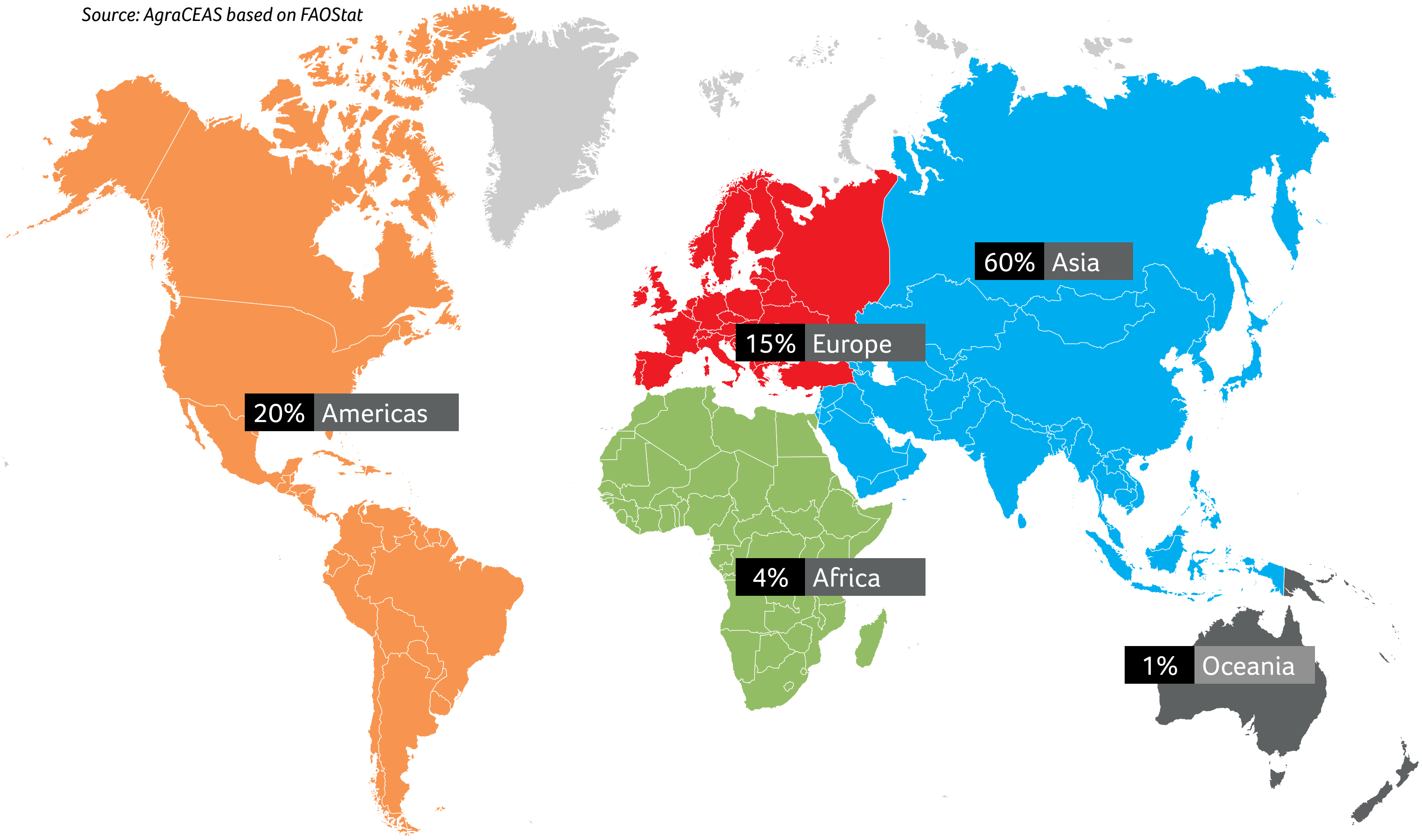


Figure 5.2: Major EU egg producers, 2016

Source: AgraCEAS based on EC statistics, https://bit.ly/2BCVbXy

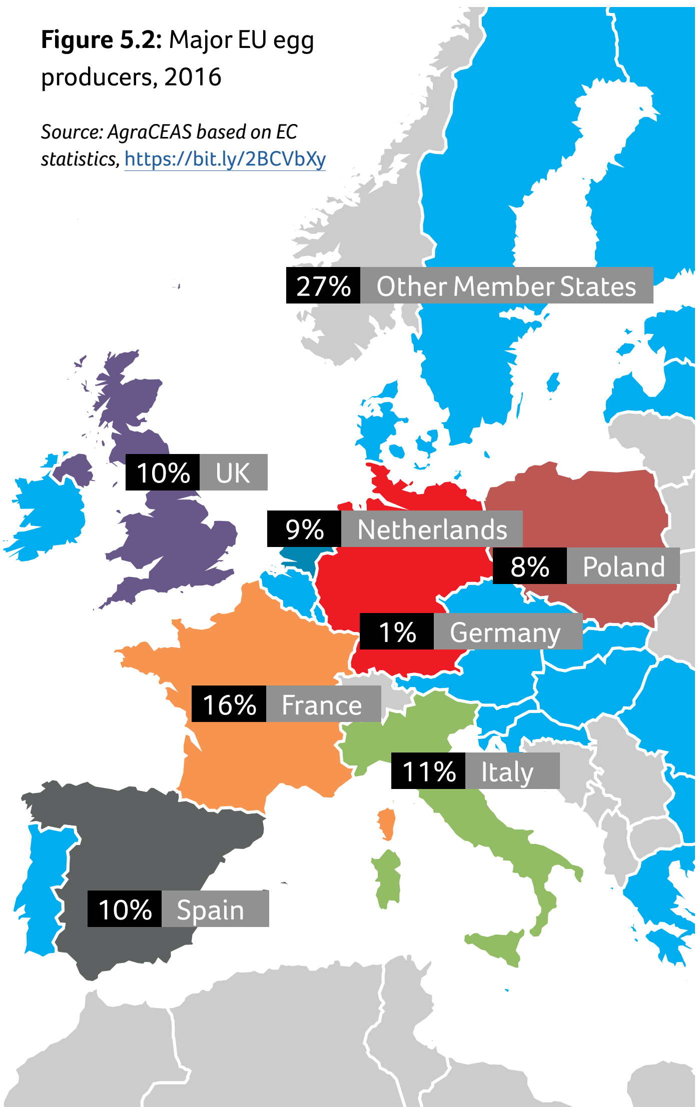


Figure 5.3: Percentage of cage-free systems in different EU MS in terms of capacity (number of birds), 2016

Source: AgraCEAS based on EC CIRCABC (2017)

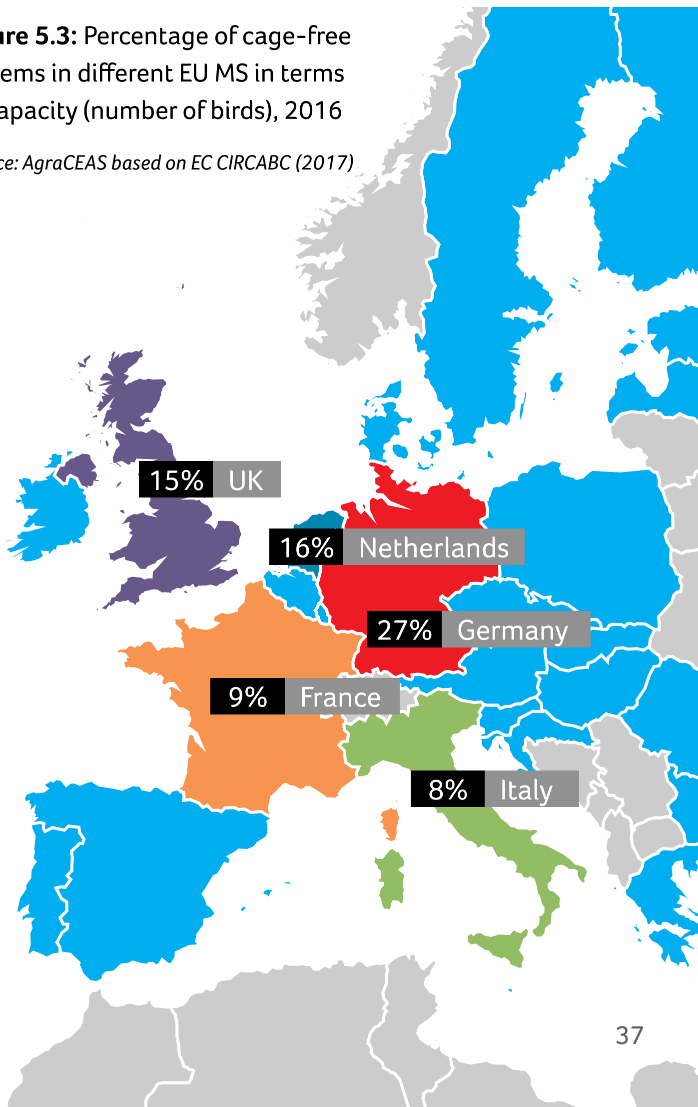
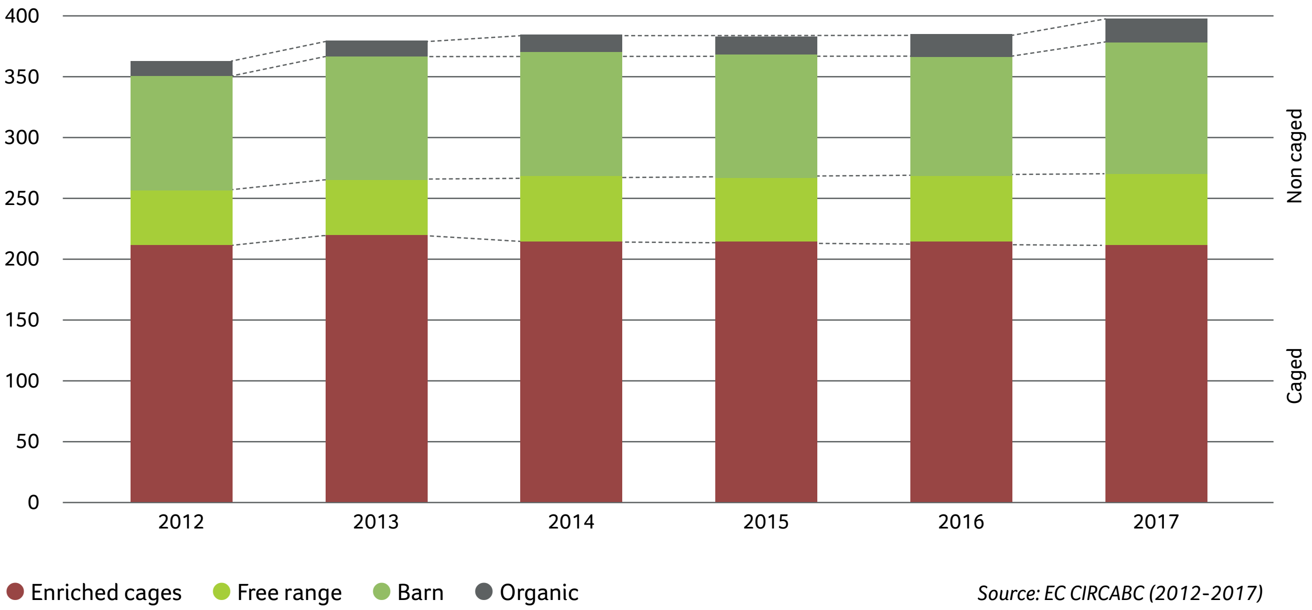


Figure 5.4. Total n. of laying hens (in millions) in the EU in the period 2012-2017, showing the evolution for enriched cages and alternative systems (barn, free-range, and organic).



Source: EC CIRCABC (2012-2017)

Table 5-1: Major EU MS using free-range, barn and organic systems (in terms of % of all laying hens in the EU)

Free range		Barn		Organic	
UK	41%	Germany	32%	Germany	31%
Germany	17%	Netherlands	21%	France	20%
France	16%	Italy	12%	Netherlands	10%
Netherlands	10%	Sweden	5%	Italy	8%
Other MS	16%	Other MS	30%	Other MS	31%

Source: AgraCEAS based on EC CIRCABC (2017)

5.2 ORGANISATIONAL STRUCTURE

In the EU, the organisational structure of cage-free egg production varies greatly between Member States. However, the production is generally organised as set out below:

- Packer concentration is relatively low, and producers will either own their own packing station, or have arrangements to sell to independent packers who then bundle supplies on short-term contracts from a relatively limited number of producers.

- Large producers using enriched cage systems may integrate some alternative egg producers, to widen the range of products they can offer to distributors.

- If eggs are produced by independent producers, they are generally sold to packing stations or (semi) integrated companies (i.e., involved in various stages of the chain such as feed provision, egg production, packing and distribution). In these cases, the farmer usually has a contract to deliver the eggs produced by 1 or 2 flocks (marketing contract), which includes conditions relating to the logistics and quality of the eggs, as well as a pricing formula (AgraCEAS Consulting, 2010).

5.3
PRODUCTION COSTS AND MARKET ASPECTS

Production costs for eggs depend on factors that vary depending on the country, production system and production parameters.

In relation to costs by country, Van Horne and Bondt (2017) investigated the production costs of barn eggs in eight Member States. The authors took into account six major indicators, namely:

- Cost of the individual hen (young hen at 20 weeks, minus the revenue from the spent hen)
- Feed (feed costs during the laying period)
- Other operating costs (e.g., electricity and animal health)
- Labour (cost of the labour of the farmer or farm staff)
- Housing (depreciation, interest and maintenance cost on building and equipment)
- General costs (book-keeping, clothing, insurance and manure disposal costs).

The results (**Table 5-2**) indicate that, in general, feed, hens, housing, and labour accounted for nearly the total costs in the eight countries surveyed. However, results vary largely between member states: while the United Kingdom and Denmark reported the highest total costs, i.e., well above 100 eurocent/kg, in Poland total costs were below 100 eurocent/kg (**Table 5-2**).

In terms of cost difference by production system several parameters besides the housing system *per se* affect production costs. For example, in some member states it is possible to find eggs labelled as free-range for sale at prices comparable to those from enriched cages; however, the production parameters of such free-range systems may be suboptimal in terms of animal welfare.[21]

Literature generally suggests that genuine efforts to optimise hen welfare and to minimise environmental externalities usually lead to higher production costs. This explains the initial large investment to set-up systems such as for instance the Rondeel (see Annex) and De Lankerenhof (Plantation; ibid.) farms, as well as the costs due to higher feed intake. However, a premium may be paid for eggs produced in such systems, e.g. in the Netherlands, one organic De Lankerenhof egg can be purchased for around EUR 0.40, one Rondeel egg for no less than EUR 0.30. The extent to which a premium can be obtained varies by EU country also depending on consumer preferences.

In sum, differences in set up and running costs, in the possibility to obtain a premium price, as well as the impact of different production parameters make a comprehensive and robust comparison of costs across countries difficult.

The most accurate indication of the differences between prices and costs can be obtained from an examination of retail prices of eggs from different systems within the same member state.

Table 5-3 provides this comparison for the Netherlands – a member state where several cage-free innovative systems have been developed. The price of eggs paid by end consumers largely varies depending on the production system, the number of "*Beter Leven*" (BL)[22] stars they are awarded, as well as package size. Prices per egg range between EUR 0.21 (free-range eggs with 2 BL stars) to EUR 0.38 (organic De Lankerenhof with 3 BL stars and the organic label).

As described in section 6.2., in the EU farmers usually have a contract to deliver their eggs, which includes conditions relating to a pricing formula (AgraCEAS, 2010). The retailer's main objective is often to offer consumers a cage-free product at a competitive price compared to enriched-cage eggs. The eggs' price to the end consumer will then not fully reflect the product's value; in turn, this may limit the potential to obtain a return for some systems (Shane, 2017). These retailer policies may cause farmers to opt for systems that are sub-optimal for animal welfare but that can contain production costs.

21 The organisational structure of the production chain can play an important role here – the large size of operators further down the chain (i.e. distributors / retailers) can result in them possessing more power over the chain. As noted in the next section, some retailers focus on the labelled production system and price as the key criteria; which can have a negative impact on production parameters.

22 The '*Beter Leven*' (i.e., "Better Life") label is issued by the Dutch Society for the Protection of Animals (Dutch SPA, Dierenbescherming). It has three levels: 1 star = regular farming with improved parameters, 2 stars = animals have an outdoor access, 3 stars = organic farming systems or systems with a comparable level of animal welfare. Source: www. beterleven.dierenbescherming.nl

Table 5-2: Costs of primary production of barn eggs in some EU countries, in 2015 (eurocent per kg)

	DK	UK	FR	IT	DE	ES	NL	PL
Total costs inclusive labour	**114.5**	**111.9**	**106.8**	**104.3**	**103.4**	**101.0**	**101.0**	**97.2**
Total costs exclusive labour	**104.5**	**106.2**	**98.1**	**99.4**	**95.7**	**95.3**	**93.4**	**95.2**
Hen cost at 20 weeks	25.6	25.1	21.7	21.3	21.3	21.8	20.9	22.8
Feed	56.1	57.5	57.7	58.1	55.9	55.9	53.8	54.8
Other	8.0	8.1	7.8	7.4	6.9	7.2	6.8	7.1
Labour	10.0	5.7	8.8	4.9	7.7	5.6	7.6	2.0
Housing	12.7	14.3	11.3	10.6	11.5	10.8	11.1	11.4
General	1.7	1.7	1.4	1.3	1.6	1.4	1.6	1.2
Manure disposal	0.4	-0.6	0.0	1.5	0.7	-0.3	1.5	0.4
Revenue spent hen	-0.1	0.0	-1.9	-0.7	-2.3	-1.4	-2.3	-2.5

Source: Adapted from Van Horne & Bondt (2017).

Table 5-3: Price of cage-free eggs paid by end consumer in the Netherlands

Production system	Beter leven stars	N. of eggs per package	Price per egg, EUR	Price per package, EUR
Barn (A)	No	6 (M size)	0.28	1.67
		10 (M size)	0.24	2.38
Barn (A)	★	4 (L size)	0.33	1.31
		6 (M size)	0.27	1.64
Free-range (A)	★★	6	0.27	1.59
		10	0.23	2.29
		15	0.21	3.19
Rondeel (A)	★★★	3	0.36	1.09
		7	0.30	2.09
		10	0.29	2.89
Kipster (B)	★★★	5	0.24	1.19
Organic (C)	★★★	6 (different sizes	0.39	1.83
		10 (different sizes)	0.29	2.89
Plantation – De Lankerenhof (organic) (D)	★★★	6	0.33	2.35
		30	0.38	11.45

Sources: AgraCEAS based on figures collected from (A) Albert Heijn, www.ah.nl, (B) Pluimveeweb, www.pluimveeweb.nl, (C) Jumbo, www.jumbo.com, (D) Landmarkt, www.landmarkt.nl.

Flat Deck Systems: According to the British Egg Industry Council (quoted in Perry, 2004), in 2004 the capital costs of a single-tier barn system in the UK ranged between EUR 20-27 per bird; operating costs amounted to approximately EUR 74-83 per bird (note that these figures are not updated and may not reflect the current situation). The set-up costs of a flat deck system (including equipment such as slats, nest boxes, automatic egg collection, etc.) has been calculated to be around EUR 30 per bird (CALCU, 2010).

Aviary systems: Evidence suggests that the set-up costs associated with **aviary housing systems** amount to EUR 12.37 per hen for the housing, and EUR 13.95 per hen for the whole inventory. Some researchers found that hens in aviaries consume around 120 g of feed to produce 390 eggs. In 2015, overall table eggs production costs from aviaries were EUR 25.44 per housed hen (Van Horne and Bondt, 2017).

Mobile sheds: Mobile houses require more substantial investments compared to other systems, due to their reduced economies of scale. Therefore, this type of hen house is best suited to supply eggs to premium markets, such as the organic (Cooper, 2005). Set-up costs for mobile sheds were reported to range between EUR 26-28 a bird per year for mobile units and large-scale static housing with automatic egg packers, to nearly EUR 36 a bird for organic mobile sheds (Cooper, 2014). In Germany, investment costs were reported to amount to EUR 50-60 per animal (Giersberg, 2017).

6.
SUSTAINABILITY OF CAGE-FREE HOUSING SYSTEMS

6.1
ENVIRONMENTAL SUSTAINABILITY

The main environmental impacts of laying hen production systems relate to:

- **Air quality** (particulate matter, ammonia and dust)
- **Water quality** (run-off)
- **Resource usage** (feed, energy, land).

In general, the environmental impact of cage-free systems concerns the following factors:

- **Ammonia emissions.** Concentrations of ammonia are generally higher in all types of housing systems with manure composting inside the hen house (i.e. presence of litter floor, which is generally the case in cage-free systems). It may happen that manure is not removed until the end of the laying cycle; in this case, its continued presence contributes to increased ammonia and particulate matter emissions. This suggests that ammonia emissions depend largely on manure management practices rather than the type of housing system. Furthermore, results from the comparison of different studies (David et al, 2015b) indicate that level of ammonia emissions may largely vary between production unit and seasons, with peaks in litter floor systems evaluated during winter[23].

[23] This effect may be a result of ventilation being decreased in order to avoid extra heating costs in colder seasons.

Table 6-1: Energy use (gigajoules, GJ) in alternative systems in the UK

Indicator	Barn	Free-range	Organic
	Consumption per 1,000 kg of eggs (Gj)		
Feed and water	12.09	12.85	19.89
Electricity	8.37	3.57	4.12
Gas and oil	1.97	2.55	2.47
Housing and land	0.19	0.26	0.32
Manure and bedding	0.42	0.45	0.38
Total	**22.20**	**18.78**	**26.41**

Source: AgraCEAS based on Leinonen at al (2012)

Table 6-2: Environmental sustainability of alternative systems in the Netherlands (lower score = better)

Indicator	Barn	Free-range	Organic
	Overall scores*		
Global warming potential	45	39	62
Ammonia emissions	21	21	0
Energy use	60	51	93
Direct and indirect land use	57	35	0
Total	**183**	**146**	**155**

* Note: Data collected from literature and a survey were incorporated in a weighting tool through which weights and compensabilities were assigned to each of the indicators. Sustainability scores were calculated on a scale from 0 to 100%.

Source: AgraCEAS based on Van Asselt et al (2015)

- **Particulate matter (PM).** Particulate matter (e.g., very fine dust particles) in cage-free housing systems can originate from the hens themselves (feathers and skin dander), feed particles, litter, and faeces (Xin et al., 2011). As indicated by the European LayWel project (2004) and David et al (2015a), the concentration of dust in alternative systems may be high due to the hens having access to nests, perches, and material for dust bathing (e.g., litter) as well as their increased physical activity, which raises settled dust.

- **Water quality.** In all systems that are equipped with manure or litter storage, manure or litter is periodically land-applied. However, this may lead to phosphorus concentration in runoff water, as phosphorus is abundant in manure. (Xin et al., 2011).

- **Resource usage.** A study carried out in the United Kingdom to evaluate the environmental impact of alternative systems concluded that the free-range is the most resource and energy efficient alternative rearing system. Feed and electricity had a major impact on primary energy use, particularly in organic systems, where this was mainly due to: a) increased physical activity of laying hens; b) larger feed intake, and c) higher heat loss, due to a lower stocking density, particularly in the coldest seasons (Leinonen et al., 2012; see **Table 6-1**).

- Similarly, a study on the sustainability of Dutch alternative systems (Van Asselt et al, 2015) concluded that the free-range system is overall more sustainable than barn and organic systems, particularly in terms of CO2 emissions potential and energy use. However, as reported in **Table 6-2**, the organic system was evaluated as the most sustainable in terms of ammonia emissions and land use (i.e. it scored 0).

Table 6-3: The environmental impact of cage-free systems

Issue	Challenge	Risk
Air quality	Concentration of ammonia or PM emissions.	Highly dependent on system and manure management. **Low** in systems that have designed innovations to face manure management (e.g., redrying of manure in the air in the Rondeel system).
Water quality	Phosphorus in runoff water.	Dependent on system and manure management. **High** in systems equipped with manure or litter storage.
Resource usage	Feed, energy.	Dependent on system, management, and climactic conditions. **High** in spacious hen houses with lower stocking density, due to increased hens' physical activity, larger feed intake, and higher heat loss (particularly in colder seasons). **Low** in systems with innovative systems for an efficient use of resources, e.g. installation of solar panels and/or use of food residues as feed.

Source: AgraCEAS based on literature review

Table 6-3 summarises the environmental impact of all cage-free housing systems. However, it should be remarked that the environmental impact depends on several factors, including climactic conditions and the farm's management decisions (e.g. stocking density, feed selection, manure management processes, etc.). Strategies to mitigate the environmental impact of cage-free systems include:

- **Improved manure management.** This can be achieved by using **automatic belts or scrapers** (with slats that collect manure under feeding and resting areas), which simplify the removal of manure, thus reducing PM and ammonia emissions (David et al., 2015b). Note however, that only a moderate amount of litter should be scraped away at any one time, unless it is replaced with a fresh layer, as the **hens need sufficiently deep litter to forage and dust bathe**. Additional best practices include the **redrying of manure in air and the use of manure as a fertiliser**, e.g. in the Rondeel system where this leads to a 50% decrease in ammonia and PM emissions.

- **Improved resource efficiency.** This can be achieved, for instance, by using food residues as hens' feed. For example, in the Kipster farm (Annex), **bakery leftovers are converted into hen feed**, thus ensuring increased resource usage efficiency.

- **Reduced carbon footprint.** By replacing fossil fuels to produce electricity with green energy (particularly in colder regions where levels of energy use are higher due to heating), it is possible to reduce greenhouse gas emissions. The best example is provided by the Kipster farm (see Annex), which is equipped with 1,096 **solar panels on the roof**, supplying the energy needed by the farm as well as an extra 60% that is sold.

6.2. A NOTE ON HUMAN HEALTH AND SAFETY

The major risk eggs pose to human health is the ***Salmonella enteritidis*** infection, following the ingestion of contaminated eggs. In cage-free housing systems, where eggs may be laid on top of manure or soil, faecal pathogens on the shell can enter the eggs.

Therefore, the risk of a Salmonellosis outbreak is lower in those housing systems equipped with automatic belts or scrapers for the frequent removal of manure, as well as systems equipped with dryers to re-dry manure in air. For example, a study by Jones et al (2016) reported that the incidence of Salmonella *spp*. in an aviary system was lower (around 3% of the hens) compared to an enriched cage with the same flock dimensions (5% of the hens).

Trampel et al. (2014) indicate some **best practices** to reduce the Salmonella risk, i.e.:

- **Taking strict biosecurity measures** (e.g. sanitise of all materials used in different flocks)

- **Keeping disease vectors** (e.g. rodents) **out of the hen houses** (e.g. repairing holes that allow entry into the hen house, removing vegetation and debris around the hen house where rodents may harbour, regularly carry out rodent inspections and trapping etc.)

- **Ensuring the highest hygiene standards** (e.g. cleaning and disinfecting the hen house after the removal of infected hens)

- **Decreasing the internal temperature of fresh shell eggs to 7 degrees Celsius**, to prevent Salmonella multiplication in contaminated eggs

- **Minimising workers' exposure**.

With regards to worker health and safety issues associated with cage-free production systems, the Sustainable Egg Coalition (undated) found out that factors that affect hen health (e.g. dust, particulate matters and ammonia levels) can also affect the health of aviaries workers. In particular, in aviaries working conditions were found to be worse compared to conventional cages, in terms of workers **exposure to PM and endotoxin**. The use of FFP-2 or FFP-3 masks by workers can greatly reduce exposure to endotoxins (Wallace et al., 2015).

ANNEX – *CASE STUDIES*: INNOVATIVE CAGE-FREE HOUSING SYSTEMS IN THE NETHERLANDS

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RONDEEL

The Rondeel system was developed by a group of farmers together with scientists from the University of Wageningen. Currently there are 7 Rondeel systems[24] in production in the Netherlands.

The Rondeel hen house has a circular shape split into 10 units, each holding 3,000 hens (i.e. the hen house holds 30,000 hens in total), with a stocking rate of 6.5 hens/m^2. In order to better address the behavioural needs of hens and give them the freedom to choose their environment, each unit comprises three areas (Sandilands and Hocking, 2012):

- **Multi-tiered night quarters** with three separate levels for feeding, nesting and egg-laying, and perching.
- **Day quarters or veranda**, providing further space and natural light. These areas are covered in artificial grass and grain is scattered every morning to encourage foraging.
- **An enclosed outdoor area**, with wood trunks and access to soil for dust bathing (CIWF, 2014).
- **A central work area**, which receives eggs from the nests on belts for farm packing and refrigerated storage.

[24] Only three of them are full sized; the others are smaller.

The system is designed to encourage a range of natural behaviours including social interaction, exploration, scratching, and dust bathing. Furthermore, good hygiene measures are in place to prevent disease (Wageningen UR project team Houden van Hennen, 2004).

Along with promoting animal welfare, this system applies **very high environmental standards**:

- The manure is redried in air and used as fertiliser, reducing PM and ammonia emissions up to 50% compared to systems where manure is manually or automatically removed, e.g. flat-deck systems and aviaries
- The hen house is naturally ventilated reducing energy consumption
- Eggs are sorted and packed on-site (in the central work area mentioned above), eliminating emissions due to transport (Clements, 2010).

Due to the production methods used in the Rondeel system (see above), the table eggs production **costs were found to be higher than in standard aviaries/ free free-range systems** (around +5%), **but 40% lower than for organic systems**. Investment costs are double compared to an aviary system; costs of buildings and machinery are high compared to other systems, but account for only 10% of the total costs (Quoted in Groot Koerkamp et al., 2009)[25]. Despite the high costs, the farm can result in increased productivity compared to some other systems, i.e. 150,000 eggs per week. In 2012, the Rondeel systems were estimated to account for 0.08% of the total egg production in the Netherlands (Van Someren Taco & Van Someren-Wang, 2012).

Given that the system has only been in operation since 2010, no thorough research has been carried out to compare the Rondeel with traditional housing systems, in terms of animal welfare, environmental standards and productivity.

THE PLANTATION

The Plantation is a large-scale egg production system representing approximately 0.4% of total egg production in The Netherlands (Spoelstra, 2013). It is characterized by two curved lines of buildings cut into the landscape and enclosing a large inner yard area, and as such can be considered a specific type of aviary housing system (Quoted in Groot Koerkamp et al., 2009). The main features of the system are set out below:

- Birds are separated in **two groups of 3,000 hens each** (i.e. the hen houses hold 6,000 hens each)
- **Hens can perform several activities** in two separated areas, which are interconnected by a logical route: on one side there is a covered resting space equipped with perches, on the other side the hens can eat, drink and lay eggs. The **droppings and dirt are removed by conveyor belts**
- In the morning, once eggs are laid, **hens have access to the inner yard, which is open air, but can be covered up when needed**. The yard can be cleaned up easily and new bedding material added, because it is accessible for machinery and has a concrete floor
- Hens can also access **outer areas**, designed for the birds to explore
- The outside access ensures that the hens are gradually exposed to circulating diseases, thus developing robust immune systems (Wageningen UR, 2004).

In 2004 the **costs of table egg production in Plantation were estimated to be higher than for** aviary/free-range systems (+17%). However, similarly to the Rondeel, production costs were **40-50% lower than for organic table egg production**. Higher costs were due to the higher feedings costs (due to the natural variation in their environment, hens consume more feed) and lower productivity. Investment costs of buildings and machinery accounted only for 10% of the total costs (Groot Koerkamp et al., 2009)[26].

No thorough research has been carried out to investigate the environmental standards of this system.

[25] **Caveat:** methods used in the source study to collect data and estimate the variation of production costs in different housing systems are not clear.

[26] *Ibid.*


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KIPSTER

The **Kipster hen house is an innovative barn system**, where hens have access to an outdoor space during daytime as well as access to a big "indoor garden" with natural light at all times. However, the hens from the Kipster farm are not technically free-range, having access to less than 10 hectares of open land (i.e. the 4m² per hen required for free range).

The 1,200 m² farm houses **24,000 hens** divided into sub-groups of 6,000 birds each, stocked at an indoor density of 6.7 birds per m². However, the modular structure would allow to expand the farm capacity up to 96,000 hens (Eurogroup for Animals, 2018). At the time of writing, the Kipster farm supplies only LIDL Netherlands; **production is estimated at around 7.5 million eggs per year** (N.A., 2017).

The main features that characterise this system are:

- **Windows on the sloping ceilings**, which provide a source natural light for the birds; this also contributes to minimise the incidence of feather pecking (hens are not beak trimmed)
- **Increased roaming space** including enrichment features such as perches, soil to scratch in, branches on which to rest, etc., where hens can fully express their natural behaviour
- **A 1,200 m² covered "indoor garden"**, with trees and straw bales on which the hens can perch
- **A covered outdoor area**, where hens can freely roam and roost on trees (LFDA, 2018).

In terms of animal welfare, the Kipster eggs have achieved the highest rating possible from the Dutch animal protection organisation Dierenbescherming, i.e. 3/3 Better Life stars (Beter Leven), given the standards of the farm (WakkerDier, 2017).

Furthermore, the system is environmentally friendly, as demonstrated by, e.g.:

- Low ammonia emissions, i.e. approximately 0.025 kg per hen
- Low particle emissions (estimated at -95%), thanks to the extraction fans that filter air
- Installation of 1,097 solar panels on the roof, which supply the energy needed and provide a further 50% which will be sold
- Reduced carbon footprint by up to 50% by providing hens with feed made from bakery residues, compared with standard feed
- Reduced carbon footprint by up to 100% by combining use of special feed, use of white birds, use of solar panels.

Kipster eggs are marketed at EUR 0.23/0.24 each (N.A., 2017).

Given that the Kipster is a recent facility, no scientific research has been conducted to thoroughly investigate its impact on animal welfare and the environment, as well as its return on investment.

GLOSSARY

The information in this glossary pertains to the EU, where specific legislation is in force concerning laying hens.

Alternative rearing system for laying hens

A cage-free system for rearing hens where the stocking density does not exceed 9 laying hens per m^2 usable area, with at least one nest for every seven hens, and adequate perches, in accordance with Article 3 of Council Directive 1999/74/EC. *Free range*, *organic*, and *barn* rearing systems (also known as methods of production) are considered alternative systems. All cage-free systems provide nests, perches and litter over at least one third of the floor surface and have a space allowance of at least 1,100 cm^2 per hen (9 birds/m^2).

Animal welfare

Animal welfare is an evolving concept, which incorporates freedom from negative emotions as well as the possibility to experience positive emotions or affective states. Any definition of animal welfare should include physical well-being (health), affective states and natural living of animals (Fraser et al., 1997). Another definition is "The animal's quality of life as it is experienced and valued by the animal itself" (Bracke et al., 1999).

Aviary, or Multi-tier system

Aviaries or multi-tier systems are multi-level systems, where hens can move freely between several levels (up to four – 3 floors plus ground floor according to EU legislation). Maximum stocking density in aviaries must not exceed 9 birds/m^2 of usable area in the EU.

Barn rearing system

A barn system allows hens to move in an indoor space of minimum at a stocking density of maximum 9 birds/m^2 of usable area, equivalent to 1100cm^2 per bird. Examples of barn rearing systems are (a) *Multi-tier system (or aviary)*, where hens can freely move between (up to four) tiers; (b) *Single-tier or flat deck system*: similar to a multi-tier system but with only one level provided above the floor.

Cage-free housing system

Same as alternative system.

Chick

A young bird, which is also referred to as '*day-old chick*', when is less than 72 hours old and not yet fed.

Combination ('combi') housing system

A combi system is a housing system that can be managed either as an enriched cage (see *enriched cage system*) or alternative system (see *alternative system*), with corresponding features (see d*efinitions of these management systems*).

End-of-lay ("spent") hen

An end-of-lay hen is typically a bird of between 60 and 80 weeks of age, which produces fewer eggs than younger laying hens. The industry commonly refers to end-of-lay hens as "spent" hens.

Enriched (or furnished cage) cage housing system

An enriched cage provides at least 750 cm^2 of cage area per hen and contains a nest, perches and litter material.

Environmental enrichment

Modification of the physical environment of animals, to meet their behavioural needs with the result of improving their welfare.

Flat deck or single-tier system

The flat deck/single-tier system features similar characteristics to the multi-tier system (see above), except that it is developed on a single above the littered floor.

Free-range rearing system

An alternative rearing system providing access to an outdoor range of at least 4 m^2 per hen.

Hen housing system (or hen house)

In accordance with Council Directive 1999/74/EC all housing systems for laying hens must consist of three main parts: (1) A u**sable area**, i.e. an area at least 30 cm wide with a floor slope not exceeding 14%, with headroom of at least 45 cm; (2) A **nest**, i.e. a space for egg laying, which is separated from the usable area; (3) For cage-free systems, a **floor litter area**, i.e. a space with friable material where hens can forage and dust bath. A hen housing system must also include feeders, drinkers, perches/roosts (i.e. poles, branches, or other resting place above the ground, where hens can sleep at night), manure belts, and a **ventilation system**, which helps to remove ammonia gases and keeps the hens cool during warmer seasons.

Laying hen

A hen of the species *Gallus gallus* that has reached laying maturity (usually at about 19 weeks age) and is reared for production of eggs.

Laying Hens Directive

Council Directive 1999/74/EC (July 1999) identified 3 types of rearing systems for laying hens and prohibited non-enriched cage systems. Therefore, in accordance with the Directive, only enriched cages and alternative systems are currently in use at the EU level.

Litter

According to Council Directive 1999/74/EC: any friable material enabling the hens to satisfy their ethological needs.

Non-enriched cage system (or conventional battery cage system)

A caged housing system comprised of a wire mesh floor, feed trough, and drinkers. There are no facilities for nesting, scratching or perching, unlike 'enriched cage' systems (see *Enriched Cages*). Non-enriched cage systems have been prohibited in the European Union since 1 January 2012.

Organic rearing system

A free-range production system with additional marketing requirements set out in Commission Regulation (EC) No 889/2008. Hens are stocked at a maximum indoor density of 6 birds/m^2 of usable area equivalent to1,660 cm^2 per bird; minimum outdoor space (required) is 4 m^2 per bird.

Particulate matter

According to the European Environmental Agency, particulate matter (which includes e.g. dust) is "*a collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface*". In the case of laying hen production, it relates to the particulate matter resulting from the production system.

Pullet

A young laying hen that has not reached maturity yet, usually under 19 weeks of age.

Range or Range area

A range or range area is an outdoor area where hens can roam freely outdoors.

Salmonella enteritidis

A bacterium common in poultry that the European Centre for Disease Prevention and Control has found to cause most salmonellosis cases and Salmonella food-borne outbreaks in humans.

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