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THE USE OF MEDICINAL PLANTS-BASED PHYTOACTIVE SUBSTANCES AS ALTERNATIVE INPUTS IN CATTLE FORAGE AND TREATMENT

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Abstract

Medicinal plants are used throughout the world both to treat diseases and to maintain the general health of both humans and animals. The aim of this work is to analyze the trends for research on the use of medicinal plants and extracts for the health of cattle. A structured analysis was performed in the Web of Science database with a combination of keywords between years 2020-2025, which enabled the assessment of multiple bibliographic networks with VOSviewer. Due to antibiotic-resistant microorganisms, attempts are being made to use medicinal plants with immunoregulatory (815 articles), antimicrobial (820 articles), antifungal (815 articles), and anti-inflammatory effects (816 articles) to sustain the animal by strengthening natural defense mechanisms. Most medicinal plants contain alkaloids, minerals, vitamins, flavonoids, saponins, which contribute to numerous physiological processes in the animal body. By supplementing the rations of cows with phytoactive substances, there is a visible improvement in the defense mechanism, digestibility of nutrients and an increase in milk production. These approaches can be used to partially or complete replacement of conventional treatments and have a dual role for both the health of the animal and increased yield of main products.

Key words*: active substances, animal health, defense mechanism, multiple benefits, type of action.*

INTRODUCTION

Throughout history, medicinal plants have represented a valuable source of therapeutic agents in the treatment of various pathologies and are still used today due to their benefits (Zhao et al., 2022). Herbal medicines have been used since ancient times due to their accessibility, effectiveness, and low cost (Shahrajabian et al., 2020) and represent a traditional method of treating various conditions (Michel et al., 2020). Of all vascular plants existing globally, approximately 10% are used for medicinal purposes, with approximately 500,000 species (Salmerón-Manzano et al., 2020) and according to IUCN and WWF, approximately 80,000 species of flowering plants are used for therapeutic purposes (Michel et al., 2020). Medicinal plants represent a natural option for supporting and improving animal health (Rochfort et al., 2008).

Animal health is the essential factor that has determined the reduction or in some countries the prohibition of antibiotics administered in animal feed as a result of the occurrence of residues in both milk and meat (Kholif et al., 2024). In order to reduce antibiotics, plant-based alternatives derived from medicinal plants are increasingly integrated into animal feed (Wang et al., 2024).

Medicinal plants contain a large number of chemical compounds, which is why many drugs have been obtained or derived from them (Grover et al., 2002). These compounds are naturally present in plants and the curative properties of medicinal plants result from these biological components (Ahad et al., 2021).

Bioactive compounds are found in different parts of plants such as: stems, roots, leaves, seeds and fruits (Sun and Shahrajabian, 2023) and give plants antioxidant, anti-inflammatory and antimicrobial properties (Iommelli et al., 2025; Dar et al., 2023). Various chemical compounds, such as flavonoids, vitamins, minerals, saponins and tannins, are present in plants, and they can improve the productive performance of animals through changes in the metabolism of the digestive tract (Alem, 2024).

Natural volatile compounds contribute to improving digestion, modifying rumen function, reducing methane production, and improving milk and meat quality in ruminants (Ramdani et al., 2023). Polyphenols are the main compounds of natural bioactive substances derived from plants. Their composition and concentration vary depending on numerous factors, and in recent years they have been used in the nutrition of ruminants, birds and pigs (Lillehoj et al., 2018). The aim of the paper is to analyze research trends regarding the use of medicinal plants and extracts for cattle health. This scientific article aims to contribute to the update of research in the zootechnical field and to the correlation of international databases on the benefits of medicinal plants used in cattle feeding, as well as to outline future research directions regarding their applicability.

MATERIALS AND METHODS

In this article, we analyzed the literature on the effects of phytoactive substances from medicinal plants used in the treatment and feeding of cattle. All extracted databases were further analyzed with VOSviewer (Arruda et al., 2022; Bukar et al., 2023) as follows. The bibliographic search was performed in the Web of Science Core Collection, with the filter for publishing years of 2020-2025, using keywords including cow, cattle, medicinal plants, anti-inflammatory, dairy cows, phytoactive substance. The keywords used for searches are found in the diagrams in Figures 1-5. In order to see the current interest of the subject, combinations of keywords containing the word cow or cattle with each of the specific keywords were used, namely: antifungal – 815 articles, anti-inflammatory – 816 articles, antioxidant – 817 articles, antimicrobial – 820 articles and immunoregulatory substances – 815 articles. To create graphical representations, a minimum number of occurrences of a keyword was used, namely 20 or 10 depending on the appearance of studies in this field and the thresholds were set to a value that not load the image and not produce confusions on the general trends. Out of a total of 2,298 keywords identified in the analyzed articles, 118 met the selection threshold required for map generation in VOSviewer (for one of the five representative maps). This approach was necessary to evaluate the large and well-founded directions in this field that provide a basis for comparison, in addition, the Bibliographic network produced by VOSviewer that visually indicates the position of a term in research and its importance, brings benefits to identify less studied niche areas. This second result is necessary for the design of future research and the realistic evaluation of the basis for comparison.

RESULTS AND DISCUSSIONS

Bibliografic analysis performed using VOSviewer highlighted several distinct keyword groups regarding the use of phytoactive substances with antifungal effects (Figure 1).

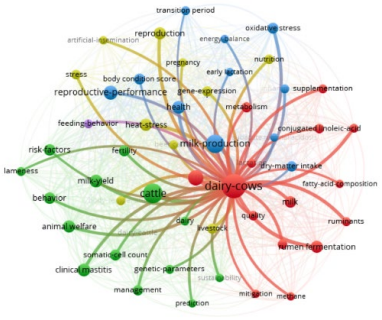

Figure 1. Antifungal bibliographic analysis and correlation with associated fields

The main keywords in the form of different clusters are, dairy cows, milk production, health, reproduction, and reproductive performance. These form strong links between them, highlighting the interdependence between the use of phytoactive substances, the animal's health status, but also productive and reproductive parameters. These clusters also represent main concepts from which secondary keywords are derived, reflecting the complexity and multidimensional nature of research on the use of antifungal phytoactive substances in cattle breeding systems. The proximity of the terms milk production and metabolism to the central node suggests a major interest in the direct effects of nutritional strategies on productive performance, while terms such as methane and sustainability, positioned peripherally, reflect emerging directions oriented towards environmental impact.

Performance is closely linked to health, behavior, risk factors, well-being and stress because these factors directly influence the metabolic efficiency, immune system functioning and adaptive capacity of animals (Chebel et al., 2016) which together have a major impact on milk production and reproductive performance (Llonch et al., 2018). Reproductive performance, fertility, lactation, milk production form closely correlated clusters, suggesting that lactation and milk production have an impact on fertility and reproductive performance (Eldawy et al., 2021; Bello et al., 2012; Nebel and McGilliard, 1993) emphasizing the need for integrated nutritional and management strategies. These indicate that scientific research on antifungal phytoactive substances is integrated into a broad context due to the links between them. Visual interpretation of the map reveals the grouping of terms into four distinct thematic areas that are differentiated by color codes, which define the architecture of current research. The red cluster represented by animal health and performance represents the central core of the network. It highlights the critical interdependence between the administration of phytoactive substances and the optimization of health status, directly correlated with productivity and reproductive performance parameters.

The map represented by anti-inflammatory substances highlights the keyword dairy cows (Figure 2), representing a cluster that forms the most networks, but the central location of the performance cluster suggests that although dairy cows represent the main key topic of the research, performance is the key concept through which the effects of nutritional and management interventions are evaluated.

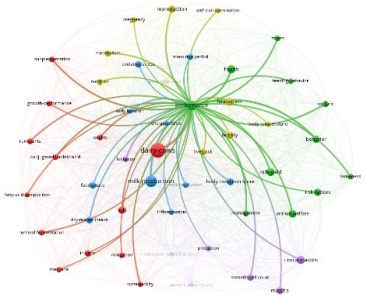

Figure 2. Anti-inflammatory bibliographic analysis and correlation with associated fields

The close association between milk production and the concepts related to transition period and oxidative stress suggests the interest of research into nutritional interventions, including the use of phytoactive substances with anti-inflammatory effects with a role in supporting and adapting metabolism in early lactation (Kumprechtová et al., 2022).

The interconnection of the term performance with aspects related to well-being and eating behavior highlights the integrative nature of performance which is influenced by biological, nutritional and management factors (Cooke et al., 2020).

Terms such as sustainability, stress, genetic parameters, growth performance, well-being are positioned on the periphery of the network but are interconnected both with each other and with the other keywords. Their position suggests that sustainability and genetics issues are being progressively integrated into studies on dairy cow performance and health (Brito et al., 2021; VandeHaar et al., 2016). These terms in the VOSviewer map indicate subthemes with low frequency but potential for development.

The graphic configuration of the map reflects the complexity of the interactions between inflammation, metabolism and productivity, being structured into five major thematic areas, namely: The Red Cluster is represented by the Thematic Core (Dairy Cows): This constitutes the central pillar of the analysis, having the highest density of nodes and connections. The Green Cluster represents Performance and Intervention Evaluation: Centrally positioned, this cluster acts as an outcome indicator, grouping together key concepts. The Blue Cluster represents Transition Physiology and Oxidative Stress: Focuses on metabolic challenges specific to the critical transition period. The Yellow Cluster represents Well-being and Eating Behavior: Integrates the ethological and management dimensions. The Purple Cluster represents Genetics and Sustainability (Emerging Directions): Represents niche areas with a currently lower keyword frequency, but with a steady increase in the specialized literature

In the graphic representation made with the help of VOSviewer, several distinct groups of keywords were highlighted reflecting the main research directions associated with the use of

phytoactive substances with antioxidant properties (Figure 3).

Performance is the centrally located cluster that interconnects with most keywords. It forms close links with oxidative stress, quality, transition period, health, early lactation, highlighting the determining role of these factors in optimizing performance in dairy cows (Cardoso et al., 2021).

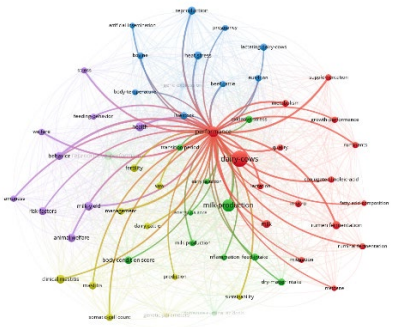

Figure 3. Antioxidant bibliographic analysis and correlation with associated fields

The proximity of the terms to the central cluster suggests that "performance" is analyzed mainly in the context of metabolic adaptation but also of maintaining health in critical stages of the production cycle (Caixeta and Omontese, 2021). Milk production, an important cluster, presents a close link with energy balance, lactation, sustainability, because this association reflects the research interest in optimizing milk production through technological interventions (Gheorghe-Irimia et al., 2023) that support both productive performance and the sustainability of livestock operations (Gaworski, 2021).

Risk factors are interconnected with animal welfare, reproductive performance, health, fertility, metabolism, feeding behavior, suggesting that risk factor management is essential for maintaining metabolic and reproductive health but also for ensuring animal welfare (Licitra et al., 2021).

Welfare and breeding performance form a distant link, being located on the periphery of the map but interconnected with other central terms, suggesting that welfare and breeding performance indicate the current orientation towards more sustainable and animal-oriented production systems (Losacco et al., 2025).

The map highlights the multidimensional role of antioxidants, grouping research into four directions of interest that define the metabolic resilience of animals: The Red Cluster represented by Performance and Systemic Health: Represents the dominant cluster and main connection node of the map. The Green Cluster stands for Technological Optimization and Energy Balance: It focuses on the applied side of nutrition. The Blue Cluster represents Risk Factor Management: Groups research that explores the interface between metabolism, well-being and reproductive function. The Yellow Cluster represents Sustainable Production Systems: Reflecting current management trends

The graph associated with the use of phytoactive substances with antimicrobial properties presents a slightly different structure in several respects (Figure 4). Although correlations are observed between most of the keywords, the bond density is lower, indicating a thematic diversity focused on certain sub-themes.

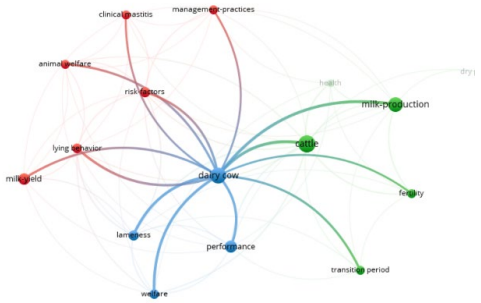

Figure 4. Antimicrobial bibliographic analysis and correlation with associated fields

The cluster represented by dairy cows is interconnected with performance, behavior, milk production and management practices, highlighting the multidimensional nature of the research. This interconnection suggests that studies on the use of phytoactive substances with antimicrobial properties are oriented not only towards productive parameters but also towards optimizing growth conditions and behavioral parameters (Priyashantha et al., 2026).

The graphic representation highlights a single link between mammary rest period and milk production, which suggests a specific thematic

association, indicating that the mammary rest period is predominantly analyzed in the context of the impact on productive performance, without being extensively integrated into other thematic directions (Manriquez et al., 2019). The configuration of this map emphasizes the transition from curative treatments to preventive management and animal welfare, being structured as follows:

The Red Cluster represented by Management and Breeding Practices: Represents an extensive field that correlates dairy cow exploitation systems with their behavior. The Green Cluster represents Breast Health and Prevention: This thematic grouping focuses on a critical point in production: the mammary rest period. The Blue Cluster represents Performance and Subject Centricity.

The bibliometric analysis performed using VOSviewer highlighted several distinct groups of keywords related to the use of phytoactive substances with immunoregulatory effects (Figure 5). The strongest relationship highlighted in the graphic representation is observed between dairy cows and fertility.

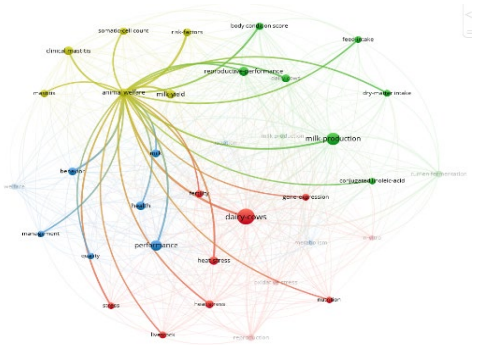

Figure 5. Immunoregulatory bibliographic analysis and correlation with associated fields

Relevant connections are also identified with terms such as gene expression, performance, milk production, animal welfare and ruminal fermentation, suggesting the multidimensional nature of the research. This network structure indicates that fertility is a central element in studies dedicated to dairy cows, being correlated with both physiological and biochemical mechanisms as well as with productive and physiological parameters (de Souza Fonseca et al., 2022; Roche et al., 2017).

Nutrition, although located on the periphery of the network, forms close relationships with most keywords, representing an integrating factor, correlated with productive, metabolic and health parameters.

The fifth map illustrates the complexity of the immune response and its integration into the animal's systemic physiology, being defined by the following clusters: The Red Cluster represents Fertility and Uterine Physiology: It constitutes the central pillar and most robust area of the map. The Green Cluster represents Physiological and Biochemical Mechanisms: It groups fundamental research on internal processes. The Blue Cluster represents Integrative Nutrition: Although positioned peripherally, this cluster correlates dietary strategies with health parameters and metabolic profile. The Yellow Cluster represents Risk Management and Behavioral Performance: Located slightly peripherally, but characterized by a dense network of connections.

CONCLUSIONS

Medicinal plants represent an important resource of bioactive compounds with antioxidant, anti-inflammatory, antimicrobial, immunoregulatory properties, which can contribute to maintaining health and improving the productive performance of cattle.

The integration of medicinal plants in cattle nutrition is considered a promising alternative to the use of antibiotics, in the context of current concerns regarding the occurrence of residues in animal products and the development of antimicrobial resistance.

The bibliometric analysis reveals a close correlation between the research of phytoactive compounds in bovine zootechnics and indicators of health, productivity and reproductive performance. The study of these substances, recognized for their antioxidant, antimicrobial and immunoregulatory valences, is approached in an integrated way, targeting the metabolic balance and physiology of dairy cows.

The integrated analysis of the maps: Antioxidant, Immunoregulatory, Anti-inflammatory, demonstrates a major paradigm shift in current research. Scientific interest has shifted from treating clinical conditions to early

modulation of metabolism and the immune system.

In most maps, the onset of lactation and the mammary dormancy period appear as major connection hubs.

A significant number of clusters, in maps (2, 4 and 5) position animal behavior and management practices as key elements in the network. Even if they sometimes appear slightly peripheral, the large number of links they form demonstrates that behavior monitoring and welfare assurance are recognized as essential tools for early detection of disease risks (such as mastitis) and for maintaining productivity.

The peripheral but emerging positioning of topics such as ecological footprint (methane emissions), genetic selection for resilience and sustainability of production systems clearly shows where the future of research is heading. These bibliometric niches indicate that future livestock performance will only be validated if it is ecologically sustainable and genomically substantiated.

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