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The direction of broiler farming research in recent decades

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Abstract

To understand the direction of broiler farming research over the past few decades, this study was conducted using Web of Science as a database. A total of 29,193 documents were published on this platform from 2014 to 2024 on various topics related to broilers. 91.86% of the existing documents were published in the form of scientific articles and the most popular categories of publications are none other than "Agriculture Dairy Animal Science" and "Veterinary Sciences**".** In terms of publication reviews, "Poultry Science" and "Animals" have been the most requested for the publication of studies conducted on broilers over the last 10 years. As for the most productive countries in terms of producing scientific documents, China and the United States have largely distinguished themselves from other countries internationally, strengthening their reputation in broiler farming. Given the vastness of the database, a combination of keywords and two filters were used. For the analysis of the data, only the top 50 most referenced and cited studies were considered. The analysis of the documents made it possible to understand that many studies have been carried out on key themes such as genetics, egg incubation, stress on broilers, nutrition, the use of antibiotics, avian diseases and on the behavior of poultry in the rearing environment. However, topics related to sperm quality, climate change, effluent management and greenhouse gas reduction are still underexplored and will certainly be the subject of future research.

Keywords: *Broilers, research, animal welfare, genetics, stress, Web of Science*

Introduction

Scientific research is research conducted with the goal of contributing to science through the systematic collection, interpretation, and evaluation of data in a planned manner (Ozhan Caparlar & Donmez, 2016). It is essential to produce new knowledge to better understand a situation or a phenomenon. It is also an essential pillar for the development of technological and social innovations. For many decades, scientific research has experienced a certain expansion, but in recent years this trend has been more accelerated. In fact, in 2022, more than 5.14 million scientific articles were published worldwide, an increase of 22.78% since 2018 (Benjamin et al., 2023).

Whether in the field of human, animal, technological or other sciences, it should be noted that no sector that wants to evolve can achieve this without the help of scientific research and the livestock sector is no exception. Protein contributes to nearly 40% of total agricultural production in developed countries and 20% in developing countries, and supports the livelihoods of at least 1.3 billion people worldwide (FAO, 2025). Even if the contribution of the livestock sector is not limited to the production of meat, milk and eggs, However, it would be difficult to fully meet the nutrient needs of the population without it. Foods of animal origin make a critical contribution to global nutrition and are an excellent source of macro- and micronutrients (Mottet et al., 2017).

At the same time, livestock products account for 18% of global calories, 34% of global protein consumption and provide essential micronutrients, such as vitamin B12, iron, zinc and calcium that can be locally difficult to obtain in adequate amounts from plant-based foods alone (Murphy & Allen, 2003; Randolph et al., 2007). However, we cannot talk about the livestock sector without talking about broilers. Indeed, broiler farming is by far the largest land-based animal production industry in the world, with around 70 billion broilers slaughtered each year (Butterworth, 2021).

In 1920, for a broiler to reach the weight of 1,500 g, it took 120 days, 44 days in 1980 and only 33 days in 1998 (GAA Albers & Ir. A. Groot, 1998). Since 2005, it is possible for broilers to reach between 1,700 g and 2,200 g of live weight after only 28 days of rearing and to more than 3,500 g in only 56 days of rearing if and only if the appropriate breeding conditions are respected (Zuidhof et al., 2014). In other words, the live weight at 6 weeks of the animals has been multiplied by 3 in 50 years (from 1 to 3 kg) and the net yields by 1.7 in 30 years (Berri & Jehl, 2001).

Over the years, it is therefore obvious that broilers have experienced a huge improvement in their productivity, thanks to the simultaneous progress of genetics, nutrition, breeding methods and veterinary medicine. To put it simply, the productivity of broilers has increased in recent years largely thanks to the various scientific research

carried out in the field. In other words, without advances in scientific research, none of its results would have been possible.

Since each discovery of scientific research is only the continuation of past results and experiments, this study was initiated with the aim of taking stock of the direction of research in broiler farming over the last decade. Understanding the direction of research at the level of broiler farming will allow us to look back on the progress already made, but also to highlight the future challenges for efficient, sustainable and even more environmentally friendly production.

Materials and methods

To carry out this study on the orientation of the Research on broiler farming Over the past ten years, the first step has been the selection of a database. The choice fell on Web of Science (WoS) rather than Scopus, PubMed or other databases because it is not a simple catalogue of academic publications. WoS is a selective, structured and balanced database, with comprehensive citation links and enhanced metadata, that meets a wide range of information purposes (Birkle et al., 2020). It is also a selective index of citations of scientific and academic publications covering journals, proceedings, books and data compilations. (Birkle et al., 2020).

The first data were obtained using the keyword "broilers" and excluding data not belonging to the last decade. In other words, only data from 2014 to 2024 on broilers were considered. As a result, more than 29,000 documents were found. Given the number of documents found, only information concerning the "type of documents published", the "Web of Science categories", the "publication journals" and the "countries" that have published on the subject were considered for the analysis of the data in the first instance.

To reduce the size of the database previously obtained, the key theme of this study was pooled with other keywords such as "genetics", "health and well-being", "antibiotics", "diseases", "behavior" and other keywords using "AND" as a Boolean operator in a second step. For example, the combinations "genetic AND broilers", "antibiotic broilers AND", etc. were used. By combining these different keywords two by two with the main theme, the data could be halved in some cases and more in others. However, to filter the data as much as possible, to obtain precise documents on the different keywords used, two additional filters were used. Indeed, the keywords used should be found in the "Title" as well as in the "Author's keywords".

For the analysis of the data in this specific case, only the top 50 most referenced and cited studies, as well as the countries that have produced the most publications related to the association of the key theme and the different keywords previously mentioned were examined. No special software was used for data analysis, as on the WoS platform there are the "Analyze Results" and "Citation Report" options. These two different options alone have made a great contribution to data analysis, as they promote efficient and timely analysis of trends, areas of research, and citations.

However, it is important to note that the most cited and referenced studies are not always representative in terms of research quality. As a result, many of the research findings may not be considered in this study. At the same time, the study of about fifty studies does not allow for an in-depth study of the available literature, even if many of the studies have been repetitive. In addition, by using the filter, many documents will not be considered, but by adding the presence of the keywords used in the abstracts of the articles, it could further enlarge the literature obtained and at the same time enrich the results obtained in this study. Regarding the third part, a conclusion was drawn for this study.

Data analysis

Status of Broiler Publications from 2014 to 2024

Table 1 shows the 10 different types of documents that exist in terms of the literature available on broilers according to the Web of Science database.

Table 1. Summary of the types of documents existing on the broilers

Document Types	Record Count	% of 29 193
Article	26817	91.861
Review Article	1456	4.987
Proceeding Paper	479	1.641
Meeting Abstract	329	1.127
Book Chapters	194	0.665
Correction	138	0.473
Early Access	125	0.428
Editorial Material	55	0.188
Retracted Publication	26	0.089
Letter	20	0.069

According to Table 1, there are 29,193 documents available on broilers. Of these, 26,775 documents were published in the form of scientific articles, i.e. 91.86% of the existing documents. 1,455 documents were published in the form of review articles, i.e. 4.99% of the existing documents. The remaining documents were published as working papers, summaries of meetings, or in the form of a book and other chapters.

Scientific production by country

Table 2 presents the different countries that are most active in terms of the production of documents on topics related to broilers.

Table 2. Scientific production according to country

Countries/Regions	Record Count	% of 29 193
CHINA	5497	18.830
USA	4823	16.521
BRAZIL	2258	7.735
IRAN	2068	7.084
EGYPT	1556	5.330
PAKISTAN	1147	3.929
INDIA	1066	3.652
POLAND	1006	3.446
CANADA	991	3.395
GERMANY	978	3.350

According to Table 2, China and the United States are the countries that have distinguished themselves the most through their quantitative contribution to research related to broilers. China alone published 5,489 documents, or 18.11% of the available literature on broilers. The USA produced 4810 documents, or 16.5% of the total production. In addition, countries such as Brazil, Iran, Egypt, Pakistan, India and others have also contributed to the production of scientific papers on broilers.

Most Active Web of Science Categories

Table 3 presents the different categories within which scientific publications on broilers have been indexed in the Web of Science database.

Table 3. categories Web of Science

Web of Science Categories	Record Count	% of 29 193
Agriculture Dairy Animal Science	14511	49.707
Veterinary Sciences	7646	26.191
Food Science Technology	1913	6.553
Microbiology	1761	6.032
Zoology	1720	5.892
Agriculture Multidisciplinary	1603	5.491
Multidisciplinary Sciences	986	3.378
Biotechnology Applied Microbiology	977	3.347
Environmental Sciences	948	3.247
Biochemistry Molecular Biology	779	2.668

As regards the categories into which the scientific studies conducted on broilers were divided, it is apparent from Table 3 that almost half of the documents, i.e. 14 511 documents existing in the Web of Science database, were categorised in the section 'Agriculture Dairy Animal Science'. Apart from this category, which stood out significantly, there are also 7,646 documents that were divided into the "Veterinary Sciences" category. Other Web of science categories such as Food Science Technology, Microbiology, Zoology and Agriculture Multidisciplinary also stood out with more than 1500 documents in each of them.

The most active scientific journals

Table 4 shows the scientific journals that have published the most articles on topics related to broiler farming.
According to Table 4, journals such as "Poultry Science" and "Animals" have been the most solicited for the publication of studies conducted on broilers over the last 10 years. Each of them has more than 1,200 articles published on topics related to broilers. Journals such as the Journal of Applied Poultry Research, British Poultry Science, Brazilian Journal of Poultry Science and others individually published an average of more than 340 articles on topics related to broiler farming.

Table 4. The most productive scientific journals

Publication Titles	Record Count	% of 29 193
POULTRY SCIENCE	3927	13.452
ANIMALS	1244	4.261
JOURNAL OF APPLIED POULTRY RESEARCH	658	2.254
BRITISH POULTRY SCIENCE	575	1.970
BRAZILIAN JOURNAL OF POULTRY SCIENCE	559	1.915
FRONTIERS IN VETERINARY SCIENCE	455	1.559
JOURNAL OF ANIMAL SCIENCE	448	1.535
PLOS ONE	424	1.452
JOURNAL OF ANIMAL PHYSIOLOGY AND ANIMAL NUTRITION	396	1.356
ANIMAL FEED SCIENCE AND TECHNOLOGY	377	1.291

The most productive countries in terms of publishing scientific papers in the field of genetics at the broiler level

Figure 1 shows the 10 countries that have published the most literature in the field of genetics for the optimization of broiler farming. According to Figure 1, on genetic issues related to broilers, a total of 2,079 documents are available on the Web of Science database. In addition, the USA with 415 documents and China with 399 documents to their credit are the countries that have published the most articles on this topic over the last decade.

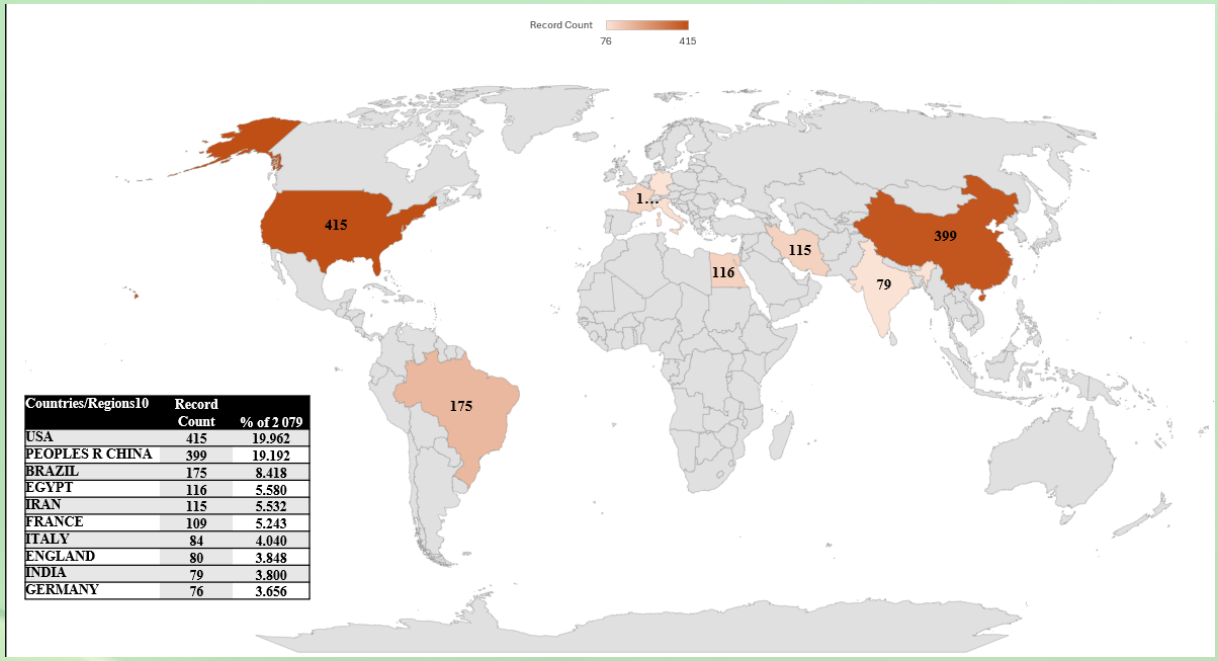


Figure 1. Most productive countries in terms of documents in the genetics sector

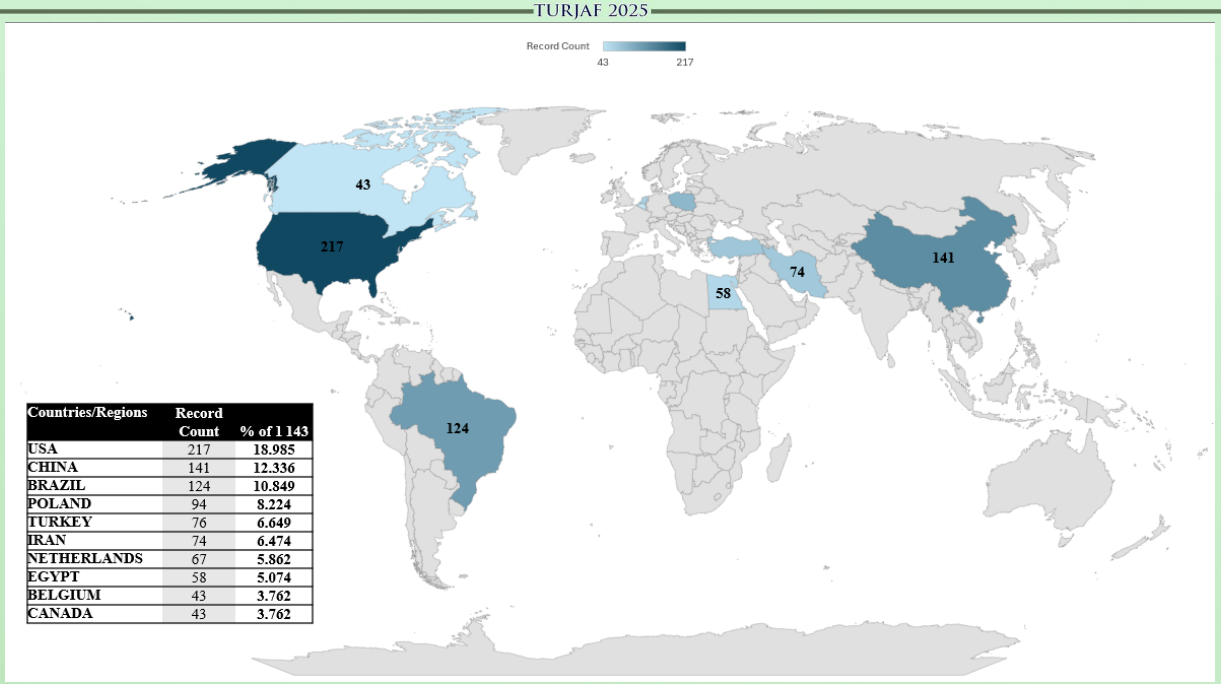
The most productive countries in terms of scientific publications in the field of egg incubation at the broiler level

Figure 2 shows the 10 countries that have published the most papers on research related to the incubation of breeding eggs for the optimization of broiler farming.

On WoS, a total of 1,143 documents are available regarding the work carried out by broiler researchers in the field of egg incubation of broiler breeding females over the last ten years. The USA, China and Brazil stood out through the number of publications they each made in this specific field. Each of these countries has published more than 120 documents. Turkey and Poland follow with more than 70 documents published per country.

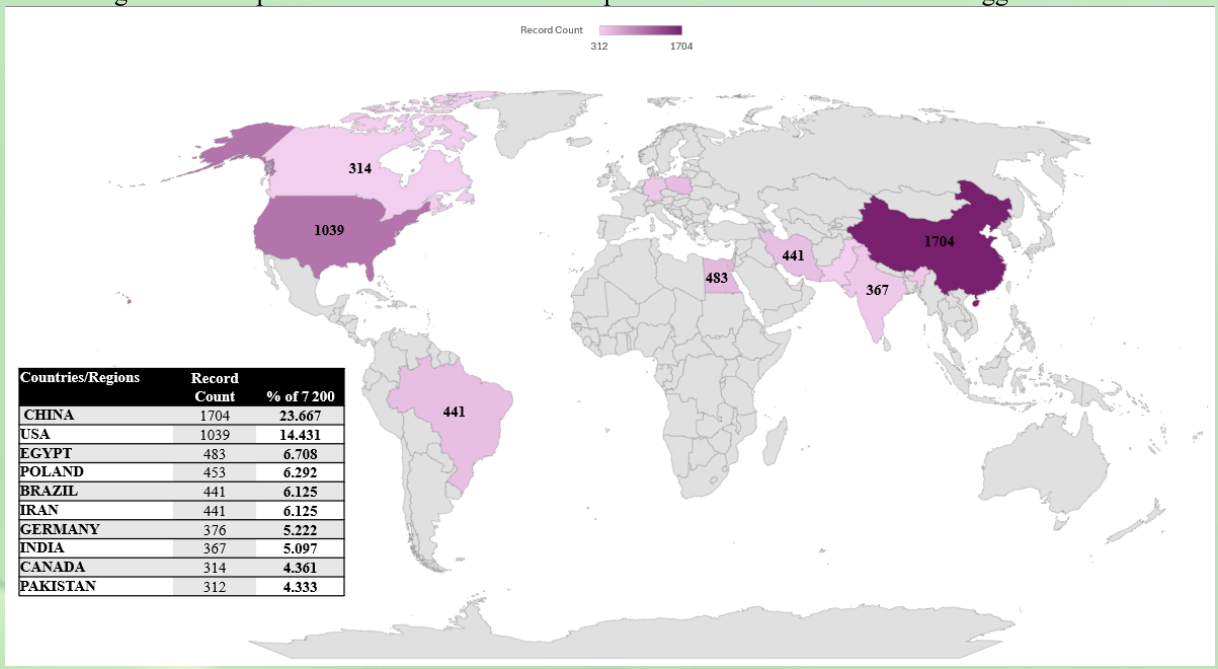
The most productive countries in terms of the production of documents in the broiler nutrition sector

Figure 3 shows the 10 countries that have published the most nutrition papers for the optimization of broiler farming. From 2014 to 2024, the broiler nutrition sector is the area in which researchers have invested the most. Indeed, more than 7,000 documents have been produced worldwide on this theme related to broilers. In this area of research, China, the USA, Egypt, Poland and Brazil alone have produced more than 50% of the available literature in the field of broiler nutrition.



Countries/Regions	Record Count	% of 1 143
USA	217	18.985
CHINA	141	12.336
BRAZIL	124	10.849
POLAND	94	8.224
TURKEY	76	6.649
IRAN	74	6.474
NETHERLANDS	67	5.862
EGYPT	58	5.074
BELGIUM	43	3.762
CANADA	43	3.762

Figure 2. Most productive countries in terms of publications in the field of broiler egg incubation



Countries/Regions	Record Count	% of 7 200
CHINA	1704	23.667
USA	1039	14.431
EGYPT	483	6.708
POLAND	453	6.292
BRAZIL	441	6.125
IRAN	441	6.125
GERMANY	376	5.222
INDIA	367	5.097
CANADA	314	4.361
PAKISTAN	312	4.333

Figure 3. Most productive countries in terms of publications in the field of broiler nutrition

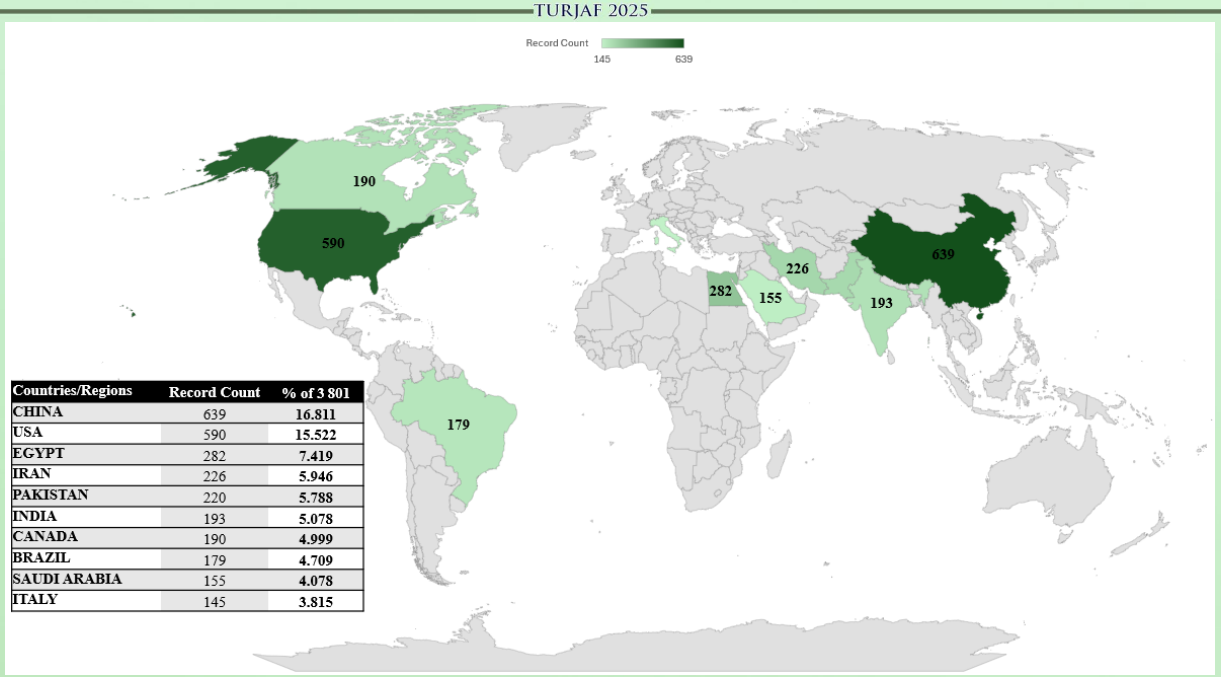
The most productive countries in terms of publications of scientific papers on antibiotics in broiler farming

Figure 4 shows the 10 countries that have published the most papers on the topic of antibiotics in broiler farming. According to the Web of Science database, nearly 4,000 documents are available on research on the use of antibiotics in broiler farming. China, the USA, Egypt, Iran and Pakistan alone have produced more than half of the literature available on the platform. China and the USA produced 639 and 590 documents respectively related to this theme. From this figure, it emerges that Italy is the country to have produced the fewest documents on this theme. Indeed, 145 documents are available to his credit.

The most productive countries in the production of scientific papers related to broiler diseases

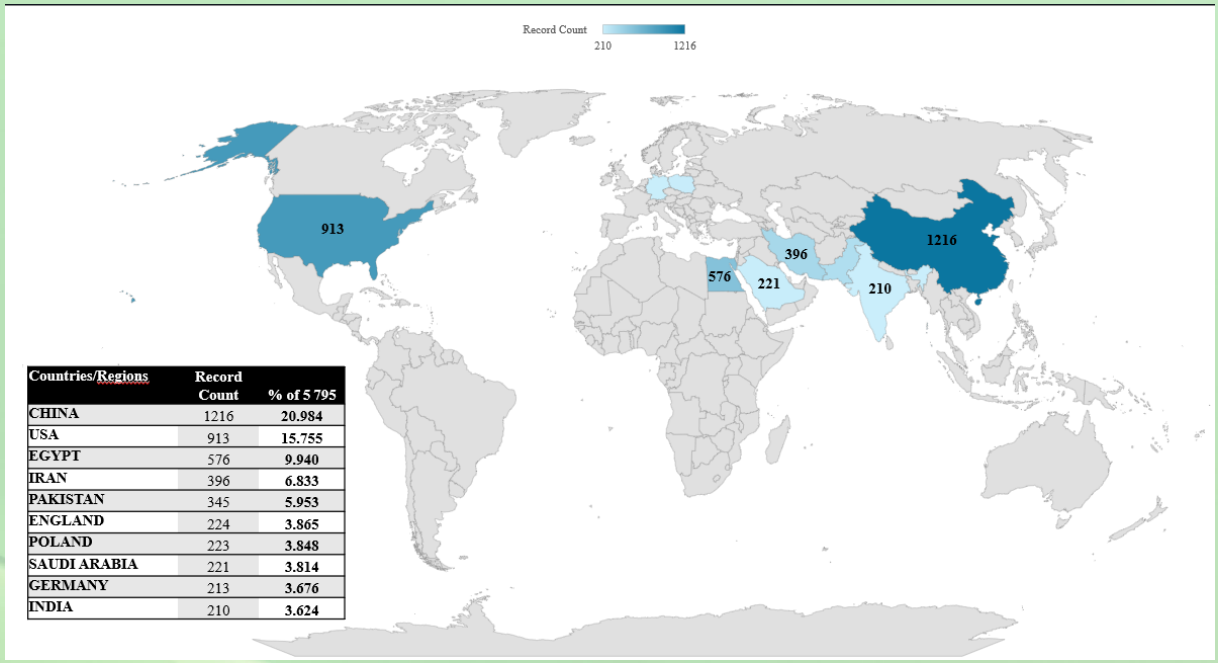
Figure 5 shows the 10 countries that have published the most papers on research on broiler diseases over the past 10 years.

More than 5,000 documents are available on this theme and China, the USA and Egypt are the countries that have produced the most documents. China produced 20% and the USA produced 15% of the literature available on WoS on topics related to diseases in the broiler farming sector.



Countries/Regions	Record Count	% of 3 801
CHINA	639	16.811
USA	590	15.522
EGYPT	282	7.419
IRAN	226	5.946
PAKISTAN	220	5.788
INDIA	193	5.078
CANADA	190	4.999
BRAZIL	179	4.709
SAUDI ARABIA	155	4.078
ITALY	145	3.815

Figure 4. Most productive countries in terms of publications on antibiotics in broiler farming



Countries/Regions	Record Count	% of 5 795
CHINA	1216	20.984
USA	913	15.755
EGYPT	576	9.940
IRAN	396	6.833
PAKISTAN	345	5.953
ENGLAND	224	3.865
POLAND	223	3.848
SAUDI ARABIA	221	3.814
GERMANY	213	3.676
INDIA	210	3.624

Figure 5. Most productive countries in terms of publication of papers on broiler diseases

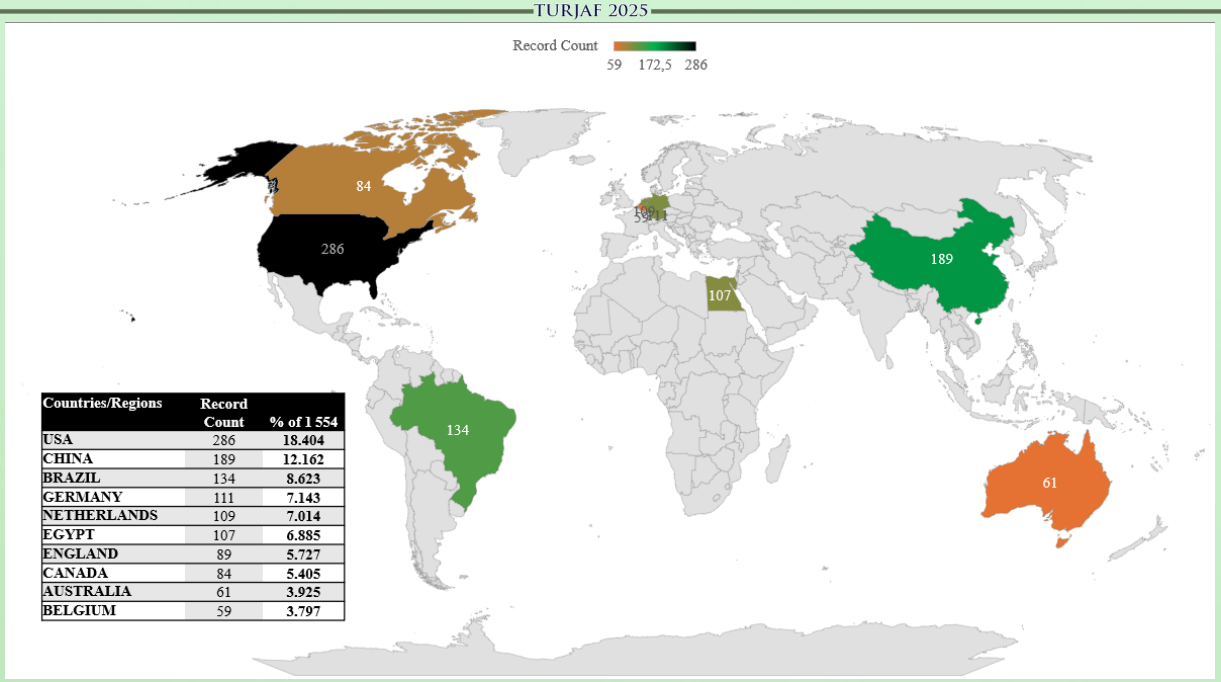
The most productive countries in terms of scientific publications on the theme: behavior, breeding conditions and welfare of broilers in the rearing environment

Figure 6 shows the 10 countries that have published the most scientific papers on research on the behavior, rearing conditions and welfare of broilers in the rearing environment over the past 10 years.

From this figure, it emerges that the USA is also at the top of other countries in terms of the production of scientific documents on the theme, breeding conditions and welfare of broilers in the rearing environment over the last 10 years. Out of 1554 documents, the USA produced 286 documents, or 18% of the total production. China and Brazil produced 189 and 134 papers respectively, i.e. 12.16% and 8.6% of the available literature on the subject, rearing conditions and welfare of broilers in the rearing environment, ranking them second and third after the USA.

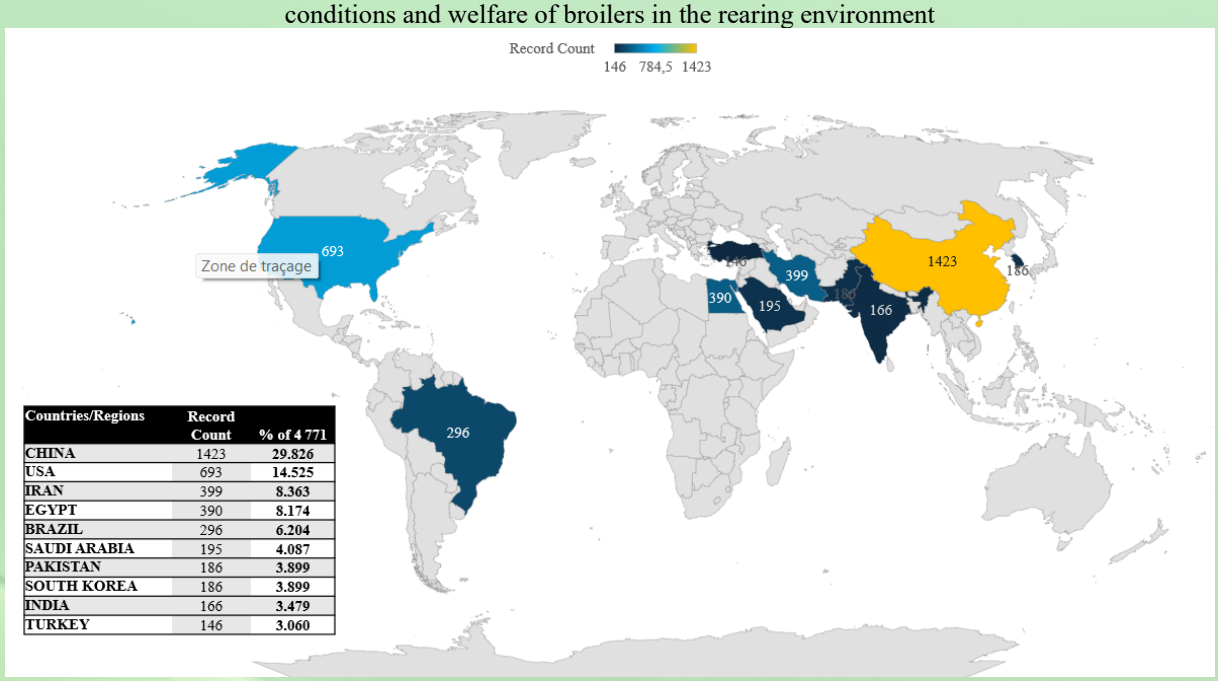
The most productive countries in terms of producing scientific papers on the topic of stress on broilers in livestock farming

Figure 7 shows the 10 countries that have published the most scientific papers on research on the topic of broiler stress in the rearing environment over the past 10 years.



Countries/Regions	Record Count	% of 1 554
USA	286	18.404
CHINA	189	12.162
BRAZIL	134	8.623
GERMANY	111	7.143
NETHERLANDS	109	7.014
EGYPT	107	6.885
ENGLAND	89	5.727
CANADA	84	5.405
AUSTRALIA	61	3.925
BELGIUM	59	3.797

Figure 6. The most productive countries in terms of scientific publications on the theme of the behavior, rearing conditions and welfare of broilers in the rearing environment



Countries/Regions	Record Count	% of 4 771
CHINA	1423	29.826
USA	693	14.525
IRAN	399	8.363
EGYPT	390	8.174
BRAZIL	296	6.204
SAUDI ARABIA	195	4.087
PAKISTAN	186	3.899
SOUTH KOREA	186	3.899
INDIA	166	3.479
TURKEY	146	3.060

Figure 7. Productive countries in terms of scientific publications on stress on broilers in the rearing environment

According to Figure 7, more than 4,500 documents are available on Web of Science about stress on broilers on farms. China, the USA and Iran are the countries that have published more than 50% of the available literature. China alone produced 1,423 documents, or 29.8% of the available documents on stress, putting it at the top of the ranking. In this figure, Turkey occupies the 10th position in the ranking with a total of 146 published documents.

The most productive countries in terms of scientific publications on research carried out on the topic of broiler breeding rooster semen

Figure 8 shows the 10 countries that have published the most scientific papers in terms of research on broiler breeding semen over the past 10 years.

According to Figure 8, there are less than 250 articles available on the topic of semen. It is therefore obvious that this field of research within broiler farming is still quite recent and needs to be further developed. Iran is the country that has produced the most articles on this topic with a total of 75 documents published, i.e. 37.5% of the total production. It is followed by China and the United States, which have produced 29 and 27 documents on this theme respectively.

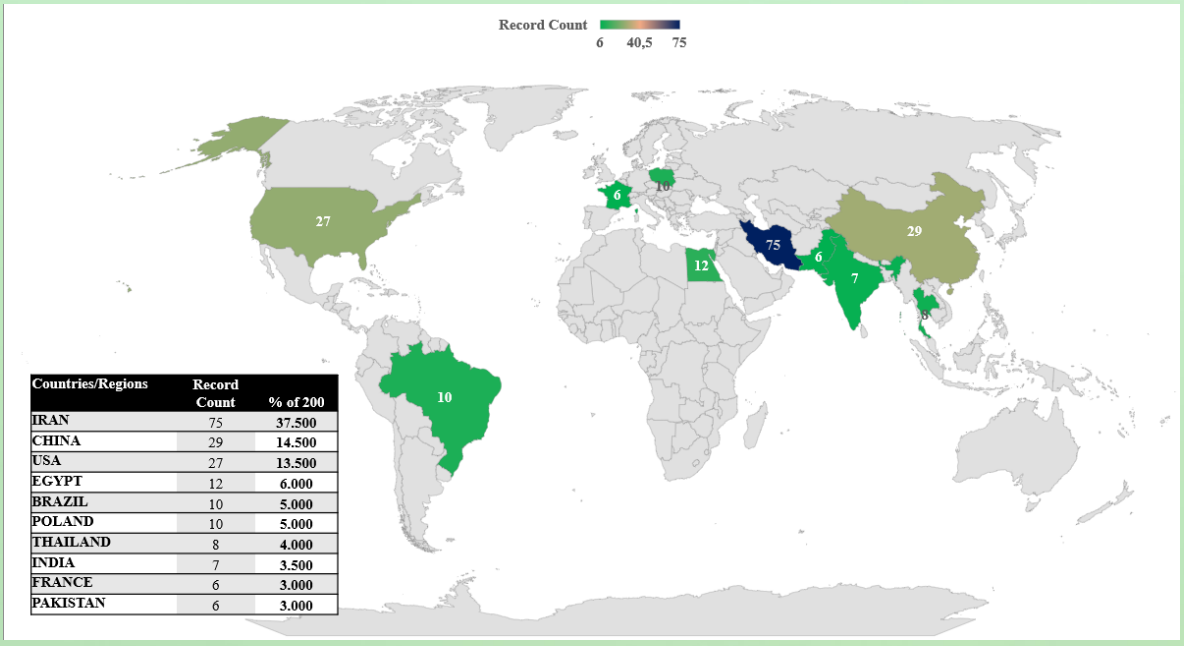
On Web of Science, less than 200 documents related to broiler production in the face of the challenge of climate change are available. This lack of literature underlines the emerging nature of this issue for the poultry industry. Of the 187 documents available, the USA is the country with the most publications with 36 documents to its credit. It is followed by Egypt and Malaysia respectively.

The most productive countries in terms of the production of documents regarding effluent management and greenhouse gas reduction in broiler farming

Figure 10 shows the 10 countries that have published the most scientific research papers on the topics of effluent management and greenhouse gas reduction in broiler farming over the past 10 years.

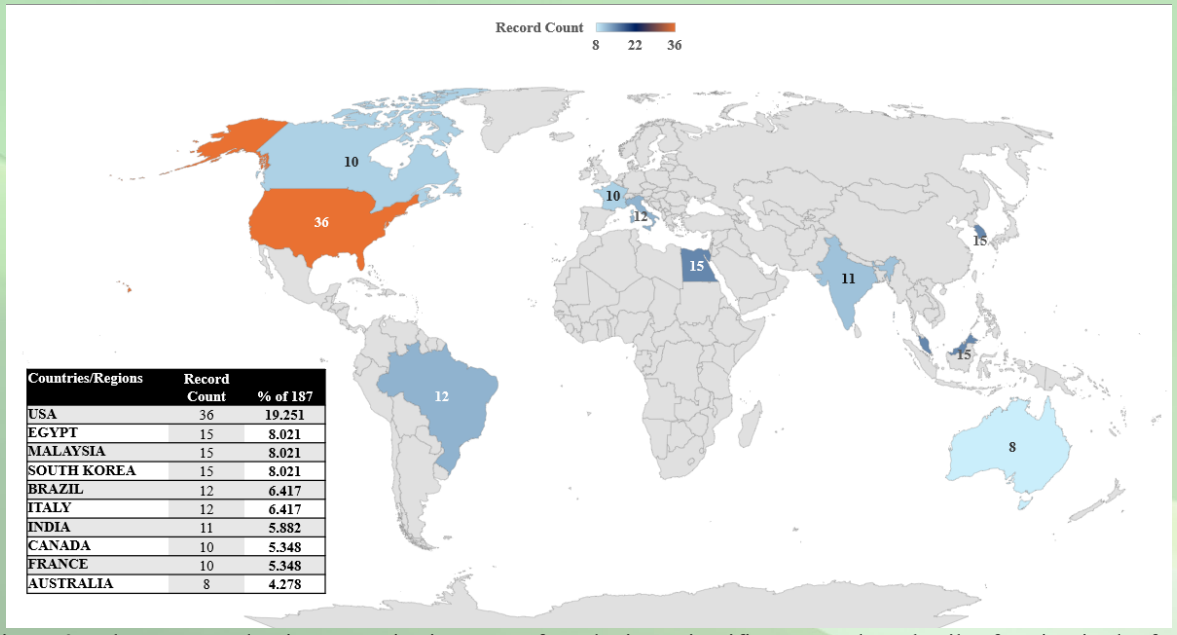
The most productive countries in terms of producing scientific papers about broiler farming in the face of the challenge of climate change

Figure 9 shows the 10 countries that have published the most scientific papers about broiler farming in the face of the challenge of climate change over the past 10 years.



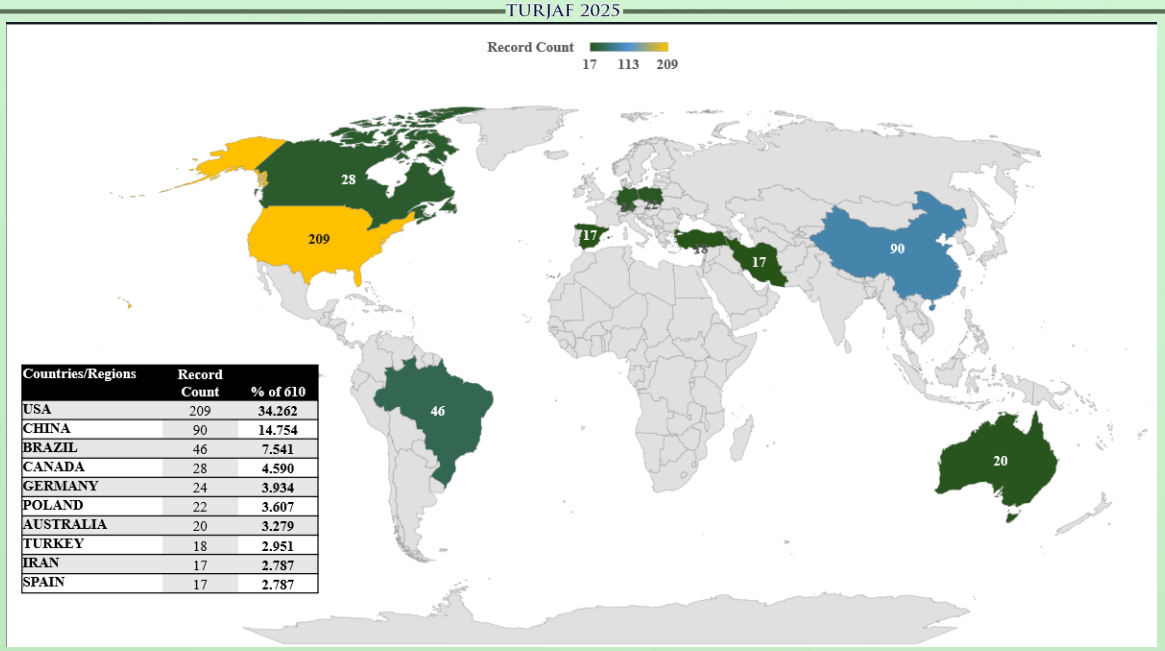
Countries/Regions	Record Count	% of 200
IRAN	75	37.500
CHINA	29	14.500
USA	27	13.500
EGYPT	12	6.000
BRAZIL	10	5.000
POLAND	10	5.000
THAILAND	8	4.000
INDIA	7	3.500
FRANCE	6	3.000
PAKISTAN	6	3.000

Figure 8 : Most productive countries in terms of publication of scientific papers on the topic of broiler breeding cockerel semen



Countries/Regions	Record Count	% of 187
USA	36	19.251
EGYPT	15	8.021
MALAYSIA	15	8.021
SOUTH KOREA	15	8.021
BRAZIL	12	6.417
ITALY	12	6.417
INDIA	11	5.882
CANADA	10	5.348
FRANCE	10	5.348
AUSTRALIA	8	4.278

Figure 9 : The most productive countries in terms of producing scientific papers about broiler farming in the face of the challenge of climate change



Countries/Regions	Record Count	% of 610
USA	209	34.262
CHINA	90	14.754
BRAZIL	46	7.541
CANADA	28	4.590
GERMANY	24	3.934
POLAND	22	3.607
AUSTRALIA	20	3.279
TURKEY	18	2.951
IRAN	17	2.787
SPAIN	17	2.787

Figure 10 : The most productive countries in terms of producing documents on effluent management and greenhouse gas reduction

According to Figure 10, more than 600 papers were published in different journals from 2014 to 2024 in terms of available documents on the topics of manure management and greenhouse gas reduction in broiler farming. Of these 610 documents available, more than a third of the documents, i.e. 209 documents, were published by the United States, followed by China with 90 documents and Brazil with 46 published documents. These three countries have once again produced more than 50% of the available literature.

Results and discussions of the direction of broiler rearing research during 2014 to 2024

Genetics

Research carried out over the last 60 years on broilers through genetic selection has resulted in rapid growth rates, increased meat yield and a significant reduction in the age of slaughter, the amount of feed and the energy required to raise these birds (Bradshaw et al., 2002). Unfortunately, these scientific advances have been achieved without considering the welfare of poultry. Indeed, the rapid growth rate of broilers is closely linked to cardiovascular diseases in poultry, thus causing mortality from sudden death syndrome and ascites, leg disorders and bone deformities leading to leg weakness, lameness and poor locomotor activity (Bessei, 2006).

From 2014 to 2024, research in the field of genetics focused on several key areas, including improving growth and feed efficiency, as well as improving meat quality, this time with poultry welfare in mind (Bailey et al., 2015; Gratta et al., 2019; Hartcher & Lum, 2020). With regard to improving feed efficiency, some research has tried to identify candidate genes, in particular AGK and GTF2I, and QTL (Quantitative Trait Loci) associated with feed efficiency associated with traits such as RFI (Residual Feed Intake) and FCR (Feed Conversion Ratio) (Chen et al., 2021; Shah et al., 2016). Genomic selection studies have been conducted with the goal of improving trait selection practices and accuracy (Sell-Kubiak et al., 2017).

Since muscular myopathies (white streaks and woody breasts) have been observed in broilers in recent years, various studies were carried out between 2014 and 2024 to understand and limit their appearance in broiler meat. At the genetic level, the studies conducted have made it possible to explore the genetic basis of myopathies in order to identify the molecular mechanisms involved (Gratta et al., 2019; Lake et al., 2021). In addition, as animal welfare is also a topical issue, research in the field of genetics related to broilers has examined the negative impacts of intensive selection (locomotor problems, metabolic diseases, etc.) on broilers with the aim of finding palliative solutions (Hocking, 2014). Finally, research has also been carried out on genetic diversity and antimicrobial resistance in certain pathogens, including *Campylobacter*and*Salmonella* with the sole aim of controlling the epidemiology of these bacteria while developing strategies to better control infections (Vidal et al., 2016; Ramires et al., 2020; Mughini-Gras et al., 2021).

Egg Incubation

Egg incubation has also been an area in which researchers have had to conduct studies over the past ten years. Research has focused on optimizing environmental conditions to improve embryo development, chick quality, post-hatch growth and bird welfare. Studies have explored the effect of incubation temperature on embryo

development. It has been noted that a temperature of 37.8°C is the optimal temperature to ensure perfect development of broiler chick embryos. Also, slight temperature variations could also allow better embryo development. Other studies have shown that temperatures that are too low significantly slow down embryonic development, while temperatures that are too high speed up embryonic development. These temperature variations can cause many malformations, abnormalities in the legs and can affect the development of long bones in chicks (Afsarian et al., 2018; Maatjens et al., 2016; Oznurlu et al., 2016; Wijnen et al., 2020).

At the same time, exposure to light during incubation has been the subject of research by some researchers to study the impact of this process on the metabolism, muscle growth and immunity of the immune system. Chicks. It has been noted that light, whether red, white or blue in color, does not affect embryonic mortality, hatching time, hatching and even less the quality of the chicks obtained. However, exposure of eggs to light could have a negative effect on the immunity and energy metabolism of broiler embryos (Archer, 2017; X. Li et al., 2021). In addition, research on the in ovo injection of nutrients, amino acids or prebiotics during incubation has made it possible to understand the positive effect of this practice on the development of broiler embryos. This practice also serves to strengthen and improve the expression of genes related to growth (Elnesr et al., 2019; Elwan et al., 2019; Stadnicka et al., 2020).

In addition, much other research has been done on egg storage time, types of incubators, moisture management, and factors (age of the parental flock, ventilation and carbon dioxide concentration**)** that can affect chick hatching (Şahan et al., 2014; Damaziak et al., 2018; Okur et al., 2018; H.T. Meteyake et al., 2020; Mesquita et al., 2021; Biesek et al., 2023).

Broiler Nutrition, Growth Performance and Meat Quality

In terms of the direction of research in this specific area, it should be noted that the studies have been directed towards several key areas, the main ones being the optimization of gut health, growth performance and meat quality through the strategic use of feed additives. These various studies have made it possible to understand that feed additives such as probiotics, phytogenics and exogenous enzymes (xylanase, glucanase and protease) have beneficial effects on the intestinal health of broilers (Cho et al., 2014; Sadeghi et al., 2015; Hafeez et al., 2016; Munyaka et al., 2016; Amerah et al., 2017). They have a positive effect on the intestinal microflora, the digestibility of nutrients and participate in the reduction of potentially pathogenic enterobacteriaceae (Munyaka et al., 2016). According to studies, phytogenics containing essential oils based on thyme and star anise in particular optimize the weight gain and feed conversion ratio of chickens, while reducing lipid oxidation and improving the meat quality of broilers (Starčević et al., 2015). Similar results have also been obtained by substituting phytogenics by the enzyme xylanase (W.-C. Liu & Kim, 2017).

At the same time, other studies have shown that the reduction of crude protein content in broiler feeds combined with an amino acid profile can optimize the sustainability of broiler production without compromising their performance (Belloir et al., 2017). On the one hand, the use of blubber from black soldier fly larvae (*Hermetia illucens*) in broiler feeding have also been the subject of research (Cullere et al., 2019).

On the other hand, in order to find an alternative to the soy proteins used in the feed of broilers, research has been carried out to analyze the impact of the use of insect proteins on the environment, on the growth performance of broilers as well as on the quality of broiler meat (Pieterse et al., 2019; Vauterin et al., 2021). Finally, research has focused on the factors contributing to myopathies such as gender, diet and genetics, while focusing on antioxidant strategies to be implemented to limit muscle degeneration (Trocino et al., 2015; Radaelli et al., 2017).

Antibiotics

Since the ban on the use of antibiotics as growth promoters in animal feed (PGAs) by the European Union in 2006 (Castanon, 2007), the poultry industry has faced enormous challenges. Since then, a lot of research has been initiated with the aim of looking for palliative solutions to the use of antibiotics in the poultry industry. Research carried out over the last decades (2014-2024) has also been oriented in this direction, and studies on organic acids as feed additives that can be used to improve the performance of broilers have been carried out (Polycarpo et al., 2017; Mehdi et al., 2018).

Other studies on probiotics include *Bacillus subtilis* and *Saccharomyces cerevisiae* as substitutes for antibiotics for the improvement of growth performance and gut health of broilers were also carried out (T. He et al., 2019). Similarly, studies on phytogenics have been carried out (Abudabos et al., 2016) given their antioxidant status and the immunity it grants to poultry when incorporated into their feed. Research on essential oils has also been carried out with the aim of evaluating their antimicrobial activity as a potential substitute for antibiotics (Y. Liu et al., 2017; Fancher et al., 2020).

Other studies have focused on assessing the economic and zootechnical impact of whether or not the use of PGAs in broiler feed is discontinued, while monitoring antibiotic resistance by pathogens (Maria Cardinal et al., 2019; Roth et al., 2019). On the environmental side, the studies carried out focused on the persistence of antibiotics in soil and slurry and their ability to pollute the environment (Ho et al., 2014; L.-Y. He et al., 2014; Berendsen et al., 2018).

Diseases

Apart from genetics, nutrition, and improving the quality of meat, research over the last ten years in the field of broiler breeding has also been oriented towards the field of avian diseases. These studies were conducted with the goal of understanding, preventing and controlling infectious and metabolic diseases that can occur in broiler farming. Some research has focused on Gumboro disease, infectious bronchitis, Newcastle disease, necrotic enteritis and woody chest disease.

As far as Gumboro disease is concerned, studies have categorized viral strains, evaluated the effectiveness of vaccines and understood the evolution of the said virus (Kurukulasuriya et al., 2017; Yilmaz et al., 2019). Research focused on Newcastle disease has been used to optimize vaccination regimens and reduce viral shedding through the use of inactivated vaccines (Sattar et al., 2016; Sultan et al., 2021). For research related to infectious bronchitis, the latter focused on the molecular genotyping of the infectious bronchitis virus as well as on the comparison of the pathogenicity of the available strains (Chacón et al., 2014; Haji-Abdolvahab et al., 2019).

Studies conducted on necrotic enteritis have made it possible to measure the occurrence of this disease and production performance in broiler farms (Silva et al., 2015; Kaldhusdal et al., 2016). Other studies have examined the role of *Clostridium perfringens* in necrotic enteritis and also seek to understand the factors that can predispose to this disease in broilers (Caekebeke et al., 2021). Woody chest disease, on the other hand, has been genomic-studied, to identify the genes and metabolic processes involved (Papah et al., 2018; Brothers et al., 2019).

Behavior, rearing conditions and welfare of broilers

Research from 2014 to 2024 also focused on improving broiler farming conditions with a view to promoting natural behaviors and reducing the stress experienced by poultry. A few studies have explored the effect of stocking density on broiler behavior (H. Ma et al., 2020; Van Der Eijk et al., 2022). These studies have made it possible to understand that low density can help reduce stress on birds and encourage locomotion and foraging behaviors while optimizing meat quality.

In order to encourage positive behaviour while reducing heat stress, environmental conditions (temperature, humidity, light, noise, etc.) as well as the enrichment of the broilers' environment by setting up perches, pecking objects and organic bedding were studied (Yngvesson et al., 2017; Bergmann et al., 2017; Çavuşoğlu & Petek, 2019; Lucena et al., 2020; Fidan et al., 2020; Bai et al., 2023).

Other studies have been conducted to understand how specific behaviors such as grooming, resting, feeding and others may be affected by rearing conditions in order to serve as an indicator of well-being (Bergmann et al., 2017; Riber et al., 2021). Also with the aim of collecting accurate information on the behavior of poultry, research has been carried out using new technologies such as computer vision and the use of electronic sensors (Lucena et al., 2020; N. Li et al., 2020; Bai et al., 2023; G. Li et al., 2023). Finally, other research has examined the impact of transport and the use of electronic feeding systems on stress and feed efficiency (Fu et al., 2022; Werner et al., 2023).

Stress

Given the major damage caused by heat stress in the poultry industry, research from 2014 to 2024 also focused on the subject. Research on stress in broiler rearing has focused on identifying and mitigating major stressors such as heat stress, density stress and immunological stress. As far as heat stress is concerned, because broilers do not have a sweat gland and have a high metabolism and more or less thick plumage, they are particularly vulnerable to this type of stress (Z. H. Song et al., 2018).

Studies have therefore explored the impacts of heat stress on the intestinal morphology, microbiota and meat quality of broilers and have evaluated feeding strategies based on the use of prebiotics such as mannan-oligosaccharides (MOS) (Cheng et al., 2019), probiotics (Al-Fataftah & Abdelqader, 2014; J. Song et al., 2014), postbiotics (Humam et al., 2019), curcumin (J. F. Zhang et al., 2018), resveratol (C. Zhang et al., 2017), betaine (S. He et al., 2015; W. Liu et al., 2019) to strengthen antioxidant status and the intestinal barrier to mitigate the negative effects of heat stress on birds. Research on immunological stress has been addressed through the analysis of immune responses and the use of immunostimulants such as astragalus polysaccharides (APS) (L. Liu et al., 2015).

As for the stress related to stocking density, studies have analyzed the effects of stocking density on the growth and welfare of broilers while taking into account interactions with heat stress (Cengiz et al., 2015; Goo et al., 2019). Since heat stress also affects meat quality, causing color changes, increased water loss and changes in muscle metabolism, studies are seeking to understand the molecular mechanisms by which heat stress deteriorates meat quality while identifying strategies that can help mitigate these effects (Lu et al., 2017; Awad et al., 2020; B. Ma et al., 2021).

Finally, genetics tries to identify the differences in resistance to existing heat stress between different breeds and strains of broilers. (Sahin et al., 2016; Y. Xu et al., 2018; Awad et al., 2020). In addition, genetic selection studies are seeking to identify genetic markers associated with stress tolerance in order to use them to optimize stress resistance in broilers (Rimoldi et al., 2015).

Sperm

The quality of the sperm of breeding roosters plays a vital role in broiler farming, as it directly impacts the fertility, hatching rate and productivity of the chickens. Given its importance, research from 2014 to 2024 was much more focused on optimizing sperm quality by using feed additives in the diet of breeding roosters. Other research has investigated the environmental and biological factors that can negatively impact on the fertility of breeding animals. As dietary supplements, it was the use of ellagic acid (Najafi et al., 2019), polyunsaturated fatty acids (PUFAs) (Teymouri Zadeh et al., 2020), organic selenium and selenium nanoparticles (SeNPS) (Asghari-Moghadam & Mehri, 2024). These studies show that these feed additives optimize the viability, motility and antioxidant parameters of the sperm of breeding roosters while reducing oxidative damage (Abbaspour et al., 2020).

In addition, studies have conducted research on the effect of bacteria on sperm motility. Only Escherichia coli bacteria producing extended-spectrum beta-lactamases (ESBL) were considered. From these studies, it appears that the impact that these bacteria have on the motility of the sperm of breeding roosters varies according to the strains (Mezhoud et al., 2015). In addition, studies on the intake of noisy protein (CP) in the diet of breeding roosters have also been performed. This research has shown that a moderate reduction in crude protein levels in the diet of breeding roosters does not really affect sperm quality. However, it has been noted that an increase in the level of crude protein in the diet of breeding roosters at the end of the cycle can improve their fertility (Graaf et al., 2019).

Climate change

Climate change has a direct impact on poultry production, including bird growth, egg production and the overall health of animals. Given heat waves, a decrease in feed consumption by animals as well as an increase in the mortality rate of the flock can thus cause severe economic losses to the poultry industry (Mn et al., 2024). Over the past 10 years they have focused their studies on the search for strategies that can allow birds to adapt to climate change. On the other hand, researchers have conducted studies to develop strategies that can mitigate the effects of climate change on poultry for much more sustainable production.

For adaptation strategies, the researchers focused on optimizing housing systems. The results of these studies revealed that improving broiler housing systems would help maintain an optimal thermal environment for good production. For this purpose, efficient ventilation, efficient cooling mechanisms and the most adequate thermal insulation should be added to broiler housing (Mn et al., 2024; Oke et al., 2024). Other studies have focused on optimizing diets, including supplementing broiler feed with antioxidants to reduce the effects of heat stress on birds. At the same time, the use of animal fat to improve energy intake in poultry feed has also been the subject of research (Kpomasse et al., 2021; Mn et al., 2024). Finally, research in genetic selection tends to select poultry that can withstand heat and resist diseases (Kumar et al., 2021).

About strategies to mitigate the effects of climate change on broiler production, research has been directed towards climate modelling and direct cooling systems to assess and mitigate the impact of climate change on production costs, performance and poultry welfare. The objective of these studies is to anticipate the challenges posed by climate change on the poultry industry in order to adapt appropriate management practices (Lourençoni et al., 2019; Mn et al., 2024; Oke et al., 2024).

Effluent management and greenhouse gas reduction

To reduce the environmental impact of livestock farming, the management of livestock manure is essential. As a result, for the preservation of the environment and to better use the effluents from broiler farming, several studies have been carried out over the last ten years. Some research has focused on studying the composition of manure according to age and the diets to which poultry have been subjected in order to understand how feed may influence manure quality and ammonia emissions (Van Emous et al., 2019). A significant portion of the research conducted over the past decade has been aimed at reducing ammonia emissions from broiler manure by manipulating the amount of crude protein in the feed and using urease inhibitors.

Other research studies manure in order to use it as an agricultural amendment to optimize soil fertility (Lima et al., 2014; Keskinen et al., 2019). The composting of broiler manure was also studied with a focus on monitoring antibiotic residues in order to understand its impact on antibiotic degradation and the reduction of environmental risks (Wang et al., 2022; X. Xu et al., 2022). A study compared four different types of broiler manure treatment, including storage, composting, anaerobic digestion and biochar production, to assess greenhouse gas emissions. The study shows that anaerobic digestion and pyrolysis appear to be the most promising treatments for reducing greenhouse gases in the environment and producing useful resources such as biogas or biochar (Kreidenweis et al., 2021). Further studies have shown that adding substances such as magnesium sulphate (MgSO4.7H2O) to bedding is an effective technique for reducing ammonia (NH3) and nitrous oxide ($N_{2O)\ in\ poultry\ houses}$ (Pereira et al., 2019).

Conclusion

This study analyzed the direction of research carried out in broiler farming over the last ten years using the Web of Science database. This analysis made it possible to understand that many studies have been carried out on key themes such as genetics, egg incubation, nutrition, antibiotic use, avian diseases, bird behavior and the level of stress suffered by broilers in the farming environment. On the other hand, about topics relating to sperm quality, climate change, effluent management and the reduction of greenhouse gases, the analysis revealed that these themes are still little explored. It is therefore obvious that future research will focus much more on these topics regarding broiler farming while highlighting bird welfare and meat quality. However, the overall goal of the 2014 to 2024 research on broilers was to promote farming practices that optimize animal welfare, natural behaviors, and productivity, considering the complex interactions between the environment, genetics, and management practices.

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