

Article

Assessing Production and Economic Impacts of Good Practices for Improving Animal Welfare in Broiler Chicken Rearing [†]

Edward Majewski ^{1,*}, Monika Gębska ², Jakub Urban ³, Ingrid de Jong ⁴, Lisa Morgans ⁵, Mukhtar Muhammad ⁵, Paolo Ferrari ⁶, Annunziata Palamara ⁶, Stefan Gunnarsson ⁷, Natalia Majo ⁸ and Anna Grontkowska ¹

¹ Institute of Economics and Finance, Warsaw University of Life Sciences, 02-787 Warsaw, Poland; anna_grontkowska@sggw.edu.pl

² Institute of Management, Warsaw University of Life Sciences, 02-787 Warsaw, Poland; monika_gebska@sggw.edu.pl

³ Institute of Animal Sciences, Warsaw University of Life Sciences, 02-786 Warsaw, Poland; jakub_urban@sggw.edu.pl

⁴ Animal Health and Welfare Department, Wageningen Livestock Research, Wageningen University & Research, 6708 WD Wageningen, The Netherlands; ingrid.dejong@wur.nl

⁵ Department of Agricultural Science and Practice, Royal Agricultural University, Cirencester GL7 6JS, Gloucestershire, UK; lisa.morgans@rau.ac.uk (L.M.); mukhtar.muhammad@rau.ac.uk (M.M.)

⁶ Centro Ricerche Produzioni Animali (CRPA), Società Consortile per Azioni, Viale Timavo 43/2, 42121 Reggio Emilia, Italy; p.ferrari@crpa.it (P.F.); a.palamara@crpa.it (A.P.)

⁷ Department of Applied Animal Science and Welfare, Swedish University of Agricultural Sciences (SLU), P.O. Box 234, 532 23 Skara, Sweden; stefan.gunnarsson@slu.se

⁸ Centre de Recerca en Sanitat Animal (CRESA), Institut de Recerca i Tecnologia Agroalimentàries (IRTA), Campus Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain; natalia.majo@irta.cat

* Correspondence: edward_majewski@sggw.edu.pl

[†] Horizon Europe research and innovation programme *BroilerNet*, running from 1 August 2022 until 31 July 2026.

Abstract

Improving animal welfare is an important objective of the European Union's Common Agricultural Policy, as well as national regulations and voluntary certification schemes. Drawing on research conducted within the *BroilerNet* project, this paper presents an assessment of the production and economic effects of good practices in broiler farming identified in 13 participating EU countries. The methodology involved defining key challenges related to animal welfare, health, and environmental impacts; identifying practices already applied under commercial conditions; conducting preliminary assessments by national expert panels; and selecting the most promising practices, referred to as *Champions*, for final economic evaluation. The assessment used gross margin analysis and budgeting techniques considering additional implementation costs and potential production benefits. Typical farm models representing different flock sizes were developed. The analysis of six *Champions* presented in the paper revealed varied outcomes depending on implementation costs, expected production benefits, and the assumptions adopted under optimistic and pessimistic scenarios. According to farmers' observations, supported by the available literature, all assessed practices improved animal welfare. Financial benefits varied with implementation costs, achievable productivity gains, and production scale, with the smallest farms benefiting less. Given the generally low implementation costs, all assessed practices merit wider dissemination.

Keywords: production assessment; economic assessment; good practices; animal welfare; broiler chicken



Academic Editor: Zlata Kralik

Received: 14 July 2026

Revised: 30 July 2026

Accepted: 1 August 2026

Published: 18 September 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and

conditions of the [Creative Commons](#)

[Attribution \(CC BY\)](#) license.

1. Introduction

Animal welfare has become an integral component of both the European Union's agricultural policy and its legal framework. Between 1974 and 1991, the EU progressively introduced animal welfare legislation for different categories of farm animals, including calves (1974), pigs (1976), and laying hens (1988), and in 1991 established general principles for the protection of farm animals through species-specific directives and broader welfare provisions [1,2]. A key legal instrument of this period was Council Directive 98/58/EC concerning the protection of animals kept for farming purposes, often referred to as the General Farm Animals Directive. The Directive established minimum standards for the protection of farm animals and required farmers to provide appropriate housing, nutrition, water supply, and care while avoiding unnecessary pain, suffering, or injury [3]. Alongside the development of secondary legislation, the recognition of animals as sentient beings gained increasing importance within EU primary law. The Amsterdam Treaty [4] introduced the Protocol on the Protection and Welfare of Animals, requiring EU institutions and member states to pay full regard to animal welfare requirements when formulating and implementing agricultural, transport, and other relevant policies [4]. Subsequently, the Treaty of Lisbon strengthened the legal status of animal welfare through Article 13 of the Treaty on the Functioning of the European Union (TFEU), which explicitly recognizes animals as sentient beings and requires the Union and its member states to pay full regard to their welfare requirements. The general legislative framework has been complemented by species-specific directives regulating housing conditions, stocking densities, environmental enrichment, feeding systems, and management practices. In the poultry sector, an important milestone was Council Directive 2007/43/EC laying down minimum rules for the protection of chickens kept for meat production [5].

The strategic dimension of EU animal welfare policy was further reinforced through a series of action plans and strategies. The first comprehensive EU Animal Welfare Action Plan covered the period of 2006–2010, followed by the EU Strategy for the Protection and Welfare of Animals 2012–2015. More recently, the Farm to Fork Strategy and related policy initiatives have provided the foundation for a renewed animal welfare agenda aimed at improving legislation, enforcement, transparency, and sustainability across the food chain [6].

This brief historical overview illustrates the evolution of EU animal welfare policy from ethical concerns reflected in early treaty provisions to a comprehensive legislative and policy framework imposing increasingly demanding welfare standards on livestock production systems. Parallel to EU legislation, which establishes mandatory requirements, numerous voluntary animal welfare schemes and private standards have emerged across Europe. These initiatives, developed by independent organizations, producer associations, or retailers, typically exceed statutory requirements and communicate welfare attributes to consumers through recognizable labels and certification systems. Examples include the following:

- RSPCA Assured (United Kingdom), which focuses on requirements related to stocking density, environmental enrichment, bedding, health management, transport, and slaughter conditions [7].
- Beter Leven (the Netherlands), developed by the Dutch Society for the Protection of Animals. Through its well-known one-, two-, and three-star system, it communicates different welfare levels to consumers and creates market incentives for farmers and food chain actors to gradually adopt higher welfare standards [8].
- KRAV (Sweden), which promotes organic farming systems that allow animals to express natural behaviors, including outdoor access and grazing opportunities, while integrating animal welfare with broader sustainability objectives [9].

- Label Rouge (France), a quality assurance scheme emphasizing slower-growing breeds, lower stocking densities, outdoor access, and production practices that often exceed minimum EU welfare requirements, particularly in poultry production [10].

These voluntary initiatives complement public regulation by creating market-based incentives for welfare improvements and responding to growing consumer demand for products produced under higher animal welfare standards. Compulsory standards, voluntary schemes, and consumer expectations jointly create a specific and evolving policy–market framework within which food producers face new and increasingly complex challenges. Adapting to these challenges requires changes in existing production methods and the search for innovative solutions. Traditionally, the pursuit of innovation has been, and still remains, the role of science. However, input suppliers and farmers themselves are increasingly contributing to this process.

The adoption of innovations depends on the effectiveness of the innovation diffusion process. According to Rogers [11] the adoption process involves a sequence of stages through which potential users progress, including knowledge, persuasion, decision, implementation, and confirmation.

These stages correspond broadly to the earlier concepts of awareness, interest, evaluation, trial, and adoption described in the pioneering work of Ryan and Gross [12]. Rogers emphasized that interpersonal communication and peer-to-peer learning become especially important during the persuasion and decision stages. More recently mission-orientated innovation systems are purported to enable transformative change [13].

The implementation of good practices in broiler production is widely recognized as desirable and consistent with sustainable development principles [14]. Their adoption is expected to generate multiple benefits, including not only improved animal welfare but also better flock health, more stable production performance, and reduced environmental impacts [15,16].

The ambition of the BroilerNet project was to create a platform for interaction between science and practice to improve the resilience of the broiler sector by creating innovation networks sharing good practices related to current challenges regarding animal welfare, animal health, and environmental sustainability. Building on the project's research, this paper aims to strengthen this connection by presenting the results of an evaluation of selected best practices improving animal welfare, with a particular focus on their economic impacts when implemented on commercial broiler farms in various EU countries. The study is expected to help address the existing knowledge gap by increasing awareness of available technological solutions and management practices that improve broiler chicken welfare, as well as their effects on broiler farm performance, contributing to the resilience and sustainability of the European broiler sector.

2. Materials and Methods

The starting point in the process of identifying and evaluating animal welfare improvement practices was the determination of key challenges faced by the broiler chicken sector in European Union countries. These challenges served as guidelines for identifying innovative solutions (“good practices”) implemented on commercial broiler farms, which were subsequently assessed within the conceptual framework presented in Figure 1.

Identifying challenges was the first step in the process of defining and evaluating good practices aimed at improving broiler chicken welfare. For this purpose, 13 Broiler Innovation Networks (BINs) were established in the partner countries to identify the most urgent innovation needs and challenges across three key themes: environmental sustainability, animal welfare, and animal health management. The BINs included broiler farmers and farmers' organizations, integrator companies, advisors, veterinarians, and

researchers. In the next step, they were responsible for collecting innovative ideas and good practices (GPs).

At the European level, Thematic Expert Networks (TENs) composed of practitioners and researchers were established to evaluate the innovative ideas and practices identified by the BINs, including cost–benefit economic assessments. Sharing knowledge and disseminating practice-ready solutions constitute the final step within this framework. BroilerNet team members were actively involved in identifying practices that addressed the challenges formulated at the start of the project. This consultation process was repeated three times over four successive years and resulted in the collection of a total of 341 practices in three thematic areas: animal welfare, health management, and environment. In the animal welfare area, farmers and project team members proposed 112 practices addressing eight challenges (Table 1). The full list of best practices for animal welfare can be found in Vonholdt-Wenker et al. [17].

Table 1. Classification of good practices according animal welfare challenges.

Challenge	Share in the Total Number of GPs	Action Areas	Specific Welfare Benefits of GP Implementation
Barn climate	17.1%	Climate control; monitoring; litter management; welfare support	Thermal comfort, improved housing conditions, and early detection of welfare problems
Farmer training	14.4%	Training; e-learning; audits; handling procedures	Improved staff competencies, reduced injuries and handling stress, and welfare program implementation
Genetics and Breeding	7.2%	Welfare-oriented selection; housing adaptation; breeding management	Improved adaptation of rearing conditions and selection criteria for animal welfare requirements
On-farm welfare assessment and management	10.8%	AI and sensor monitoring; welfare indicators; self-assessment	Early detection and objective assessment of welfare, fast response to problems related to welfare that arise
Young chick management	12.6%	Microclimate; early feeding; survival support	Supporting chicks in their first days of life, leading to reduced stress, lower mortality, and improved final rearing results
Stress and damage from catching	14.4%	Mechanization; training and team organization; stress reduction	Reduced injuries, handling stress, and number of manual actions
Light management	9.0%	Photoperiod; LED; natural/full-spectrum light	Improved behavioral welfare and biological rhythm
Stress management during catching/thinning	14.4%	Fasting reduction; catching procedures; equipment	Improved staff organization, reduced pre-slaughter stress and damage
Total	100%	—	—

The Good Practice Evaluation Tool was used to identify the best practices among all of those collected in the countries involved in the project. The evaluation was based on a set of criteria designed to determine the extent to which each practice addressed a specific challenge and the potential for measuring its impact on broiler farm performance. Practices were assessed and scored against the following criteria.

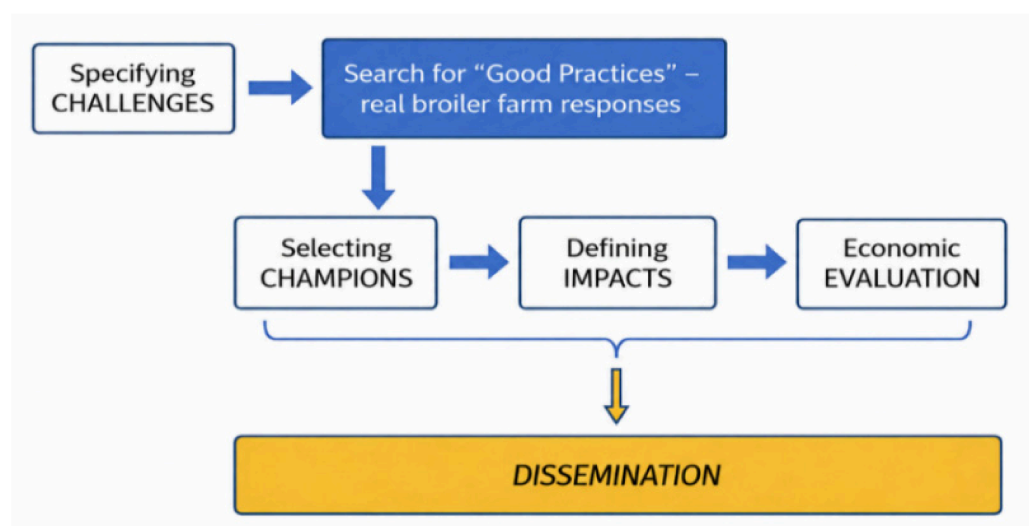


Figure 1. Conceptual framework for assessing good practices that improve broiler welfare.

Technical excellence

Assessment of the quality of the practice (includes the clarity, level of detail, and technical validity of the GP; the robustness and the extensiveness of the scientific evidence behind the GP; the degree of innovation/novelty of the GP; the extent to which the GP has been tried, tested, and refined).

Impact

Assessment of the impact (includes the extent to which the GP addresses one or more of the challenges highlighted by the BINs; the extent to which the agricultural practice has a positive economic, social, and environmental impact at farm level; the extent to which there is a positive impact on animal health and welfare and/or environmental sustainability; the duration of the potential/actual impact resulting from the GP; the relevance and benefits of the GP for the sector as a whole).

Exploitability

Assessment of the feasibility and uptake potential of the practice (includes feasibility and ease of adoption of the GP by other farmers; scalability of the GP; transferability of the GP to other contexts/farming systems/countries; the speed at which the GP can be exploited (in the short, medium, or long term)).

With reference to the criteria above, each practice was evaluated according to the guidelines presented in Table 2.

Table 2. The scoring guidelines for the evaluation of practices collected.

0—Negative	The practice cannot be assessed due to missing or incomplete information.
1—Poor	The practice is inadequately described, or there are serious inherent weaknesses.
2—Fair	The practice broadly addresses the criterion, but there are significant weaknesses.
3—Good	The practice addresses the criterion well, but a number of shortcomings are present.
4—Very Good	The practice addresses the criterion very well, but a small number of shortcomings are present.
5—Excellent	The practice successfully addresses all relevant aspects of the criterion. Any shortcomings are minor.

The final selection of the top 24 best practices was based on a ranking list constructed according to the total number of points allocated to each practice. The selection process

was carried out by the members of the Thematic Expert Networks (TENs) through the following steps:

1. Filtering out practices that do not clearly address the challenges under consideration;
2. Scoring and providing brief comments on the 10 best practices selected individually by each TEN expert;
3. Calculating the average score for each good practice selected by all TEN experts and ranking the highest-performing practices;
4. Discussing and ranking the top five best practices at the TEN discussion meetings. The authors deleted the text before the words “Champions” through a structured expert assessment.

2.1. Defining Impacts

Assessing the impacts of good practice implementation on animal welfare and production performance constituted an intermediate step in estimating economic outcomes. Improvements in animal welfare are inherently difficult to quantify, and their contribution to the economic performance of broiler farms can often be assessed only indirectly through the identification of potential benefits and additional costs associated with implementation. Table 3 presents examples of potential impacts that may result in changes in production volume, input use, and production costs. Adjustments in broiler and input prices may also need to be considered when a good practice requires higher-quality inputs or improves broiler quality, thereby enabling farmers to achieve premium market prices.

Table 3. Potential farm-level impacts of implementing good practices.

Production	Inputs/Costs	Prices
Feed conversion rate	Feed composition	Broilers
Mortality	Labor	Inputs
Length of the cycle	Veterinary services	Labor
Daily weight gains	Biosecurity	
Meat quality	Additional (new) inputs	
	Investments in fixed assets	

Broiler farms in which the analyzed practices had been implemented were the primary source of information on the actual implementation process, including additional inputs and costs, as well as outcomes observed by farmers and their advisors. This information formed an integral part of the standardized descriptions of each practice and served as the basis for formulating assumptions for the economic analyses. However, farm-level data were in some cases incomplete or available only in a descriptive form, as systematic and continuous measurements were not carried out on many farms. Farmers frequently rely on personal observations and it is uncommon to have standardized monitoring systems across such a range of farming systems. They may observe changes such as lower mortality, fewer disease outbreaks, or reduced veterinary interventions, but these observations are not always recorded quantitatively or consistently, particularly when data collection is conducted for purposes other than the formal evaluation of implementation outcomes. As a result, available datasets may be incomplete and may not fully capture causal relationships. Reliance on self-reported data can also introduce systematic measurement bias, whereby reported values deviate from actual values through either overestimation or underestimation.

When farm-level data are insufficient, economic analyses typically draw on multiple sources of information, including experimental and pilot studies, the peer-reviewed sci-

tific literature, and expert judgment [18]. Therefore, the following additional information sources were used in the study:

1. Agricultural advisors and veterinarians involved in the practical implementation of the analyzed practices;
2. Scientific experts;
3. Published studies reporting the results of scientific experiments.

To reduce the potential consequences of incomplete data and measurement bias, particularly where available information did not provide precise parameter values but only indications for defining plausible ranges of outcomes, a sensitivity analysis was conducted. Following OECD recommendations [18,19], multiple scenarios were estimated instead of relying on single-point outcome estimates.

The gross margin (GM) was the key indicator used to assess the financial performance of broiler farms following the implementation of animal welfare improvement practices. It was calculated as the difference between revenues from broiler sales and the direct costs attributable to broiler rearing. The economic impacts were assessed using the partial budgeting method. Under this approach, only revenue and cost components that changed as a result of implementing a specific practice and consequently increased or decreased the gross margin were considered.

The assessments were conducted using typical farm models constructed to represent the most common types of broiler farms in each country participating in the BroilerNet project. The typical farm concept is widely used in agricultural economic analysis because the sector comprises a large number of heterogeneous farm businesses that differ in size, resource endowment, production structure, technologies applied, and natural farming conditions [20,21]. Typical farm models make it possible to capture this diversity while providing a consistent basis for comparative economic analysis. The set of typical farm models developed for the 13 countries included three production systems (conventional, free range, and organic) and four broiler flock size categories (small, medium, large, and very large). Each farm model solution consisted of a set of technical and economic performance indicators.

The data used to construct the models were collected in 2022 by the project partner representing each country. The resulting 2022 baseline models served as a reference against which the modeled outcomes incorporating the assumed effects of implementing the selected good practices were compared.

2.2. Selected Animal Welfare Practices and Assumptions for Economic Assessments

Table 4 presents the animal welfare improving practices selected for inclusion in this paper. Practices GP01–GP04, and GP06 were nominated animal welfare “Champions”. The GP05 practice, champion in the category of environmental impacts, was added due to its animal welfare and health effects. These cases were identified as the most innovative and impactful, demonstrating significant improvements in animal welfare while also generating meaningful changes in revenues or costs, which lie at the core of economic assessment.

Table 5 provides a brief description of the animal welfare “Champions,” including the activities, tools, and specific inputs involved in their implementation, as well as information collected from farmers and their advisors regarding the observed effects.

The following subsections present the detailed parameters used for estimating the economic effects of implementing the analyzed practices within the respective typical farm models. These parameters were developed based on practice descriptions, expert and scientific knowledge, and, in particular, accumulated experience and relevant literature sources.

Table 4. Selection of good practices responding to animal welfare challenges.

Code	Title	Country *
GP01	Interventions providing straw and natural light in broiler houses based on the EBENE self-assessment tool	France
GP02	Package of measures to minimize stress and injuries while catching broilers	Greece
GP03	Preheating the poultry house	France
GP04	Elevated platforms to mitigate negative effects of genetic selection for rapid growth on lameness	Spain
GP05	Litter aeration and litter addition	France
GP06	Stocking density reduction and the Foot Health Program	Sweden

* Country from which the good practice was submitted.

Table 5. Description of good practices responding to animal welfare challenges.

Code	Title of the Good Practice (Champion)	Effects Observed by Farmer Recommending the Practice
GP01	Providing straw and natural light in broiler houses based on the EBENE self-assessment	
	The EBENE application is a tool designed to conduct structured welfare assessments using a detailed questionnaire and observational protocols that assess various aspects of poultry welfare (e.g., access to feeders, drinkers, perches, space availability, mortality rates, enrichment, farmer practices, and sexing). It can be used to diagnose and identify areas requiring improvements. Specific activities undertaken based on conclusions of the evaluation were the addition of enrichment (bales of straw) and installing windows to provide natural light entering the broiler house.	Promoting active behaviors (e.g., foraging, dust bathing, positive social interactions among the broilers) and improving litter quality, thereby reducing the incidence of footpad dermatitis.
GP02	Package of measures to minimize stress and injuries while catching broilers	
	The package of measures includes the following activities: • Training collection personnel in proper handling of broilers; • Providing antioxidants and electrolytes to the broilers 24 h before catching; • Conducting regular welfare inspections to ensure proper collection and loading practices; • Using blue light during collection; • Creating more collection points to minimize handling time.	Mitigating stress and reducing injuries due to creation of a calmer environment.
GP03	Preheating of the poultry house	
	Heating starts 36 h before introducing the chicks (72 h if the ground is frozen in the winter). The temperature is gradually increased to the optimal level (30–32 °C) measured at chicks' level. After removal of excessive moisture through ventilation, litter is added.	Preheating reduces stress and facilitates initial adaptation to the broiler house environment.
GP04	Elevated platforms to mitigate negative effects of genetic selection for rapid growth on lameness	
	The practice consists of installing elevated resting places (platforms), stimulating natural behaviors, and improving broiler comfort. It is assumed that one platform with an area of 2.1 m ² is provided for every 5000 broilers.	It reduces footpad dermatitis, hock burns, and walking difficulties, even at a high stocking density.
GP05	Litter aeration and litter addition	
	The practice includes litter aeration, which may be carried out every five days until the chickens reach 20 days of age, as well as the addition of fresh litter, particularly in areas that are moist or have become caked.	Aeration improves broiler welfare by maintaining drier litter conditions and reducing ammonia concentrations within the broiler house.

Table 5. Cont.

Code	Title of the Good Practice (Champion)	Effects Observed by Farmer Recommending the Practice
GP06	Stocking density reduction and the Foot Health Program	
	The practice aims to reduce footpad dermatitis by requiring a reduction in stocking density when slaughterhouse inspection results exceed the minimum threshold score. Because no farm-level intervention was reported, the impacts of reducing stocking density to different levels were assessed separately from other measures.	Productivity and financial performance were evaluated by considering the positive effects of lower stocking density on broiler welfare and health.

In line with the adopted sensitivity analysis framework, three scenarios were developed for each practice: A (optimistic), B (moderate), and C (pessimistic). The scenarios differ primarily in the magnitude of the expected benefits resulting from the implementation of a given practice, while the associated implementation costs exhibit relatively smaller variation across scenarios.

2.2.1. Assumptions for GP01 Model: Providing Straw and Natural Light in Broiler Houses

Table 6 presents the parameters used to model the implementation of activities identified through the self-assessment of animal welfare using the EBENE diagnostic tool.

Table 6. Assumptions for the economic evaluation of recommended actions based on EBENE diagnostics.

ITEM	Benefits			Inputs		
	A	B	C	A	B	C
Higher weight gain (g/broiler)	30.0	20.0	10.0			
Premium price (%)	5.0	0	0			
Veterinary costs (%)	−1.50	−1.25	−1.0			
Additional labor for litter (hours)				6.0	6.0	6.0
Increased water consumption (%)				5.0	5.0	5.0
Savings on energy use (%)	−10.0	−7.5	−5.0			
Additional litter (EUR/broiler)				0.005	0.005	0.005
Investment to provide natural light (EUR/m ²)				25	25	25

The proposed practice concerns the application of a diagnostic tool, EBENE, whose significance extends beyond the mere observation of production practices. Active engagement of farmers in reflecting on animal welfare issues can motivate them to undertake activities that improve the welfare of farm animals [22–25], which may in turn have a positive impact on productivity and financial performance. The main benefits considered in the model were improved weight gain and reduced energy costs resulting from lower electricity consumption due to the provision of natural light in buildings. In addition, the optimistic scenario included a price premium associated with improved animal welfare.

Investments required to provide natural light in broiler houses are substantially less expensive in newly constructed buildings where windows are incorporated into the original design [26,27]. For the cost–benefit analysis for this practice, a higher value of investment was assumed, considering retrofitting of existing buildings.

Literature review supporting assumptions for modeling

The practice has a rather moderate impact on production performance, as the evidence is more consistent for activity and behavioral expression. Bailie et al. [28] found that the provision of natural light reduced the time broilers spent lying and improved gait scores and latency-to-lie, whereas the effects of straw bales alone were more limited and varied with bird age. The welfare benefits of straw bales may therefore be enhanced when they are combined with natural light or other forms of environmental enrichment [28,29]. Research indicates that natural light can stimulate walking, exploration, foraging, and other active behaviors and may improve certain indicators of leg health. However, its effects on production performance and other welfare outcomes are not consistent across studies. Bailie et al. [28] reported improved gait scores and latency-to-lie, while de Jong and Gunnink [29] found increased walking, exploration, and foraging but no significant effects on lameness, footpad dermatitis, hock burn, injuries, or production performance. Fouda et al. [30] observed a higher body weight at five weeks of age but less significant effects on overall weight gain, feed consumption, feed conversion ratio, and footpad dermatitis. The benefits of natural light are more consistently associated with increased activity and the expression of natural behaviors than improved production performance. Outcomes depend on the intensity, distribution, and duration of light, as well as house design, bird age, genotype, and overall management conditions [28–32].

2.2.2. Assumptions for GP02 Model: Package of Measures to Minimize Stress and Injuries During Catching of Live Broilers

Table 7 presents parameters used to model the production and economic impacts of introducing the package.

Table 7. Assumptions for the economic assessment of the Champion: package of measures to minimize stress and injuries during catching of live broilers. *

ITEM	Benefits			Inputs		
	A	B	C	A	B	C
Increased sales due to lower condemnation ¹ after catching (%)	0.10	0.08	0.07			
Additional inputs: antioxidants and electrolytes (EUR/1000 L of water)				5.1	5.1	5.1

¹ condemnation: carcasses rejected by the slaughterhouse due to damages or defects. * Assumptions based on Langkabel et al. [33].

The primary effect of implementing this practice is related to post-slaughter quality assessment carried out at the slaughterhouse. Identified defects and injuries result in a reduction in carcass value and, in some cases, complete rejection, thereby decreasing sales revenues. Reducing stress during catching improves animal welfare, leading to lower bird fearfulness and, consequently, a reduction in the number of defects identified after slaughter. The main benefit of implementing the practice is a lower condemnation rate and increased sales revenues. The key measures involved include low-cost employee training and the use of antioxidants and electrolytes.

Literature review supporting assumptions for modeling

The antioxidants and electrolytes given to broilers have stress-mitigation effects. Electrolytes are critical in maintaining water balance, regulating acid–base homeostasis, and supporting nerve and muscle function. Stress-related dehydration and metabolic disturbances increase the demand for key electrolytes, such as sodium, potassium, chloride, calcium, and magnesium [34]. Supplementing broilers with electrolytes before catching

may help prevent dehydration, reduce stress-related metabolic imbalances, and improve their ability to withstand transport stress [35] by maintaining physiological balance and improving overall resilience.

2.2.3. Assumptions for GP03 Model: Preheating of the Poultry House

Table 8 presents parameters used to model production and economic impacts of introducing the practice.

Table 8. Assumptions for the economic assessment of the Champion: preheating of the poultry house.

ITEM	Benefits			Inputs		
	A	B	C	A	B	C
Higher weight gains (g/broiler)	30.0	20.0	10.0			
Lower veterinary costs (%)	−1.5	−1.5	−1.5			
Mortality reduction (percentage points)	0.55	0.45	0.35			
Additional consumption of water (%)				5.0	4.0	3.0
Additional energy cost (%)				5.5	5.5	5.5

Preheating of broiler houses is one of the essential best practices in poultry production by ensuring comfort for chicks immediately after hatching. Improving animal welfare at the earliest stage of the production cycle positively affects bird health and production performance, as the poorly developed thermoregulatory systems of chicks make them highly sensitive to temperature fluctuations [36]. Preheating reduces stress and facilitates initial adaptation to the environment. The assumed benefits include improved weight gains, reduced mortality, and lower veterinary costs.

Literature review supporting assumptions for modeling

Proper preheating of broiler houses and maintaining optimal floor and air temperatures (30–32 °C at chick level) reduce cold stress, improve chick activity, and increase feed and water intake, resulting in better growth and feed efficiency [37–39]. Chicks exposed to low temperatures divert energy to thermoregulation rather than growth, leading to poorer performance and greater flock variability.

Research also indicates that preheating during the first days of life is a key factor in reducing stress and supporting early development [40]. Adequate brooding temperatures lower early mortality by reducing the risk of dehydration, kidney infections, and other stress-related health issues [37,41]. In addition, stable environmental conditions improve flock uniformity, reduce culling, and enhance processing efficiency, while better litter and air quality help limit respiratory diseases and footpad dermatitis [38,42].

2.2.4. Assumptions for GP04 Model: Provide the Farms with Elevated Platforms (Spain)

Table 9 presents parameters used to model the production and economic impacts of introducing the practice, which is considered a mitigation strategy for the negative effects of genetic selection for rapid growth on lameness.

The farmer who implemented platforms on the farm was unable to identify measurable production benefits resulting from their installation. Any positive effects were likely too small to be detected without systematic measurements conducted before and after implementation. Following consultation with a scientific expert, who indicated potential benefits such as improved average weight gains due to reduced lameness, lower mortality, higher sales revenues, and reduced veterinary costs, an optimistic scenario (A) was developed.

Table 9. Assumptions for the economic evaluation of GP04: provide the farms with elevated platforms. *

ITEM	Benefits			Inputs		
	A	B	C **	A	B	C
Higher weight gain [g/broiler]	20.0	10.0	-			
Lower veterinary costs [%]	−2.0	−1.0	-			
Lower mortality [percentage points]	−1.0	−1.0	-			
Higher labor input [%]				2.0	2.0	2.0
Higher costs of cleaning and disinfection [%]				1.5	1.5	1.5
Cost of platforms [EUR/1000 broilers/year]				11.0	11.0	11.0

* Assumptions based on De Roest et al. [43], Riber et al. [44], Norring et al. [45], Gebhardt-Henrich et al. [46], Baxter et al. [47], Ventura et al. [48]. ** The pessimistic scenario reflects the statements of the farmer, who did not observe measurable effects.

As part of the sensitivity analysis, two additional scenarios were defined: a moderate scenario (B), assuming benefits 50% lower than those proposed by the expert, and a pessimistic scenario (C), reflecting the farmer's assessment that no measurable production benefits could be observed. In addition to the investment costs associated with platform installation, the analysis also accounted for increased labor requirements as well as higher cleaning and disinfection costs.

Literature review supporting assumptions for modeling

Perching on elevated places is considered an integral part of chicken behavior. Several studies have reported beneficial effects of elevated platforms on broiler welfare [48–52]. Compared to perches, elevated platforms are considered a better solution for fast-growing broiler chickens due to the broilers' weight, leg weakness, and difficulties finding their balance on bars [44]. Improvements in animal welfare were reported depending on platform surface area, the age of broilers when platforms were provided, and platforms' shape, construction, and accessibility [53,54]. Mocz et al. [55] suggest that providing elevated platforms or straw bales helps improve broiler welfare by reducing footpad dermatitis, hock burns, and walking difficulties, even at a high stocking density. Some reports present measurable financial effects of results concerning enrichment in broiler production [56].

2.2.5. Assumptions for GP05 Model: Litter Aeration and Litter Addition

Table 10 presents parameters used to model the production and economic impacts of introducing the practice.

Table 10. Assumptions for the economic assessment of the Champion: litter aeration and litter addition.

ITEM	Benefits			Inputs		
	A	B	C	A	B	C
Higher weight gain [g/broiler]	10.0	7.5	5.0			
Lower veterinary costs [%]	2.0	1.0	0.5			
Lower mortality [percentage points]	0.5	0.5	0.5			
Higher labor costs [%]				2.0	2.0	2.0
Higher energy costs [%]				0.1	0.1	0.1
Higher litter costs [%]				20.0	20.0	20.0
Additional costs of small equipment [EUR/m ²]				0.35	0.35	0.35

It is assumed that improved broiler welfare resulting from drier litter conditions and reduced ammonia concentrations within the broiler house will enhance bird performance,

leading to greater productivity as well as lower mortality and veterinary costs. However, in addition to the investment cost of aeration equipment, increased expenditures on litter, energy, and labor are expected.

Literature review supporting assumptions for modeling

The scientific rationale for this practice is based on the close relationship between litter moisture, clumping, fecal accumulation, and ammonia emissions. Wet and clumped litter compromises the hygiene of the poultry house and increases the risk of contact dermatitis, including footpad lesions [57,58]. Litter rotation can accelerate drying and improve litter friability only if moisture is effectively removed from the building [59].

The practice of litter aeration is important from an animal welfare perspective. Dry litter is associated with reduced risk of footpad and hock dermatitis and lower litter ammonia concentrations, which are important for both bird health and working conditions in the building [56,60–63]. Furthermore, treatments that reduce litter pH, moisture content, and microbial load have been shown to improve litter quality and partially support broiler performance [15].

2.2.6. Assumptions for GP06 Model: Reducing Stocking Density and the Foot Health Program

Preventing footpad dermatitis is one of the major animal welfare concerns in broiler production. For this reason, the Foot Health Program (FHP), implemented in Sweden, was selected as one of the Champions. The FHP provides a regulatory and advisory mechanism encouraging broiler farmers to achieve tangible improvements in animal welfare through better flock management, improved feed composition, and higher litter quality.

The program is based on the assessment of footpad dermatitis at the slaughterhouse by an official veterinarian employed by the Swedish Food Agency. For each flock, 1000 feet are inspected and scored on a scale ranging from 0 to 200 points. Exceeding the threshold of 40 points results in an obligation to reduce stocking density below the maximum level of 36 kg/m² permitted in Sweden. The higher the footpad score, the greater the required reduction in stocking density. The stocking density restriction is lifted once the score recorded during a subsequent inspection falls below the 40 point threshold.

Various measures intended to improve animal welfare through better broiler flock management were assessed under other Champion good practices. Therefore, in the present analysis, the Swedish FHP was used primarily as a basis for estimating the economic and production effects of reducing stocking density to different levels. It was assumed that all typical farm models maintained an appropriate standard of broiler management and housing conditions.

The assessments were conducted for conventional farm types across four flock size categories. The stocking density scenarios were defined with reference to Council Directive 2007/43/EC:

- General maximum of 33 kg live weight/m²;
- Weight of 39 kg/m² permitted if additional environmental, monitoring, and documentation requirements are met;
- Weight of 42 kg/m² permitted exceptionally where farms demonstrate low mortality and consistently good management;
- 30 kg/m² as required by the signatories of the European Chicken Commitment (ECC) from their suppliers of broilers. To ensure comparability between the model results and to isolate the effect of stocking density, the calculations for the 30 kg/m² scenario were based on the same Ross 308 broiler breed as the other models. This scenario should therefore not be interpreted as representing full compliance with the ECC, which also requires the use of approved breeds demonstrating higher welfare outcomes.

An additional model was constructed for a maximum stocking density of 42 kg live weight/m² combined with thinning. Under this scenario, the cumulative live weight of broilers produced over the production cycle could reach 46 kg/m², although the stocking density present in the house at any given time does not exceed 42 kg/m².

All 2022 baseline typical farm models were standardized to a stocking density of 42 kg/m². These standardized models served as the common reference scenarios for comparing the economic effects of reductions in stocking density. The quantities of the principal variable inputs, including chicks, feed, and water, were adjusted according to the changing number of broilers placed in each model. Expenditures on energy, veterinary services, biosecurity, and miscellaneous inputs were maintained at the levels recorded in the respective 2022 baseline models. For the lower-density scenarios, benefits associated with the reduction in the number of broilers kept per square meter were incorporated into the calculations, as presented in Table 11. Parallel models in which no performance or welfare-related benefits were assumed were also calculated. These represented the pessimistic scenario included in the sensitivity analysis.

Table 11. Assumptions for the economic assessment of the Champion: reducing stocking density and the Foot Health Program.

ITEM	Benefits		
	Model 39 kg/m ²	Model 33 kg/m ²	Model 30 kg/m ²
Higher weight gain [g/broiler]	+10	+20	+25
Lower veterinary costs [%]	−1%	−4%	−5%
Lower mortality [percentage points]	0.1	0.15	0.2
Lower labor input [%]	−1%	−2%	−3%

Literature review supporting assumptions for modeling

Reducing stocking density is included in the Foot Welfare Program as a measure to prevent footpad dermatitis. Evidence suggests that it improves animal welfare and may also increase weight gain and final body weight in broilers [64–69], although effects on the feed conversion ratio and mortality are less consistent. A positive effect of lower stocking density on weight gain was also reported by van der Eijk et al. [70] in an experimental study in which genotype and stocking density were examined independently. Similar results were reported by Weimer et al. [71], who emphasized that the benefits reflect not only stocking density itself but also broader improvements in welfare and production conditions.

3. Results

3.1. Baseline Model 2022 Characteristics

Table 12 presents selected indicators characterizing the baseline models of typical farms, calculated as weighted averages for country models representing the respective flock sizes and production systems. Within the sample of 120 models, conventional farms of all flock sizes (small, medium, large, and very large) outnumbered other farm types, reflecting the structure of broiler production in the EU and countries included in the study.

Average productivity indicators for the conventional baseline models showed relatively little variation across flock size categories, apart from the expected differences in the number of broilers produced. Small and medium-sized flocks had slightly less favorable feed conversion ratios (FCRs), averaging 1.656 and 1.616, respectively, compared with 1.592 for large flocks and 1.584 for very large flocks. Mortality rates were not significantly associated with either flock size or production system, remaining within a relatively narrow

range from 3.50% in very large conventional flocks to 3.83% in small conventional flocks and 3.84% in free range flocks. The average live weight of broilers was higher in the small and medium flocks (2.48 and 2.43 kg), correlating with the average length of the cycle (41.2 and 40.8 days, respectively).

Table 12. Performance indicators—2022 Base Models by flock size and production system.

Indicators	Conventional				Free Range	Organic
	Small	Medium	Large	Very Large		
Technical parameters						
Number of broilers [th.]	145.7	410.4	1332.6	20,474.5	136.3	24.5
Number of cycles	6.0	6.3	6.8	6.8	3.8	3.1
CoV (%)	15.7	13.5	15.3	9.5	25.1	24.4
Length of cycle (days)	41.2	40.8	39.0	38.8	79.2	84.6
CoV (%)	4.1	8.4	14.2	7.6	17.5	6.2
Live weight [kg]	2.48	2.43	2.35	2.35	2.75	3.32
CoV (%)	10.8	8.7	15.5	17.4	12.9	21
FCR	1.653	1.616	1.592	1.584	2.63	2.741
CoV (%)	8.1	7.1	7.1	5	8.8	13.2
Mortality (%)	3.83	3.80	3.73	3.50	3.84	3.70
CoV (%)	17.2	19.6	27.9	27.9	29.5	53.0
Financial indicators						
Broiler price [EUR/kg]	1.226	1.228	1.264	1.255	1.826	2.998
CoV (%)	5.9	8.2	9.5	4.9	8.9	59.3
Chick price [EUR/bird]	0.43	0.4	0.42	0.41	0.46	0.67
CoV (%)	9.4	9.2	11.4	8.8	14.0	69.8
Revenue [EUR/kg LW]	1.249	1.237	1.271	1.262	1.831	3.012
CoV (%)	7.4	7.8	8.9	5.3	9.2	59.1
Total costs [EUR/kg LW]	1.079	1.054	1.078	1.131	1.414	2.121
CoV (%)	11.2	9.6	10.7	3.5	8.2	22.6
Gross margin [EUR/kg LW]	0.170	0.183	0.193	0.131	0.417	0.891
CoV (%)	36.1	28.8	36.0	37.9	33.4	155.6

Several indicators differed substantially in the free range and organic models because of the specific characteristics of these production systems. The most notable difference was the approximately twofold longer production cycle, which consequently resulted in fewer production cycles per year. Feed conversion ratios were also considerably higher than in conventional systems, ranging from 2.63 to 2.74, compared to an average of approximately 1.6 in the conventional models.

Most production indicators exhibited moderate variation across farm types. The greatest variability was observed in the number of production cycles per year and mortality rates, as indicated by their relatively high coefficients of variation.

In terms of profitability, medium-sized and large conventional farms achieved the highest average gross margins per kilogram of live weight at approximately EUR 0.19/kg. The corresponding gross margin was noticeably lower for very large conventional farms at EUR 0.13/kg. Free range and organic production systems generated substantially

higher gross margins per kilogram of live weight, primarily because of the premium prices received for broilers produced under these systems. The coefficient of variation for the gross margin was relatively high across all farm types, ranging from 28.8% to 37.9% in conventional and free range systems. The very high coefficient of variation recorded for organic farms at 155.6% was attributable to unusually high organic broiler prices in one of the countries included in the sample. Figure 2 presents the structure of variable costs of production.

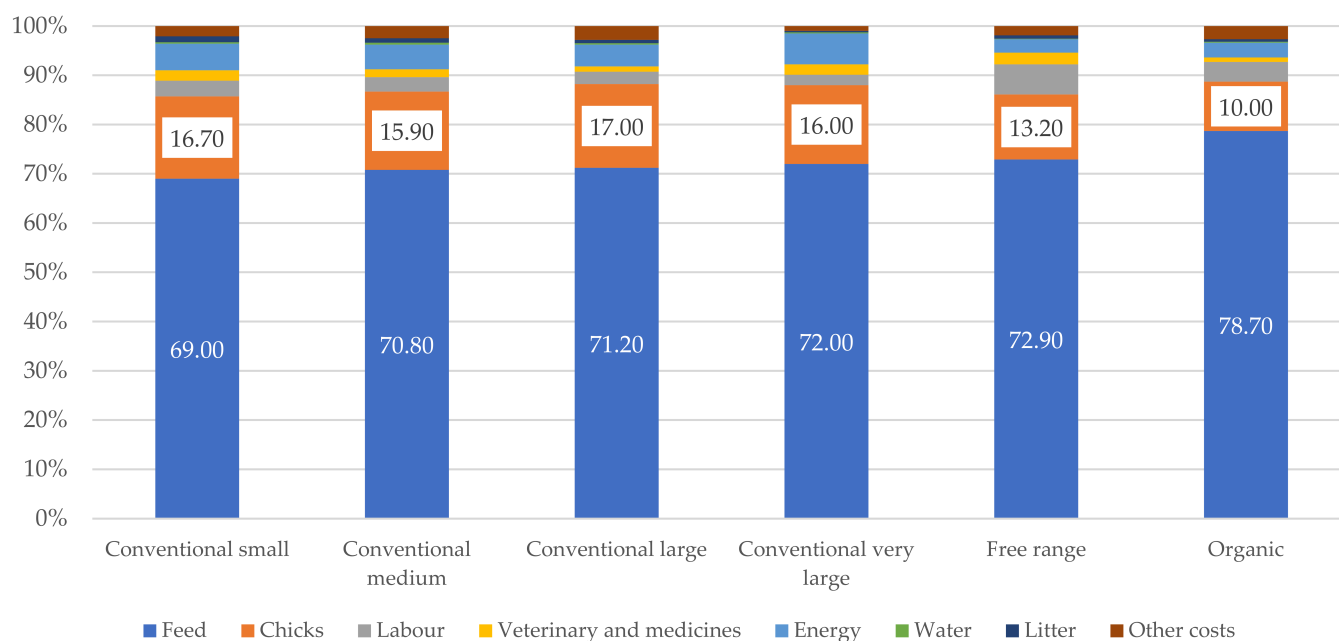


Figure 2. Cost structure by farm size and production system.

Feed and chick costs constituted the largest component of the direct costs included in the gross margin calculation, accounting for between 85.7% and 88.7% of the total. The dominating contribution of feed and day-old chicks is characteristic of broiler production and consistent with the cost structures reported in previous studies (e.g., [72]).

It should be emphasized, however, that European feed prices in 2022 were considerably higher than the five-year average and exceeded the long-term trend line. These exceptionally high prices increased the share of feed costs in total production costs and consequently reduced gross margins. The choice of 2022 as the reference year was determined by the study timetable. Owing to the use of the partial budgeting method, this choice did not affect the comparative assessment of the analyzed scenarios, even though feed prices declined significantly in subsequent years. It did, however, result in lower absolute gross margin values.

Fixed costs, including depreciation, maintenance of fixed assets, and general farm overheads, were not included in the calculations. This reflects the partial budgeting approach adopted in the study, under which only costs and benefits that changed as a result of implementing a particular practice were considered. Consequently, the exclusion of existing fixed costs did not affect the estimated economic impacts, provided that these costs remained unchanged following implementation. Any additional investment or other fixed costs directly attributable to a specific practice were, however, included in its economic assessment.

3.2. Results of the Economic Assessments

Separate farm type models were developed for each assessed good practice by incorporating the changes specified in the adopted assumptions. The results generated by these models were subsequently compared with those of the corresponding 2022 baseline models. Section 3.2 presents only the estimated financial impacts of implementing the selected Champion good practices and does not provide a detailed comparison of production performance indicators. Changes in the key production parameters relative to the baseline models, such as broiler live weight, mortality rate, and feed conversion ratio (FCR), were moderate and consistent with the assumptions adopted for the respective scenarios.

GP01: Interventions providing straw and natural light in broiler houses based on the EBENE self-assessment of animal welfare

EBENE self-assessment makes it possible to identify weaknesses in broiler flock management and therefore provides a basis for implementing corrective measures. In the case analyzed, provision of natural light in the broiler house and use of straw for enrichment were identified as effective measures for improving animal welfare.

Table 13 presents the estimated financial results for farms operating conventional production systems following the implementation of this practice. Free range and organic farms were excluded from the analysis because broilers in these systems spend a substantial part of the day outdoors, making the source of light inside of the poultry house relatively less important.

Table 13. GP01: financial impacts of intervention “providing straw and natural light in broiler houses” based on the EBENE self-assessment of animal welfare.

Scenario	Conventional			
	Small	Medium	Large	Very Large
Revenue [EUR/kg live weight]				
Baseline	1.249	1.237	1.271	1.262
A	1.255	1.243	1.277	1.268
B	1.249	1.236	1.271	1.262
C	1.249	1.236	1.271	1.262
Total direct costs [EUR/kg live weight]				
Baseline	1.079	1.054	1.078	1.131
A	1.079	1.047	1.070	1.122
B	1.083	1.051	1.074	1.127
C	1.087	1.055	1.079	1.131
Gross margin [EUR/kg live weight]				
Baseline	0.170	0.183	0.193	0.131
A	0.176	0.196	0.207	0.146
B	0.166	0.185	0.197	0.136
C	0.162	0.181	0.192	0.131

Despite the expenditure required to modernize the broiler houses through the installation of windows, the gross margin was either slightly higher or remained close to the baseline level across all flock size models and scenarios. A clear financial benefit was observed only in Scenario A, in which a premium price was assumed. Under this scenario, the gross margin increased by between EUR 0.11 and EUR 0.15 per kilogram of live weight.

Production costs in Scenario A were also slightly lower than in Scenarios B and C by approximately EUR 0.04–0.05 per kilogram of live weight. This difference resulted from the assumed savings in veterinary and energy costs.

Figure 3 presents a graphic illustration of gross margin change in relation to the 2022 baseline model.

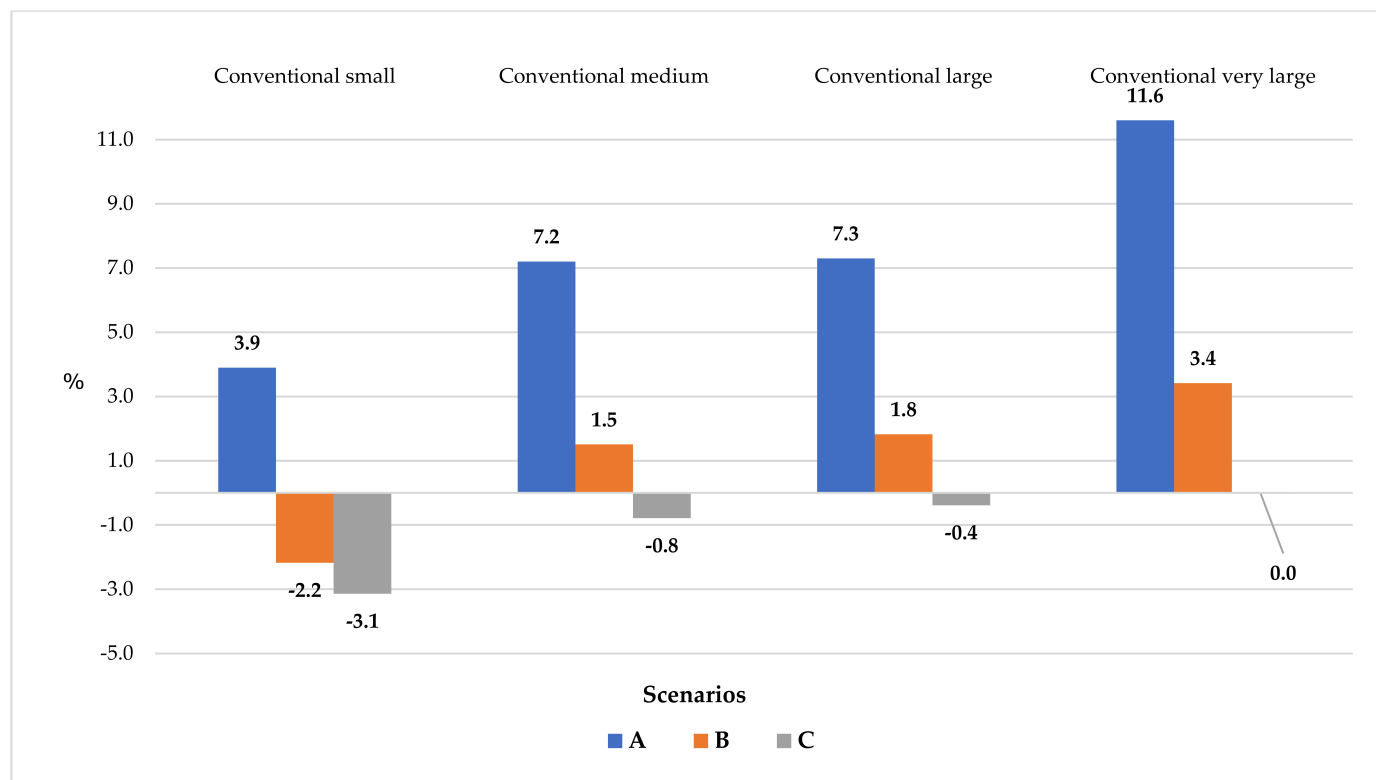


Figure 3. Change in average values of gross margin after implementation of GP01 “providing straw and natural light in broiler houses” relative to the 2022 baseline model (%).

The chart confirms the observed differences in gross margin. Because of high refitting costs, clear financial benefits would arise only if a price premium were obtained, as assumed in Scenario A. Under the moderate scenario (B), small financial gains were recorded for farms with larger flocks, whereas small farms did not benefit because of their insufficient scale of production. Under the pessimistic scenario (C), the practice was not economically viable for any farm type. Nevertheless, because the deterioration in gross margin relative to the baseline model was minimal, the results do not preclude implementation of the practice for animal welfare reasons. This may be particularly relevant for well-managed farms where the likelihood of the pessimistic scenario can be considered relatively low.

GP02: Package of measures to minimize stress and injuries while catching broilers

The economic assessment of implementing this practice was conducted for both conventional and alternative production systems (Table 14). Only very large flocks were excluded from the analysis, as it was considered unlikely that at such a large production scale automated broiler catching would be replaced by manual catching.

As the practice is applied during the final stage of the production cycle, its implementation has only a very limited effect on production performance and financial outcomes. The only direct benefit is a reduction in carcass condemnations at slaughter, resulting in higher sales revenue. The additional costs of antioxidants and electrolytes, together with a slight increase in labor inputs, are approximately offset by the higher revenue. Consequently,

the gross margin remains close to the baseline level and varies only marginally across the scenarios (Figure 4).

Table 14. Financial impacts of minimizing stress and injuries while catching broilers.

Scenario	Conventional			Free Range	Organic
	Small	Medium	Large		
Revenue [EUR/kg live weight]					
Baseline	1.249	1.237	1.271	1.831	3.012
A–C	1.250–1.249	1.238–1.237	1.272–1.271	1.832–1.831	3.015–3.014
Total direct costs [EUR/kg live weight]					
Baseline	1.079	1.054	1.078	1.414	2.121
A–C	1.079–1.080	1.054	1.078–1.078	1.414	2.120
Gross margin [EUR/kg live weight]					
Baseline	0.170	0.183	0.193	0.416	0.892–0.894
A–C	0.171–0.170	0.184–0.183	0.194–0.193	0.418–0.418	0.896

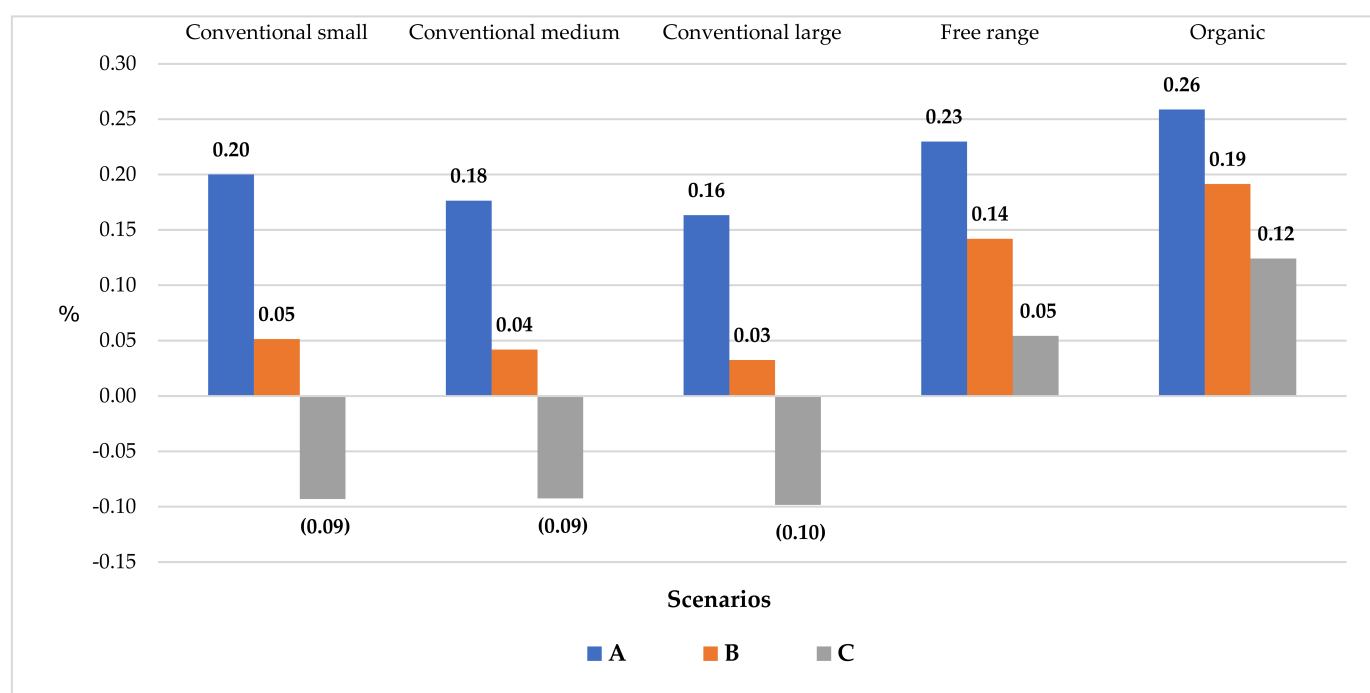


Figure 4. Change in average values of gross margin after implementation of GP02 “minimizing stress and injuries during catching” relative to the 2022 baseline model (%).

Only under the optimistic and moderate scenarios did reductions in carcass condemnations result in a slight improvement in financial performance. Compared with the baseline model, the gross margin increases by 0.16–0.25% under Scenario A and by 0.03–0.12% under Scenario B. Under the pessimistic scenario, positive financial effects are observed only on farms using alternative production systems, where the gross margin increased by 0.05–0.12% owing to substantially higher broiler selling prices. On conventional farms, this scenario results in a slight deterioration in the gross margin, amounting to 0.09%.

GP03: Preheating of the poultry house

Under the assumptions adopted in the analysis, preheating the poultry house before chick placement significantly improves both production and financial performance (Table 15).

The implementation of this practice primarily results in a moderate increase in energy costs associated with preheating the poultry house. At the same time, however, it generates substantial improvements in chick health, reduces mortality, enhances broiler weight gain, and increases gross margins compared with the baseline model.

Figure 5 illustrates the resulting financial benefits.

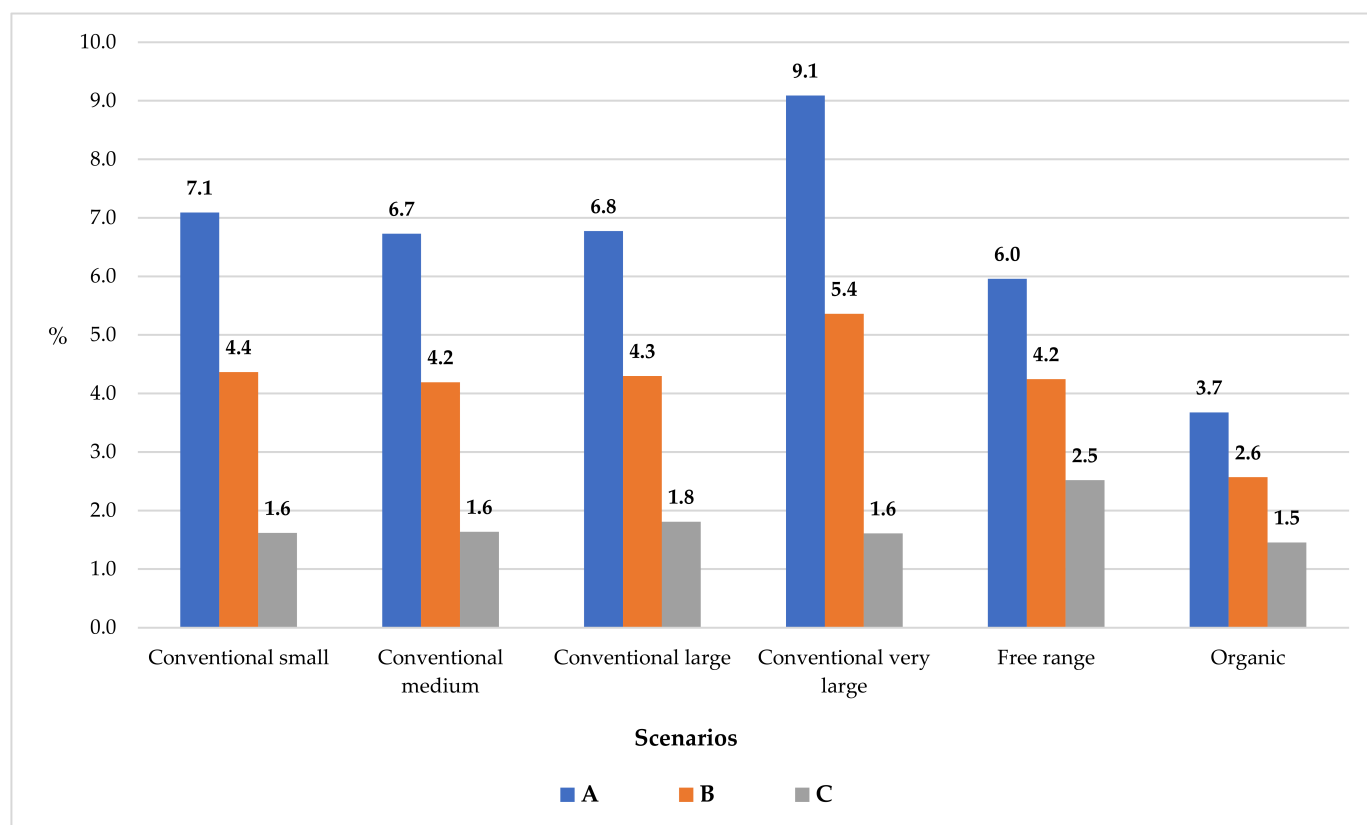


Figure 5. Change in average values of gross margin after implementation of GP03 “Preheating of the poultry house” relative to the 2022 baseline model (%).

Table 15. Financial impacts of preheating the broiler house.

Scenario	Conventional				Free Range	Organic
	Small	Medium	Large	Very Large		
Revenue [EUR/kg live weight]						
Baseline	1.249	1.237	1.271	1.262	1.831	3.012
A	1.254	1.241	1.276	1.267	1.840	3.022
B	1.253	1.241	1.275	1.266	1.838	3.021
C	1.252	1.240	1.274	1.265	1.837	3.019

Table 15. Cont.

Scenario	Conventional				Free Range	Organic
	Small	Medium	Large	Very Large		
Total direct costs [EUR/kg live weight]						
Baseline	1.079	1.054	1.078	1.131	1.414	2.121
A	1.068	1.042	1.065	1.120	1.392	2.091
B	1.072	1.047	1.07	1.125	1.399	2.101
C	1.077	1.051	1.075	1.129	1.405	2.110
Gross margin [EUR/kg live weight]						
Baseline	0.170	0.183	0.193	0.131	0.416	0.892
A	0.186	0.199	0.211	0.147	0.441	0.924
B	0.181	0.194	0.205	0.141	0.434	0.914
C	0.175	0.189	0.199	0.136	0.427	0.904

Despite the increase in energy costs, financial benefits are achieved under all scenarios and are particularly substantial in the optimistic scenario (A). These benefits result not only from improved animal welfare but also from better chick health during the critical initial stage of the production cycle.

GP04: Providing the farms with elevated platforms

The practice primarily aims to improve animal welfare by facilitating natural behavior and mitigating the negative effects of genetic selection for rapid growth, including lameness. However, it translates only to a limited extent into improved production and financial results (Table 16).

Table 16. Financial impacts of implementing the practice “Providing farms with elevated platforms”.

Scenario	Conventional			
	Small	Medium	Large	Very Large
Revenue [EUR/kg live weight]				
Baseline	1.249	1.237	1.271	1.262
A	1.259	1.246	1.280	1.271
B	1.254	1.241	1.276	1.267
C	1.249	1.237	1.271	1.262
Total direct costs [EUR/kg live weight]				
Baseline	1.079	1.054	1.078	1.131
A	1.072	1.048	1.071	1.125
B	1.078	1.053	1.077	1.130
C	1.084	1.059	1.083	1.136
Gross margin [EUR/kg live weight]				
Baseline	0.170	0.183	0.193	0.131
A	0.187	0.198	0.209	0.146
B	0.176	0.188	0.199	0.137
C	0.165	0.178	0.188	0.126

Against the very low implementation costs of this practice, even a modest improvement in productivity under the adopted assumptions, mainly due to lower mortality and additional weight gains, results in improved financial performance in both the optimistic and moderate scenarios. In Scenario C, consistent with the farmer's declaration that no positive effects were observed or measured, the gross margin is slightly lower than in the baseline scenario.

Figure 6 illustrates the changes in farm level financial impacts.

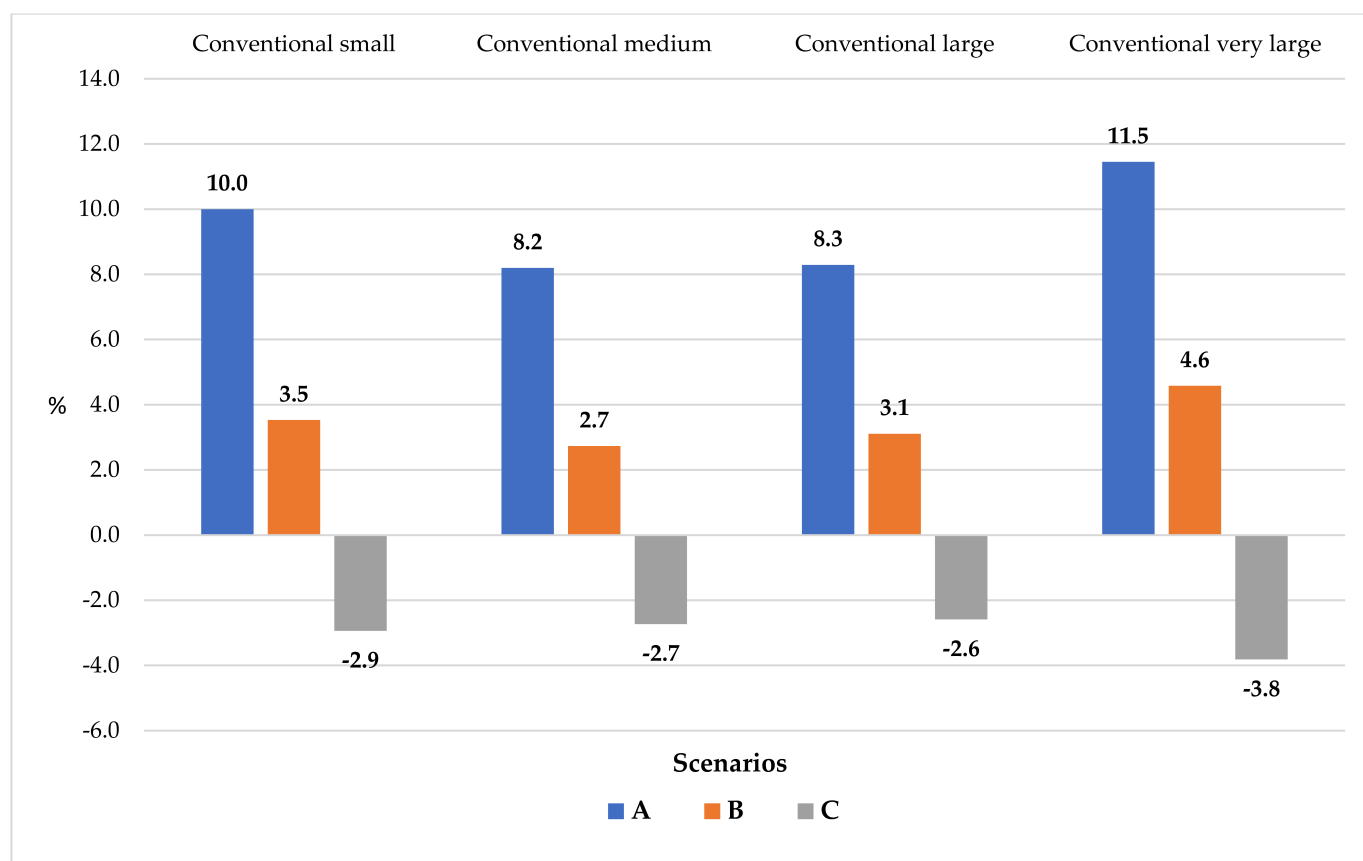


Figure 6. Change in average values of gross margin after implementation of GP04 "Providing the farms with elevated platforms" relative to the 2022 baseline model (%).

The variation in financial outcomes across flock size categories is limited for both positive and negative effects. This is one of the two practices for which the gross margin of small flocks decreases compared to the baseline. This disadvantage relates to spreading investment costs over a smaller number of birds, despite even higher revenue per unit of production (kilogram).

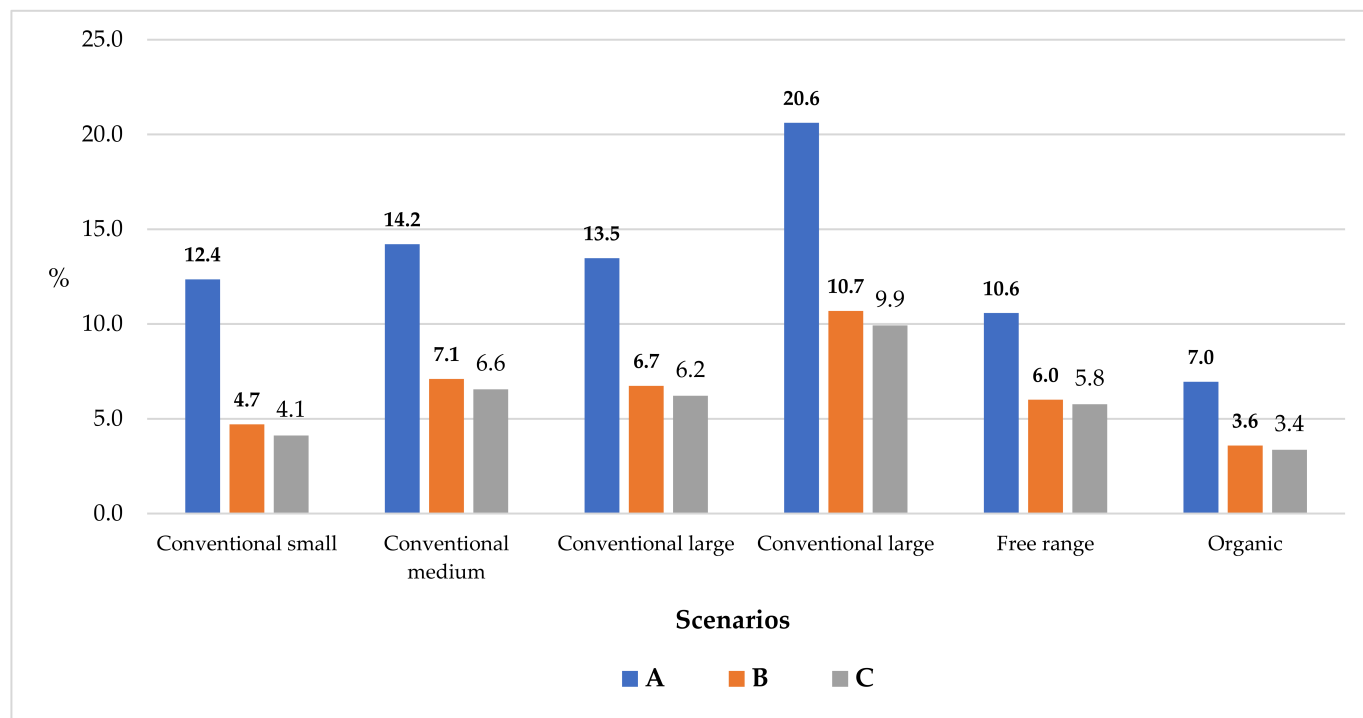
GP05: Aeration and litter addition

The practice involves purchasing aeration equipment, but due to potential benefits generates positive financial effects under all scenarios (Table 17).

Despite higher litter, labor, and energy costs, as well as the additional costs of purchasing and operating the small aeration equipment, this practice has positive financial effects under all scenarios compared to the baseline model. All types of farms perform noticeably better under Scenario A because of more pronounced benefits. For this practice, increased weight gains resulting from improved animal welfare, and productivity is the most important factor contributing to financial outcomes.

Table 17. Financial impacts of implementing the practices of aeration and litter addition.

Scenario	Conventional				Free Range	Organic
	Small	Medium	Large	Very Large		
Revenue [EUR/kg live weight]						
Baseline	1.249	1.237	1.271	1.262	1.831	3.012
A	1.279	1.266	1.301	1.292	1.876	3.082
B	1.266	1.253	1.288	1.279	1.857	3.052
C	1.266	1.253	1.288	1.279	1.857	3.052
Total direct costs [EUR/kg live weight]						
Baseline	1.079	1.054	1.078	1.131	1.414	2.121
A	1.088	1.057	1.082	1.134	1.416	2.128
B	1.088	1.057	1.082	1.134	1.416	2.128
C	1.089	1.058	1.083	1.135	1.417	2.130
Gross margin [EUR/kg live weight]						
Baseline	0.170	0.183	0.193	0.131	0.416	0.892
A	0.191	0.209	0.219	0.158	0.460	0.954
B	0.178	0.196	0.206	0.145	0.441	0.924
C	0.177	0.195	0.205	0.144	0.440	0.922

Figure 7 illustrates the changes in farm level financial impacts.**Figure 7.** Change in average values of gross margin after implementation of GP05 “Aeration and litter addition” relative to the 2022 baseline model (%).

GP06: Stocking density reduction and the Foot Health Program

Unlike for previous practices, instead of conducting a sensitivity analysis, several reduced stocking density scenarios were constructed. A baseline model for density of 42 kg live weight/m² served as a reference for comparison. Two categories of models for alternative densities were constructed:

- Models M 30, M 33, M 39, and M 42 + thinning, in which costs and revenues were adjusted to the number of broilers raised;
- Models marked by the letter B (e.g., M 33 B) for reduced densities, assuming better growth and higher final weights of broilers as an additional benefit due to the lowered number of birds (for more details, see Section 2.2.6 and Table 11).

Table 18 presents the results of the analysis.

Table 18. Financial impacts of reducing stocking density in rearing chicken broilers.

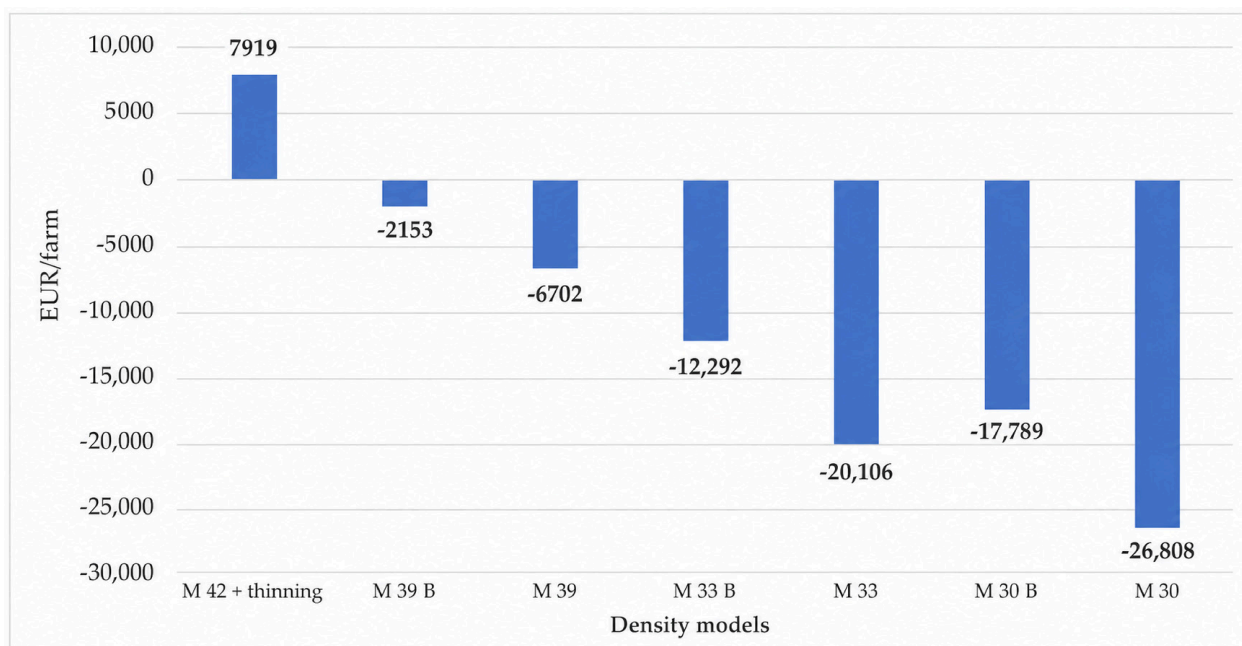
Stocking Density Model	Conventional			
	Small	Medium	Large	Very Large
Sales M 42 Ref. = 100				
M 42 Reference [tons live weight]	368.1	1056.4	3116.5	45,494.3
M 42 Reference = 100	100	100	100	100
M 42 + thinning = 100	110.0	110.0	110.0	110.0
M 39 B	93.9	93.9	93.9	93.8
M 39	92.9	92.9	92.9	92.9
M 33 B	80.2	80.2	80.2	80.2
M 33	78.6	78.6	78.6	78.6
M 30 B	73.3	73.3	73.3	73.3
M 30	71.4	71.4	71.4	71.4
Gross margin: M 42 = 100				
M 42 – Reference	EUR/kg 0.170	0.192	0.196	0.126
	M 42 = 100 100	100	100	100
M 42 + thinning	102.4	102.6	102.4	112.5
M 39 B	102.9	103.4	103.6	106.2
M 39	96.1	97.5	97.7	96.5
M 33 B	100.1	103.2	103.8	107.7
M 33	86.3	91.2	91.9	87.9
M 30 B	97.6	102.3	103.2	107.3
M 30	80.0	87.1	88.1	82.2

Compared with the reference stocking density model (M 42), only the thinning scenario results in a 10% increase in sales across all production scales. In all other models, sales decrease as stocking density declines to 71.4% of the reference. In all optimistic scenarios (B), reductions of sales are 1.0–1.9 percentage points smaller than in their corresponding no-benefit models, depending on the assumed weight gains.

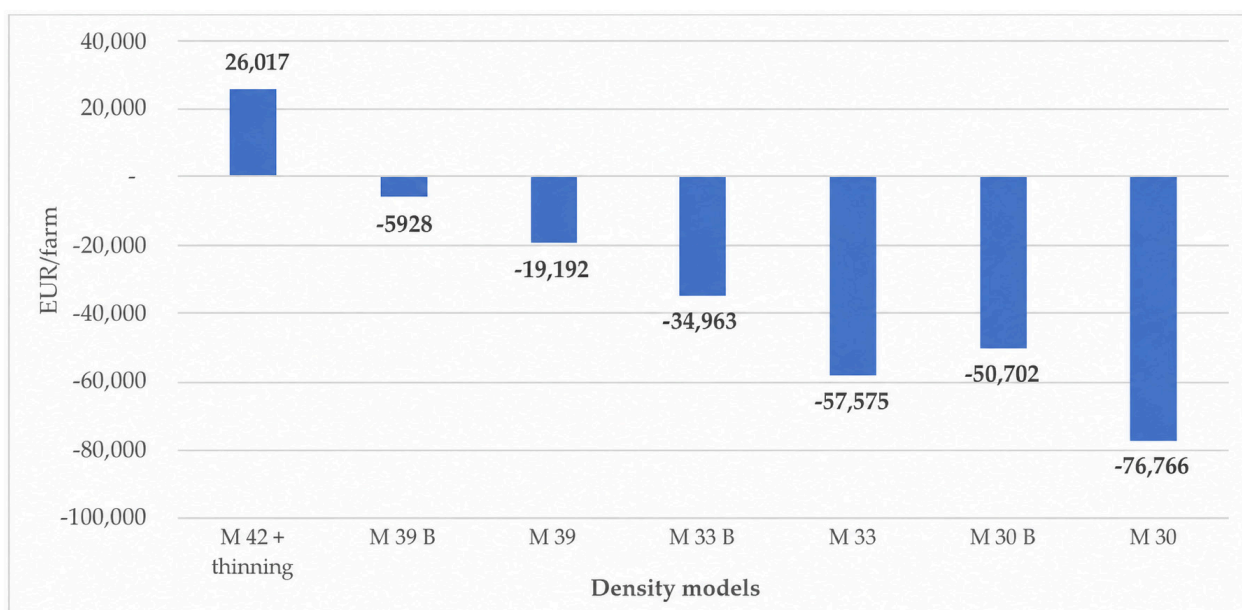
Gross margins per kilogram of live weight follow a different pattern. In all models assuming additional benefits, the gross margin exceeds that of the reference model, except for the lowest stocking density scenario (M 30 B). The smallest financial gains are observed

in farms with small flocks (0.1–2.4%), while in the M 30 B variant the gross margin is 2.4% lower. The highest gains are achieved by the most cost-effective farms with very large flocks (7.3–12.5%). In contrast, under the lowest stocking density without additional benefits (M 30), the gross margin decreases by 12–20% relative to the reference model.

Regardless of whether gross margins per unit of production (EUR/kg of live weight) are higher or lower than in the reference model (M 42), the total gross margin per farm (EUR/farm) is substantially lower in all model scenarios except for M 42 with thinning (Figure 8a–d). Although reductions in stocking density proportionally decrease feed and chick costs, these savings and improved unit margins are not sufficient to compensate for the decline in revenue resulting from the lower number of broilers marketed.

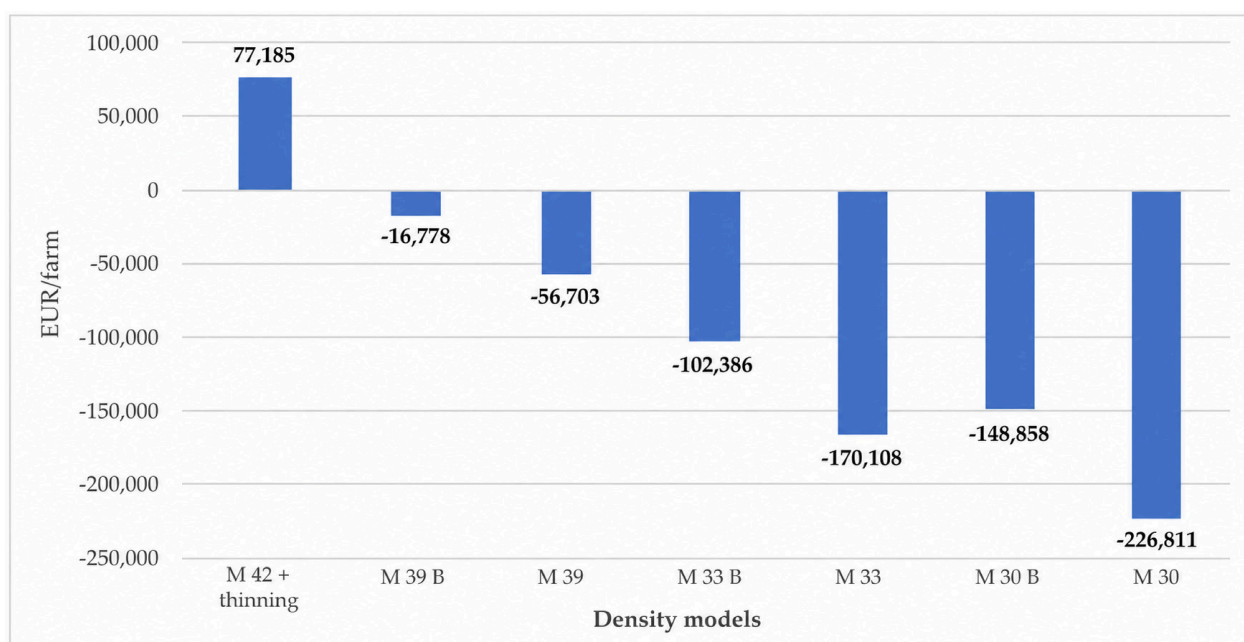


(a)

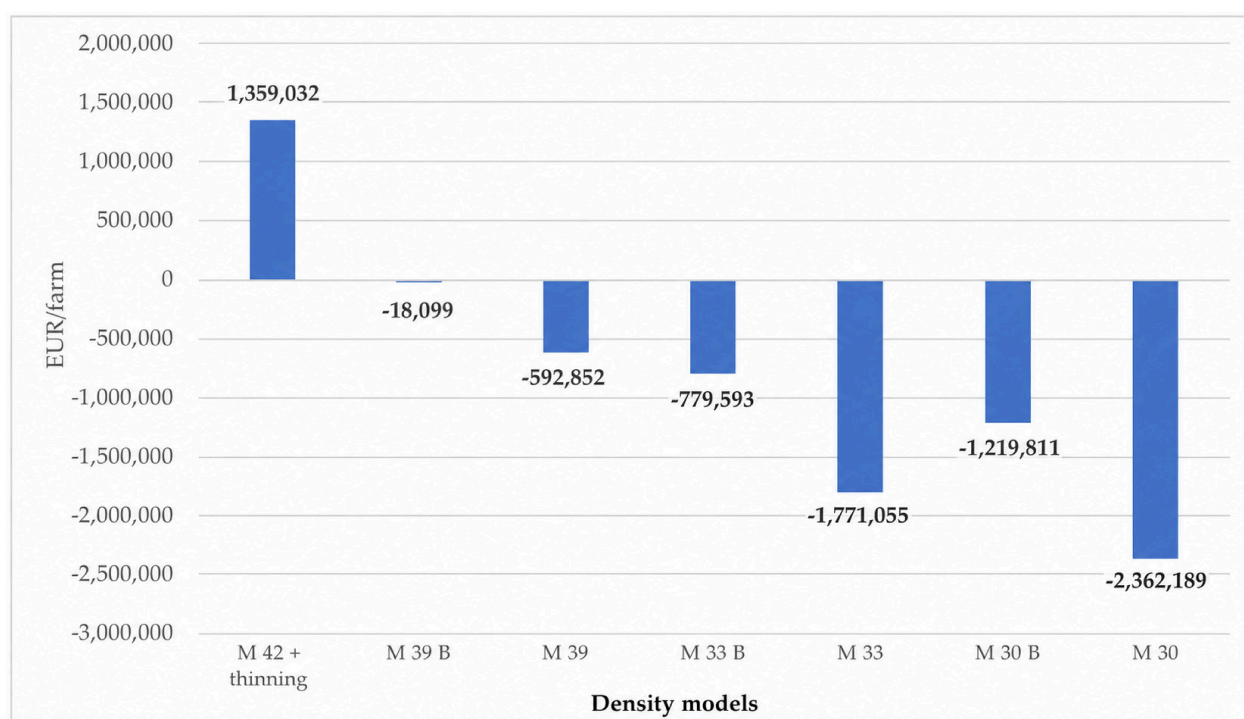


(b)

Figure 8. Cont.



(c)



(d)

Figure 8. (a) Difference in gross margin (EUR per farm) relative to the reference model (M42) in farms with small flocks. (b) Difference in gross margin (EUR per farm) relative to the reference model (M42) in farms with medium flocks. (c) Difference in gross margin (EUR per farm) relative to the reference model (M42) in farms with large flocks. (d) Difference in gross margin (EUR per farm) relative to the reference model (M42) in farms with very large flocks.

The reduction in gross margins compared to the M 42 reference is modest only for the M39B scenario, ranging from—2153 EUR/farm in the cluster of small farms to 18,000 in the group of very large farms. Further reductions in stocking density to 33 and 30 kg/m², however, result in substantial losses that have a significant impact on the budgets of all farm types, regardless of flock size.

4. Discussion

Implementation of the broiler welfare practices examined in this paper in most cases leads to improved financial performance, with the important exception of substantial reductions in stocking density. The magnitude of changes in the gross margin, used as the indicator of financial outcomes, varies depending on the type of animal welfare intervention and the scenario considered in the sensitivity analysis. The largest gains are observed on very large farms under the optimistic scenario, where gross margins increase by up to 20.6% relative to the 2022 baseline. Improvements are also observed on free range and organic farms; however, the financial gains per farm are less substantial than in conventional systems due to the much smaller scale of production and dependent on size of premium for product.

Specifically, the practice of minimizing stress and injuries during bird catching results in only marginal changes in gross margin, ranging from −0.10% (pessimistic scenario, large conventional farms) to +0.26% (optimistic scenario, organic farming system). This is because the intervention is implemented at the final stage of the production cycle and its only quantifiable economic benefit is a reduction in carcass condemnations at the slaughterhouse. The greatest financial benefits are associated with practices that improve weight gain and reduce mortality. The assessed practices varied considerably in their potential effects on animal welfare and productivity. The assumptions underlying the financial impact analyses are broadly supported by several studies. De Jong et al. [29] showed that litter quality affects both welfare and production outcomes, including feed conversion ratio. These findings support the assumed benefits of litter aeration. Other studies confirm the importance of appropriate brooding temperatures for broiler performance [73–75]. Studies on broiler catching procedures were less common, possibly because they apply to the very end of the production cycle. Nijdam et al. [76] found no differences between manual and mechanical catching in meat quality, although some stress and mortality indicators varied. Langkabel et al. [33] showed that the occurrence of lesions was influenced by bird weight, flock characteristics, and the catching team. Improved handling may therefore reduce welfare risks and some at-slaughter losses. The evidence concerning elevated platforms is mixed. De Roest et al. [77] found no significant effect on average daily weight gain. Moczek et al. [55] reported improvements in walking ability and leg health, but no effect on mortality. Overall, the literature provides considerably more evidence regarding the behavioral and health benefits of broiler enrichment than its effects on productivity.

A considerably smaller number of studies have examined the financial effects of welfare improvements. De Roest et al. [77] assessed the economic impact of elevated platforms in relation to stocking density. Increasing density from 35 to 39 kg live weight/m² resulted in a 0.5% increase in production costs compared with a 1.9% increase when stocking density was reduced by 10% without platforms. Their economic value may therefore arise primarily from maintaining production capacity while improving animal welfare, rather than from direct productivity gains. Gocsik et al. [78] showed that the economic feasibility of higher-welfare production systems is strongly influenced by producer prices and the level and stability of welfare-related price premiums. Other studies indicate that intermediate-welfare systems may achieve substantial welfare improvements at relatively modest additional cost [79,80].

However, direct comparisons with these studies should be made cautiously, especially when referring to studies comparing production systems operating under different production and market conditions, including differences in breed, growth rate, housing, stocking density, prices, and welfare premiums. In contrast, the present analysis estimates the net effect of implementing individual practices under *ceteris paribus* assumptions. Prices, breeds, production systems, and other external conditions are held constant, and only the

additional costs and benefits directly attributable to each practice are included. Reducing stocking density is widely regarded as an effective measure for improving the physical comfort, health, and overall welfare of broiler chickens. Lower densities provide birds with more space for movement and the expression of natural behaviours, improve access to feeders and drinkers, and reduce health-related risks.

The strongest agreement with previous economic research concerns stocking density. In the present study, reducing stocking density from the reference level of 42 kg/m² lowered the total gross margin per farm in all reduced-density scenarios, even when gross margin per kilogram increased due to assumed health and productivity benefits. Using a similar partial budgeting approach for Belgian broiler production, Verspecht et al. [81] likewise found that farm income declined by 46% when stocking density was reduced from 46 to 38 kg/m² and by 74% when it was reduced to 30 kg/m². The losses reported in that study were more severe than those estimated in the present analysis. This difference may be explained by the higher reference density, different technical assumptions, and the price and cost levels prevailing in the considerably earlier study period. Verspecht et al. [81] also reported that profit increased from EUR 3.98/m² at 33 kg/m² to EUR 6.10/m² at 42 kg/m² and EUR 7.50/m² at 48 kg/m². Under the market conditions considered in their study, the estimated threshold for maintaining profitability was approximately 46 kg/m². Similarly, Utnik-Banaś et al. [82] estimated that reducing stocking density to 33 kg/m² would lower farm income from EUR 2.40 to EUR 0.77/m² under 2009 prices and would result in losses under 2011 prices. They concluded that a price increase of approximately 5–6% would be required to compensate for the reduction in production volume. These findings support the results of the present study, indicating that improvements in performance per bird may be insufficient to offset the decline in the number of broilers sold.

While the implementation of most low-cost practices aimed at improving broiler welfare can be recommended even when they do not generate measurable financial benefits, the prospect of a substantial, EU-wide reduction in stocking density raises concerns. According to Sheppard and Edge [83], lowering the stocking density from 38 to 30 kg/m² would reduce broiler meat production by approximately 21% while increasing operational costs per unit of output by 5.6%. Even if such a reduction were introduced as a legal requirement, it would be unlikely to receive broad acceptance within the industry because of the associated financial losses. This raises concerns about the stability and competitiveness of the EU broiler market considering that poultry meat, owing to its favorable nutritional characteristics and relatively low prices, is steadily increasing its share of total meat consumption in the European Union up to the level of pork meat [84,85]. A large-scale reduction in broiler stocking density could therefore lead to a significant decline in poultry meat supply. Given the deterioration in production profitability, producers may be reluctant to invest in additional housing capacity to maintain current output levels without external support.

5. Conclusions

The identification of a large number of practices implemented in broiler production in each of the partner countries participating in the BroilerNet project indicates clear potential to improve animal welfare in this sector. This potential exists even though some of the good practices, such as preheating of broiler houses, are already applied in a relatively large number of farms.

The analysis of implementation in the studied broiler farms, supported by literature reviews, shows that all animal-welfare-oriented measures improve, to varying degrees, broiler health. This, in turn, generates positive production effects and, depending on the type of practice, lowers various categories of costs and generates financial performance effects. The financial assessment of stocking density reductions was less favorable. Despite

generating some welfare benefits, lower stocking densities reduce the number of broilers produced and consequently lead to lower revenues and financial returns.

The conclusions drawn from the analyses of good practice implementation should be interpreted in light of the limitations of the assessments. These limitations arise mainly because, in accordance with the study approach, each practice was described on the basis of an individual case identified on a single farm. Although farmers reported numerous animal welfare benefits, often consistent with findings published in the scientific literature, complete data on the on-farm effects were not always available because the relevant indicators had not been systematically measured. Therefore, expert knowledge and published data were also used in the assessments, as is common in this type of economic analysis. To reduce the uncertainty surrounding the estimated financial outcomes, sensitivity analyses were conducted, providing a broad range of results under optimistic, moderate, and pessimistic scenarios.

Future research should therefore focus on replicated implementation of specific practices across a larger number of farms and countries and should link the assessments with the awareness and attitudes of other actors upstream and downstream in the value chain. It is also important to emphasize that most practices improving animal welfare are low-cost measures that not only do not significantly burden farm budgets but may also generate benefits improving financial performance. More capital-intensive practices may deserve premium prices and processing industry or policy support. Raising the awareness of producers, as well as consumers of animal products, is an important factor supporting improvements in animal welfare, particularly because the European Union is a global leader in raising animal welfare standards, which are not always welcomed by farmers. Therefore, regardless of legislative measures, there is ample scope for the dissemination and implementation of best practices, with possible support from the Common Agricultural Policy in the case of the most costly measures.

Author Contributions: Conceptualization, E.M., M.G., J.U., L.M., P.F. and S.G.; methodology, E.M., M.G., J.U., I.d.J., S.G., L.M., P.F., A.P., M.M. and N.M.; software, E.M., M.G., J.U. and A.G.; investigation, E.M., M.G., J.U., I.d.J., S.G., L.M., M.M., N.M., A.G., P.F. and A.P.; data curation, E.M., M.G., J.U., M.M., N.M. and A.G.; writing—original draft preparation, E.M., M.G., J.U. and P.F.; writing—review and editing, E.M., M.G., J.U., I.d.J., S.G., L.M., M.M., N.M., A.G., P.F. and A.P.; visualization, A.G. All authors have read and agreed to the published version of the manuscript.

Funding: Horizon Europe research and innovation programme, grant agreement No 101060979.

Institutional Review Board Statement: The study did not involve any invasive treatment of animals, nor did the study involve sensitive personal data from individual farmers. Therefore, ethical approval by an ethics committee for animal experiments or any human ethical review were not required under EU legislation.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest: Authors Paolo Ferrari and Annunziata Palamara were employed by the company Centro Ricerche Produzioni Animali, CRPA, Reggio Emilia, Italy. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

BIN	Broiler Innovation Networks
CoV	Coefficient of Variation
GP	Good Practices
GPET	Good Practice Evaluation Tool
ECC	European Chicken Commitment
EU	European Union
FCR	Feed Conversion Ratio
FHP	Foot Health Program
LED	Light Emitting Diode
TFEU	Treaty on the Functioning of the European Union
RSPCA	Royal Society for the Prevention of Cruelty to Animals
TENs	Thematic Expert Networks

References

- Appleby, M.C. The European Union Ban on Conventional Cages for Laying Hens: History and Prospects. *J. Appl. Anim. Welf. Sci.* **2003**, *6*, 103–121. [CrossRef]
- Miele, M.; Lever, J. Civilizing the Market for Welfare Friendly Products in Europe? The Techno-Ethics of the Welfare Quality® Assessment. *Geoforum* **2013**, *48*, 63–72. [CrossRef]
- Official Journal of the European Communities. *Concerning the Protection of Animals Kept for Farming Purposes*; Council Directive 98/58/EC; Official Journal of the European Communities: Luxembourg, 1998. Available online: <https://www.legislation.gov.uk/eudr/1998/58/body/data.xht?view=snippet&wrap=true> (accessed on 5 May 2026).
- European Union. *Protocol on Protection and Welfare of Animals. Annexed to the Treaty of Amsterdam*; Official Journal of the European Communities: Luxembourg, 1997.
- Official Journal of the European Union. *Laying down Minimum Rules for the Protection of Chickens Kept for Meat Production*; Council Directive 2007/43/EC; Official Journal of the European Union: Luxembourg, 2007.
- European Commission. *A Farm to Fork Strategy for a Fair, Healthy and Environmentally-Friendly Food System*; European Commission: Brussels, Belgium, 2020.
- RSPCA Assured. *RSPCA Assured Standards*; RSPCA Assured: Horsham, UK, 2024.
- Ingenbleek, P.; Immink, V. Consumer Decision-Making for Animal-Friendly Products: Synthesis and Implications. *Anim. Welf.* **2011**, *20*, 11–19. [CrossRef]
- KRAV. *KRAV Standards 2024*; KRAV: Uppsala, Sweden, 2024.
- Label Rouge. *Les Volailles Label Rouge*; Syndicat National des Labels Rouges: Paris, France, 2023.
- Rogers, E.M. *Diffusion of Innovations*, 5th ed.; Free Press: New York, NY, USA, 2003.
- Ryan, B.; Gross, N.C. The Diffusion of Hybrid Seed Corn in Two Iowa Communities. *Rural Sociol.* **1943**, *8*, 15–24.
- Klerkx, L.; Begemann, S. Supporting food systems transformation: The what, why, who, where and how of mission-oriented agricultural innovation systems. *Agric. Syst.* **2020**, *184*, 102901. [CrossRef]
- Bist, R.B.; Bist, K.; Poudel, S.; Subedi, D.; Yang, X.; Paneru, B.; Mani, S.; Wang, D.; Chai, L. Sustainable Poultry Farming Practices: A Critical Review of Current Strategies and Future Prospects. *Poult. Sci.* **2024**, *103*, 104295. [CrossRef]
- de Toledo, T.d.S.; Roll, A.A.P.; Rutz, F.; Dallmann, H.M.; Dai Prá, M.A.; Leite, F.P.L.; Roll, V.F.B. An Assessment of the Impacts of Litter Treatments on the Litter Quality and Broiler Performance: A Systematic Review and Meta-Analysis. *PLoS ONE* **2020**, *15*, e0232853. [CrossRef]
- Gadde, U.; Kim, W.H.; Oh, S.T.; Lillehoj, H.S. Alternatives to Antibiotics for Maximizing Growth Performance and Feed Efficiency in Poultry: A Review. *Anim. Health Res. Rev.* **2017**, *18*, 26–45. [CrossRef]
- Vonholdt-Wenker, M.L.; Nofrarias, M.; Cerdà-Cuellar, M.; Majó, N.; de Jong, I.C.; Malchow, J. Bridging the gap: A comparative analysis of industry approaches and scientific perspectives on broiler health and welfare in Europe. *Front. Anim. Sci.* **2026**, *7*, 1834365. [CrossRef]
- OECD. *Cost-Benefit Analysis and the Environment*; OECD Publishing: Paris, France, 2018.
- OECD. *Scientific Advice for Policy Making*; OECD Publishing: Paris, France, 2015.
- Verhaagh, M.; Deblitz, C.; Rohlmann, C. A Standard Operating Procedure to Define Typical Farms. Available online: http://www.agribenchmark.org/fileadmin/Dateiablage/B-Pig/Misc/sop_pig_1801.pdf (accessed on 3 July 2026).
- Feuz, D.M.; Skold, M.D. Typical Farm Theory in Agricultural Research. *J. Sustain. Agric.* **1992**, *2*, 43–58. [CrossRef]

22. van Dijk, L.; Elwes, S.; Main, D.; Mullan, S.; Jamieson, J. Farmer Perspectives on Welfare Outcome Assessment: Learnings from Four Farm Assurance Scheme Consultation Exercises. *Anim. Welf.* **2018**, *27*, 1–11. [\[CrossRef\]](#)
23. Schultheiß, U.; Zapf, R.; Brinkmann, J.; Cimer, K.; March, S.; Schrader, L.; Schubbert, A.; Lühken, S.; Gieseke, D.; Michaelis, S. Tools for On-Farm Self-Assessment of Animal Welfare. *Landtechnik* **2023**, *78*, 114–123.
24. March, S.; Brinkmann, J.; Winckler, C. Improvement of Animal Health in Organic Dairy Farms through ‘Stable Schools’: Selected Results of a Pilot Study in Germany. *Org. Agric.* **2014**, *4*, 319–323. [\[CrossRef\]](#)
25. Huxley, J.N.; Main, D.C.J.; Whay, H.R.; Burke, J.; Roderick, S. Animal Welfare Assessment Benchmarking as a Tool for Health and Welfare Planning in Organic Dairy Herds. *Vet. Rec.* **2004**, *155*, 237–239. [\[CrossRef\]](#)
26. Linhoss, J.E.; Falana, O.B.; Davis, J.D.; Purswell, J.L.; Edge, C.M.; Olanrewaju, H.A.; Baker-Cook, B.I.; Hanlon, C. An Updated Review on the Effect of Lighting on Broilers and the Environment of Commercial Houses. *Worlds Poult. Sci. J.* **2025**, *81*, 373–401. [\[CrossRef\]](#)
27. Linhoss, J.E.; Davis, J.D.; Campbell, J.C.; Purswell, J.L.; Griggs, K.G.; Edge, C.M. Comparison of Commercial Broiler House Lighting Programs Using LED and Natural Light: Part 1—Spatial and Temporal Analysis of Light Intensity. *J. Appl. Poult. Res.* **2022**, *31*, 100272. [\[CrossRef\]](#)
28. Bailie, C.L.; Ball, M.E.E.; O’Connell, N.E. Influence of the Provision of Natural Light and Straw Bales on Activity Levels and Leg Health in Commercial Broiler Chickens. *Animal* **2013**, *7*, 618–626. [\[CrossRef\]](#)
29. de Jong, I.C.; Gunnink, H. Effects of a Commercial Broiler Enrichment Programme with or without Natural Light on Behaviour and Other Welfare Indicators. *Animal* **2019**, *13*, 384–391. [\[CrossRef\]](#)
30. Fouda, M.M.; Darwish, R.A.; Abou-Ismael, U.A.; Mohammed, A.S. Comparative Effects of Natural and Artificial Light on Behaviour, Performance and Welfare of Broiler Chickens. *Mansoura Vet. Med. J.* **2018**, *19*, 321–333.
31. Kang, S.W.; Christensen, K.D.; Kidd, M.T.; Orlowski, S.K.; Clark, J. Effects of a Variable Light Intensity Lighting Program on the Welfare and Performance of Commercial Broiler Chickens. *Front. Physiol.* **2023**, *14*, 1059055. [\[CrossRef\]](#)
32. Youssef, T.; Jackson, A.; Bourassa, D.; Linhoss, J.; Baker-Cook, B. Evaluating the Impact of Natural and Artificial Light Treatments on Fear Response and Welfare Parameters in Commercial Broilers. *Poult. Sci.* **2026**, *105*, 106343. [\[CrossRef\]](#)
33. Langkabel, N.; Baumann, M.P.O.; Feiler, A.; Sanguankiat, A.; Fries, R. Influence of Two Catching Methods on the Occurrence of Lesions in Broilers. *Poult. Sci.* **2015**, *94*, 1735–1741. [\[CrossRef\]](#)
34. DOZ. *Role of Electrolytes in Animal Health*; DOZ Veterinary Science: Hasaka, Syria, 2024.
35. Biopoint. *Importance of Electrolyte Supplementation for Poultry Health*; Biopoint Agriculture Reports: Iwno, Poland, 2024.
36. Lamidi, W.A. Comparative Analysis of Broilers’ Rearing in Different Housings Systems in Wet Humid Climate, South West Nigeria. 2014. Available online: <https://core.ac.uk/download/234660111.pdf> (accessed on 5 May 2026).
37. Broiler Guide. Broiler Management Guide. Available online: https://www.academia.edu/8955574/Broiler_Management_Guide (accessed on 5 May 2026).
38. AgriFutures Australia. Drying and Pre-Heating Litter before Chick Placement. Available online: https://chicken-meat-extension-agrifutures.com.au/wp-content/uploads/2023/11/23-073_Drying-and-pre-heating-litter-before-chick-placement.pdf (accessed on 5 May 2026).
39. Aviagen. Getting the Breeder Chick Started. Available online: https://aviagen.com/assets/Tech_Center/AA_Technical_Articles/AAServiceBulletinChickStart.pdf (accessed on 5 May 2026).
40. Dawkins, M.S.; Donnelly, C.A.; Jones, T.A. Chicken Welfare Is Influenced More by Housing Conditions than by Stocking Density. *Nature* **2004**, *427*, 342–344. [\[CrossRef\]](#)
41. Nijdam, E.; Zailan, A.R.; van Eck, J.H.; Decuyper, E.; Stegeman, J.A. Pathological Features in Dead on Arrival Broilers with Special Reference to Heart Disorders. *Poult. Sci.* **2006**, *85*, 1303–1308. [\[CrossRef\]](#)
42. de Jong, I.C.; van Harn, J.; Gunnink, H.; Hindle, V.A.; Lourens, A. Footpad Dermatitis in Dutch Broiler Flocks: Prevalence and Factors of Influence. *Poult. Sci.* **2012**, *91*, 1569–1574. [\[CrossRef\]](#)
43. De Roest, K. Costs and Benefits of the Improvement of Biosecurity on Pig and Broiler Farms. *Anim. Res. Vet. Sci.* **2023**, *7*, 1–7. [\[CrossRef\]](#)
44. Riber, A.B.; van de Weerd, H.A.; de Jong, I.C.; Steinfeldt, S. Review of Environmental Enrichment for Broiler Chickens. *Poult. Sci.* **2018**, *97*, 378–396. [\[CrossRef\]](#)
45. Norring, M.; Kaukonen, E.; Valros, A. The Use of Perches and Platforms by Broiler Chickens. *Appl. Anim. Behav. Sci.* **2016**, *184*, 91–96. [\[CrossRef\]](#)
46. Gebhardt-Henrich, S.G.; Toscano, M.J.; Würbel, H. Perch Use by Broiler Breeders and Its Implication on Health and Production. *Poult. Sci.* **2017**, *96*, 3539–3549. [\[CrossRef\]](#)
47. Baxter, M.; Richmond, A.; Lavery, U.; O’Connell, N.E. A Comparison of Fast Growing Broiler Chickens with a Slower-Growing Breed Type Reared on Higher Welfare Commercial Farms. *PLoS ONE* **2021**, *16*, e0259333. [\[CrossRef\]](#)
48. Ventura, B.A.; Siewerdt, F.; Estevez, I. Effects of Barrier Perches and Density on Broiler Leg Health, Fear, and Performance. *Poult. Sci.* **2010**, *89*, 1574–1583. [\[CrossRef\]](#)

49. Liu, Z.; Torrey, S.; Newberry, R.C.; Widowski, T. Play Behaviour Reduced by Environmental Enrichment in Fast-Growing Broiler Chickens. *Appl. Anim. Behav. Sci.* **2020**, *232*, 105098. [\[CrossRef\]](#)
50. Malchow, J.; Puppe, B.; Berk, J.; Schrader, L. Effects of Elevated Grids on Growing Male Chickens Differing in Growth Performance. *Front. Vet. Sci.* **2019**, *6*, 203. [\[CrossRef\]](#)
51. Chuppava, B.; Visscher, C.; Kamphues, J. Effect of Different Flooring Designs on the Performance and Foot Pad Health in Broilers and Turkeys. *Animals* **2018**, *8*, 70. [\[CrossRef\]](#)
52. Kaukonen, E.; Norring, M.; Valros, A. Perches and Elevated Platforms in Commercial Broiler Farms: Use and Effect on Walking Ability, Incidence of Tibial Dyschondroplasia and Bone Mineral Content. *Animal* **2017**, *11*, 864–871. [\[CrossRef\]](#)
53. Baxter, M.; Richmond, A.; Lavery, U.; O'Connell, N.E. Investigating Optimal Levels of Platform Perch Provision for Windowed Broiler Housing. *Appl. Anim. Behav. Sci.* **2020**, *225*, 104967. [\[CrossRef\]](#)
54. Bailie, C.L.; Baxter, M.; O'Connell, N.E. Exploring Perch Provision Options for Commercial Broiler Chickens. *Appl. Anim. Behav. Sci.* **2018**, *200*, 114–122. [\[CrossRef\]](#)
55. Mocz, F.; Michel, V.; Janvrot, M.; Moysan, J.-P.; Keita, A.; Riber, A.B.; Guinebretière, M. Positive Effects of Elevated Platforms and Straw Bales on the Welfare of Fast-Growing Broiler Chickens Reared at Two Different Stocking Densities. *Animals* **2022**, *12*, 542. [\[CrossRef\]](#)
56. Meyer, M.M.; Johnson, A.K.; Bobeck, E.A. A Novel Environmental Enrichment Device Improved Broiler Performance without Sacrificing Bird Physiological or Environmental Quality Measures. *Poult. Sci.* **2019**, *98*, 5247–5256. [\[CrossRef\]](#)
57. Dunlop, M.W.; Moss, A.F.; Groves, P.J.; Wilkinson, S.J.; Stuetz, R.M.; Selle, P.H. The Multidimensional Causal Factors of 'Wet Litter' in Chicken-Meat Production. *Sci. Total Environ.* **2016**, *562*, 766–776. [\[CrossRef\]](#)
58. Wilcox, C.H.; Sandilands, V.; Mayasari, N.; Asmara, I.Y.; Anang, A. A Literature Review of Broiler Chicken Welfare, Husbandry, and Assessment. *World's Poult. Sci. J.* **2024**, *80*, 3–32. [\[CrossRef\]](#)
59. Pepper, C.-M.; Dunlop, M.W. Review of Litter Turning during a Grow-out as a Litter Management Practice to Achieve Dry and Friable Litter in Poultry Production. *Poult. Sci.* **2021**, *100*, 101071. [\[CrossRef\]](#)
60. Oliveira, M.D.; Sousa, F.C.; Saraz, J.O.; Calderano, A.A.; Tinôco, I.F.F.; Carneiro, A.P.S. Ammonia Emission in Poultry Facilities: A Review for Tropical Climate Areas. *Atmosphere* **2021**, *12*, 1091. [\[CrossRef\]](#)
61. Durmuş, M.; Kurşun, K.; Polat Açık, İ.; Tufan, M.; Kutay, H.; Benli, H.; Baylan, M.; Kutlu, H.R. Effect of Different Litter Materials on Growth Performance, the Gait Score and Footpad Dermatitis, Carcass Parameters, Meat Quality, and Microbial Load of Litter in Broiler Chickens. *Poult. Sci.* **2023**, *102*, 102763. [\[CrossRef\]](#)
62. Brink, M.; Janssens, G.P.J.; Demeyer, P.; Bağcı, Ö.; Delezie, E. Ammonia Concentrations, Litter Quality, Performance and Some Welfare Parameters of Broilers Kept on Different Bedding Materials. *Br. Poult. Sci.* **2022**, *63*, 768–778. [\[CrossRef\]](#)
63. Alabi, O.M.; Olagunju, S.O.; Aderemi, F.A.; Lawal, T.E.; Oguntunji, A.O.; Ayoola, M.O.; Oladejo, O.A.; Adeleye, B.E.; Adewumi, A.A.; Alabi, B.D.; et al. Effect of Litter Management Systems on Incidence and Severity of Footpad Dermatitis among Broilers at Finisher Stage. *Transl. Anim. Sci.* **2024**, *8*, txad145. [\[CrossRef\]](#)
64. Shynkaruk, T.; Long, K.; LeBlanc, C.; Schwean-Lardner, K. Impact of Stocking Density on the Welfare and Productivity of Broiler Chickens Reared to 34 d of Age. *J. Appl. Poult. Res.* **2023**, *32*, 100344. [\[CrossRef\]](#)
65. Guardia, S.; Konsak, B.; Combes, S.; Levenez, F.; Cauquil, L.; Guillot, J.-F.; Moreau-Vauzelle, C.; Lessire, M.; Juin, H.; Gabriel, I. Effects of Stocking Density on the Growth Performance and Digestive Microbiota of Broiler Chickens. *Poult. Sci.* **2011**, *90*, 1878–1889. [\[CrossRef\]](#)
66. Dozier, W.A.; Thaxton, J.P.; Purswell, J.L.; Olanrewaju, H.A.; Branton, S.L.; Roush, W. Stocking Density Effects on Male Broilers Grown to 1.8 Kilograms of Body Weight. *Poult. Sci.* **2006**, *85*, 344–351. [\[CrossRef\]](#)
67. Dozier, W.A.; Thaxton, J.P.; Branton, S.L.; Morgan, G.W.; Miles, D.M.; Roush, W.B.; Lott, B.D.; Vizzier-Thaxton, Y. Stocking Density Effects on Growth Performance and Processing Yields of Heavy Broilers. *Poult. Sci.* **2005**, *84*, 1332–1338. [\[CrossRef\]](#)
68. Feddes, J.; Emmanuel, E.; Zuidhof, M. Broiler Performance, Body Weight Variance, Feed and Water Intake, and Carcass Quality at Different Stocking Densities. *Poult. Sci.* **2002**, *81*, 774–779. [\[CrossRef\]](#)
69. Buijs, S.; Keeling, L.; Rettenbacher, S.; Van Poucke, E.; Tuytens, F.A.M. Stocking Density Effects on Broiler Welfare: Identifying Sensitive Ranges for Different Indicators. *Poult. Sci.* **2009**, *88*, 1536–1543. [\[CrossRef\]](#)
70. van der Eijk, J.A.J.; van Harn, J.; Gunnink, H.; Melis, S.; van Riel, J.W.; de Jong, I.C. Fast- and Slower-Growing Broilers Respond Similarly to a Reduction in Stocking Density with Regard to Gait, Hock Burn, Skin Lesions, Cleanliness, and Performance. *Poult. Sci.* **2023**, *102*, 102603. [\[CrossRef\]](#)
71. Weimer, S.L.; Mauromoustakos, A.; Karcher, D.M.; Erasmus, M.A. Differences in Performance, Body Conformation, and Welfare of Conventional and Slow-Growing Broiler Chickens Raised at 2 Stocking Densities. *Poult. Sci.* **2020**, *99*, 4398–4407. [\[CrossRef\]](#)
72. van Horne, P.L.M. *Economics of Broiler Production Systems in the Netherlands: Economic Aspects within the Greenwell Sustainability Assessment Model*; Wageningen Economic Research: Wageningen, The Netherlands, 2020.
73. Henriksen, S.; Bilde, T.; Riber, A.B. Effects of Post-Hatch Brooding Temperature on Broiler Behavior, Welfare, and Growth. *Poult. Sci.* **2016**, *95*, 2235–2243. [\[CrossRef\]](#)

74. Deaton, J.W.; Branton, S.L.; Simmons, J.D.; Lott, B.D. The Effect of Brooding Temperature on Broiler Performance. *Poult. Sci.* **1996**, *75*, 1217–1220. [[CrossRef](#)]
75. Lekrisompong, N.; Romero-Sanchez, H.; Plumstead, P.W.; Brannan, K.E.; Yahav, S.; Brake, J. Broiler Incubation. 2. Interaction of Incubation and Brooding Temperatures on Broiler Chick Feed Consumption and Growth. *Poult. Sci.* **2009**, *88*, 1321–1329. [[CrossRef](#)]
76. Nijdam, E.; Delezie, E.; Lambooij, E.; Nabuurs, M.J.; Decuypere, E.; Stegeman, J.A. Comparison of Bruises and Mortality, Stress Parameters, and Meat Quality in Manually and Mechanically Caught Broilers. *Poult. Sci.* **2005**, *84*, 467–474. [[CrossRef](#)]
77. De Roest, K. Costs and Benefits of Innovations Able to Reduce the Use of Antimicrobials on Pig and Broiler Farms. *Anim. Res. Vet. Sci.* **2023**, *7*, 100052. [[CrossRef](#)]
78. Gocsik, É.; Lansink, A.G.J.M.O.; Saatkamp, H.W. Mid-Term Financial Impact of Animal Welfare Improvements in Dutch Broiler Production. *Poult. Sci.* **2013**, *92*, 3314–3329. [[CrossRef](#)]
79. Vissers, L.S.M.; de Jong, I.C.; van Horne, P.L.M.; Saatkamp, H.W. Global Prospects of the Cost-Efficiency of Broiler Welfare in Middle-Segment Production Systems. *Animals* **2019**, *9*, 473. [[CrossRef](#)]
80. Gocsik, É.; Brooshooft, S.D.; de Jong, I.C.; Saatkamp, H.W. Cost-Efficiency of Animal Welfare in Broiler Production Systems: A Pilot Study Using the Welfare Quality® Assessment Protocol. *Agric. Syst.* **2016**, *146*, 55–69. [[CrossRef](#)]
81. Verspecht, A.; Vanhonacker, F.; Verbeke, W.; Zoons, J.; Van Huylenbroeck, G. Economic Impact of Decreasing Stocking Densities in Broiler Production in Belgium. *Poult. Sci.* **2011**, *90*, 1844–1851. [[CrossRef](#)]
82. Utnik-Banaś, K.; Żmija, J.; Sowula-Skrzyńska, E. Economic Aspects of Reducing Stocking Density in Broiler Chicken Production Using the Example of Farms in Southern Poland. *Ann. Anim. Sci.* **2014**, *14*, 663–671. [[CrossRef](#)]
83. Sheppard, A.; Edge, S. *Economic and Operational Impacts of the Proposed EU Directive Laying Down Minimum Standards for the Protection of Chickens Kept for Meat Production*; Centre for Rural Research, University of Exeter: Exeter, UK, 2005.
84. AHDB Europe: How Much Do They Consume? Available online: <https://mainsitelive.azurewebsites.net/trade-and-policy/export-opps/regions/europe/consumption> (accessed on 27 July 2026).
85. Per Capita EU-27 Consumption of Eat, Fish and Dairy (by Weight). Available online: https://www.eea.europa.eu/en/analysis/maps-and-charts/per-capita-eu-27-consumption-1?utm_source=chatgpt.com (accessed on 27 July 2026).

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.