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THE BENEFITS OF NATURAL ANTIOXIDANTS ADMINISTRATION IN BROILER CHICKEN GROWTH – A BIBLIOMETRIC ANALYSIS

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Abstract

Facilitating the transition from current production and consumption models to circular ones represents one of the global challenges that the agri-food sector must face. The application of bioeconomy principles in animal husbandry can bring real benefits both at the agricultural producer level and in terms of the environment. Several categories of agriculture by-products have a high potential for their use in animal feed, providing a high supply of antioxidants, which has an positive impact on safety and security issues. Vegetal waste utilization in natural antioxidants production is a solution for producers in order to satisfy the preferences of meat consumers as well as the trends that have occurred among them, but it will also bring positive contribution related to the environment resource preservation. In this context, many studies, both at national and global level, where published in the scientific literature field related to the use of natural antioxidants benefits, at the livestock farm management. This paper aims to present from a bibliometric perspective the main outcomes of the previous studies, offering a qualitative analysis related to the most relevant works.

Key words*: broiler chicken, Circular Economy Plan, livestock farm, natural antioxidants.*

INTRODUCTION

The present research joins to the objectives of sustainable development (United Nations, 2015) in the context of the transition from linear to circular production and consumption systems is one of the most pressing challenges for the agri-food sector in our days. Facilitating the implementation of the bioeconomy principles into practice are gaining increasing relevance, for all interested parties: decision-makers, researchers, economic agents in the field. Thus, circular economy integration, innovative practice, climate change mitigation and ensuring a more sustainable resource management at the farm level are the core principles for the legislative framework: EU Bioeconomy Strategy (EC, 2018), The European Green Deal and the Circular Economy Action Plan (EC, 2020) are among the key legislative components that need to be considered. To respond to the increasing demand for food, farmers should optimize their capacity and enhance efficiency through the adoption of IT products and services (Marin et al., 2020).

According to strategic objectives, encouraging the valorisation of agricultural by-products can facilitate the reduction of environmental impact through innovative practices.

FAO's definition describes agricultural by-products concept as being "materials remaining after the primary product has been removed from agricultural commodities during processing" (FAO, 2013). Regarding the livestock sector, this approach highlights the opportunity offered by the integration of bio-based solutions at the farm level. The natural antioxidants derived from plant waste it can serve as a good practice example based on the valorisation of opportunities offered by the bioeconomy.

Furthermore, the utilization of plant residual biomass for animal feed represents a model of integrated activity at the mixed farm level and a potential solution for closing the loop in agriculture (Dhiman et al., 2025).

The growing interest in the valorization of vegetable residues obtained at the level of basic production in order to ensure animal nutrition, especially for the broiler chicken category, is also highlighted by the existence of several

projects financed through the Union's Horizon Europe research and innovation programme: BroilerNet (2022-2026), GeneBEcon (2022-2025), ProFuture (2020-2024), Innovative Bio-based Food/Feed Ingredients.
Regarding their common European projects objectives several aspects can be mentioned: sustainable agro-food chain, facilitating the application of circular economy and bioeconomy principles, multi-actor approach, innovation in livestock nutrition and others.
According to Eurostat data published in 2024, the countries that stand out with a high number of herds in the broiler chicken category are Poland, Spain, Germany and the Netherlands.
Regarding this aspect, Romania ranks 12th place (out of 23 countries analyzed), with a value of 194415.4 thousand heads. Also, at national level, there is a progressive increase in broiler chicken herds from 2015 (163186.9 thousand heads).
In Romania, National Institute of Statistics data highlights an increase in the average annual consumption of the chicken meat category over the last ten years: 28 kg/person/year (in 2023), compared to the value recorded in 2013, respectively 18.2 kg/person/year.
This paper aims to analyze studies published in international databases (Web of Science) and examine their dynamics in relation to the evolution of statistical data, in the context of the European legislative framework highlighting the importance of applying circular economy principles in the management of mixed farms with both crop and livestock production.

MATERIALS AND METHODS

First introduced in 1969 by Alan Pritchard (Bredahl, L., 2022), bibliometric analysis is the main method that we use to develop this research.
As a concept definition, bibliometric analysis is defined in various previous study as "quantitative technique method for exploring and analysing a large volume of scientific data related to a specific topic" (Donthu et al, 2021).
Regarding the data collection process, *Web of Science* database was interrogated, considering this as a primary tool for running the bibliometric analysis.
The search was based on the following key words "broiler chicken antioxidants nutrition".
Thus, preliminary results indicate a total of 739 documents related to the topic.
In addition to the bibliometric analysis, the analysis of statistical data regarding the dynamics of the broiler chicken market at the European level, as well as the dissemination of European policies and strategies relevant to the livestock sector in the bioeconomy transition context were also involved as methods in order to develop research.

RESULTS AND DISCUSSIONS

Web of Science publications profile on broiler nutrition

To achieve this paper objective, searching through Web of Science database by the key words "broiler chicken antioxidants nutrition" was the first step.
In return, a total of 739 documents was reflected, linked to multiple disciplines as indicated in each WoS category description: *Agriculture Dairy Animal Science* (503 publications), *Veterinary Sciences* (230), *Zoology* (65 publication) and *Agriculture Multidisciplinary* (55 publication). In Figure 1 it can be observed the publication hierarchy related to the introduced key words by WoS category.

Figure 1. Web of Science infograph
for "broiler chicken nutrition", by section

According to the same results, the highest number of papers related to the paper subject were published in *Poultry science* (97 publications), *Animals* (57 publications), *Italian journal of animal science* (30 publications), *Tropical animal health and*

production (24 publications), *Livestock science* (20 publications) (Figure 2).

Figure 2. Web of Science infograph for "broiler chicken nutrition", by publication

The evolution of research in broiler nutrition and the role of natural antioxidants

The dynamics of the number of published papers in synergy with the searched terms is also of interest. Figure 3 highlights their evolution over the period 1995-2025. Thus, it can be observed a constant increase regarding the published papers related to the broiler chicken growth and the benefits outcomes from the natural antioxidant's intake.

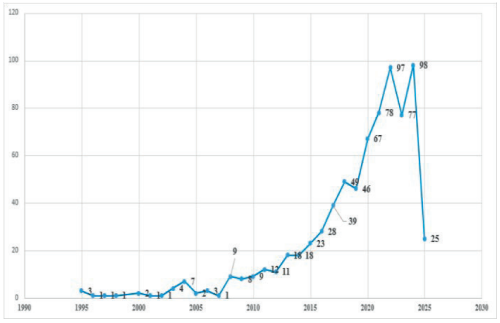

Figure 3. Evolution of publications number by year (1995-2025). Source: Authors illustration based on data provided by Web of Science

Although the first publications related to the subject date back to 1995, the number of references begins to take shape only starting in 2018, when it approaches 50 papers. Most of the works were registered in 2024, whose specific objectives align with the importance of capitalizing on residual production for broiler chicken nutrition. However, this value can be exceeded by the number of reference publications for the current year, given that it already reaches a number of 25 documents (in April 2025).

Improving the broiler chicken nutrition and health status – Beginning of research

The first 3 studies published in 1995 present the results of experimental research in order to demonstrate the positive and negative effects that the administration of antioxidants can produce in broiler chickens/chickens growth: "Effects of synthetic antioxidants in feed of different technological treatments on the performance of broilers" (Lauridsen & Jensen, 1995); "Toxicological studies on potentiated ionophores in chickens. I. Tolerance study" and "Toxicological studies on potentiated ionophores in chickens. II. Compatibility study" (Lehel et al., 1995). Thus, between 1995-1998 the first published studies had the main objectives to determine the importance of integrating antioxidants into the diet of broiler, regardless of their typology (natural or synthetic).

Evolution of specialized WoS publications - global and European perspective

The number of specialized publications regarding the dissemination of the results obtained from the valorisation of the vegetable residual production in the form of natural antioxidants and their introduction at the level of broiler chickens nutrition also differs depending on the region (Figure 4 and Figure 5).

Globally, most published papers in the context of studying sustainable nutrition management in broiler chickens are highlighted in China (174), Iran (128) and Egypt (87).

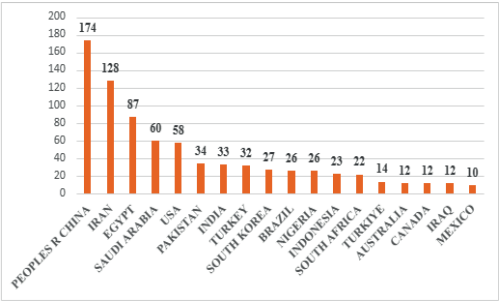

Figure 4. The number of publications by region. *Global perspective*. Source: Authors illustration based on data provided by Web of Science

Thus, it can be seen how several factors such as: the structure of vegetal production, the particularities of domestic demand and supply of food products, the level of investments and progress made at the level of innovative practices together with legislative measures also echo in terms of the distribution of the number of scientific publications of interest at the level of European states and beyond. For examples, the highest number of documents recorded in China can be substantiated, since 2020 the use of antimicrobial additives to promote growth in animal feed was banned, including for broiler chicken's category. This measure was adopted in response to concerns about antibiotic resistance and to protect public health and the environment. This legislative restriction has led to a significant increase in research into natural alternatives, especially plant-based antioxidants, which can improve immunity, meat quality, and the overall condition of poultry (Wang et al., 2024).

At the European level, most published papers in the context of studying sustainable nutrition management in broiler chickens are highlighted in Italy (24), Greece (128) and Poland (11).

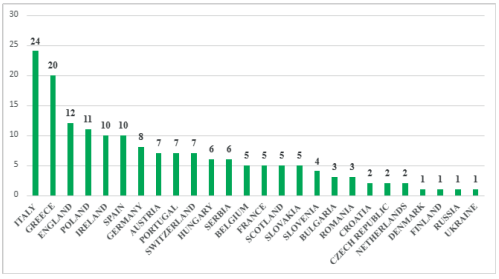

Figure 5. The number of publications by region. *European perspective.* Source: Authors illustration based on data provided by Web of Science

Thus, a synergistic relationship can be drawn between the countries on whose territory the most publications on the subject studied have been registered and the high level of the number of herds as well as the production of meat and meat products in the broiler chicken category. For instance, in Italy several important studies were conducted in order to facilitate the knowledge transition related to the natural alternatives in livestock nutrition, in terms of understanding and application innovative practice (Serra et al., 2024; Tufarelli et al., 2016).

Main outcomes from previously research

Reference studies reveal over time the impact that the daily administration of natural products can generate on relevant parameters regarding the health status of broiler chickens: blood biochemistry, immunoglobulins, antioxidant capacity of broiler chickens related with heat stress (Nakamura et al., 2022), but also from the economic performance and efficiency perspective: growth performance, feed conversion ratio (Mokhtari et al., 2018). Thus, mushroom extract, grape pulp or lavender oil are just some of the natural alternatives of synthetic treatments studied by experts in the field.

The study entitled "Performance and antioxidant status of broiler chickens supplemented with dried mushrooms (Agaricus bisporus) in their diet" (Giannenas et al., 2010) presented the results of experimental research carried out on a sample of 90 broiler chickens, regarding the impact derived through the daily administration of dried mushroom (10-20 g for each kg of feed), for 6 weeks. Following this experiment, the main conclusions show "growth-promoting and tissue antioxidant-protective activity when supplemented in broiler chicken diets." Other experiments studied the effect that introducing different natural base products ("pomegranate peel infusion (PPI)" - Ghosh, S, et al., 2020; "lavender essential oil (LEO)" - Yarmohammadi Barbarestani et al., 2020; "Grape seed extracts (GSE)" - Farahat et al., 2017) into the broiler daily diet could have on several determined parameters. The main outcomes and coordinates regarding the mentioned simulations are presented in Table 1.

Thus, main outcomes of the studies related to Table 1 can be outlined:

A - Introducing in broiler chicken nutrition with Agaricus bisporus mushrooms improve both growth performance and provides antioxidant protection to tissues (Giannenas et al., 2010).

B - Introducing a low-dose of pomegranate peel infusion in broilers diet is beneficial in as a important source of natural antioxidants. (Ghosh et al., 2020).

C - Adding 600 mg/kg of lavender essential oil to broiler chicken nutrition is a potential solution in order to improve growth performance, gut microbiota balance, intestinal morphology, and antioxidant activity (Yarmohammadi Barbarestani et al., 2020).
D - The use of grape seed extracts as natural antioxidant, in a dose of 125-250 mg/kg is an optimal choice regarding the broiler nutrition improvement (Farahat et al., 2017*).*

Table 1. Experimental research methodology and the main outcomes

N*	Product	Intake	T**	Investigated parameters	*O
90	mushroom Agaricus bisporus	10 - 20 g /kg of feed	6 wk	malondialdehyde production, glutathione level, body weight, antioxidant status	**A**
200	Pomegranate peel infusion (PPI)	50 ml/l in drinking water	6 wk	quadratic effect, hypo-lipidaemic effect, lipid peroxidation, glutathione and catalase, antioxidant defence system.	**B**
480	Lavender essential oil (LEO)	300 - 600 mg/kg	6 wk	growth performance, gut microbiota balance, intestinal morphology, antioxidant activity	**C**
245	Grape seed extracts (GSE)	125, 250, 500, 1000 and 2000 kg/mg	6 wk	growth performance, serum lipid profile, liver glutathione, thigh muscle tightness malondialdehyde and humoral immune response	**D**

*Broiler sample dimension; **Duration of experiment; *O - outcomes of the research; Source: authors prelucration according to the cited literature (A-D).

More recent studies are related in establish a potential synergy between introducing natural products in broiler nutrition ("leaf extract" - Nakamura et al., 2022; "brown seaweed extract" - Akinyemi & Adewole, 2022; "baicalein - flavonoid", which is *extracted from the root of Scutellaria* - Zhou et al., 2019).
The main outcomes and coordinates regarding the mentioned simulations are presented in Table 2.
Thus, main outcomes of the studies related to Table 2 can be outlined:

E - Leaf extract introduced in broilers nutrition improve the antioxidant system and "reduced lipid peroxidation and drip loss in the pectoralis major muscle" (Nakamura et al., 2022).
F - Introducing a nutritional supplementation of brown seaweed improved the growth performance of broiler regardless the heat stress. The negative effects of heat stress were diminished through the improved plasma enzyme activities of broilers (Akinyemi & Adewole, 2022).
G - The baicalein usage can be effective in terms of natural additive solution regarding the broiler chicken nutrition (100 to 200 mg/kg can be considered as the optimum dosage (Zhou et al., 2019*).*

Table 2. Recent experimental research methodology and the main outcomes

N*	Product	Intake	T**	Investigated parameters	*O
24	leaf extract	concentration of 0.5% or 2.0%	2 wk	body weight, weight gain, feed intake, feed conversion ratio and tissue weights did not differ among the three groups, malondialdehyde, content, antioxidant enzymes	**E**
336	Brown seaweed (*Ascophyllum nodosum*)	1 – 2 ml in 1 l drinking water until 2% of drinking water (ml/l)	4 wk	growth performance, blood biochemistry, immunoglobulins, the antioxidant capacity with heat stress	**F**
192	Baicalein - flavonoid	100 - 200 mg/kg	3 wk	growth performance, immunity, and antioxidant activity	**G**

*Broiler sample dimension; **Duration of experiment; *O - outcomes of the research; Source: authors prelucration according to the cited literature (E-G).

Evolution of specialized WoS publications - national perspective

At the national level, according to the WoS data query, it can be observed from Figure 5 a low number of publications. Thus, only 4 studies related to the benefits outcome from introducing natural antioxidants in broiler chicken nutrition were conducted by Romanian authors (Table 3).

Table 3. Studies published at national level in WoS database related to the topic "broiler chicken natural antioxidants intake"

Title	Author/s	Year	Keyword
Dietary Supplementation with Natural Antioxidants: Assessment of Growth Performance and Meat Quality in Broiler Chickens	Saracila et al.	2021	meat; antioxidants; chicken; sensory; texture; heat stress
Artemisia annua as Phytogenic Feed Additive in the Diet of Broilers (14-35 Days) Reared under Heat Stress (32 ºC)	Saracila et al.	2018	Artemisia annua; broiler chickens; growth Performance; gut microbiota; heat stress.
Comparative Effects on Using Bilberry Leaves in Broiler Diet Reared under Thermoneutral Conditions vs. Heat Stress on Performance, Health Status and Gut Microbiota	Mazur-Kuśnirek et al.	2023	bilberry leaves; broiler; heat stress; intestinal microflora; thermoneutral condition
Natural and inexpensive nutritional herbal solutions to alleviate heat stress in poultry.	Cornescu et al.	2019	diet, heat-stress, herbal, poultry, temperature.

Thus, all the studies mentioned in the table above present the results obtained from experimental research on the effects of natural compounds (antioxidants, medicinal plants) as a natural replacement for additives in broiler nutrition. Climate change is highlighted from the perspective of the negative impact of high temperatures on the performance of broiler chickens. Also, the integration of natural antioxidants in the nutrition of broiler chickens is presented as optimal in order to reduce the negative effects that heat stress can generate. Several indicators such as body weight, the conversion from synthetic to natural feed, the mortality rate, parameters for meat quality are highlighted in order to establish the efficiency of livestock management.

CONCLUSIONS

The present research addresses the specific measures undertaken in order to facilitate the transition from linear to circular production and consumption models. Starting from the sustainable development goals assumed at global and European level, capitalizing on the principles of the circular economy is one of the possible solutions in order to ensure the balance between the rational use of natural resources and the generation of income at the level of local producers. The livestock sector is no exception to this premise, and the valorisation of residual production in order to ensure animal feed is an opportunity both in order to transpose the circular principles into practice and in order to close the loop at the level of the agri-food value chain.

The bibliometric analysis was carried out at the level of publications published in international databases on the introduction of natural antioxidants in the nutrition of broiler chickens. The main results obtained show that the dynamics of the number of publications is directly influenced by the legislative measures undertaken and by the integration of specific concepts at the level of global and European objectives. Thus, starting with 2017-2018, the number of studies has increased significantly, even if their contribution remains low compared to the number of specialized works, which study the valorisation of residual production in the vegetal sector. The present research addresses the specific measures undertaken in order to facilitate the transition from linear to circular production and consumption models. Starting from the sustainable development goals assumed at global and European level, capitalizing on the principles of the circular economy is one of the possible solutions in order to ensure the balance between the rational use of natural resources and the generation of income at the level of local producers. The livestock sector is no exception to this premise, and the valorisation of residual production in order to ensure animal feed is an opportunity both in order to transpose the circular principles into practice and in order to close the loop at the level of the agri-food value chain.

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