REVIEW REGARDING BROILER PRODUCTION SYSTEMS AND MEAT QUALITY

A.-E. Moise*, M. Tudorache, I. Custură, G.M. Pîrlea (Gheciu Pîrlea), T.Ș. Vlad, I.Ș. Bordei (Bololoi), V.-D. Lungu, D. Drăgotoiu

University of Agronomic Sciences and Veterinary Medicine, Animal Production Engineering and Management, Marasti Boulevard, no. 59, sector 1, Bucharest, Romania

Abstract

This paper investigates the influence of intensive, free-range and organic broiler production systems on growth performance, meat quality, animal welfare and consumer perception. Based on literature data, the analysis considers parameters such as stocking density, slaughter age, genotype, feeding and microclimate conditions, as well as their impact on composition, color, texture, pH, water-holding capacity, oxidative stability and microbiological safety. The synthesis shows that intensive systems ensure efficiency and yield but may compromise welfare and certain sensory traits, while alternative systems provide nutritional and sensory benefits and greater consumer acceptance, although with higher production costs and oxidative susceptibility. The review highlights the need for integrated approaches that balance productivity, sustainability and ethical standards in poultry production.

Key words: *broilers, nutrition, quality, sustainability, welfare*

INTRODUCTION

Throughout human evolution, meat has played a central role in nutrition, representing an essential source of protein and energy for the development and survival of the species. Currently, the consumption of poultry meat, especially chicken, is on an upward trend globally, a phenomenon explained by a series of interconnected factors: its high nutritional value, culinary versatility, economic accessibility, the perception that it is a healthy food option, but also the relatively low level of cognitive dissonance associated with the slaughter of broilers compared to other species [1]. Meat consumption is closely linked to the nutritional intake of populations, but dietary patterns vary significantly from one country to another. These differences are influenced by multiple factors such as socio-economic status, cultural traditions, religious rules, gender and ethnicity [2, 3]. Moreover, interactions between various socio-economic categories shape eating behavior, and income and education level stand out as major determinants of it [4]. Within the poultry industry, the concept of "meat quality" has a complex meaning, including all physical, chemical, biochemical, morphological, microbial, sensory, technological, hygienic, nutritional and culinary characteristics. This integrated vision increasingly responds to the expectations of modern consumers, concerned about health and maintaining an optimal physical condition. In this context, nutritional labels that signal characteristics such as "light", "lean", "low-fat" or "reduced-calories" are becoming essential elements in the purchasing decision-making process [5]. Thus, chicken production systems, whether organic, free-range or intensive, take on strategic importance, as

* Corresponding author: eandrada62@yahoo.com
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they directly influence the nutritional, sensory and technological characteristics of the meat. These characteristics determine both the degree of acceptance of the product on the market and the way in which it meets consumer expectations regarding health, safety and food quality. Globally, poultry production is dominated by intensive systems, based on litter-based housing and the raising of broilers in large groups. These include both fully controlled environment halls and naturally ventilated buildings. In some regions, such as China, other methods are also used, such as cage or perforated floor systems, but these remain a minority [6]. It is estimated that approximately 93% of global chicken production comes from specialized, predominantly intensive, rearing systems, while household-type or laying hen production has a low share and is rather regional in relevance. In contrast, systems considered to have a higher welfare standard include indoor housing with low stocking density, equipped with environmental enrichment elements (e.g. pecking structures, brushing devices, access to natural light).

A major aspect of rearing systems is stocking density, a factor that influences both the welfare of the broilers and the economic performance of the farms. According to a recent study, reducing density to the levels recommended by European legislation improves growth indicators and technical-economic efficiency, highlighting the direct link between welfare standards and zootechnical productivity [7]. In addition, free-range and organic categories provide broilers with access to the outdoors, allowing the manifestation of a more varied behavioral repertoire. Another defining aspect is the genotype used: in these systems, breeds with a slower growth rate are preferred, associated with better health and reduced risks of locomotor and metabolic problems [8, 9]. The structure and prevalence of poultry farming systems differ considerably globally, reflecting both the socio-economic characteristics and consumer demands of each region:

• *Sub-Saharan Africa*: Approximately 78% of chicken meat production comes from specialized systems, while 14.9% is provided by households and 7.1% from laying hens, highlighting the significant role that small-scale production still plays in the region;

• *Asia*: In China, fast-growing white-feathered chickens dominate production (57%), followed by slower-growing local breeds (27%), while meat from organic systems has a marginal share of less than 1% [10]. In Thailand, household production has been almost completely replaced by industrial production in closed houses [11];

• *Europe*: around 90% of production is carried out in intensive systems, with the remainder being provided by alternative systems such as free-range and organic. In countries such as France, the Netherlands and the UK, the proportion of poultry raised in systems with higher welfare standards or slow-growing breeds is significant [12];

• *Latin America*: over 97% of meat is produced in high-capacity intensive systems, which underlines the dominance of the industrial model in the region [13];

• *North America*: most poultry is raised intensively, but there is a growing demand for products from "antibiotic-free" or organic systems, reflecting consumer sensitivity to food safety and welfare [14];

• *Oceania*: around 98% of production comes from specialized systems, but demand for free-range chicken has grown steadily, reaching around 15% of the Australian market [15].

These regional differences highlight that the choice of production system is not uniform globally, but reflects a combination of economic, cultural, political and regulatory factors. At the same time, consumer preference for products perceived as "more natural" or with a high standard of animal welfare is contributing to the

diversification of production models, particularly in Europe and Oceania. Overall, intensive systems continue to dominate global poultry production, but there is a clear trend towards the expansion of alternative systems, such as free-range and organic. This change is supported both by pressure from animal welfare regulations and by consumer demand for products perceived as healthier, more sustainable and more ethical. In the European Union, intensive farming remains predominant.

MATERIAL AND METHOD

Given the importance of poultry meat in human nutrition and the diversity of production systems used globally, it is essential to analyze how these practices influence the characteristics of the final product. The main broiler rearing systems are analyzed below: organic, free-range and intensive, highlighting their particularities and impact on zootechnical performance and meat quality parameters, namely chemical composition, color, texture, pH, water retention capacity and cooking losses, oxidative stability, microbiological quality and consumer perception.

The main broiler rearing systems are described below: intensive, free-range and organic, highlighting their particularities and impact on meat quality.

Ecological (organic) systems:

Organic broiler systems are distinguished by clear standards for stocking density, outdoor access and minimum age at slaughter. On these farms, the maximum permitted stocking density is 21 kg/m², and at least 4 m² of outdoor space, mostly covered with vegetation, must be provided for each broilers. Broilers must have daily access to the open air for at least one third of their life, and slaughter cannot take place before 70–81 days [16, 17, 18]. However, the share of organic production remains very low, below 1% of the total in the United Kingdom. An important aspect of these systems is the frequent use of traditional breeds with slower growth rates, which supports the welfare of the broilers and reduces the risk of locomotor and metabolic problems. In some cases, access to the outside is facilitated by "popholes" placed on the sides of the houses, which allow the broilers to explore their natural environment [19]. In addition to space and lifespan requirements, organic standards set strict rules on nutrition and welfare conditions. Feed must be certified organic, and broilers need both safe housing and the freedom to forage and forage naturally in a clean, pollution-free environment. This contributes to a more varied diet and an increased intake of vitamins and minerals [20]. In terms of meat quality, studies have shown clear differences compared to intensive production. Organic chickens have a higher percentage of pectoral and leg muscle, along with a lower accumulation of abdominal fat [21]. Muscle analyses have reported lower final pH and water retention capacity, but also higher cooking losses, increased brightness, higher iron content and a higher proportion of n-3 polyunsaturated fatty acids. At the same time, TBA-RS values were increased, suggesting a higher susceptibility to oxidation, probably correlated with the higher level of physical activity. However, from a sensory point of view, breast meat from these systems was assessed as having a higher quality [16, 17]. Some studies have not found significant differences between free-range and cage-raised broilers, suggesting that grazing does not compromise this trait [22]. However, other research has reported less tender breast meat in free-range compared to conventionally raised broilers [23].

Free-range systems:

Standard free-range systems provide broilers with conditions intermediate between intensive and organic. Regulations set a maximum stocking density of 27.5 kg/m² in housing and require daily access to outdoor areas for at least half of their lives. In the European Union, each heard must have

a minimum of 1 m² of outdoor space, while slaughter usually takes place at a minimum age of 56 days [16, 18, 24]. These systems typically use slower-growing breeds associated with higher welfare standards [25]. Broilers are allowed to engage in natural behaviors such as pecking, scratching, and exploring the outside environment, which contribute to better leg and heart health and a significantly higher quality of life than in intensive farms [16]. Free-range poultry is also supported by animal welfare organizations as a sustainable land use practice [20]. National standards require that free-range poultry intended for organic meat or egg production be raised without artificial colors, synthetic chemicals, and certified organic feed. In addition, the use of antibiotics is prohibited in treatments applied to organic poultry [19].

From a welfare perspective, free-range systems respect the fundamental principles known as the "five freedoms": freedom from hunger and thirst, freedom from discomfort, protection from pain and disease, freedom from natural behaviours and freedom from fear or stress [20]. Access to grass, insects and soil stimulates exploration and physical activity, contributing to a better overall health. Also, simple environmental enrichments, such as straw bales, can increase the activity level of broilers even indoors [26]. From a productive and qualitative point of view, the literature shows that broilers raised exclusively indoors achieve higher weights and more efficient feed conversion, but accumulate more abdominal fat, which can compromise carcass quality. In contrast, livestock with outdoor access have lower fat content and a more favorable meat lipid profile, but their mortality is higher, being associated with exposure to environmental risks [27]. From a sensory perspective, meat from these systems is sometimes perceived as "too firm", although not all studies objectively confirm significant differences in tenderness between indoor and outdoor systems [28, 29]. More recently, it has been shown that green matter intake in the diet of free-range broilers can influence carcass yield. Some studies have reported positive effects, suggesting a higher body weight of livestock with access to pasture [29].

Intensive systems:

Most broiler chickens are raised in large, fully enclosed housing units where microclimate parameters: temperature, artificial lighting, ventilation, access to feed and water, are strictly monitored and adjusted to maximize production performance [30]. A commonly used practice is to maintain a low light level, which stimulates feed consumption and reduces locomotor activity, thus contributing to an accelerated growth rate [18].

Genetic selection plays a central role in these systems, with chicks specifically bred to maximise biological efficiency and feed conversion. They reach an average growth rate of around 62 g/day and are slaughtered at around five weeks of age, when their body weight is around 2.2 kg. Feed and water are administered via automated linear systems, and feed recipes are formulated differently depending on the stage of development to meet changing nutritional needs [31]. Chicken stocks are extremely large, often containing between 25,000 and 50,000 individuals raised on sawdust or straw bedding. This is not replaced during the production cycle, but only after the ctocks is slaughtered, which can contribute to moisture accumulation and increase the risk of leg injuries or respiratory problems [32]. The standard stocking density is 38 kg/m², but in some countries legislation allows this threshold to be exceeded up to 42 kg/m², subject to compliance with additional ventilation and monitoring standards [33].

In addition to conventional systems, there are intensive variants with higher welfare standards, where stocking density is reduced and breeds with slower growth rates are used. These reduce the incidence of locomotor and metabolic problems and can provide a better

balance between efficiency and broiler welfare [34]. However, these practices are adopted on a limited scale, mainly due to higher costs and the high demand for cheap and uniform meat. Although intensive systems ensure fast production and low cost per unit of meat, the literature also reports a number of challenges. Broiler flocks raised under such conditions tend to accumulate more abdominal fat and have a higher incidence of health problems related to the accelerated growth rate [35]. In addition, meat quality can be negatively influenced by environmental stress and the limitation of natural behaviors, which raises issues related to ethical acceptability and consumer perception [30].

RESULTS AND DISCUSSIONS

Although intensive systems represent the dominant production model globally and provide remarkable efficiency in terms of growth rate and production costs, these advantages often come with consequences on meat quality and broiler welfare. Accelerated growth rate, high stocking densities and limitation of natural behaviors can influence not only the health of the stocks, but also the physicochemical and sensory characteristics of the final product. Thus, parameters such as color, texture, pH, water retention capacity, chemical composition and lipid profile can be affected by the growing conditions. In addition, stress induced by environmental factors or by the handling of broilers in intensive systems can contribute to the appearance of technological defects such as PSE (pale, soft, exudative) meat or DFD (dark, firm, dry) meat [35].

The impact of genotype and rearing system on chicken meat characteristics and quality:

To support producers in adopting sustainable and efficient farming strategies, a thorough understanding of how the genotype of the broilers, the production system and the diet administered influence the characteristics of the meat is necessary. Such factors determine both the zootechnical performance and the physicochemical and sensory properties of the final product [36]. The relationship between environmental factors and genotype plays a central role in establishing the parameters that define the quality of the meat, from the chemical composition and lipid profile to the sensory traits perceived by consumers [37]. This complex interaction explains why the same breed of chicken can present different characteristics depending on the type of farming system (intensive, free-range or organic). Studies indicate that chickens from organic farming systems present higher quality characteristics, reflected in particular in the chemical composition of the meat. Thus, a higher content of polyunsaturated fatty acids, a reduced proportion of lipids and a generally improved nutritional value were reported, compared to broilers raised in conventional systems [38].

Available data confirm that genotype is the main determinant of carcass performance, significantly influencing both body weight and tissue distribution. Fast-growing lines achieve higher values for live weight, carcass weight and development of commercial parts, especially the pectoral muscle, compared to slow-growing lines [39]. These results are consistent with the literature, which highlights the genetic advantage of breeds selected for intensive growth, compared to traditional or slow breeds. However, a recurring aspect in studies is the higher accumulation of abdominal fat in fast-growing chickens, especially in organic systems, which limits their attractiveness for consumers oriented towards lean meat. In contrast, slow-growing chickens, although less efficient in terms of production, have advantages through reduced levels of adipose tissue and more appreciated sensory characteristics [40, 41]. The influence of the rearing system, although smaller than that of the

genotype, becomes relevant in interaction with it, especially on fat deposition. This genotype and environment interaction suggests that performance and final carcass quality cannot be analyzed separately, but must be evaluated integratively. In general, conventional systems associated with fast genotypes maximize yields and efficiency, while organic systems and slow genotypes offer benefits related to welfare and nutritional profile, but at a higher production cost [29]. Fast-growing broilers have heavier internal organs, especially the liver, proventriculus and gizzard, which reflects a more intense metabolism and more efficient nutrient utilization [40, 41]. In contrast, the grown ones raised in organic systems develop a more pronounced digestive tract (liver and intestine), which is explained by the increased fiber intake [42, 43]. [29] reported more robust digestive tracts in those with access to pasture, compared to those raised exclusively indoors. These observations were confirmed by [44], who showed that fast-growing, but organically raised broilers combine a high body mass with more developed digestive organs, thus influencing feed conversion and carcass composition.

The differences between conventional, free-range and organic systems are directly reflected in the chemical composition and nutritional profile of the meat. Early studies showed that organic broilers have lower abdominal fat and higher crude protein content [25]. These results were later confirmed by [23], who reported leaner and higher protein content in organic chickens compared to conventional ones. Free-range and organic systems were also associated with higher levels of polyunsaturated fatty acids (especially omega-3) and lower levels of saturated fat [23, 45]. A large meta-analysis by [46] confirmed these results, reporting higher PUFA and lower MUFA content in organic products. At the technological level, [47], have highlighted in organic meat a higher mineral content, a higher pH, an improved water retention capacity and reduced cooking losses, parameters that suggest a higher technological quality. However, there are also differences in terms of meat texture and color. Organically raised broilers presented firmer meat and a more intense color, aspects that influence consumer perception. In addition, access to pasture indirectly contributes to an improved nutritional composition, by stimulating the development of the gastrointestinal tract [42]. Last but not least, the role of nutrition is complemented by functional interventions. The administration of vitamins, probiotics or enzymes has the ability to modify meat quality parameters, including protein content and lipid composition, emphasizing that diet and growth environment must be analyzed together [48]. The basic composition of raw poultry meat is dominated by protein (18.4–23.4%), followed by lipids (1.3–6.0%) and minerals (0.8–1.2%), proportions influenced by genotype, rearing system and diet [49]. In particular, free-range and organic chickens tend to have a higher protein content, a lower level of crude fat and a healthier lipid profile [46, 50, 51]. These differences reflect the effect of the rearing environment, through a more varied diet, intense physical activity and access to pasture.

Characteristics analyzed:

- *Colour:*

Meat colour is considered an essential indicator of quality and one of the first parameters by which consumers assess the freshness and attractiveness of the product. Evaluated by the parameters L*(brightness), a*(redness) and b*(yellowness), colour varies depending on genetic and nutritional factors and, in particular, on the rearing system adopted. In conventional production, where broilers are raised in closed housing, with low levels of physical activity and a standardised diet, the

meat tends to have higher values of lightness (L*), which translates into a paler and more uniform appearance. This type of colour is often associated with standardisation and industry efficiency, but does not always reflect consumer preferences, who in some regions appreciate more intense shades, considered to indicate higher quality meat [40]. Alternative systems, such as free-range, generate meat with a more pronounced colour. Access to pasture allows the accumulation of carotenoid pigments from vegetation, which leads to an increase in b* values. In parallel, the higher level of muscular activity stimulates the synthesis and accumulation of myoglobin, contributing to an increase in the a* parameter, associated with a more natural and attractive appearance [36, 51]. In organic systems, where dietary diversity and access to the outdoor environment are even more accentuated, the effects on color are often more evident. Research has reported a reduction in brightness and an intensification of red and yellow tones, which gives the product a distinct visual identity and is perceived as premium [25, 45]. Recent studies have confirmed these results, showing that broilers with constant access to the outdoors have richer shades of both skin and muscle [52]. Alternative systems (free-range and organic) contribute to obtaining meat with more intense color and, implicitly, with a sensory value perceived as superior. The perception of color varies significantly depending on the cultural context and consumer preferences.

➢ *Texture*

Texture, especially tenderness, is one of the most important sensory parameters of chicken meat, having a direct impact on consumer preferences and product acceptability. This characteristic is influenced by biological factors, but also by the rearing system, which shapes the broilers physical activity, metabolism and muscle fiber structure. In conventional systems, early slaughter of broilers provides soft and fine meat, associated with high tenderness. However, this advantage is often correlated with a higher intramuscular fat content, which favors juiciness but can reduce firmness [53]. Intensive systems have been associated with the emergence of modern myopathies, such as woody breast, characterized by a dense, fibrous texture that does not meet consumer expectations [54]. In contrast, free-range and organic broilers, exposed to a higher level of physical activity, develop more robust musculature, which is reflected in firmer and denser meat. Instrumental tests confirm increased values of cutting force, a characteristic appreciated in markets that value a product perceived as natural and authentic [25, 36]. A comparative study showed that stocking density has a limited effect on sensory quality, as tenderness and juiciness do not show significant differences between broilers raised in conventional and free-range systems, although muscle fibers were thicker in the latter, suggesting a firmer texture [55]. Recent meta-analyses highlight that texture evaluation is strongly influenced by cultural context and consumer preferences. Thus, firmness is valued as an indicator of quality and authenticity in some regions, while in others it is perceived as a disadvantage [56]. Data suggest that alternative systems (free-range and organic) tend to produce firmer and more robust meat, but the perception of this trait remains relative and dependent on cultural and market factors.

➢ *pH*

The pH of chicken meat is a critical parameter for the evaluation of technological and sensory quality, influencing color, water retention capacity, tenderness and microbiological stability. It is mainly determined by the amount of muscle glycogen and the intensity of post-mortem glycolysis, factors that depend on

both the genotype and the slaughter conditions, as well as the rearing system. In conventional systems, characterized by accelerated growth rate and early slaughter, final pH values are usually lower (≈5.7–5.9). This profile reflects higher glycogen accumulations and an intense metabolism, which may favor the appearance of the defect known as PSE (pale, soft, exudative), associated with pale color and high water losses [57]. In contrast, broilers raised in free-range systems have lower glycogen reserves, as a result of the increased level of physical activity and access to pasture. These differences are reflected in a higher pH (≈6.0), which gives the meat a darker shade, better water retention capacity and a firmer texture [25, 36]. Similar results have been reported for organic systems, where the longer growing period and nutritional diversity determine slightly higher pH values than conventional ones. For example, [23] highlighted that organic chickens not only have a higher pH, but also lower cooking losses, aspects that may increase sensory acceptability. [45] also confirmed that slow-growing broilers from organic systems have meat with stable pH and appreciated sensory qualities. Some studies have not reported significant differences between system types, suggesting that factors such as genetic line, pre-slaughter stress level or diet may influence pH to the same extent as the rearing environment [58]. Although the differences are moderate, they have direct consequences on sensory quality and consumer perception.

➢ *Flavour*

Flavour is a defining sensory attribute of poultry meat and a major determinant of consumer acceptability. It results from the lipid and protein composition of muscle tissue and from chemical reactions that occur during heat treatment, when volatile compounds responsible for characteristic notes are formed. In conventional systems, where broilers grow rapidly on standardized grain diets, the flavour profile is uniform but less intense. Research has shown that lower levels of polyunsaturated fatty acids (PUFA) in intramuscular fat limit flavour complexity, resulting in less distinctive sensory notes [23]. In contrast, broilers raised in free-range and organic systems develop a richer flavour profile, due to the diversified intake of bioactive compounds from pasture vegetation and increased physical activity. [25] showed that organic chickens have higher concentrations of PUFA, which, during cooking, generate aldehydes, alcohols and ketones associated with distinct aromas. In the same direction, [36] confirmed that slow-growing lines raised with access to the outdoors produce meat with more complex sensory notes compared to conventional lines. The results are supported by [58] and [59], who demonstrated that diet and rearing environment directly influence the composition of volatile compounds, highlighting the fact that extensively raised broilers produce meat with a more intense aroma, especially due to the high content of n-3 fatty acids. These differences give the product a distinct sensory identity, preferred by consumers who associate strong aromas with naturalness and authenticity. Another significant aspect is cultural perception. In western markets, the more intense aromatic notes of organic and free-range meat are often appreciated, while in other regions there is a preference for the more delicate aromas characteristic of conventional meat [60]. The literature suggests that alternative rearing systems (free-range and organic) contribute to a more intense and complex aroma of chicken meat, through a more diverse lipid profile and a natural diet. Although the differences may be subtle, they constitute important competitive advantages in markets that value products perceived as healthier, more natural and with a higher sensory value.

➢ *Chemical composition*

Poultry meat is distinguished by a high content of proteins with high biological value, a variable proportion of lipids and a considerable supply of essential minerals. However, these characteristics are not uniform, but vary depending on factors such as the genotype, the feeding regime and the rearing system adopted. In conventional systems, where broilers are selected for rapid growth and slaughtered at young ages, the composition of the meat reflects a stable protein content, but a higher proportion of total lipids and abdominal fat. These features are the result of the intense metabolism and the limitation of physical activity, which favors the deposition of adipose tissue [36, 61]. In contrast, in free-range systems, the higher level of locomotor activity and the diversity of food sources lead to meat with a higher protein content and a lower proportion of lipids. Studies by [38] confirm that broilers with access to pasture produce leaner but more protein-dense meat, which gives it a higher nutritional value. At the same time, access to vegetation and insects contributes to the enrichment of the mineral and antioxidant profile [42]. In organic systems, these effects are even more pronounced, especially in slow-growing breeds. The meat obtained has a high protein content and a lipid profile considered beneficial for health, due to higher concentrations of polyunsaturated fatty acids, especially omega-3 [25]. Higher levels of micronutrients such as zinc and iron have also been reported, as a result of feeding with certified organic feed and access to natural soils [62]. The results were also confirmed by a large meta-analysis carried out by [46], which showed that products from organic systems contain, on average, higher levels of PUFA and a higher quality protein composition compared to conventional ones.

➢ *Water holding capacity and cooking losses*

Water holding capacity is the ability of muscle tissue to retain water during handling, processing and thermal preparation, being an essential parameter for juiciness, tenderness and sensory acceptability of chicken meat. Drip loss and cooking loss are complementary indicators frequently used to evaluate the technological quality of the product [63]. In conventional systems, characterized by accelerated growth rate and high metabolic stress, a lower water holding capacity and higher cooking losses have been reported. These effects are correlated with lower post-mortem pH values and an increased incidence of PSE (pale, soft, exudative) defect [35]. In contrast, free-range chickens generally have higher WHC and lower cooking losses. Additional physical activity and access to pasture reduce muscle glycogen levels and slow down post-mortem glycolysis, thus preventing sudden drops in pH and associated water losses [36]. Similar results have been reported for organic systems, where a diversified diet and a later age at slaughter contribute to superior muscle stability. [23] found that organic chickens had lower cooking losses than conventional chickens, a finding also confirmed by [45], who found a correlation between higher pH, improved WHC and favourable sensory characteristics. Parameters such as genotype, processing temperature or preparation methods can significantly influence WHC and cooking losses. For example, [64] showed that technological variations can modulate these values, even within the same growing system.

➢ *Oxidative stability and antioxidant potential of chicken meat*

Lipid oxidation is one of the main limiting factors in the quality and shelf life of chicken meat, causing undesirable changes in color, flavor and nutritional

value. The oxidative stability of muscle tissue is determined both by the fatty acid composition and by the presence of antioxidant compounds, such as vitamin E, carotenoids or polyphenols. In conventional systems, chickens are raised on standardized diets that generate meat with a relatively lower content of polyunsaturated fatty acids (PUFA). This composition confers greater resistance to oxidation, but the reduced intake of natural antioxidants limits long-term stability. Consequently, maintaining quality requires the addition of synthetic antioxidants to feed or their use in processing [65]. In free-range systems, broilers access to vegetation and insects results in meat with a higher content of PUFA, especially omega-3 fatty acids. This feature improves nutritional value, but increases susceptibility to lipid peroxidation. However, the concomitant intake of natural compounds with antioxidant action, vitamin E and carotenoids, from pasture vegetation, contributes to maintaining a balance between oxidability and antioxidant protection [42, 66]. Even more pronounced effects are reported in organic systems, where certified feed and prolonged access to the natural environment result in increased concentrations of α-tocopherol and carotenoid pigments. Studies [62] and [67] have shown that these resources improve resistance to oxidation, even in conditions of a higher proportion of PUFA. Also, recent research shows that supplementing organic food with natural antioxidants extends the shelf life and maintains the sensory qualities of meat for longer periods [41].

➢ *Microbiological quality of chicken meat*

The microbiological quality of chicken meat is an essential criterion for food safety, influencing both product acceptability and public health risks. Bacterial contamination can occur both during the life of the broilers, through exposure to soil, water and feed, and later, during the slaughter and processing stages. Among the pathogens of major relevance are *Salmonella spp.*, *Campylobacter spp.*, *Listeria monocytogenes* and resistant strains of *Escherichia coli.* In conventional systems, high stocking density and the use of antimicrobials as growth promoters or for prophylactic purposes increase the risk of the emergence and dissemination of antibiotic-resistant bacteria.

This phenomenon represents a global concern for public health, with direct implications for the effectiveness of antimicrobial therapies [68, 69]. In free-range systems, broilers benefit from lower densities but are directly exposed to natural environments that can host pathogens. Although this organization limits the horizontal transmission of infections within the flock, the risk of contamination with Campylobacter and Salmonella remains significant, with some studies reporting higher prevalences compared to intensive farms [70, 71]. However, the diversity of the gut microbiota in these broilers is considered an advantage, contributing to increased resistance to colonization by pathogenic bacteria [72]. In organic systems, strict restrictions on the use of antibiotics considerably reduce the risk of antimicrobial resistance. Available data show that bacterial strains isolated from meat from organic farms generally show lower levels of resistance compared to conventional ones [73,74]. However, more frequent access to environmental microflora may lead to higher initial contamination, without however implying serious clinical consequences when rigorous hygiene measures are applied at slaughter.

An additional aspect is the perception of consumers, who frequently associate organic and free-range products with higher microbiological safety. However, the literature shows that the actual differences in pathogen prevalence are often smaller

than assumed, being influenced more by local hygiene and processing standards than by the type of farming system.

➢ *Consumer perception and marketing of chicken meat*

In recent decades, consumer attention has expanded beyond the sensory and nutritional characteristics of chicken meat, including an increased interest in the production systems from which it comes. Labels such as organic and free-range have acquired symbolic meaning, being associated with animal welfare, sustainability and food safety, aspects that directly influence purchase intention [75]. The literature shows that products from alternative systems are often perceived as being of higher quality, even when the objective differences in technological or nutritional parameters are moderate [76, 77].

In Europe, consumers frequently associate free-range and organic meat with "more natural" products, characterized by a richer sensory profile and a reduced environmental impact [78]. In the United States and Asia, some consumers appreciate the firmer texture and more intense flavor of slow-raised poultry, while others remain loyal to the tenderness characteristic of conventional chicken [79]. This cultural diversity in terms of sensory expectations determines market segmentation strategies, with producers adapting their positioning according to consumer profiles. From a marketing point of view, transparent labeling and independent certifications, play a key role in strengthening consumer confidence. Communication campaigns that emphasize animal welfare, sensory quality and microbiological safety also help to justify the higher price of products from alternative systems. In the current context, where demand for products perceived as healthier and more sustainable is increasing, poultry nutrition is taking on a central role in determining meat quality. Recent studies highlight the potential of natural additives to improve zootechnical performance and product stability, without compromising food safety [80].

CONCLUSIONS

Comparative analysis of broiler rearing systems highlights that genotype and rearing environment are the main determinants of zootechnical performance and meat quality. Fast-growing lines, predominantly used in intensive systems, provide superior yields and economic efficiency, but are associated with higher levels of abdominal fat, an increased frequency of metabolic problems and variable sensory quality. In contrast, free-range and organic systems, based on breeds with a slower growth rate, offer benefits in terms of animal welfare, nutritional profile and sensory characteristics of meat, but with a higher production cost and increased risks related to mortality and oxidative stability. The results from the specialized literature confirm that parameters such as color, texture, pH, water retention capacity, chemical composition, oxidative stability and microbiological quality are significantly influenced by the type of system adopted.

Meat from alternative systems is perceived by consumers as more natural, healthier and of higher quality, even if the objective differences are not always major. In this context, consumer perception and marketing strategies play a central role in the valorization of products from systems with high welfare standards. Overall, the need for an integrated approach is emerging that correlates productive efficiency with nutritional, sensory, ethical and food safety requirements.

The development of sustainable production models, capable of responding to both market demands and challenges related to animal welfare and public health, remains the main direction of evolution of the poultry industry.

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