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Extensive Poultry Production as a Precursor to Organic Table Egg Production

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Abstract

Organic egg production is a controlled system for producing food of animal origin that integrates requirements relating to food safety, animal health and welfare, environmental protection, and transparent consumer information. Unlike conventional systems, organic production requires the non-cage housing of laying hens, access to outdoor areas, the use of organically produced feed, restrictions on the use of veterinary medicinal products, and a mandatory inspection and certification system. The principal European Union legal framework governing organic production is established by Regulation (EU) 2018/848, while Commission Implementing Regulation (EU) 2020/464 specifies certain technical requirements for organic livestock production, including poultry production (European Parliament and Council, 2018; European Commission, 2020).

The aim of this paper is to present the fundamental principles of organic production of hen eggs intended for human consumption, with particular emphasis on production systems, feeding, housing, health management, disease prevention and treatment, animal welfare, and technological challenges encountered in production. Particular attention is given to compliance with European Union legislation, including regulations governing organic production, the welfare of laying hens, feed hygiene, Salmonella control, and marketing standards for eggs (Council Directive 1999/74/EC; Regulation (EC) No 852/2004; Regulation (EC) No 853/2004; Regulation (EC) No 183/2005; Regulation (EC) No 2160/2003; Regulation (EU) 2023/2465; Regulation (EU) 2023/2466).

Keywords: Organic Production, Hen Eggs, Laying Hens, Organic Feeding, Animal Welfare, Salmonella, EU Legislation

Introduction

Hen eggs are among the most important foods of animal origin in the human diet. They are characterised by their high biological value, which is reflected in the quality of their proteins and their favourable amino acid profile. In addition, eggs contain fats, vitamins, and minerals. Owing to these valuable nutritional properties, eggs are widely consumed in households and extensively used in the food industry. The typical chemical composition of a hen egg is presented in the following table.

Table 1: Chemical composition of a hen egg (%) (Višnjić, 1982) [48]

Constituent	*Egg white (albumen)*	*Egg yolk*	*Whole egg*
Moisture	87,7	49,0	65,5
Protein	10,0	16,0	11,9
Fat	0,05	31,6	9,3
Ash	0,8	1,5	0,9

As a foodstuff, the egg possesses nutritional properties that are difficult to compare with those of any other food. It has been estimated that 20 eggs, each weighing 60 g, have a nutritional value equivalent to that of 1 kg of beef, whereas six to eight eggs are equivalent in nutritional value to 1 litre of milk (Oberhofer, 1929) [29]. It should also be emphasised that eggshell colour does not affect the qualitative characteristics of the egg.

With regard to the intensity of egg production, numerous authors have reported that approximately 70% of production performance is determined by environmental conditions, particularly feeding and housing, whereas the remaining 30% is attributable to the genetic background of the birds (Kadipski and Zahariev, 1977) [21].

Numerous factors influence the choice of a poultry production system. Accordingly, three principal systems can be distinguished: (a) extensive, (b) semi-intensive, and (c) intensive. In the past, the extensive system was the sole means of obtaining eggs. In practice, this system involved minimal human management of the hens, and breeders implemented no systematic selection measures. Feeding was based primarily on the resources that hens could find while ranging freely. To protect themselves from predators, hens instinctively roosted on tree branches. They nested in dense vegetation, where their nests were difficult to detect. If left undisturbed, a hen would incubate the eggs at the nesting site and subsequently hatch her chicks.

Under the extensive production system, hens had sufficient space for movement and, consequently, for searching for and obtaining food. They ranged freely through farmyards, orchards, gardens, and fields. In such environments, they were able to obtain sufficient feed of animal origin, particularly insects. Hens were highly efficient at collecting insects from agricultural crops and also consumed grain remaining in fields after harvest. For this reason, some farmers used specially adapted carts to transport poultry. In the morning, the hens were placed in these carts and transported to particular plots, such as potato fields infested with Colorado potato beetles or stubble fields where sufficient quantities of grain remained after harvest.

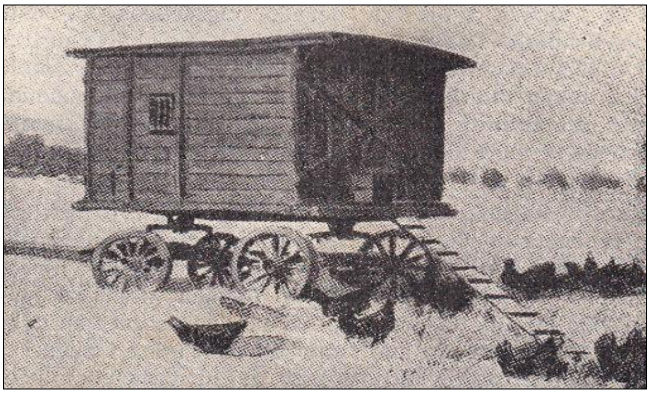

Fig 1: Cart used for transporting hens (Oberhofer, 1929) [29]

At that time, no consideration was given to an ecological approach to production; nevertheless, this method of transporting hens may be regarded as a pioneering step towards organic production.

Modern consumers increasingly consider not only the nutritional value of products but also production methods, animal welfare, food safety, the origin of animal feed, and the environmental impact of production (FAO/WHO, 2002; EFSA, 2023 [7]).

Intensive table egg production systems, in which hens are confined to cages and have severely restricted opportunities for movement, have made it virtually impossible to ensure an adequate level of welfare.

The organic production of hen eggs intended for direct consumption and use in the manufacture of confectionery and other food products emerged as a clear response to the need for a system that provides a higher level of laying-hen welfare, controlled feeding, reduced reliance on external inputs, and greater transparency for consumers.

Within the European Union, the designation of a product as "organic" is not merely a marketing claim but a legally regulated category. Such products must be produced in accordance with the provisions of Regulation (EU) 2018/848. This legal act establishes the principles of organic production and the rules governing labelling, inspection, certification, and the use of the EU organic production logo (European Parliament and Council, 2018).

With regard to egg production, the organic system primarily requires that laying hens are not kept in cages, have regular access to outdoor areas, are fed organically produced feed, are housed in accordance with prescribed stocking-density limits, and that animal health management is based primarily on preventive measures.

In addition to all the aforementioned requirements, production must comply with the general hygiene requirements applicable to food and animal feed. As products of animal origin, eggs may pose a considerable risk to consumers unless appropriate microbiological monitoring is implemented to detect the possible presence of microbiological hazards, particularly Salmonella spp. (Regulation (EC) No 852/2004; Regulation (EC) No 853/2004; Regulation (EC) No 2160/2003).

Organic table egg production offers numerous advantages but also presents several specific technological challenges. Free access to outdoor runs facilitates the expression of natural behaviours; however, it may also increase hens' exposure to parasites and to mammalian and avian predators.

Parasite infestation, particularly by ectoparasites affecting the plumage, is a problem as old as poultry farming itself. To prevent parasites from spreading along the walls of poultry houses, it was traditionally recommended that the walls be whitewashed and that an appropriate disinfectant be added to the limewash to improve cleaning and protection. Inside the poultry house, hens roosted on wooden perches. It is well known that parasites can readily climb wooden supports and thereby reach the hens. The following illustration presents a relatively old but effective method of preventing the spread of parasites. Small containers filled with oil were placed on the supports to which the hens' roosting perches were attached. The oil formed a barrier that the parasites were unable to cross, thereby preventing them from reaching the hens. This represented another environmentally sound method of protecting poultry, although it was not described as such at the time.

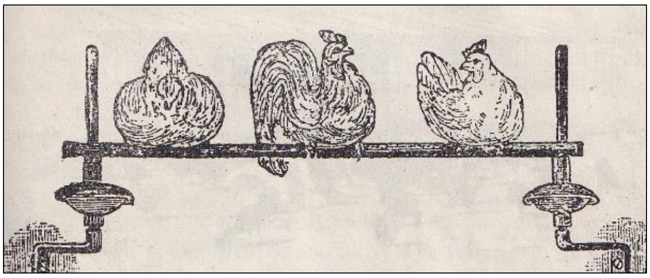

Fig 2: Roosting perches for hens and oil containers placed on the supports (Oberhofer, 1929) [29]

In addition, hens are exposed to changing weather conditions. Although non-cage systems provide greater opportunities for movement, they are also associated with increased risks of floor-laid eggs, various injuries, feather pecking, and cannibalism. For these reasons, organic egg production requires a high level of professional expertise, continuous monitoring, appropriately designed housing facilities, effective management of outdoor areas, and the consistent implementation of biosecurity measures (Lay *et al*., 2011; Bonnefous *et al*., 2022; EFSA, 2023) [25, 4, 7].

Location Selection for Poultry House Construction

The selection of a location for the construction of a facility intended for laying hens, as well as for other poultry categories, plays a highly important role in the subsequent successful implementation of production. The poultry house must provide hens with a comfortable environment during the time they spend indoors. In addition, it must provide easy and rapid access to the outdoor range.

When selecting the site, consideration must be given to both the wider area (macro-location) and the immediate area (micro-location). The parameters affecting macro-location include the orographic, pedological, and hydrological characteristics of the terrain, as well as climatic conditions, with particular emphasis on prevailing winds and the type and amount of precipitation. The availability of an adequate water supply must also be assessed.

The micro-location refers to the specific land on which the poultry house will be constructed. Both the construction site and the outdoor range must be dry. With regard to the outdoor range, the presence of a watercourse may be advantageous, as it can provide the hens with an adequate supply of water. One of the fundamental considerations is the orientation of the poultry house in relation to the cardinal directions. To maximise the use of solar energy, particularly during colder periods, the longitudinal axis of the building should be oriented in a north–south direction.

To ensure that the construction site remains dry, the groundwater level should be at least 2.0 m below the ground surface. Where access roads are absent, they must be constructed. According to FAO recommendations (2004, as cited in Plavša, 2021 [34]), a poultry house should be located at least 500 m from the owner's residence, 100 m from the property boundary, 1,500 m from schools, kindergartens, churches, and public areas, 1,500 m from the outermost urban dwellings, 150 m from public roads, 100 m from wells, streams, and lakes, and 500 m from drinking-water sources.

European Union Regulatory Framework

Organic production of table eggs in the European Union is governed by Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and the labelling of organic products. This Regulation constitutes the principal legal instrument establishing the general principles of organic production, including rules governing poultry husbandry, meat and egg production, animal welfare, veterinary treatments, inspection and certification systems, labelling, and the placing of organic products on the market. This regulatory approach strengthens consumer confidence, harmonises production rules, and creates a level playing field for all organic producers within the European Union (European Parliament and Council, 2018).

The technical requirements for organic production are further specified in Commission Implementing Regulation (EU) 2020/464, which lays down certain rules for the application of Regulation (EU) 2018/848.

Animal housing and hygiene requirements relating to maximum stocking densities, access to outdoor areas, the design and arrangement of poultry houses, and the conditions governing the use of multi-tier systems are particularly important in the organic production of table eggs.

Under EU organic production rules, the maximum indoor stocking density is generally limited to six laying hens per square metre of usable indoor floor area, while each hen must be provided with at least 4 m² of outdoor space. Specific requirements also apply to the provision of perches, nests, and littered areas (European Commission, 2020; Göransson *et al*., 2024 [16]).

It is noteworthy that the zoohygienic requirement concerning the outdoor area provided per hen is less stringent than earlier recommendations in poultry hygiene. Puhač and Katić (1962) [35] stated that the outdoor range should provide no less than 6.5–7.0 m² per bird. It is also noteworthy that EU legislation does not differentiate between housing six laying hens of a heavy strain or breed and six hens of a light, smaller-bodied strain or breed per square metre of usable indoor floor area. Producers are therefore expected to adjust the actual stocking density according to the type and body size of the laying hens.

Regulation (EU) 2018/848 and Commission Implementing Regulation (EU) 2020/464 stipulate that, while respecting the prescribed stocking density, a single compartment of a poultry house may accommodate no more than 3,000 laying hens. At the maximum permitted stocking density of six hens per square metre, a flock of 3,000 hens requires at least 500 m² of usable indoor floor area. Such a flock must also be provided with a minimum outdoor area of 12,000 m². Hens must be provided with access to the outdoor range whenever weather and physical conditions permit.

With regard to broilers, EU legislation defines stocking density on the basis of the birds' total live weight rather than the number of individual birds. The standard maximum stocking density is set at 33 kg/m². Under specified conditions, this limit may be increased to 39 kg/m² or 42 kg/m². Such increases are permitted only when additional requirements relating to housing conditions, environmental parameters, monitoring, and management are met (Council Directive 2007/43/EC, Article 3 and Annex I; Council Directive 1999/74/EC, Annexes I and II; EUR-Lex). These requirements include:kontrola temperature i vlažnosti vazduha, kontrola koncentracije amonijaka i CO_2.

a) Adequate ventilation and, where necessary, heating or cooling of the poultry house;
b) Mortality records and regular inspection of the flock;
c) A contingency plan for relocating broilers in the event of equipment failure or an inability to maintain the required environmental conditions;
d) Appropriate litter, lighting, water supply, and feeding.

Although Council Directive 2007/43/EC permits an increase in broiler stocking density to 39 kg/m² or 42 kg/m² subject to additional microclimate-control requirements, continuous monitoring of these zoohygienic parameters is, from an animal-welfare perspective, a fundamental requirement at all stocking densities, including the standard density of 33 kg/m². This suggests that the stated “enhanced” monitoring requirements should not be regarded as special conditions applicable exclusively to higher stocking densities, but rather as an integral component of good production practice in intensive broiler farming.

It must therefore be acknowledged that defining these measures as a “condition” for increasing broiler stocking density does not represent a genuinely additional or more stringent requirement. All of these parameters must be monitored continuously, irrespective of stocking density. A more logical approach would have been to relate the permitted stocking density to the type and body size of the hybrid or breed concerned, distinguishing between light and heavy types. Differences in stocking density would then be fully justified. As currently formulated, these provisions may create confusion, ambiguity, and the potential for differing interpretations.

When laying hens are kept in enriched cages, each hen must be provided with a cage area of at least 750 cm². An enriched cage must contain a nest for egg laying, suitable perches, and a littered area in which the hens can peck and scratch.

In addition to organic production legislation, provisions governing the welfare of laying hens also apply. Council Directive 1999/74/EC establishes minimum standards for the protection of laying hens, including the definition of housing systems and basic requirements relating to space allowance, equipment, and housing conditions. Organic production must comply with at least these general requirements, while in practice imposing additional conditions relating to the expression of natural behaviour, access to outdoor ranges, and organic feeding (Council Directive 1999/74/EC).

Many of the aforementioned elements and requirements had already been implemented considerably earlier—half a century ago or more. Poultry farmers recognised that periodically moving birds to new areas could be highly beneficial and effective. Mobile poultry houses were constructed and used for this purpose. Although these facilities were not designed to accommodate large numbers of laying hens, they fulfilled virtually all the fundamental requirements of organic production and animal welfare. Several types of portable or transportable poultry houses are presented in the following illustrations.

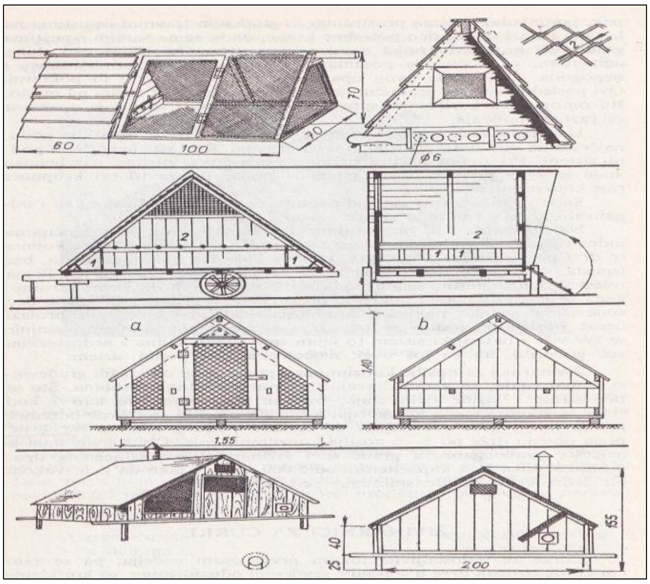

Fig 3: Types of mobile poultry houses (Krstić, 1977) [23]

These mobile poultry houses were not surrounded by fencing, and the hens were therefore able to range freely without restriction.

Food safety requirements are established by Regulation (EC) No 852/2004 on the hygiene of foodstuffs and Regulation (EC) No 853/2004 laying down specific hygiene rules for food of animal origin. All food business operators are required to ensure the necessary hygienic conditions throughout production, handling, storage, and distribution. In table egg production, this includes the hygiene of housing facilities, equipment, personnel, packaging, storage areas, and transport (Regulation (EC) No 852/2004; Regulation (EC) No 853/2004).

Feed intended for laying hens must be produced, stored, and used in accordance with feed hygiene requirements. Regulation (EC) No 183/2005 establishes requirements for feed hygiene and traceability throughout the production chain.

In organic production, the origin of all feed ingredients must be known and documented, while the use of non-organic or otherwise unauthorised ingredients must be strictly controlled (Regulation (EC) No 183/2005).

Health management of laying hens producing table eggs, including the potential use of veterinary medicinal products, must comply with Regulation (EU) 2019/6 on veterinary medicinal products. This Regulation is also important for ensuring the responsible use of antimicrobial medicinal products, as modern livestock production requires a reduction in antibiotic use and the development of effective preventive health programmes (Regulation (EU) 2019/6; Simjee *et al*., 2022 [45]).

With regard to the placing of eggs on the market, legislation governing marketing standards is particularly important. Commission Delegated Regulation (EU) 2023/2465 and Commission Implementing Regulation (EU) 2023/2466 regulate marketing standards for table eggs, including grading, marking, packaging, storage, transport, and presentation for sale. The European Commission stipulates that eggs and their packaging must be appropriately marked, that eggs must be graded according to quality and weight, and that packing centres, storage, and transport must be organised in accordance with the applicable legislation (European Commission, 2023).

Rearing System and Selection of Laying Hens

In intensive table egg production systems, laying hens were traditionally housed in cages with severely restricted opportunities for movement. They were provided with high-quality feed, with the primary objective of achieving the maximum annual egg yield. Under these housing conditions, hens were protected from numerous environmental influences, including predators, insects, and fluctuations in climatic conditions. The artificial control of the housing microclimate ensured that the required environmental conditions were continuously maintained. However, such systems provided little opportunity to safeguard the welfare and quality of life of laying hens.

Intensive production was preceded by extensive and semi-intensive husbandry systems. Both systems provided considerably better conditions in terms of laying-hen welfare but were insufficiently productive, with relatively low egg yields. In response to this limited productivity, intensive systems were developed to maximise egg production, with little consideration initially given to laying-hen welfare. Over time, greater awareness of animal welfare led to the recognition that intensive systems of table egg production were detrimental to hens. Consequently, production practices began to reintroduce certain elements of extensive husbandry, leading to the gradual development of organic production. Today, organic egg production is governed by comprehensive animal husbandry, hygiene, and legal requirements. Successful production, including organic production, depends on a wide range of prerequisites. One of the most important is the selection of an appropriate laying-hen genotype.

Industrial intensive systems use high-performing commercial hybrids selected for high egg production, efficient feed conversion, and uniform laying performance. By contrast, hens in organic systems are exposed to more complex environmental conditions: they move freely, use outdoor ranges, and come into contact with soil, temperature fluctuations, insects, microorganisms, and potential predators. Consequently, in addition to laying performance, selection criteria must include vitality, disease resistance, temperament, ability to utilise outdoor ranges, plumage condition, eggshell quality, and adaptability to non-cage housing systems (Bestman and Wagenaar, 2014; Hammershøj *et al*., 2021) [3, 18]. U ekološkoj proizvodnji posebno su interesantni genotipovi koji pokazuju dobar balans između proizvodnje i otpornosti. Istraživanja o organskim farmama nosilja ukazuju da upravljanje jatom, period odgoja, izbor hibrida i uslovi držanja značajno utiču na zdravlje i dobrobit nosilja (Bestman and Wagenaar, 2014) [3].

The intended production system determines how replacement pullets should be reared. If the laying hens are subsequently to be housed in facilities equipped with perches, nests, litter, and outdoor ranges, the pullets should become accustomed during the rearing period to moving freely, using perches, locating feed and water, and interacting with litter. Lambton *et al*. (2010) [24] reported that behaviour during the rearing period may influence the subsequent occurrence of feather pecking during the laying phase, thereby confirming the importance of appropriate early-life management.

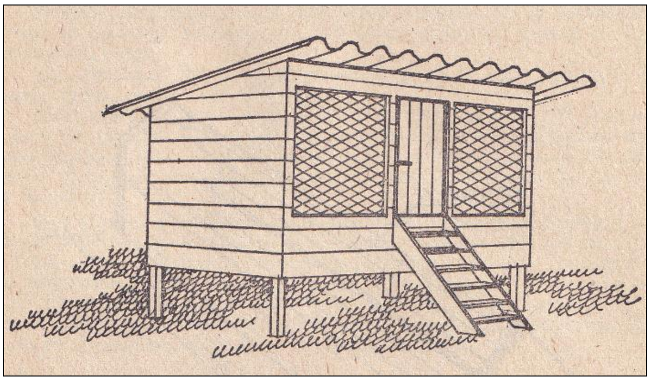

Fig 4: Principles of pullet rearing for organic egg production, although this term was not used at the time. The mobile poultry house accommodated approximately 40 pullets up to five months of age. The pullets learned to ascend and descend the steps and were provided with unrestricted opportunities for movement (Simonović, 1971) [46]

The transfer of pullets to the laying facility must be carefully managed to minimise stress. Sudden changes in feed, lighting programmes, equipment, or social structure may reduce feed intake, delay the onset of lay, increase the incidence of floor-laid eggs, and cause behavioural disturbances. The pullet-rearing system should therefore resemble the subsequent laying system as closely as possible.

Housing of Laying Hens

A facility intended for the organic production of table eggs must be designed to provide protection from adverse climatic conditions, adequate ventilation, sufficient space, dry and good-quality litter, appropriate lighting conditions, nests, perches, feeders, drinkers, and easy and continuous access to an outdoor range.

Compared with cage systems, floor-based non-cage systems allow laying hens to express a wider range of natural behaviours. Despite these evident advantages, such systems also present certain challenges and require more demanding management, as hygiene, parasite infestations, injuries, and the behaviour of hens in large groups are more difficult to control (Lay *et al*., 2011; EFSA, 2023) [25, 7].

In organic table egg production systems, laying hens are housed on the floor, which must be adequately insulated. A layer of litter contributes to this thermal insulation. Litter quality is one of the key determinants of both welfare and hygiene. Litter allows hens to scratch, dust-bathe, and perform exploratory behaviours; however, it must remain dry, clean, and friable. Wet litter increases ammonia concentrations and the risks of leg and foot lesions, soiled eggs, and microbial proliferation.

To facilitate the drainage of any excess moisture from the deep-litter area towards the slatted sections, the floor should have a slight slope of 0.5–1% from the centre towards the sides. Hens do not perceive this gradient because the deep-litter layer provides a level upper surface on which they move and rest.

Two methods may be used for establishing the litter layer. The first involves adding the entire quantity of litter material at once to achieve the desired depth of 20–25 cm. In the second method, the material is added gradually. An initial layer of 6–8 cm is applied, after which the remaining material is added progressively over a period of 7–10 days. When the litter is properly established, its temperature during autumn and winter ranges from 12 to 18°C in the surface layer at a depth of 3–5 cm and from 20 to 28°C at a depth of 15–25 cm (Gorškov *et al*., 1978). European legislation prescribes a somewhat shallower litter depth of 10–15 cm. When the poultry house is stocked, the prepared deep-litter layer should initially be 5–10 cm thick.

At least one third of the total floor area must be covered with litter, which must remain dry and friable. The litter material should consist of small particles, allowing hens to scratch and dust-bathe. When outdoors, hens perform these behaviours on bare soil within the range.

The recommended mixture for deep litter consists of one third peat, one third wood shavings, and one third chopped straw (Plavša, 2021) [34].

The useful life of the litter and, particularly, its water-absorption capacity depend on the type of material used.

Table 2: Quality characteristics of different materials used as poultry litter (Puhač and Katić, 1962) [35]

Characteristics	***Peat***	***Straw***	***Chaff***	***Sawdust***	***Wood shavings***
Service life (days)	360	60	40	170	60
Water absorption capacity (kg of water per 100 kg of litter material)	1.200	300	200	250	300
Quantity of litter required per chick (kg)	0,27	1	1	2,5	2,25

When straw is used as litter, it must be chopped. Approximately 18–20 kg of straw is required per hen. When rearing chicks up to 60 days of age, 2.0–2.5 kg of chopped straw should be provided per chick, while 3.0–3.5 kg is required per bird from 61 to 150 days of age.

The quantity of litter required naturally increases with the age of the replacement stock. Successful rearing also requires an understanding of certain physiological characteristics of chickens, particularly their thermoregulatory system. Compared with other domestic animal species, poultry have a relatively high body temperature. Another distinctive characteristic is their comparatively large body surface area per unit of body weight. Consequently, their heat loss is considerably greater than that of other domestic animals. As ambient temperature rises, hens lose increasing amounts of water vapour through respiratory evaporation. Evaporative heat loss may account for as much as 80% of total heat loss. During winter, respiratory heat loss decreases considerably, while heat is dissipated primarily through radiation and convection (Puhač and Katić, 1962) [35].

Housing facilities for laying hens must maintain stable microclimatic conditions. When the indoor air temperature falls to −12.2°C, laying performance decreases by approximately 25%, while a complete cessation of egg production has been recorded at −17.8°C.

Elevated temperatures also have adverse effects, causing a progressive reduction in feed intake and, ultimately, its complete cessation. The optimal indoor temperature for laying hens ranges from 18 to 20°C.

At air temperatures above 26°C, the body temperature of hens begins to rise. At an ambient temperature of 38°C, egg weight is only 89% of that recorded at 21°C. Indoor air temperatures of 38–40°C may result in hen mortality due to severe heat stress. A rapid increase in air temperature accompanied by an increase in relative humidity is particularly hazardous. The normal body temperature of a hen ranges from 40 to 42°C. When the indoor air temperature remains at 37–38°C, hens' body temperature may increase to 43.0–43.5°C (Melnik *et al*., 1979).

Within the thermal environment, two temperature categories should be distinguished: (a) the thermoneutral zone and (b) the lower critical temperature under normal feeding conditions.

Table 3: Thermoneutral zone in chickens according to age (Lyhs *et al*., 1971, as cited in Asaj, 1974 [1])

Age (weeks)	***Thermoneutral zone (°C)***	***Lower critical temperature under normal feeding conditions (°C)***
1	34-35	31-32
2	34-35	31-32
5	32-35	29-31
8	29-34	24-26
12	26-34	13-15
18	21-29	7-9
23	18-26	5-6
1 year	17-27	5-6

EFSA (2023) [7] emphasised that restricted movement, the inability to express natural behaviours, impaired resting, injuries, and stress are significant consequences of inadequate laying-hen housing systems.

Nests must be sufficiently spacious, clean, readily accessible, available in adequate numbers, and attractive to laying hens. A maximum of seven hens is permitted per individual nest. Where group nests are used, at least 1 m² of nest space must be provided for a maximum of 120 hens. The nest floor should be covered with material that allows hens to express natural pre-laying and nesting behaviours.

Inadequately positioned nests, an insufficient number of nests, or difficult access to them increases the incidence of floor-laid eggs. Such eggs represent both a technological and a hygienic problem, as they are more likely to become soiled or damaged and may pose a greater microbiological risk. Modern systems use appropriate lighting, the timely opening of nests, and pullet training to reduce the occurrence of this problem.

Long before organic table egg production was formally established and regulated, Nečov (1988) [27] recommended that individual nests should be 30–35 cm wide and 35–40 cm deep and positioned approximately 30 cm above floor level.

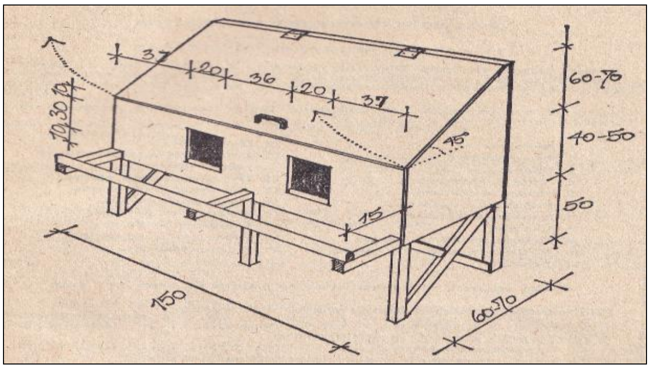

Fig 5: Proposed design of a group nest for approximately 50 laying hens, dating from a period before organic poultry production was formally recognised (Simonović, 1971) [46]

Perches are essential because they provide hens with opportunities to rest and express natural behaviour. However, inappropriate positioning, excessive height, or unsuitable perch materials may increase the risk of falls, collisions, and keel-bone injuries. Scientific assessments of laying-hen welfare increasingly identify keel-bone fractures and deformities as important welfare indicators in non-cage systems (EFSA, 2023 [7]; Nalesso *et al*., 2025).

Suitable perches must be provided for hens to roost on at night. EU legislation requires 18 cm of linear perch space per hen. Poultry keepers also recognised the importance of perches in extensive production systems. Depending on the size of the hens, these perches or wooden rails had a diameter of 3–7 cm. They had to be installed in a manner that allowed them to be easily removed and cleaned. Their upper edges had to be smooth so that the hens could grip them easily and securely.

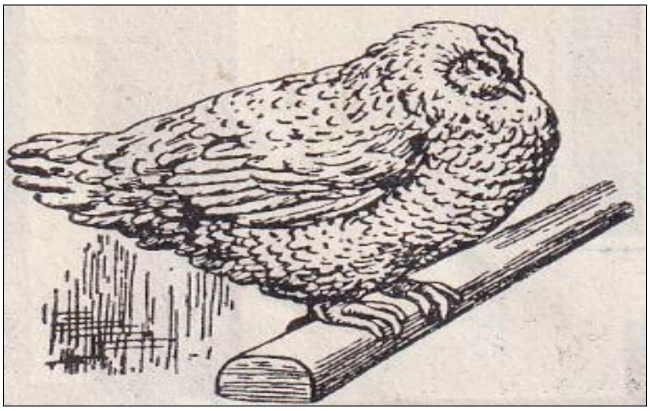

Fig 6: Properly designed roosting perch (Oberhofer, 1942) [30]

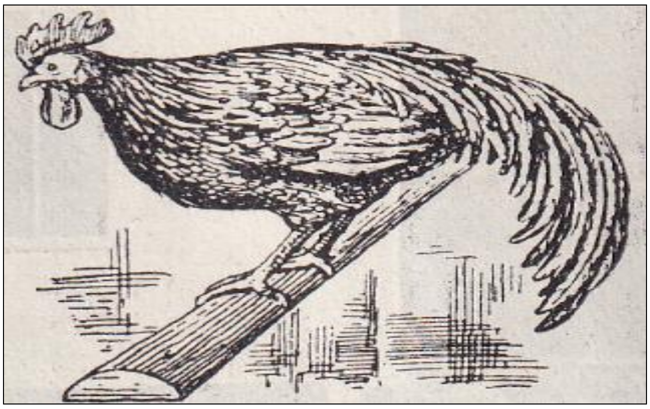

Fig 7: Poorly designed roosting perch (Oberhofer, 1942) [30]

Perches should not be positioned at different heights, as hens naturally attempt to occupy the highest level. Birds roosting on the upper perches may soil those below them with droppings, while descending from the highest level may also be difficult and increase the risk of injury.

Fig 8: Extensive production system: the highest perches are occupied by the highest-ranking members of the social hierarchy. The dominant rooster and leading hens occupy the highest level, while the second-ranking rooster and lower-ranking hens occupy the level below (Photo: M. Bošnjak)

At least 15 cm of linear perch space must be provided per laying hen. The distance between adjacent perches should be at least 30 cm, although a greater distance may be provided. Perches must also be positioned at least 20 cm from the wall of the poultry house. Perches, feeders, and drinkers should be installed above the slatted section of the floor, thereby preventing the deep litter from becoming soiled or wet.

The recommended cross-sectional dimensions of a perch are 5 × 6 cm, with the upper edges rounded (Puhač and Katić, 1962) [35].

Fig 9: Inadequate housing arrangement. In the absence of roosting perches, hens sleep in an area that they also use for nesting. This area becomes contaminated with droppings, resulting in frequently soiled eggs (Photo: M. Bošnjak)

As early as 1929, Oberhofer stated that a poultry house for 100 hens should provide no less than 50 m² of floor area, equivalent to 0.5 m² per hen. This is considerably greater than the minimum space allowance currently prescribed by the European Union.

Adequate lighting must be provided within the poultry house and may comprise both natural and artificial light. The illuminance in the area occupied by the hens should range from 10 to 20 lx. Natural light is provided through windows. To minimise heat loss, the windows should be double-glazed. They should be positioned relatively high, approximately 1.5 m above floor level, and installed flush with the interior wall surface to prevent hens from perching on them. Protective wire mesh should be fitted on the inside to prevent the birds from damaging the glass.

Window area is determined in relation to the total floor area. Approximately 1 m² of window area should be provided for every 10–12 m² of floor area, corresponding to a window-to-floor area ratio of 1:10–1:12. Horizontally oriented rectangular windows are preferable to square windows. Recommended dimensions are 0.60–0.80 m in height and 1.20–1.50 m in width.

The windows should be top-hung and open outwards. A minimum daylight factor of 2% must be maintained within the poultry house.

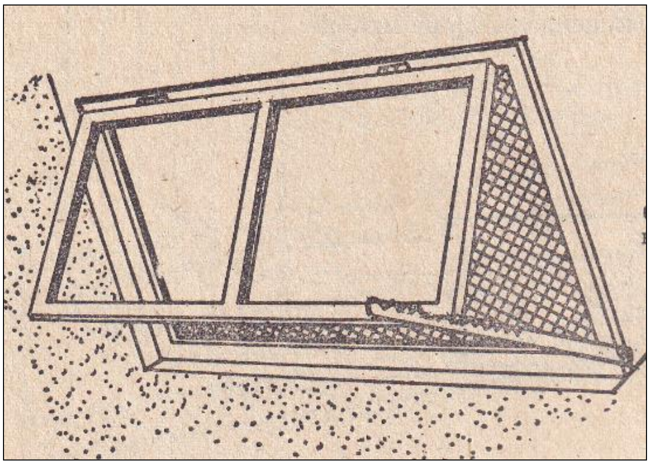

Fig 10: Poultry-house window and its opening mechanism (Simonović, 1971) [46]

Under the light–dark regime applied in organic table egg production, laying hens may be exposed to light for a maximum of 16 hours per day and must be provided with at least eight consecutive hours of uninterrupted darkness.

In laying-hen houses, a minimum illuminance of 10 lx must be maintained at bird-eye level throughout all areas accessible to the hens. In broiler houses, the minimum illuminance is 20 lx at bird-eye level, and at least 80% of the usable floor area must be illuminated. EU legislation does not prescribe specific illumination standards for other poultry categories (Council Directive 1999/74/EC, Annex I, point 3; Council Directive 2007/43/EC, Annex I, point 6; EUR-Lex).

These lighting regimes apply to adult birds. Chicks must be gradually accustomed to both the intensity of illumination and the duration of the photoperiod. A sudden increase in day length may have considerable adverse effects, particularly on gonadal development (Melnik *et al*., 1977) [26].

Although the strong emphasis placed on animal welfare is commendable and should be fully supported, certain reservations may nevertheless be expressed regarding the provisions of Council Directive 1999/74/EC of 19 July 1999 laying down minimum standards for the protection of laying hens.

To achieve the highest possible level of welfare, it would also appear necessary to prescribe a minimum building volume per bird, expressed as the number of cubic metres that must be provided per laying hen. The same requirement should apply to chicks and broilers. Neither the internal height at the centre or ridge of the building nor the height of the side walls is prescribed or recommended. Similarly, the required dimensions of ventilation inlets and outlets per hen or chick are not specified. All these factors undoubtedly influence the birds' quality of life and welfare.

Ventilation is an important factor in ensuring optimal welfare within poultry houses. Ventilation systems may be classified as (a) natural or (b) mechanical. Natural ventilation is driven by differences in air pressure between the interior of the building and the external environment. Exhaust air is removed through ventilation ducts that discharge it outside the building. The exhaust duct is generally positioned centrally and releases the air at the highest point of the roof.

As early as 1988, Petrović recommended that 0.2–0.3 m² of fresh-air inlet area should be provided for every 1,000 m³ of air extracted from the building. In practice, air inlets commonly measure 2.75 × 0.57 m. In laying-hen houses, these inlets are positioned approximately 60 cm above floor level, while the side walls are approximately 3 m high. To ensure effective air exchange, exhaust fans are installed in the highest central section of the building. By extracting stale air, these fans generate the pressure difference required for a continuous inflow of fresh air through the ventilation inlets.

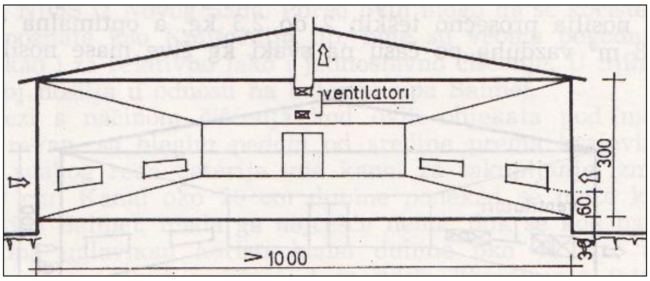

Fig 11: Cross-section of a poultry house with a ceiling (Petrović, 1988) [33]

To ensure adequate ventilation and the required frequency of air exchange within a poultry house, certain physiological characteristics of poultry must be considered, particularly their metabolic rate. In chickens, metabolism is approximately twice as rapid as in large livestock species. This characteristic, together with the relatively large surface area of their respiratory organs, means that chickens require approximately twice as much oxygen per kilogram of live weight. They also exhale approximately twice as much carbon dioxide as large livestock species.

Consequently, the quantity of moisture released through respiration is also greater, and poultry are particularly sensitive to elevated humidity. In addition to respiratory moisture, the total moisture content within the building is affected by evaporation from excreta and drinking water. Chicken excreta contain approximately 80% water. Owing to these factors, the required air-exchange rate in poultry houses should be at least 15 air changes per hour during summer and 5–10 air changes per hour during the remainder of the year.

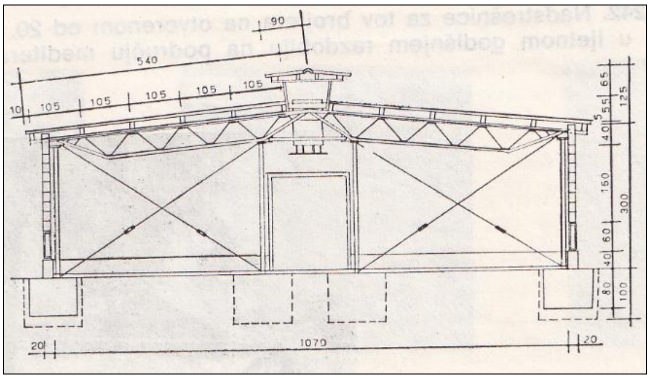

Fig 12: Cross-section of a poultry house dating from 1970, designed for a floor-based housing system that provided a high level of animal welfare (Asaj, 1974) [1]

During winter, the air velocity generated by the ventilation system should be maintained within a narrow range of 0.1–0.2 m/s. During summer, when ambient temperatures are considerably higher, air velocity should range from 0.3 to 0.8 m/s and may be increased to 1–2 m/s during periods of extreme heat.

In addition to air velocity, ventilation must satisfy the respiratory requirements of the hens by providing an adequate supply of fresh air. During cold weather, the minimum ventilation rate should be 0.7–1.0 m^3/h per laying hen. During summer, the maximum ventilation rate may range from 6 to 10 m^3/h per hen.

However, ventilation standards expressed solely per bird do not account for biological and physiological differences among laying hens. The requirements of light commercial hybrids or breeds differ considerably from those of heavier hybrids or breeds. Heavier hens produce more metabolic heat and release greater quantities of water vapour and carbon dioxide, while their excreta contribute to greater ammonia generation. These are the principal reasons why heavier hens require substantially higher air-exchange rates than lighter hens.

When light-type hens weighing 1.4–1.6 kg are compared with medium-heavy and heavy hens weighing 2.2–2.5 kg, the difference in body weight amounts to approximately 40–70%. This clearly indicates proportional differences in the production of metabolic heat, carbon dioxide, and moisture. The prescribed standards may be sufficient to safeguard the welfare of lighter hens but may not adequately meet the requirements of heavier birds. It is therefore evident that the physiological needs of these two groups cannot be met by identical ventilation rates.

European legislation generally regulates laying-hen welfare and housing conditions on a per-bird basis. Although this approach simplifies inspection and enforcement, it does not fully account for physiological requirements or define ventilation parameters using a physiologically based model.

The limitations of this approach are further demonstrated by the physiological fact that, per 1,000 kg of live weight, poultry have approximately three times the pulmonary ventilation volume of cattle. As previously noted, this results in the release of proportionally greater quantities of carbon dioxide and water vapour.

During the first 30 days of life, chicks should be maintained at a relative humidity of 65–70%. Thereafter, the recommended relative humidity should be reduced to 55–60%.

Because hens in floor-based systems are housed on deep litter, any increase in water vapour that is not adequately removed by ventilation raises the moisture content of the litter and increases the concentration of ammonia within the building. Such conditions contribute to a higher incidence of respiratory infections, keratoconjunctivitis, and other diseases (Puhač and Katić, 1962) [35].

Inadequate ventilation also causes substantial deterioration in production parameters. Laying-hen productivity may decrease by 40–50%, while feed wastage may increase to 30–40%. Disease occurrence, particularly among younger birds, becomes considerably more frequent, with morbidity increasing three- to fourfold.

Bessarabov (as cited in Melnik *et al*., 1977) [26] found that floor-based housing systems were generally associated with a 21.8% increase in digestive tract disorders and a 10.8% increase in respiratory diseases. The prevalence of hypovitaminosis increased by 10.4%, hepatic disorders by 8.6%, nutritional dystrophy by 3.0%, and asphyxia by 7.0%.

The following physiological data further demonstrate that ventilation requirements should take greater account of the physiological needs of poultry. A one-day-old chick requires approximately 2,267 cm^3 of air per minute, whereas a four-week-old chick requires approximately 0.042 m^3, or 42,475 cm^3, per minute. The required air-exchange rate also increases with age. For four-week-old chicks, the recommended rate is 15 air changes per hour, meaning that the entire volume of air within the building must be replaced 15 times per hour.

During summer, ventilation should be adjusted so that the indoor air temperature for young birds does not exceed 26.5°C. This may be achieved with an air-exchange rate of 8–10 air changes per hour, increasing to 15 air changes per hour on particularly hot summer days.

When high outdoor temperatures cause the indoor temperature to rise, the ventilation rate should range from 5.0 to 5.9 m^3/h per kilogram of live weight. During cold periods, the corresponding rate should range from 1.4 to 1.8 m^3/h per kilogram of live weight (Ivanovič *et al*., 1978).

Air velocity within the building also has a considerable effect on poultry. During summer, air velocity in facilities housing young birds older than 30 days should not exceed 1.2 m/s. In houses containing adult poultry, the optimal air velocity during colder periods is approximately 0.3 m/s, with a maximum value of 0.6 m/s. Introducing air at a temperature considerably lower than the hens' body temperature may cause health problems, particularly those affecting the respiratory tract.

Ventilation rates according to outdoor air temperature and chick age are presented in the following table.

Table 4: Ventilation rate (m^3/h/kg of live weight) according to outdoor air temperature and chick age (Ivanovič, 1978)

Age (days)	***−20°C***	***−10°C***	***Summer period***
1-30	1,10	1,44	5,80
31-60	1,60	2,26	5,00
61-180	1,44	1,76	4,56

According to the operating principle, mechanical ventilation systems may function under either positive or negative pressure. In a positive-pressure system, fans force air into the building, from which it exits through ventilation outlets. In a negative-pressure system, fans extract air from the building, while replacement air enters through ventilation inlets. Negative-pressure systems are used almost exclusively in poultry production: exhaust fans remove indoor air, thereby drawing fresh air into the building through the inlets.

With regard to natural ventilation, the principal questions concern the required number, dimensions, and positioning of air inlets and exhaust outlets. It has been recommended that 19.5 cm² of air-inlet area and 9.7 cm² of exhaust-outlet area should be provided per hen (Puhač and Katić, 1962) [35]. These authors recommended positioning air inlets 90–145 cm above floor level and identified roof ventilation as the most effective method of removing stale air. This may consist of a single central exhaust duct or a continuous series of exhaust openings extending along the entire roof ridge.

One potential disadvantage of this system is the position of the air inlets. When they are installed at the recommended height, incoming air—particularly warm air during summer—may not descend sufficiently to the level occupied by the hens. Consequently, it may fail to provide adequate air movement over the deep-litter surface and through the bird-occupied zone, thereby reducing the effective removal of ammonia.

For ease of reference, the prescribed and recommended values for zoohygienic parameters contained in EU legislation are summarised in the following table.

Table 5: Recommended values for zoohygienic parameters in laying-hen housing

Parameter	***Recommended value***
Indoor air temperature	18–22°C
Indoor relative humidity	50–70%
Ammonia (NH_3)	<20 ppm
Carbon dioxide (CO_2)	<3,000 ppm
Carbon monoxide (CO)	<10 ppm
Hydrogen sulphide (H_2S)	<5 ppm
Dust concentration	As low as possible, preferably <3 mg/m³
Air velocity—winter	0.1–0.2 m/s
Air velocity—summer	0.3–0.8 m/s
Feeding	100% organic feed, with an emphasis on roughage and access to pasture whenever possible
Beak trimming	Not permitted as a routine procedure; it may be performed only in exceptional cases and with authorisation from the competent authority
Veterinary treatments	Preventive measures should be prioritised. Antibiotics must not be used routinely or preventively and may be administered only when necessary under veterinary supervision and in accordance with organic production rules

Outdoor Ranges and Open-Air Areas

Access to open-air areas is one of the fundamental characteristics of organic egg production. Outdoor ranges allow hens to walk, scratch, peck, dust-bathe, experience natural light, and consume vegetation and insects. They therefore provide greater opportunities for the expression of natural behaviours, which represents an important component of animal welfare (Bonnefous *et al.*, 2022; Göransson *et al.*, 2024) [4, 16].

Dust bathing is particularly important. It provides a form of bodily stimulation and performs an important hygienic function by helping hens clean and maintain their plumage. A dust-bathing bout generally lasts 20–30 minutes and begins approximately eight hours after the start of the daily light period, corresponding to the midpoint of a 16-hour photoperiod (Vestergaard, 1982; van Liere, 1991; Wiers *et al.*, 1999, as cited in Schrader, 2008 [44]). Hens typically perform this behaviour approximately once every two days.

Foraging is one of the fundamental behavioural motivations of chickens. The red junglefowl spends approximately 60% of its active time searching for food (Dawkins, 1989, as cited in Schrader, 2008 [44]). Foraging involves substantial leg activity, as birds scratch and displace the soil with their feet before searching for food with their beaks. Pecking and manipulating food items require considerable mobility of the head and beak. Webster (2002, as cited in Schrader, 2008 [44]) reported that a hen may perform as many as 15,000 beak movements.

Nevertheless, the use of outdoor ranges also presents certain risks. Free-range access increases the likelihood of contact with parasites, bacteria, viruses, rodents, and mammalian and avian predators. Bonnefous *et al.* (2022) [4] reported that outdoor access may increase the risk of certain bacterial, viral, and parasitic infections while simultaneously allowing hens to express behaviours that contribute positively to their welfare.

Young birds should also be provided with access to outdoor ranges during the rearing period. Movement in the open air over soil and grass-covered surfaces allows them to search for and consume insects and green forage, scratch the ground, and dust-bathe.

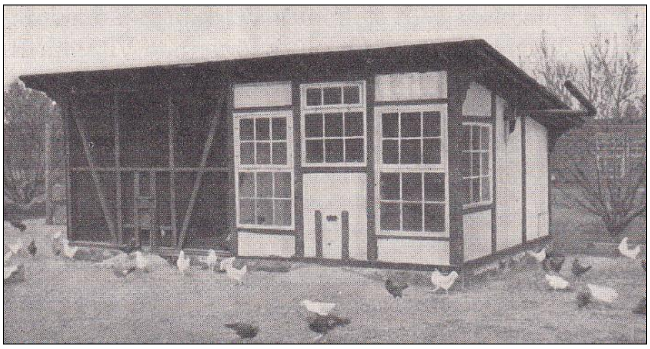

Fig 13: Chick-rearing facility with an enclosed section for colder weather, an open section for warmer days, and an outdoor range (Nusshag, 1957) [28]

Hens should be encouraged to use the outdoor range as evenly as possible. This can be achieved by providing canopies, shrubs, trees, mobile shelters, drinkers, and other features that encourage hens to move farther away from the poultry house. In the absence of protective cover, large numbers of hens tend to remain close to the exit openings, resulting in vegetation loss, mud formation, and manure accumulation. Recent research indicates that vegetation cover plays an important role in promoting more uniform use of outdoor ranges (Pacher-Deutsch *et al.*, 2025) [32].

Fig 14: Mobile poultry house for laying hens. The outdoor range is fenced but provides no additional shelter. During periods of high temperature, wind, or rain, the hens remain inside the poultry house or seek shelter beneath it (Photo: M. Urošević)

In organic production systems, outdoor ranges must be fully functional and suitable for regular use. This means that the land must be adequately drained, partially shaded, protected from predators, and managed in a manner that prevents excessive soil contamination. Range rotation, periodic resting of the land, and maintenance of vegetation are important measures for reducing parasite pressure and protecting the environment.

Feeding of Laying Hens

Irrespective of the production system, laying-hen diets must provide adequate levels of energy, protein, essential amino acids, minerals—including calcium, phosphorus, and sodium—trace elements, and vitamins. These nutritional principles apply equally to organic production. The principal requirement is that feed must originate from organic production and comply with rules prohibiting the use of genetically modified organisms and restricting feed additives to those authorised for organic production (Regulation (EU) 2018/848; Regulation (EC) No 183/2005).
Accordingly, feed provided to laying hens must be 100% organically produced, as required by Regulation (EU) 2018/848. Exceptions to this requirement are permitted only under specific conditions and circumstances, including the following:

1. Catastrophic circumstances—such as drought, flooding, fire, or outbreaks of animal disease (epizootics). When such circumstances occur, the EU Member State concerned must submit a duly justified request to the competent authorities. On the basis of the evidence provided, the temporary use of non-organic feed may be authorised to preserve the continuity and viability of existing production.
2. Certain feed additives and non-organic feed materials may be used only with the explicit authorisation of the competent authorities when an organic alternative is unavailable. This primarily applies to certain mineral ingredients, vitamins, trace elements, and similar nutritional components.

Each daily ration must consist entirely of feed of organic origin, except where specifically authorised derogations apply. At least 30% of the feed must originate from the holding itself or, where this is not possible, be produced in cooperation with organic or in-conversion production units and feed operators in the same region. Roughage, fresh or dried forage, or silage must be included in the daily ration, with the form of roughage depending on the season. The diet must satisfy all the physiological and behavioural needs of laying hens. The use of synthetic growth promoters and synthetic amino acids is strictly prohibited, except where temporary authorisation may be granted by specific legal acts under exceptional circumstances. Genetically modified organisms, products produced from GMOs, and products produced by GMOs are also prohibited. Only feed materials and additives listed as authorised under Commission Implementing Regulation (EU) 2021/1165 may be used.
It should be emphasised that EU legislation does not prescribe upper and lower limits for the dietary concentrations of energy, protein, lysine, methionine, calcium, or phosphorus. The final formulation of the diet is determined by the nutritionist responsible for feeding the laying hens on the farm. EU legislation primarily regulates the production methods and origin of feed materials.
The principal nutritional challenge is ensuring an adequate supply of high-quality protein and essential amino acids, particularly methionine and lysine. Amino acid deficiencies may reduce laying performance, impair plumage quality, and increase the tendency towards feather pecking. Kim *et al*. (2022) [22] reported that dietary energy and protein concentrations significantly affect laying performance and egg quality.
Calcium and phosphorus have a particularly important and decisive role in eggshell formation and the maintenance of skeletal health. Deficiencies or an inappropriate calcium-to-phosphorus ratio may result in thin eggshells, a higher proportion of cracked eggs, reduced egg production, and skeletal disorders. According to Zhang *et al*. (2022) [50], ambient temperature, calcium and phosphorus intake, and the quality of the limestone source significantly affect eggshell quality and bone status in laying hens.
While using outdoor ranges, hens consume green forage, various seeds, insects, and other naturally available feed resources. Although this is highly beneficial, these resources cannot replace a complete diet. A fully balanced compound feed must therefore be provided, as the nutritional contribution of the outdoor range is highly variable and depends on the season, vegetation quality, soil moisture, and the ranging activity of the hens.
Adequate pop-holes must be provided to ensure safe access to and from the poultry house. Their number depends on flock size. Each pop-hole should be at least 40 cm wide and 35 cm high. A total opening width of at least 1 m must be provided for every 500 hens.

Fig 15: Even small groups of hens require access to an outdoor range. The provision of shelters offering protection from direct sunlight is highly beneficial (Photo: M. Bošnjak)

On the basis of Regulation (EU) 2018/848 on organic production and the labelling of organic products, Commission Implementing Regulation (EU) 2020/464, and data reported in the scientific literature, a table was compiled comparing EU requirements with scientifically recommended values for laying hens.

Table 6: Comparative overview of selected parameter values prescribed by EU legislation and scientifically recommended values for laying hens

Parameter	***EU requirement***	***Scientifically recommended value for laying hens***
Organic origin of feed materials	100% organic feed, except for authorised derogations	100%
Feed originating from the holding or the same region	At least 30%	30% or more
Roughage	Mandatory daily provision	5–10% of the diet or daily access to roughage
Metabolisable energy	Not specified	11.0–11.8 MJ ME/kg
Crude protein	Not specified	15.5–17.5%
Lysine	Not specified	0.70–0.85%
Methionine + cystine	Not specified	0.60–0.70%
Calcium	Not specified	3.5–4.2%
Total phosphorus	Not specified	0.55–0.65%
Available phosphorus	Not specified	0.30–0.40%
Sodium	Not specified	0.15–0.18%
Crude fibre	Not specified	3–5%
Synthetic amino acids	Prohibited	Not used
Growth promoters	Prohibited	Not used
Genetically modified organisms (GMOs)	Prohibited	Not used

Clean, hygienically safe water of an appropriate temperature must be continuously available. Reduced water intake rapidly results in decreased laying performance. During summer, drinking water plays an important role in mitigating the effects of heat stress, whereas in winter the freezing of drinkers and water lines must be prevented.
When linear drinkers are used, at least 2.5 cm of drinking space must be provided per laying hen. With circular drinkers, at least 1 cm of drinking space per hen is required. Where automatic nipple drinkers are used, at least one nipple must be provided for every 10 laying hens. Drinkers must be kept clean and thoroughly cleaned at least once daily, even when they appear clean. All nipple drinkers should be inspected every day.
How much water should be provided? Laying hens, as well as all other poultry categories, must have continuous access to sufficient quantities of fresh, clean water. Because laying hens with outdoor access also consume green forage, it is difficult to determine precisely how much water they will consume inside the poultry house.
As a general guideline, daily water consumption is approximately 95 mL per bird at five weeks of age and 185–200 mL per bird at 11 weeks of age. These values refer to young birds housed continuously indoors.
The average daily water consumption of hens with access to an outdoor range ranges from 0.2 to 0.3 L per bird (Jahansen *et al*., 2010).

Health Management and Disease Treatment

Health management in organic production must be based primarily on disease prevention. Fundamental measures include sourcing healthy replacement stock, quarantining newly introduced birds, regularly observing the flock, implementing vaccination programmes established by a veterinarian, controlling parasites, applying biosecurity measures, maintaining feed and water hygiene, ensuring adequate ventilation, and controlling rodents. Organic production does not prohibit the treatment of sick animals, but it restricts the routine and unjustified use of veterinary medicinal products. Their use must comply with EU legislation, particularly Regulation (EU) 2019/6 (Regulation (EU) 2019/6).
Salmonella represents one of the most important hazards in table egg production. According to the WHO, human salmonellosis is most commonly associated with the consumption of contaminated foods of animal origin, including eggs, meat, poultry meat, and milk (WHO, 2018) [49].
Within the European Union, Salmonella control is based on coordinated control programmes that have contributed substantially to reducing the number of human cases. The European Commission identifies these coordinated programmes as one of the EU's successful food-safety initiatives, resulting in a considerable reduction in reported cases compared with the period before 2004 (European Commission, Control of Salmonella).
Regulation (EC) No 2160/2003 establishes a framework for controlling Salmonella and other food-borne zoonotic agents. In egg production, this involves regular flock monitoring, verification of the origin of laying hens, biosecurity, poultry-house hygiene, rodent control, appropriate egg handling, and the implementation of prescribed measures following a positive test result (Regulation (EC) No 2160/2003).
Parasitic infections are more common in free-range systems than in fully enclosed production systems. Bestman *et al.* (2023) [2] reported that intestinal parasites are common among laying hens in non-cage systems, may adversely affect welfare and production performance, and must be controlled through preventive measures and systematic monitoring.
The poultry red mite, intestinal helminths, and coccidia may represent serious problems in organic production. Their control must be based on thorough cleaning of poultry houses, elimination of parasite refuges, rotation of outdoor ranges, laboratory examination of faecal samples, the use of authorised treatments, and veterinary supervision.

Animal Welfare

Laying-hen welfare is a central component of organic production. It encompasses physical health, adequate nutrition, access to water, opportunities to express natural behaviours, freedom from unnecessary pain and stress, protection from disease and injury, and appropriate housing conditions. EFSA (2023) [7] identified restriction of movement, impaired resting, group stress, injuries, fractures, feather pecking, inability to perform exploratory behaviours, and predation-related stress as important welfare consequences for laying hens.
Feather pecking and cannibalism are serious problems in non-cage and organic systems. Hartcher *et al.* (2016) [19] described severe feather pecking as a harmful and widespread behaviour that adversely affects both animal welfare and production efficiency.
Risk factors for feather pecking include genotype, inadequate rearing conditions, insufficient environmental enrichment, poor nutrition, inadequate fibre intake,

excessive light intensity, flock non-uniformity, and stress. Lambton *et al*. (2010) [24] demonstrated that the risk of developing both gentle and severe feather pecking may be associated with factors present during the rearing period and with housing conditions in non-cage systems.

Plumage, foot, and keel-bone condition, together with flock behaviour, should be monitored regularly. Plumage damage may indicate feather pecking, parasite infestation, nutritional deficiencies, or stress. Foot lesions frequently indicate wet litter, inadequate hygiene, or unsuitable flooring. Keel-bone fractures and deformities are increasingly used as welfare indicators in non-cage systems (EFSA, 2023 [7]; Nalesso *et al*., 2025).

Egg Hygiene and Food Safety

Egg safety depends on flock health, nest cleanliness, the frequency of egg collection, equipment hygiene, storage conditions, packaging, and transport. Eggs may become externally contaminated through the shell or, less commonly, internally through the reproductive tract of the laying hen. The primary objective should therefore be to prevent contamination rather than attempt to remedy it subsequently through washing or other inappropriate procedures.

Eggs should be collected regularly, at least once daily and several times per day in larger flocks. Nests must remain clean and dry. Floor-laid eggs should be separated from nest-laid eggs because they are more likely to be soiled and microbiologically contaminated. Prolonged storage at an inappropriate temperature may promote the growth of Salmonella. EFSA specifically warns that extending egg storage time in retail settings or consumers' homes increases the risk of foodborne illness associated with Salmonella Enteritidis (EFSA, Salmonella topic).

Eggs intended for the market must be graded, marked, stored, and transported in accordance with EU marketing standards. The European Commission stipulates that eggs and their packaging must be appropriately marked, that eggs must be graded according to quality and weight, and that packing centres, storage facilities, and transport operations must comply with the applicable egg-marketing requirements (European Commission, Eggs).

Technological Challenges in Organic Egg Production

Organic egg production faces a greater number of technological challenges than intensive indoor production systems. The first challenge is lower and more variable productivity. Laying hens in organic systems expend more energy on movement and thermoregulation, are exposed to fluctuating weather conditions, and receive organic feed that may be more expensive and more difficult to formulate with precise nutrient concentrations. Rakonjac *et al*. (2021) [37] demonstrated that both the housing system and genotype may affect production performance and egg quality.

The second challenge concerns egg quality. Organic and free-range systems may influence egg weight, yolk colour, shell quality, Haugh units, and chemical composition. Rakonjac *et al*. (2018) [36] investigated the effects of housing system and laying-hen age on egg quality and chemical composition by comparing cage, floor-based, and organic production systems.

Rodríguez-Mengod *et al*. (2024) [43] reported that organic production may affect both the external and internal characteristics of eggs, including egg weight, shape, shell quality, and albumen quality. These findings confirm that egg quality cannot be evaluated independently of the housing system, genotype, laying-hen age, and diet.

The third challenge is the occurrence of floor-laid eggs. These eggs increase labour requirements, reduce hygienic quality, and are more susceptible to damage. Contributing factors include inappropriate nest placement, an insufficient number of nests, inadequate lighting, stress, unsuitable pullet-rearing conditions, and behavioural disturbances. Current solutions include appropriate pullet training, the provision of well-designed nests, frequent egg collection, and, in larger production systems, automated or semi-automated systems for detecting and collecting floor-laid eggs.

The fourth challenge is feather pecking and cannibalism. These behavioural disorders may result in injuries, infections, reduced production, and increased mortality. Because routine beak trimming is avoided in organic production, preventive measures involving balanced nutrition, environmental enrichment, lighting control, appropriate pullet rearing, and genotype selection are of crucial importance (Hartcher *et al*., 2016; Lambton *et al*., 2010; EFSA, 2023) [19, 24, 7].

The fifth challenge is parasite control. Outdoor access increases contact with soil and excreta, thereby creating favourable conditions for the transmission and development of intestinal parasites. Bestman *et al*. (2023) [2] highlighted the association between outdoor-range use and the occurrence of intestinal parasites on organic and free-range farms.

The sixth challenge is biosecurity. Contact with wild birds, rodents, and other animals increases the risk of introducing infectious agents. It is particularly important to prevent spilled feed and poorly maintained outdoor areas from attracting wild birds. Biosecurity measures in organic production must be designed to minimise disease risks without compromising the fundamental principle of outdoor access.

The seventh challenge concerns climatic extremes. High temperatures reduce feed intake, impair eggshell quality, and decrease egg production. Low temperatures increase energy requirements, while prolonged periods of rainfall adversely affect the condition of outdoor ranges and litter. Adequate ventilation, shade, drainage, water quality, and dietary adjustments are therefore essential components of production management.

The eighth challenge is production economics. Organic feed is more expensive, while organic production requires more space, labour, and extensive record-keeping. Organic eggs consequently command a higher price; however, their market success depends on consumer confidence, consistent product quality, and clear and accurate labelling.

Environmental Impact

Organic egg production has the potential to contribute to sustainable agriculture, but only when outdoor ranges, manure, nutrients, and soil are managed appropriately. Its potential benefits include the integration of production with the land, the use of organic feed, reduced reliance on synthetic inputs, and greater opportunities for nutrient cycling. However, inadequate range management may lead to localised accumulations of nitrogen and phosphorus, vegetation loss, soil erosion, and the contamination of surface waters.

Laying-hen manure is a valuable source of plant nutrients but also a potential source of pathogens. Its storage and application must be managed in a manner that prevents water pollution, excessive odour emissions, and the spread of disease. Maintaining vegetation cover on outdoor ranges is important both for animal welfare and soil protection.

Egg Quality

When all requirements prescribed by the European Union are considered and fully implemented, a logical question arises as to whether the quality and composition of eggs produced in organic systems differ from those obtained in conventional production systems.

Samman *et al.* (2009) analysed 180 commercially available eggs originating from conventional and organic production systems. They found no significant differences in the concentrations of monounsaturated and polyunsaturated fatty acids between eggs from the two systems. Eggs produced organically contained slightly higher concentrations of palmitic and stearic acids; however, these differences were not statistically significant and therefore had no relevant nutritional implications for consumers.

Filipiak-Flokiewicz *et al.* (2017) also investigated the chemical composition of eggs obtained from conventional and organic production systems. The authors demonstrated that differences in fatty acid profiles were influenced more strongly by the composition and quality of the hens' diets than by the production system itself. Organically produced eggs contained slightly more yolk protein and higher concentrations of copper and potassium. However, no significant differences were observed in the basic chemical composition of the eggs.

For ease of comparison, selected parameters of eggs from conventional and organic production systems are presented in the following table.

Table 7: Comparative overview of selected parameters in eggs from conventional and organic production systems

Parameter	***Conventional eggs***	***Organic eggs***	***Comment***
Moisture (%)	74–76	74–76	No significant difference
Protein (%)	12.3–12.8	12.4–13.0	No significant difference
Fat (%)	10.3–10.9	10.4–11.0	No significant difference
Minerals (%)	0.9–1.1	0.9–1.1	No significant difference
Cholesterol (mg/100 g)	360–390	350–390	Differences are not significant
Omega-3 fatty acids	Lower concentration	Often higher concentration	Depends on diet and access to outdoor ranges
Omega-6:omega-3 ratio	Higher	Lower and more favourable	Potential advantage of organic eggs
Lutein and zeaxanthin	Lower or similar concentrations	Often higher concentrations	Associated with the consumption of green forage on outdoor ranges
Vitamin E	Similar or slightly lower concentration	Often slightly higher concentration	Not confirmed by all studies

Conclusion

Organic production of table eggs is a complex production system requiring the integrated application of knowledge in animal husbandry, poultry nutrition, preventive veterinary medicine, food hygiene, animal welfare, and European legislation. Its principal value lies in providing laying hens with a higher level of welfare, access to open-air areas, organic feed, greater production transparency, and increased consumer confidence.

Production must comply with Regulation (EU) 2018/848 on organic production, Commission Implementing Regulation (EU) 2020/464 laying down rules for its application, Council Directive 1999/74/EC on the welfare of laying hens, legislation governing food and feed hygiene, Regulation (EC) No 2160/2003 on the control of Salmonella, and the current EU marketing standards for eggs (European Parliament and Council, 2018; European Commission, 2020; Council Directive 1999/74/EC; Regulation (EC) No 852/2004; Regulation (EC) No 853/2004; Regulation (EC) No 183/2005; Regulation (EC) No 2160/2003; Regulation (EU) 2023/2465; Regulation (EU) 2023/2466).

The most important prerequisites for successful organic production include the appropriate selection of laying-hen breeds or hybrids, high-quality pullet rearing, suitable housing, functional outdoor ranges, balanced organic diets, regular health monitoring, appropriate egg handling, and accurate record-keeping. Technological problems such as floor-laid eggs, feather pecking, parasite infestations, predation-related stress, climatic extremes, and higher production costs can be substantially reduced through professional management.

Nevertheless, an important question remains: when all prescribed requirements have been met and production is conducted in accordance with the relevant technological protocols, has the intended objective been fully achieved? Despite extensive monitoring and control, one factor cannot be completely controlled—the quality of the ambient air breathed by the hens and surrounding the crops used in their diets. Furthermore, to improve laying-hen welfare, numerous zoohygienic parameters require more precise definition, while certain existing provisions should be formulated more clearly.

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