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The perks of being an organic chicken – animal welfare science on the key features of organic poultry production

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Modern poultry production entails a number of important animal welfare issues. However, welfare is often considered to be better in organic than in non-organic production, largely due to the focus on naturalness within the former which has been embedded within the EU regulations on organic production. The aim of this paper was to review the relevant scientific literature to assess (i) how animal welfare science relates to the key features of organic poultry production which originally stem from organic visions and ideological reasons, and (ii) whether there is scientific evidence to show that these key features, as stipulated in current EU regulations, contribute to higher welfare in organic poultry production. We identified seven key features that are intended to improve poultry welfare in organic production: appropriate breeds, no mutilations, outdoor access, natural light, perch space and raised sitting levels, provision of roughage, and lower stocking densities. In general, the animal welfare science available supports the potential for higher animal welfare in organic poultry production, based on the requirements as laid down in the current EU regulations. However, there is still room for improvement, and some aspects that may further improve animal welfare in organic poultry production include the use of alternative laying hen hybrids with the potential for better welfare, even more slow-growing broilers, appropriate management of the free-range areas in practice to ensure that they are used by the birds, additional raised sitting level space allowance for broilers, and the use of “dark brooders” for chicks.

KEYWORDS

laying hen, broiler, animal housing, management, natural behaviour, legislation, EU regulation

1 Introduction

The development of organic agriculture, which began in the first half of the 20th century, was a response to the preceding intensification of agriculture (Padel et al., 2004). It involved the convergence of a number of alternative agricultural movements based on the pursuit of a more natural way of living and a more sustainable way of farming (Padel et al., 2004), a desire to preserve rural life, and the holistic conviction that healthy soils give healthy food, promoting human health (Vaarst et al., 2004).

The organic vision is based on a holistic approach, and the concept of an integrated agricultural system where there is harmony between the land, the people and animals (Vaarst et al., 2004). Initially, animals were primarily considered to be important as part of such an integrated agricultural system, but organic farming eventually also came to include concerns for the welfare of animals per se in intensive livestock production (Padel et al., 2004). Good animal health and high animal welfare standards are thus inherent to organic agriculture; in particular, natural living and the ability to express natural behaviours in a natural environment is considered to be a prerequisite for good animal welfare (Vaarst and Alrøe, 2012a; IFOAM, 2024a). Since organic production is based on an ecocentric view, natural living is considered to be valuable in itself (Lund and Algers, 2003; Lund, 2006). Indeed, organic standards more explicitly focus on natural behaviours in comparison to other animal welfare regulations (Lundmark et al., 2014).

In 1972, the International Federation of Organic Agriculture Movements (IFOAM) was founded to promote the organic movement worldwide (IFOAM, 2024a). This non-governmental umbrella organisation coordinates a global network of organic agriculture member organisations, and the IFOAM vision encompasses the world-wide adoption of an ecologically, socially and economically sound agricultural system in line with the four principles of organic agriculture – health, ecology, fairness and care (IFOAM, 2024a). Although not always explicitly stated, high animal welfare standards are embedded in each of these four principles of organic agriculture (Vaarst and Alrøe, 2012a). To harmonise the organic concept and what it encompasses, IFOAM has established internationally applicable basic standards for organic farming. Based on the four principles and the organic vision, these standards serve as guidance for organic organisations developing national standards (Padel et al., 2004).

Organic production and marketing have been regulated in the EU since 1991, first including only crop production, with EU regulations on organic animal husbandry introduced in 1999. Since 2022, the EU requirements for organic animal production are set by *Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007* (hereafter referred to as EU regulation 2018/848) and the *Commission implementing regulation (EU) 2020/464 of 26 March 2020 laying down certain rules for the application of Regulation (EU) 2018/848 of the European Parliament and of the Council* (hereafter referred to as EU regulation 2020/646). These provide a common legal framework within the EU, while also reflecting the IFOAM principles (Padel et al., 2004). According to the first preamble in the EU regulation 2018/848: "Organic production is an overall system of farm management and food production that combines best environmental and climate action practices, a high level of biodiversity, the preservation of natural resources and the application of high animal welfare standards and high production standards in line with the demand of a growing number of consumers for products produced using natural substances and processes".

The general objective of the current EU organic regulations in terms of improved animal welfare is to safeguard the species-specific behavioural needs of animals, and to ensure that husbandry practices, including stocking densities, housing conditions and choice of breeds, meet the animals' developmental, physiological and ethological needs (EU regulation 2018/848). This entails, for example, outdoor access, lower stocking densities, and the use of appropriate breeds. To highlight some of the specific features intended to improve animal welfare in organic poultry production, the minimum requirements as laid down by the EU regulations on organic production are presented in Table 1, alongside the minimum rules for the protection of laying hens and broiler chickens in conventional production, as stipulated in the *Council Directive 1999/74/EC of 19 July 1999 laying down minimum standards for the protection of laying hens* (hereafter referred to as directive 1999/74/EC) and the *Council Directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production* (hereafter referred to as directive 2007/43/EC).

Commercial poultry production encompasses a number of welfare problems, which are not limited to conventional production but can be found in organic poultry as well (Åkerfeldt et al., 2021), such as keel bone fractures (Thøfner et al., 2021) and severe feather pecking in laying hens (Jung and Knierim, 2018), and impaired gait in broilers (Göransson et al., 2020). Some might even argue that organic poultry production brings about welfare issues generally not found in non-organic systems, such as exposure to parasites, extreme weather conditions and predators in outdoor areas (Holt, 2021).

Although the focus of this paper is on the EU regulations on organic production, it may nonetheless be of international relevance, since the content of the EU organic regulations is a reflection of the internationally applicable IFOAM Standards. Governmental and private organic standards that successfully pass an assessment against the IFOAM Standards are included in the "IFOAM Family of Standards" (IFOAM, 2024b). The EU organic regulations were included in 2013 (IFOAM 2024b), and as such they share common objectives and requirements with the other worldwide organic standards included in the IFOAM Family of Standards. Although the purpose of the IFOAM Standards is to harmonise the organic concept across countries, there is nonetheless room for adaptation to local ecological conditions, and there may thus be specific requirements that partly differ between various organic standards, also within the IFOAM Family of Standards (Padel et al., 2004).

Organic production is based on a solid ideology with clear visions and principles, and the specific requirements stipulated in both private and governmental organic standards are not necessarily grounded solely on scientific evidence. Thus, the aim of this paper is to review relevant scientific literature to assess (i) how animal welfare science relates to the key features of organic poultry production which originally stems from organic visions and ideological reasons, and (ii) whether there is scientific evidence to show that these key features, as stipulated in current EU regulations, contribute to higher welfare in organic poultry production. The key features of organic poultry production included and outlined below are those directly linked to and intended to improve animal welfare.

2 Seven key features of organic poultry production to improve bird welfare

2.1 Appropriate breeds

The current EU regulations hold that the choice of breeds or strains should be "appropriate to the principles of organic production" and that preference should be given to those breeds or strains that, for example, have a high capacity to adapt to local conditions and that are not associated with specific diseases or health problems as seen in intensive production (EU regulation 2018/848).

For broilers, this means that slow-growing (as defined by the competent authority in each member state) hybrids should be used (EU regulation 2018/848). Numerous studies comparing broiler hybrids with different growth rates demonstrate that fast growth is associated with impaired mobility and lameness (Dixon, 2020; Rayner et al., 2020; Baxter et al., 2021; Dawson et al., 2021). This constitutes a welfare issue not only due to the associated pain (Caplen et al., 2013) but also because of difficulties in accessing resources such as perches (Wallenbeck et al., 2016; Malchow et al., 2019; Baxter et al., 2021), and, as a result of inactivity and spending extended periods of time sitting down, the development of hock burns (Dixon, 2020). Slow-growing broilers, on the other hand, are more active and display more play and exploratory behaviour in comparison with fast-growing hybrids (Baxter et al., 2021; Dawson et al., 2021). The performance of such behaviours may be rewarding in themselves (Mellor, 2015a), but higher activity levels can also lead to better welfare through beneficial effects on skeletal development and leg health (Güz et al., 2021). Slow-growing broilers have also been associated with a lower prevalence of foot pad dermatitis (Kjaer et al., 2006; Sarica et al., 2014; Wilhelmsson et al., 2019), as well as lower mortality rates (Rayner et al., 2020). Furthermore, it should be noted that the welfare benefits of using slow-growing hybrids extend to the broiler breeders, with reference to the welfare issues following severe feed restrictions (EFSA, 2023a).

The laying hen hybrids used on organic farms are commonly the same as those used in other commercial egg production systems. Amongst these, there are strain differences in terms of, for example, fearfulness and fear responses (Nelson et al., 2020; Brown et al., 2022), immune function (Hofmann et al., 2021; Schmucker et al., 2021), levels of feather pecking (Brinker et al., 2014), susceptibility to keel bone damages (Stratmann et al., 2016), behaviour, and resource use (Ali et al., 2016), including use of outdoor areas (Wurtz et al., 2022). By choosing one hybrid over another, some welfare

TABLE 1 Minimum standards for the housing and management of laying hens (Directive 1999/74/EC) and broiler chickens (Directive 2007/43/EC) in conventional and organic (EU regulation 2018/848, EU regulation 2020/464) poultry production in the European Union.

	Laying hens		Broilers	
	Conventional	Organic	Conventional	Organic
Stocking density	9 hens per m^2 usable indoor area	6 hens per m^2 usable indoor area	33 kg/m^2 [1]	21 kg/m^2
Perches and/or raised sitting areas	15 cm perch per hen	18 cm perch per hen	Not required	5 cm perch and/or 25 cm^2 raised sitting level per chicken
Outdoor access	Not required	1/3 of life and 4 m^2 per hen[2]	Not required	1/3 of life and 4 m^2 per chicken[2]
Lighting	Light levels sufficient to see one another, investigate the surroundings and display normal activity levels	Natural lights inlets	20 lux max. illuminating at least 80% of the area[3]	Natural light inlets
Nocturnal rest (hours per day with no artificial light)	About 1/3 of day	8 h continuous	6 h of which 4 is continuous	8 h continuous
Mutilations (beak trimming)	Permitted in order to prevent feather pecking and cannibalism (<10 days old)	Not permitted, only as an exception (≤3 days old)	Permitted in order to prevent feather pecking and cannibalism (<10 days old)	Not permitted, only as an exception (≤3 days old)
Roughage	No requirement	Permanent access to sufficient quantities when kept indoors	No requirement	Permanent access to sufficient quantities when kept indoors
Growth rate	N/A	N/A	Fast-growing breeds permitted	Slow-growing breeds, or reared to a minimum age of 81 days[4]

[1]Up to 42 kg/m^2 are allowed provided that certain requirements are complied with. [2]Whenever weather and seasonal conditions allow, and except when temporary restrictions have been imposed. [3]Temporary reduction may be applied when necessary. [4]Slow-growing is defined by the national competent authority.

benefits might thus be acquired. However, there is currently no breed considered to be a 'higher welfare breed' showing, for example, a particularly high resistance to disease, low levels of severe feather pecking or keel bone damages, and ample use of outdoor areas (Fernyhough et al., 2020). Corresponding to the welfare issues associated with high growth rates in broilers, genetic selection for extraordinarily high levels of egg production and the early onset of lay has been linked to problems like keel bone fractures (Thøfner et al., 2021), reduced immunocompetence (Schmucker et al., 2021), and decreased engagement in social behaviour (Dudde et al., 2018). Indeed, dual-purpose hens, which produce less and smaller eggs than commercial layer hybrids, appear to be less fearful (Giersberg et al., 2020a) and display significantly less severe feather pecking and cannibalism (Giersberg et al., 2020b; Rieke et al., 2021) than commercial laying hen hybrids.

In conclusion, the transition from fast-growing broilers to more slow-growing hybrids, on both organic and non-organic farms, has resulted in notable welfare improvements. Similarly, research findings suggest that selecting for lower egg production can alleviate certain welfare issues in laying hens. Although some of the currently used hybrids may be relatively better suited for organic egg production, the welfare benefits achieved through a well thought-through choice between these are, nevertheless, limited.

2.2 No mutilations (beak trimming prohibited)

Mutilations, such as beak trimming, is not allowed in organic production (although beak trimming may be undertaken during the first three days of life, but only as an exception) (EU regulation 2018/848).

While beak trimming is performed as a preventative strategy against severe feather pecking and cannibalism (Glatz and Underwood, 2021), the process constitutes a welfare issue in itself, considering that the beak is highly innervated and very sensitive (Gentle, 1989). The traditional hot blade (HB) technique involves a heated guillotine-type blade used to cut and cauterize the beak tissue of the upper and lower beak tip (Glatz and Underwood, 2021). This method has been associated with acute pain and a reduction in beak-related behaviours (Gentle et al., 1997; Marchant-Forde et al., 2008), as well as neuroma formation and evidence of chronic pain (Lunam et al., 1996). It may also impair normal exploratory behaviour due to a loss of sensitivity and magnetoreception (Freire et al., 2011). Infrared (IR) beak trimming, i.e. cutting the beak with infrared radiation so that the beak tip softens and falls off over subsequent days (Glatz and Underwood, 2021), has largely replaced the HB method as the former seem to have less negative welfare consequences than the latter (EFSA, 2023b). Although some have suggested that IR treatment does not induce acute pain (Gentle and McKeegan, 2007), other findings indicate that it might, since young chicks have been observed to be less active and to spend less time eating and drinking during the first days after the procedure compared to control chicks (Marchant-Forde et al., 2008). Acute pain may arise especially if too much tissue is removed, e.g. due to poorly calibrated equipment (Dennis and Cheng, 2012; Glatz and Underwood, 2021). The evidence for long-term pain following IR beak trimming is also inconsistent, since neuromas have been demonstrated in adult hens (Glatz and Hinch, 2008), though not in more recent studies (McKeegan and Philbey, 2012; Struthers et al., 2019). The details of how the IR procedure affects the beak tissue are not yet fully understood (Struthers et al., 2019), and the formation of neuromas might depend, for example, on the level of beak treatment (Glatz and Underwood, 2021).

In general, laying hen flocks with intact beaks show a higher prevalence of, and more severe, plumage damage compared to beak trimmed hens (e.g. Lambton et al., 2010; Sepeur et al., 2015; Riber and Hinrichsen, 2017; van Staaveren et al., 2021). Some studies also report higher mortality in non-trimmed flocks (Lambton et al., 2013; Sepeur et al., 2015; Riber and Hinrichsen, 2017), although others have found no such association (Schuck-Paim et al., 2021). Blunt beaks do not only result in less damage as a consequence of feather- or injurious pecking, but beak trimmed birds have also been seen to perform less of these behaviours (Lambton et al., 2010; Schwarzer et al., 2021). However, these behaviours may also be evident in beak trimmed flocks (Lambton et al., 2010, 2013). Thus, it is important to emphasise that the mitigation of feather- and other types of injurious pecking also involves other important preventative strategies, including various housing and management practices such as providing high-quality foraging substrates (EFSA, 2023b).

In conclusion, beak trimming may induce pain and compromise the function of the beak as an important tool, e.g. for foraging. Nevertheless, infrared beak trimming is considered to be a more welfare-friendly alternative, in comparison with the hot blade technique. The potential welfare issues of the procedure must be weighed against the welfare issues associated with feather pecking and cannibalism. Although beak trimming may help mitigate these problems, it is not a solution that addresses the root cause(s) of feather pecking, nor does the procedure eliminate the behaviour or the resulting damage.

2.3 Outdoor access

Laying hens and broilers in organic production should have outdoor access during at least one third of their life, and whenever weather and seasonal conditions and the state of the ground allow, except for when temporary restrictions have been imposed due to, for example, outbreaks of aviary influenza (EU regulation 2018/848). Moreover, such open-air areas should be attractive to the birds and provide them with sufficient protection, such as shelters or trees (EU regulation 2020/464).

Individual broiler chickens that show relatively high levels of foraging behaviour have been shown to also use the free-range more, indicating that the increased foraging opportunities that the outdoor area offers are highly important (Ferreira et al., 2022). Laying hens have been shown to prefer the free-range for the performance of foraging as well as dust bathing (Campbell et al., 2017; Thuy Diep et al., 2018), especially the areas that provide protection and shade (Larsen et al., 2017; De Koning et al., 2018).

In laying hens, free-ranging appear to have a protective effect against severe feather pecking, likely due to the enhanced foraging opportunities, alongside a lowered indoor stocking density (Lambton et al., 2010; Bestman and Wagenaar, 2014; Bestman et al., 2017). Moreover, providing an outdoor area enables the animals to make a choice between this and the indoor space. Such a choice allows the birds to exert some control over their environment, which may in itself be rewarding and improve animal welfare (Leotti et al., 2010). Free-ranging has also been associated with, for example, better cardiovascular function and improved gait in broilers, of which the latter might be due to better muscle and bone strength following increased locomotion and activity levels (Taylor et al., 2018). No such positive effect of free-ranging on skeletal bone quality has yet been demonstrated in laying hens (Sibanda et al., 2020). Some results indicate that free-ranging may also contribute to improved foot health in broilers and laying hens (Gouveia et al., 2009; Dal Bosco et al., 2014; Rodriguez-Aurrekoetxea and Estevez, 2016), whereas other findings suggest the opposite (Pagazaurtundua and Warriss, 2006; Sarica et al., 2014; Grafl et al., 2017; Taylor et al., 2020). The effect of outdoor access on foot health in poultry is thus not completely clear, and probably depends largely on actual range use and ground conditions.

One major drawback of outdoor access that may compromise poultry welfare is the evident risk of predators, which has been reported as a major mortality cause in free-range systems (Bestman and Bikker-Ouwejan, 2020; Göransson et al., 2020). Although the risk of predator attacks might be difficult to completely eliminate, especially from aerial predators, proper fencing and sufficient protective cover can nevertheless help reduce this welfare issue (Van de Weerd et al., 2009; Göransson et al., 2021; Bonnefous et al., 2022). Another peril of free-ranging is that of infectious disease transmission, considering the biosecurity challenges associated with outdoor access (Gonzales et al., 2017; Guinat et al., 2022). The introduction of, for example, highly pathogenic avian influenza (HPAI) virus may lead to widespread disease outbreaks, with severe health impairments, high mortality rates and mass culling of poultry flocks. Direct contact with infected wild birds in the free-range is an important and indisputable risk factor. However, the transmission of HPAI is epidemiologically complex and has also been shown to occur farm-to-farm due to human-mediated activities (EFSA, 2017; Guinat et al., 2022). Due to the aforementioned biosecurity challenges and the difficulties of disinfecting an outdoor area, free-range systems may also leave poultry more exposed to gastrointestinal parasites (Bonnefous et al., 2022). However, a number of studies indicate that free-ranging may not necessarily constitute a risk factor for endoparasitic infections, given that hens use and disperse well throughout the range (Jansson et al., 2010; Sherwin et al., 2013; Thapa et al., 2015).

In conclusion, outdoor access can improve poultry welfare by providing greater opportunities to perform highly motivated behaviours, such as foraging and dust bathing, which may in addition reduce welfare issues such as severe feather pecking in laying hens. Moreover, free-ranging can also improve bird health. Outdoor access is not without welfare risks, such as predation and infectious disease transmission, though. However, appropriate management and design of the free-range area can, to a certain extent, combat and reduce these risks.

2.4 Natural light and eight-hour nocturnal rest period

In organic production, the birds must have a nocturnal rest period without artificial light of at least eight consecutive hours. Moreover, natural light inlets are required (EU regulation 2018/848).

One important component of 'natural light' is ultraviolet (UV) light. Poultry, in contrast to humans for example, have the capacity to perceive UVA wavelengths (315-400 nm) (Prescott and Wathes, 1999b). UV light is reflected in the chicken plumage, as well as certain foraging substrates, and thus lighting including this spectral characteristic might be imperative for foraging and normal social behaviours in poultry (Prescott and Wathes, 1999a; Maddocks et al., 2001). Not only do laying hens seem to prefer an environment containing UV light (Wichman et al., 2021), but laying hens (Sobotik et al., 2020) and broilers (House et al., 2020) provided with it show lower stress and fear levels. Moreover, there is also some evidence indicating that UVB light (280–315 nm) exposure may have positive animal welfare consequences through improved skeletal health in both laying hens and broilers (see Rana and Campbell, 2021 for a review). Besides the UV wavelengths contained in natural light, the natural variations seen throughout the day in terms of colour and light intensity have been suggested to positively affect poultry behaviour and their circadian rhythm (Prescott and Wathes, 1999b). Increased activity levels have been observed in both laying hens (Wichman et al., 2021) and fast-growing broilers provided with natural light (Bailie et al., 2013; de Jong and Gunnink, 2019), with a reduced time spent lying down and resting in the latter, which might thus also indirectly contribute to improved leg health in broilers (Bailie et al., 2013).

The general consensus is that continuous (i.e. artificial light on 24 h per day) or near-continuous lighting programmes should be avoided, and that providing broilers (on which the predominant amount of relevant research has been performed) with a longer (≥ 4 h) period of darkness contributes to improved welfare (Bayram and Özkan, 2010; Schwean-Lardner et al., 2014; Sun et al., 2017). Four hours of darkness per day, at least, appears to allow for the development of a circadian rhythm and flock behavioural synchronisation (Bayram and Özkan, 2010; Schwean-Lardner et al., 2014). However, a more pronounced effect was found when the dark period extended over seven or ten hours (Schwean-Lardner et al., 2014). A clear circadian rhythm not only promotes the performance of more active behaviours during the light period but also allows for synchronised resting within the flock during the dark period, which helps prevent sleep disruption and, thus, sleep deprivation (Schwean-Lardner et al., 2014). Longer periods of darkness (≥4 or ≥6 h) have been shown to positively affect the immune system status (Hofmann et al., 2020), decrease mortality (Schwean-Lardner et al., 2013), improve leg health and walking abilities (Schwean-Lardner et al., 2013; Karaarslan and Nazlıgül, 2018), and reduce fearfulness (Bayram and Özkan, 2010). Although lighting programmes with a clear day and night better enable the development of a circadian rhythm, the welfare implications of providing the dark period as one distinct period, rather than interrupting it (i.e. turning the lights on for a few hours), warrant further research (EFSA, 2023a). Turning the lights on during the dark period, as compared to providing the same number of uninterrupted dark hours, seems to stimulate a higher feed intake and thus increase body weight gain in fast-growing broilers (Duve et al., 2011; Sun et al., 2017). Hence, an uninterrupted nocturnal period may indirectly have positive welfare consequences associated with a somewhat reduced growth rate. However, using an intermittent lighting scheme has recently been shown to increase broiler synchronisation and improve resting (Forslind, 2023).

In conclusion, there is scientific evidence indicating that poultry welfare may be improved by providing a light environment similar to the one in which avian vision evolved. Although several constituents of natural light may be important, it is clear that the UV wavelengths contained in natural light are an essential component. Providing chickens with extended nocturnal (dark) periods has profound welfare benefits, as opposed to using continuous or near-continuous lighting programmes; no less than seven to eight hours without artificial lights is recommended for broilers (EFSA, 2023a). However, whether six, eight or ten hours of darkness is optimal from an animal welfare perspective, and whether an uninterrupted dark period or intermittent lighting programmes should be used, is not completely clear.

2.5 Perches and raised sitting levels

Laying hens in organic production must be provided with a minimum of 18 cm of perch per bird. For broilers, a minimum of 5 cm of perch or 25 cm^2 of raised sitting level per bird is required (EU regulation 2020/464).

Laying hens are highly motivated to perch, especially during the night-time, and the opportunity to do so is imperative for their welfare (Olsson and Keeling, 2000). Riddle et al. (2018) showed that the horizontal space requirements while perching was, on average, around 18 cm and 22 cm in two white and two brown hybrids, respectively. However, in another study of a different brown hybrid, the body width while perching was found to be slightly less than 15 cm (Giersberg et al., 2019). These authors have emphasised the importance of considering such hybrid differences when stipulating minimum standards (Riddle et al., 2018; Giersberg et al., 2019). Others have concluded that providing 15 cm perch per bird (as required in conventional EU egg production) is insufficient if synchronised perching within a flock is to be ensured, suggesting that at least 18-20 cm per bird would better enable this (Newberry et al., 2001; Savory et al., 2002; Cook et al., 2011). It has also been suggested that additional welfare benefits, regarding plumage condition and breast skin lesions, might come from increasing the perch space allowance further (up to 32.2 cm per bird) (Steenfeldt and Nielsen, 2015b). Laying hens show a clear preference for the top perches in multi-tier systems, especially during the night, and have been observed to occupy as little as 12 cm per hen on these, leaving ample space available on lower perches (Steenfeldt and Nielsen, 2015b; Giersberg et al., 2019). Thus, to improve laying hen welfare, it is important not only to provide sufficient perch length but also to consider perch height (Brendler and Schrader, 2016; Riddle et al., 2018).

Studies show that broilers, like laying hens, are highly motivated to perch, i.e. to sit in an elevated position (Kaukonen et al., 2017; Malchow et al., 2019). The opportunity to perform this behaviour is not only important for animal welfare in itself, but raised sitting levels may also have further positive effects on, for example, leg health (Bailie et al., 2013; Kaukonen et al., 2017) and incidences of hock burns and foot pad dermatitis (Karaarslan and Nazlıgül, 2018; Lourenço da Silva et al., 2021; Mocz et al., 2022). However, not all findings point to such welfare benefits (Ventura et al., 2010; de Jong and Gunnink, 2019; de Jong et al., 2021), which might be due to differences in terms of number, design and type of items provided for perching, as well as other factors, e.g. strain and stocking density. Elevated structures such as platforms and straw bales seem to increase the performance of active behaviours, including foraging and exploratory behaviours (Bergmann et al., 2017; Vasdal et al., 2019; Lourenço da Silva et al., 2021). Certain structures may also provide shelter for resting in an otherwise barren environment (Bergmann et al., 2017; Lourenço da Silva et al., 2021), and perches and platforms have been shown to decrease physical disturbances amongst broilers and, thus, better allow for sufficient rest (Ventura et al., 2012; Forslind, 2023). Moreover, increasing the environmental complexity by providing raised sitting levels, which may come in various forms and shapes (Göransson et al., 2021), can increase the expression of behaviours indicative of positive emotions (Vas et al., 2023) and reduce fearfulness of humans in broilers (Baxter et al., 2020; Lourenço da Silva et al., 2021). Systematic research concerning the space allowance and number of elevated structures in relation to flock size is limited (Riber et al., 2018). It has been shown that a higher perch space allowance (15 vs 7.5 cm per bird) increases the proportion of broilers in a flock perching, especially at night (Nielsen, 2004). Baxter et al. (2020) provided broilers with platforms (0.5, 0.6 or 0.7 m^2 per 1000 birds, i.e. 5, 6 or 7 cm^2 per bird), and concluded that the additional platforms were used fully and thus resulted in a higher flock level of perching. On average, 11.5 birds per m^2 were using the platforms at any one time, which corresponds to around 870 cm^2 occupied by each broiler (Baxter et al., 2020). Although this might not correspond exactly to the space occupied by slow-growing hybrids on elevated structures of a different sort, it nonetheless shows that providing 5 cm perch or 25 cm^2 raised sitting level per bird only enables a small proportion of the flock to perch simultaneously.

In conclusion, providing an additional 3 cm perch per bird (compared to the 15 cm required in conventional production) seems to improve laying hen welfare, although certain slightly larger hybrids might require more than this. Perching is also an important behaviour in broilers; providing raised sitting areas can e.g. increase leg health, improve rest and reduce fearfulness. Although there is a lack of relevant research, the current space requirements for broilers seem to allow only a small proportion of the flock to perch at any one time.

2.6 Provision of roughage

Livestock in organic production should be fed with feed materials produced in accordance with the rules of organic production, taking into account the physiological needs and nutritional requirements of the animals (EU regulation 2018/848). Moreover, to meet their ethological needs, poultry should be provided with sufficient quantities of roughage whenever they do not have outdoor access or when feed availability from the outdoor area is limited (EU regulation 2018/848).

Roughage (e.g. straw, silage, and lucerne) as a source of (insoluble) dietary fibre has been shown to successfully reduce severe feather pecking and cannibalism in laying hens (El-Lethey et al., 2000; Steenfeldt et al., 2007; Patt et al., 2022 but see Schreiter et al., 2019 for review), although a genotype-environment interaction effect has been suggested (Schreiter et al., 2020). A high-fibre diet may increase the time spent eating (van Krimpen et al., 2008) and reduce stress levels (El-Lethey et al., 2000), which likely contributes to the aforementioned positive effect on feather pecking in laying hens (Desbruslais et al., 2021). Moreover, dietary fibre can also improve gut health in both laying hens and broilers by stimulating intestinal development and favouring beneficial intestinal microbiomes (see Desbruslais et al., 2021 and Jha and Mishra, 2021 for reviews). It has been suggested that better gut health may also contribute to reduced feather pecking behaviour in layers, although more research is needed regarding this particular aspect of providing dietary fibre (Mens et al., 2020). In the aforementioned studies, foraging materials have predominantly been provided *ad libitum.* The EU regulations require that roughage must be provided in "sufficient quantities", but the protective effect of roughage against severe feather pecking has not been evaluated in terms of specific amounts.

Roughage can function as environmental enrichment and contribute to a more complex environment, which has been associated with improved poultry welfare, for example, due to the higher expression of social play, comfort behaviours and ground-scratching (Vas et al., 2023), and reduced fearfulness (Nazar et al., 2022). More foraging has been observed in broilers given maize roughage compared to those given no or other types of enrichment (Bach et al., 2019). When provided with straw bales, broilers will peck and scratch at these (Bergmann et al., 2017; Baxter et al., 2018). However, straw bales seem to be perhaps more important for providing cover and for resting behaviour (Bailie et al., 2013; Bergmann et al., 2017), whereas other substrates might better stimulate foraging (Baxter et al., 2018; Holt et al., 2023). In terms of foraging substrates, most preference studies in broilers involve different litter types such as peat, wood shaving and chopped straw (Villagrá et al., 2014; Monckton et al., 2020; Holt et al., 2023), whereas such studies investigating various types and ways of presenting roughage in particular are scarce. Nonetheless, it has been suggested that providing several different substrates, as well as maintaining novelty, is important in order to stimulate ground scratching and curiosity-based inquisitive exploration (Newberry, 1999; Holt et al., 2023; Vas et al., 2023). On the other hand, it is also important to acknowledge the biosecurity risks associated with providing roughage (Riber et al., 2018), since the risk of infectious disease is also highly relevant for bird health and welfare.

In conclusion, roughage can function as environmental enrichment and provide additional foraging opportunities. As such, roughage can reduce feather pecking and cannibalism in laying hens, and thereby improve poultry welfare, although the format and specific type of roughage provided must be considered. However, knowledge of bird preferences in terms of roughage is limited, especially in broiler chickens.

2.7 Lower stocking density

Organic husbandry practices and housing conditions "shall ensure that the developmental, physiological and ethological needs of the animals are met" (EU regulation 2018/848). The stocking density "shall provide for the comfort, well-being and species-specific needs of the animals". The maximum stocking density in organic production is 6 birds per m^2 usable area of the indoor area for laying hens, and 21 kg live weight per m^2 indoor usable area for broilers (EU regulation 2020/464).

The substantial amount of research concerning the welfare consequences of housing broilers at different stocking densities shows that, in general, relatively high stocking densities are associated with direct and indirect welfare impairments (EFSA, 2023a). However, there is no evident threshold stocking density above which overall welfare is clearly compromised, and appropriate management and other environmental factors in commercial production can, to a certain extent, negate some of the adverse effects of high stocking densities (Dawkins et al., 2004). When comparing 25 kg/m^2 (or 8-10 birds/m^2) with relatively higher stocking densities in fast-growing broilers, a number of positive welfare consequences have been found related to lower stocking density, including improvements in gait and skeletal bone quality (Sun et al., 2013), and foot pad health and the prevalence of hock burns (Ventura et al., 2010; Sun et al., 2013). Higher activity levels and the use of environmental enrichment (Ventura et al., 2012; de Jong and Goërtz, 2017) have also been observed, as well as a reduced frequency of disturbances amongst chickens (Ventura et al., 2012) and an enhanced immune system status (Gomes et al., 2014). Although strain-environment interactions might hamper the direct extrapolation of these results to more slower-growing hybrids (Rayner et al., 2020), similar welfare improvements in terms of health and behaviour have also been associated with lower stocking densities in the latter (van der Eijk et al., 2022, 2023). Notwithstanding the above, studies in which even lower as well as a wider range of, stocking densities have been evaluated in terms of broiler welfare, show that more pronounced welfare benefits may come from a further decrease in stocking density (Buijs et al., 2009, 2010). Indeed, EFSA (2023a) recently recommended a maximum stocking density of 11 kg/m^2 in fast-growing broilers. Furthermore, it has been suggested that broilers may perceive the proximity of conspecifics as aversive at a stocking density of 15 kg/m^2 or higher (Buijs et al., 2011).

Stocking density and how it impacts the welfare of laying hens in non-cage systems is, however, not as well researched, and of the relevant studies, only a few include a stocking density of or lower than 6 birds/m^2. However, in a recent report, EFSA, 2023b) recommended a maximum stocking density of 4 adult laying hens per m^2 to improve welfare. When hens were housed at either 5, 6, 7 or 10 birds/m^2 in an experimental study, the highest stocking density had adverse effects on egg laying, as well as litter moisture and ammonia emission, and certain blood parameters indicated elevated stress levels in these hens (Kang et al., 2016). It has also been shown that, within the range 4-12 birds/m^2, relatively lower stocking densities may have a positive effect on range use in laying hens (Gilani et al., 2014; Steenfeldt and Nielsen, 2015a). Although research findings regarding the correlation between stocking density and severe feather pecking are inconsistent (EFSA, 2023a), this behaviour has been found to be lower at 6.7 than at 9.4 birds/m^2 (Schwarzer et al., 2021). However, no evident welfare improvements were observed when different stocking densities (7, 9 or 12 birds/m^2) were studied in single-tier aviaries on a commercial farm, indicating that other housing and management factors may have a more profound influence on laying hen welfare (Nicol et al., 2006; Zimmerman et al., 2006). Due to behavioural synchronisation within laying hen flocks, the actual stocking density in certain areas of the house may vary largely (Channing et al., 2001). Thus, to increase laying hen welfare in non-cage systems, rather than space allowance per se, an even distribution of resources in sufficient amounts, as well as a system design that counteracts crowding, might be more important (Nicol et al., 2017). Moreover, behavioural differences between strains, for example in terms of resource preferences and anti-predator responses, may also have to be considered (Ali et al., 2016).

In conclusion, the lower stocking densities in organic production may contribute to improved poultry welfare in terms of health and behavioural freedom, especially for broiler chickens, as compared to conventional production in which relatively higher stocking densities are permitted. More pronounced welfare benefits may come from the use of even lower stocking densities though. Moreover, a housing system designed to promote an even distribution of birds might be just as important for laying hen welfare.

3 Discussion and animal welfare implications

Organic agriculture is associated with high animal welfare standards, which can be found embedded within the four principles of organic production (Vaarst and Alrøe, 2012a). The organic principles, in turn, have been embodied in organic standards such as the EU regulations on organic production to reflect the underlying values of the organic movement at the farm level (Vaarst et al., 2004). The aim of this paper was to assess and discuss how the key features of organic poultry production, as stipulated in the current EU regulations, relate to contemporary animal welfare scientific knowledge.

3.1 Mitigating negatives and promoting positives

In general, the scientific evidence at hand shows that some of the key features of organic poultry production may indeed contribute to improved bird welfare – not only by mitigating certain negative aspects of chicken meat and egg production, but also by promoting positive and pleasant experiences. For instance, the use of more slow-growing broiler hybrids has resulted in improved leg health, and thereby reduced lameness associated pain (Caplen et al., 2013; Dixon, 2020). Due to improved physical mobility in combination with a relatively lower stocking density, these slower-growing broilers are able to perform, for example, more exploratory and play behaviours (Dawson et al., 2021). Moreover, the emphasis on opportunities to perform natural behaviours in organic animal farming, e.g. through the provision of raised sitting areas also for broilers, outdoor access and roughage, may improve poultry welfare by enabling the animals to engage in highly motivated behaviours that they find rewarding (Špinka, 2006; Mellor, 2015a), such as perching, dust bathing and foraging (Weeks and Nicol, 2006).

Also based on the EU regulations on organic farming, Duval et al. (2020) came to a somewhat similar conclusion in terms of potentially higher animal welfare within the organic dairy industry. Murphy and Legrand (2023) recently introduced the concept of "welfare potential" of a production system, referring to its inherent ability to ensure the welfare of animals, taking into account the three welfare approaches of biological functioning, natural living and subjective feelings. Thus, a production system that offers greater opportunities for the animals to perform highly motivated behaviours and for positive experiences, as in organic poultry production, increases its "welfare potential" (Murphy and Legrand, 2023).

3.2 Room for improvement

Notwithstanding the welfare benefits associated with some of the key features of organic poultry production, several of these areas exhibit some room for improvement. For instance, while relatively low stocking densities may have positive consequences for poultry welfare in terms of both health and behaviour, research shows that more pronounced welfare improvements may come from stocking densities being even lower than those required in EU organic poultry production, as concluded by EFSA (2023a). Moreover, even if the welfare issues associated with rapid growth rates in broilers have largely been mitigated in the relatively slow-growing hybrids (Dawson et al., 2021), the latter still shows some gait impairments and lameness (Göransson et al., 2020). The hybrids used in commercial organic production often have an average daily weight gain of around 45-50 g (Göransson et al., 2020), and studies show that using hybrids with even lower growth rates may result in further welfare improvements (Castellini et al., 2016). Although raised sitting levels also bring about important welfare improvements in organic broiler production, the provision of perches and platforms according to the minimum space requirements is insufficient considering the size of commercial flocks (Göransson et al., 2021). Animal welfare is not a relative concept but is the state of an animal on a continuum from poor to good, yet animal welfare regulations are often considered in relation to other regulations (e.g. in other countries, legislation and private standards), rather than relative to what the animals actually need or want to have good welfare (Mellor, 2015b). Making a comparison between production systems in terms of overall animal welfare is a challenging task, but by using the Welfare Quality® assessment protocol, Wagner et al. (2021) concluded that the overall welfare was higher on organic dairy farms than in conventional production. However, it was also concluded that there is room for improvement within organic dairy production, especially with regards to cow health (Wagner et al., 2021). Similarly, many other authors have emphasised that although potential welfare improvements sit within the regulatory framework for organic animal farming, important challenges remain to ensure a high level of welfare (Sundrum, 2001; Hovi et al., 2003; Marley et al., 2010; Duval et al., 2020; Åkerfeldt et al., 2021). The organic standards might allow for a relatively higher level of animal welfare due to a relatively higher level of minimum requirements than other regulations, but it does not necessarily guarantee a good or the best possible animal welfare from the animals' point of view. Animal welfare regulations are the outcome of compromises between scientific knowledge, values, traditions, consumer demands, practicability and economy (Croney and Millman, 2007; Yeates et al., 2011; Lundmark et al., 2014). This might result in goal conflicts between the intentions of a regulation and the actual requirements (Waiblinger et al., 2007; Vaarst and Alrøe, 2012b; Lundmark et al., 2014), i.e. between the fundamental values of organic production and what is in fact feasible at the farm level. Thus, while high animal welfare standards are important in organic farming, the interests of other stakeholders must also be taken into account, and therefore the magnitude of the welfare improvements to be made within the context of modern commercial poultry production might be limited (Appleby, 2019). Relatively higher welfare standards within organic animal farming might nonetheless place pressure on and contribute to welfare improvements in the standards for conventional production (Duval et al., 2020).

3.3 Two sides of the same coin

Some of the key features of organic poultry production intended to increase animal welfare, such as outdoor access and the ban on mutilations, are sometimes put forth as being disadvantageous for bird welfare (Riber and Hinrichsen, 2017; Bonnefous et al., 2022). For instance, outdoor access includes the risk of predators and infectious disease transmission, which can have detrimental consequences for bird welfare. However, notwithstanding these perils, appropriate management of the free-range can at least mitigate these risks to a certain extent, e.g. through appropriate fences to protect against ground predators and avoiding puddles or pools of water as a measure to improve biosecurity (Bonnefous et al., 2022). Marley et al. (2010) discussed the advantages and disadvantages of pasture access for dairy cows in organic production, and emphasised too that appropriate management of the outdoor area is vital in order to reduce the risk of compromised animal health and welfare. Since the damages and injuries resulting from severe feather pecking and cannibalism have been shown to be lower in beak-trimmed flocks (Riber and Hinrichsen, 2017; van Staaveren et al., 2021), the banning of beak trimming in organic egg production may be considered problematic from an animal welfare perspective. However, the procedure does not prevent the behaviour, which is still evident in mutilated hens (Lambton et al., 2010, 2013). Many have concluded that beak trimming should not be necessary if good management practices are implemented (Glatz and Underwood, 2021; EFSA, 2023b), including lower stocking densities, outdoor access and increased foraging opportunities – all of which organic egg production indeed entails. On the other hand, the risk of severe feather pecking might also increase in organic egg production, since organic animal production also entails the prohibition of dietary synthetic amino acids (EU regulation 2018/848). Insufficient protein levels and amino acid imbalances have been associated with severe feather pecking in laying hens (Van Krimpen et al., 2005; Mens et al., 2020). Moreover, essential amino acids, such as lysine, methionine and tryptophan, are vital for normal feather synthesis, intestinal development and gut health, immune system function and protection against oxidative stress, and must be provided in the poultry diet (see Alagawany et al., 2021 for a review). However, since protein sources produced according to organic standards are limited, and due to the prohibition of synthetic amino acids in organic feedstuff, the formulation of a well-balanced diet that meets the nutritional requirements of poultry is a major challenge in organic production (van Krimpen et al., 2016).

3.4 Degrees of naturalness

As previously discussed, the strong emphasis on naturalness and natural living in organic agriculture may in several ways improve poultry welfare through, for example, outdoor access, natural light and better foraging and perching opportunities. It is common for animal welfare regulations, in organic and non-organic animal production, to include some kind of requirements concerning the animals' ability to behave naturally (Lundmark et al., 2014). However, naturalness is often considered to be a quite narrow concept that does not cover all aspects of what is natural for an animal (Lundmark et al., 2014). Indeed, it might be argued that some important aspects of a natural chicken life are missing in commercial (organic) poultry production. For instance, young chicks are hatched in incubators and reared artificially. Not only is the absence of a mother hen highly unnatural, but research shows that natural brooding of chicks has welfare benefits like lower fearfulness and a reduced risk of severe feather pecking (see Edgar et al., 2016 for a review). While natural brooding is not commercially viable, "dark brooders" can be used as a practical on-farm solution to artificially provide certain aspects of maternal care and thereby improve chick welfare. However, these are rarely used in rearing facilities (Sirovnik and Riber, 2022). Similarly, the unnaturalness and welfare implications of the early cow-calf separation in dairy production has been discussed in relation to the organic values (Marley et al., 2010). After hatching, laying hens and broilers are kept in flocks that comprise thousands of birds. Normal social behaviour, which involves the establishment of a pecking order (Rushen, 1982), becomes an impossible task in such large flocks. It has been suggested that laying hens and broilers in commercial production instead adapt a more “tolerant social system” (Estevez et al., 1997; Hughes et al., 1997; D’Eath and Keeling, 2003). Although the welfare implications of the frequent and recurrent encounters with unfamiliar birds is unclear (D’Eath and Keeling, 2003; Appleby et al., 2004), negative welfare consequences for the birds in these highly unnatural large flocks cannot be excluded. Again, the welfare implications and the unnaturalness of the social interactions on large-scale commercial dairy farms has been discussed in relation to the organic values (Marley et al., 2010). The IFOAM organic standards, and in extension the EU regulations on organic production, represent a compromise between the fundamental values of the organic movement and what is in fact feasible at the farm level and within the present market situation (Vaarst et al., 2004). Hence, some aspects of “naturalness” have been deemed both important and feasible, whereas other aspects might not be practicable within the contemporary production context (Padel et al., 2004; Vaarst et al., 2004). Considering the aforementioned consequences on normal feather synthesis and severe feather pecking behaviour, the prohibition of synthetic amino acids in organic feedstuff may be considered a negative aspect of “naturalness”. However, the underlying reason for this ban is more complex than mere unnaturalness, including issues of environmental sustainability (Leming, 2012; Benavides et al., 2020). It has also been argued the use of dietary synthetic amino acids would enable an increased animal production performance and a subsequent intensification of organic farming, which would be in disagreement with the organic vision and would impair animal welfare in the long-term (NAHWOA, 2002). This again illustrates the goal conflicts that can occur between different areas of concern that a regulation covers, e.g. between animal welfare, environmental protection and food safety (Lundmark et al., 2014), which in extension further reflects the inevitable compromises between different fundamental values that are necessary both in the short and long term in modern organic animal production.

3.5 Actual welfare improvements at the farm level

For poultry welfare to improve in practice, it is important that the potential welfare benefits associated with the aforementioned requirements as stipulated in the EU organic regulations are actually experienced by the birds at the farm level. For instance, outdoor access is not the same as outdoor use, and the mere provision of a free-range area is obviously not sufficient to improve animal welfare; this has also been discussed regarding pasture access for dairy cows (Wagner et al., 2018). Studies show that outdoor areas on commercial organic poultry farms do not always contain appropriate and sufficient overhead protection in the form of vegetation and/or artificial shelters (Göransson et al., 2021, 2023), making the birds reluctant to enter the free-range or to leave the vicinity of the house (Dawkins et al., 2003; Gilani et al., 2014). It is clearly stated in the EU organic regulations that outdoor areas for poultry shall be attractive to the birds and mainly covered with vegetation composed of a diverse range of plants (EU regulation 2020/464). Hence, it is also important that an effective control system is developed to enforce an animal welfare standard (Main et al., 2014). It has previously been concluded that management is one of the most important factors affecting animal welfare at the individual farm level (Sundrum, 2001; Marley et al., 2010; Murphy and Legrand, 2023), and while outdoor access in particular is an aspect that can be managed at the farm level in order to improve poultry welfare, other factors may be more difficult for the individual farmer to influence. One example is the choice of laying hen hybrids, which, according to the EU organic regulations, should be appropriate for organic production and ensure a high level of animal welfare, whereas in practice there are few alternatives besides the genotypes used in non-organic production (Fernyhough et al., 2020). Hence, although the organic regulations may have higher “welfare potential” on paper (Murphy and Legrand, 2023), some aspects currently fail at an implementation level.

4 Concluding remarks

- In general, the animal welfare science at hand supports the potential for higher animal welfare in organic poultry production, based on the requirements as laid down in the current EU regulations. The minimum requirements discussed may contribute to better poultry welfare not only by mitigating certain negative aspects of chicken meat production and egg production but also by promoting positive and pleasant experiences.
- As in any other intensive poultry production system, animal welfare issues can be found in organic poultry production as well. Research shows that the welfare benefits that the aforementioned requirements bring could be even greater.
- Some aspects of organic poultry production may not only be beneficial for animal welfare but also involve certain risks. Appropriate management strategies are important to reduce those welfare risks.
- For actual welfare improvements experienced by the animals, it is vital that the requirements as stipulated on paper in the organic standards transfer all the way to the commercial farm.
- Some key aspects that may further improve animal welfare in organic poultry production include the use of alternative laying hen hybrids with the potential for better welfare; slow-growing broilers with an even lower growth rate; appropriate management of the free-range areas in practice to ensure that they are used by the birds; additional raised sitting level space allowance for broilers; and the use of “dark brooders” for chicks.

- The future development of organic animal welfare standards is somewhat dependent on the progress of non-organic regulations. If the gap between organic and non-organic production systems becomes too large, in terms of minimum requirements, organic farmers will find it increasingly difficult to compete on the same market as conventional farmers. If the overall legal baseline is raised through changes in non-organic regulations, there might also be room for improvement within the organic standards. The new EU legislation for farm animals currently under development may enable further animal welfare improvements within the organic standards.

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