

## Innovative use of *Lamiaceae* extracts in animal feeding-stuffs and nutritional supplementations: a patent-based analysis

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*(Accepted July 14, 2025)*

The use of medicinal and aromatic plants (MAPs), particularly those from the *Lamiaceae* family, has gained remarkable attention in animal nutrition due to their bioactive compounds such as phenolics, terpenes, and flavonoids. These compounds offer multiple benefits, including antimicrobial, antioxidant, and growth-promoting properties, making them ideal candidates for incorporation into feeding products and nutritional supplements specially adapted for animals. This study presents a comprehensive patent analysis to investigate the innovation landscape surrounding feeding-stuffs formulated with *Lamiaceae* extracts. Patent data was collected from specialized databases (Patentscope, The Lens, and Espacenet) and analyzed based on key International Patent Classification (IPC)

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codes: A23K (feeding-stuffs adapted for animals) and A61K36/53 (*Lamiaceae* family). The analysis covered 485 patent documents published between 1977 and 2024, including patent applications, granted patents, and other document types. Results reveal a steady increase in patenting activity, with significant peaks observed in 2008, 2018, and 2021, reflecting the growing interest in natural feed formulations. China (83 documents) emerged as the leading jurisdiction, followed by the United States (74 documents) and Japan (69 documents). Major applicants, including Nestlé SA and Ralco Nutrition Inc., demonstrated a strong focus on leveraging *Lamiaceae* extracts in animal nutrition. The technological fields identified through IPC classifications emphasized the role of *Lamiaceae* in advancing sustainable animal nutrition. This study highlights the innovation potential of *Lamiaceae*-based feeding-stuffs, underlining their importance in enhancing livestock health and productivity while contributing to eco-friendly agricultural practices. Future research should explore synergistic applications and field validations to optimize their usage in commercial animal nutrition.

**KEY WORDS:** *Lamiaceae* / feeding-stuffs / animal nutrition / bioactive compounds / patent data / patent analysis

The utilization of medicinal and aromatic plants (MAPs), their derived compounds, and extracted biomolecules has gained significant traction in animal nutrition [Alem, 2024]. This trend is driven by advancements in biochemistry and nutrition, aiming to enhance the health and productivity of livestock. Among the prominent MAP families, *Lamiaceae* holds a pivotal role. This family includes plants such as rosemary (*Salvia rosmarinus*), thyme (*Thymus vulgaris*), oregano (*Origanum vulgare*), and lavender (*Lavandula angustifolia*), which are known for their rich profiles of bioactive compounds such as phenolics, terpenes, and flavonoids [El Boukhari and Fatimi 2023ab, Kosakowska et al. 2024].

The incorporation of *Lamiaceae* extracts into feeding-stuffs and nutritional supplements provides notable benefits, including antimicrobial, antioxidant, and growth-promoting properties, particularly in enhancing animal health and productivity [Granados-Chinchilla 2017]. These extracts serve as valuable natural alternatives to synthetic additives in both livestock farming and aquaculture due to their bioactivity and medicinal properties [El Boukhari et al. 2024, 2025].

*Lamiaceae* extracts, such as oregano and rosemary, exhibit strong antimicrobial effects against various pathogens, including bacteria and fungi [Orso et al. 2022, Sharma and Sharma 2021]. These antimicrobial properties play a critical role in reducing reliance on antibiotics, addressing growing concerns about antibiotic resistance in animal farming [Orso et al. 2022]. In addition to their antimicrobial properties, *Lamiaceae* extracts are rich in bioactive compounds that provide significant antioxidant benefits. These antioxidants help mitigate oxidative stress in animals, which can otherwise impair their health and performance [Al-Nuri et al. 2022]. For example, *Micromeria fruticosa* has demonstrated high 1,1-Diphenyl-2-picrylhydrazyl (DPPH) scavenging activity, indicating its potent antioxidant properties [Al-Nuri et al. 2022]. The growth-promoting effects of *Lamiaceae* extracts are another critical advantage. By enhancing feed digestibility and nutrient absorption, these extracts support better growth performance in livestock [Alem 2024, Sharma and Sharma 2021]. In aquaculture, they contribute to improved immune responses and

overall fish health, leading to higher growth rates and productivity [Orso *et al.* 2022].

While *Lamiaceae* plant extracts are widely recognized for their antimicrobial, antioxidant, and growth-promoting benefits, their toxicological profile warrants careful consideration to ensure safe and effective use in animal feeding-stuffs. Most studies indicate that *Lamiaceae* species such as rosemary, thyme, and oregano are generally safe at controlled dosages, with low acute toxicity levels across various livestock species [Alem 2024]. However, excessive intake of certain essential oils – notably those rich in thymol, carvacrol, or pulegone – can result in hepatic stress, neurological symptoms, or gastrointestinal irritation [El Boukhari and Fatimi 2025a, 2025b, El Boukhari *et al.* 2025]. Furthermore, species-specific responses must be considered, as ruminants, monogastrics, and aquatic species may metabolize phytochemicals differently. Some *Lamiaceae*-derived compounds can interact with gut microbiota or alter enzymatic activity, leading to unforeseen physiological effects if used improperly. Thus, toxicological evaluations, including LD<sub>50</sub> (i.e., the median lethal dose) values and chronic exposure studies, are critical for defining safe inclusion rates in commercial feed formulations. Regulatory frameworks in the European Food Safety Authority (EFSA) and the Association of American Feed Control Officials (AAFCO) provide guidance for maximum allowable concentrations, emphasizing the value of standardization and quality control in the use of botanical feed additives.

The efficacy of *Lamiaceae* extracts can vary depending on factors such as the specific plant species and the extraction methods employed [Uwineza *et al.* 2021]. These variables may influence their overall effectiveness in different applications, highlighting the need for careful consideration when integrating these extracts into feeding-stuffs and nutritional supplements [Alem 2024]. In this regard, the efficacy, safety, and consistency of *Lamiaceae*-based supplements in animal nutrition rely heavily on rigorous quality control and standardization of plant extracts. Variability in bioactive compound content due to species differences, geographical origin, cultivation practices, and extraction methods can significantly affect the nutritional and pharmacological outcomes in animals. Therefore, establishing consistent quality parameters is essential to ensure batch-to-batch reproducibility and therapeutic reliability. Key quality control measures include the use of validated analytical techniques such as high-performance liquid chromatography, gas chromatography–mass spectrometry, and Fourier-transform infrared spectroscopy to quantify marker compounds and active phytochemical constituents like thymol, carvacrol, and rosmarinic acid, as well as contaminant screening (e.g., heavy metals, mycotoxins, etc.) and adherence to established feed additive standards to confirm batch-to-batch reliability and functional performance in animal diets [Wang *et al.* 2024]. Additionally, guidelines from international bodies such as the EFSA and the AAFCO emphasize the need for contaminant testing and microbial safety assessments [European Food Safety Authority, 2025, European Federation of Internal Medicine 2024]. The development of pharmacopeial monographs and adherence to Good Agricultural and Collection Practices (GACP) are further recommended to standardize raw material quality and

preserve the phytochemical integrity of *Lamiaceae* plants used in feed formulations [Dusemund et al. 2024, Tolosa et al. 2019, Monbaliu et al. 2012].

To better understand the innovation landscape in this domain, this study employs patent analysis, focusing on two critical IPC codes: A23K (feeding-stuffs specially adapted for animals) [Lee and Song 2024] and A61K36/53 (*Lamiaceae* family) [Jalil et al. 2024, El Boukhari and Fatimi, 2023b, Granados-Chinchilla 2017]. Patent classification systems like the International Patent Classification (IPC) offer valuable insights into technological advancements and the application trends in feeding-stuffs formulated with *Lamiaceae* extracts. The IPC codes provided insight into the broader patterns of intellectual property within this domain. Furthermore, by mapping the patents to their respective IPC codes, the study explored the role of bioactive compounds from *Lamiaceae* in advancing sustainable and health-promoting feeding solutions for livestock.

## Material and methods

### Data collection protocols

Data was retrieved from specialized patent databases, including Patentscope [World Intellectual Property Organization, 2024c], The Lens [Cambia Institute, 2024], and Espacenet [European Patent Office, 2024]. Filters included patent types (patent applications, granted patents, amended patent, granted patent, limited patent, patent of addition, etc.), jurisdictions, applicants, and publication years.

### International patent classification

The study focused on patents associated with feeding-stuffs adapted for animals (IPC code A23K and its sub-codes) and *Lamiaceae* plants (IPC code A61K36/53) [World Intellectual Property Organization, 2024b]. More specifically, detail concerning the IPC code A23K and its sub-codes are presented in Table 1 [World Intellectual Property Organization, 2024a]. However, the IPC code A61K36/53 concerns the medicinal preparations of undetermined constitution containing material from *Lamiaceae* (e.g., thyme, rosemary, lavender, etc. [Jalil et al. 2024], El Boukhari and Fatimi 2023b], Granados-Chinchilla 2017]. This classification focuses on the use of plants from the *Lamiaceae* family for developing nutritional supplementations as medicinal preparations [El Boukhari and Fatimi 2025a, 2025b]. These plants, rich in bioactive compounds, are widely recognized for their therapeutic and aromatic properties, contributing to a variety of health and wellness applications.

## Results and discussion

### Analysis framework

The analysis framework employed in this study is based on two main components: quantitative metrics and technological fields. Quantitative metrics focused on

**Table 1.** Definitions and descriptions of IPC code A23K and its sub-codes [World Intellectual Property Organization, 2024a, 2024b]

| Code      | Definition                                                                                          | Description                                                                                                                                                  |
|-----------|-----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A23K      | Feeding-stuffs specially adapted for animals; methods specially adapted for the production thereof  | This IPC code encompasses innovations and technologies related to the formulation and production of animal feed                                              |
| A23K10/00 | Animal feeding-stuffs                                                                               | This sub-code pertains specifically to the composition and types of feed developed for animals, focusing on their nutritional value and effectiveness        |
| A23K20/00 | Accessory food factors for animal feeding-stuffs                                                    | This sub-code includes additives, supplements, and enhancements used in feed formulations to improve their nutritional or functional properties              |
| A23K30/00 | Processes specially adapted for preservation of materials in order to produce animal feeding-stuffs | This category covers methods aimed at maintaining the quality and longevity of feed ingredients during storage and production                                |
| A23K40/00 | Shaping or working-up of animal feeding-stuffs                                                      | This sub-code involves the techniques and processes used to form, shape, or modify feeding-stuffs for ease of consumption or improved utility                |
| A23K50/00 | Feeding-stuffs specially adapted for particular animals                                             | This sub-code focuses on feed formulations tailored to meet the specific dietary needs of different animal species, optimizing their health and productivity |

assessing the volume and distribution of patent documents. This included examining the total number of published documents, their respective document types (e.g., patent applications, granted patents, and related documents), identifying top jurisdictions where these patents were filed, and pinpointing leading applicants actively working on innovations in feeding-stuffs and nutritional supplements (Fig. 1). On the other hand, technological fields were evaluated by analyzing IPC classification codes associated with the patents. This step enabled the identification of relevant technological innovations specifically tied to animal nutrition and feeding-stuffs.

**Timeframe and Evolution of patent publications**

To ensure historical completeness while maintaining relevance, the review spans patent documents published from 1977 to 2024 (Fig. 1A). This interval was chosen because the earliest identified patent relevant to the use of *Lamiaceae* extracts in animal feeding-stuffs and nutritional supplementations was published on March 4, 1977. This is the Japanese Patent Application JPS5228922A, titled “Medicine Mixture for Animals”, which focused on a formulation comprising a mixture of various herbal components, including plants from the *Lamiaceae* family [Kirisawa and Ooyama, 1977]. This application marked the first documented use of *Lamiaceae* species – among others – in the context of animal nutrition. No relevant patents prior to 1977 were

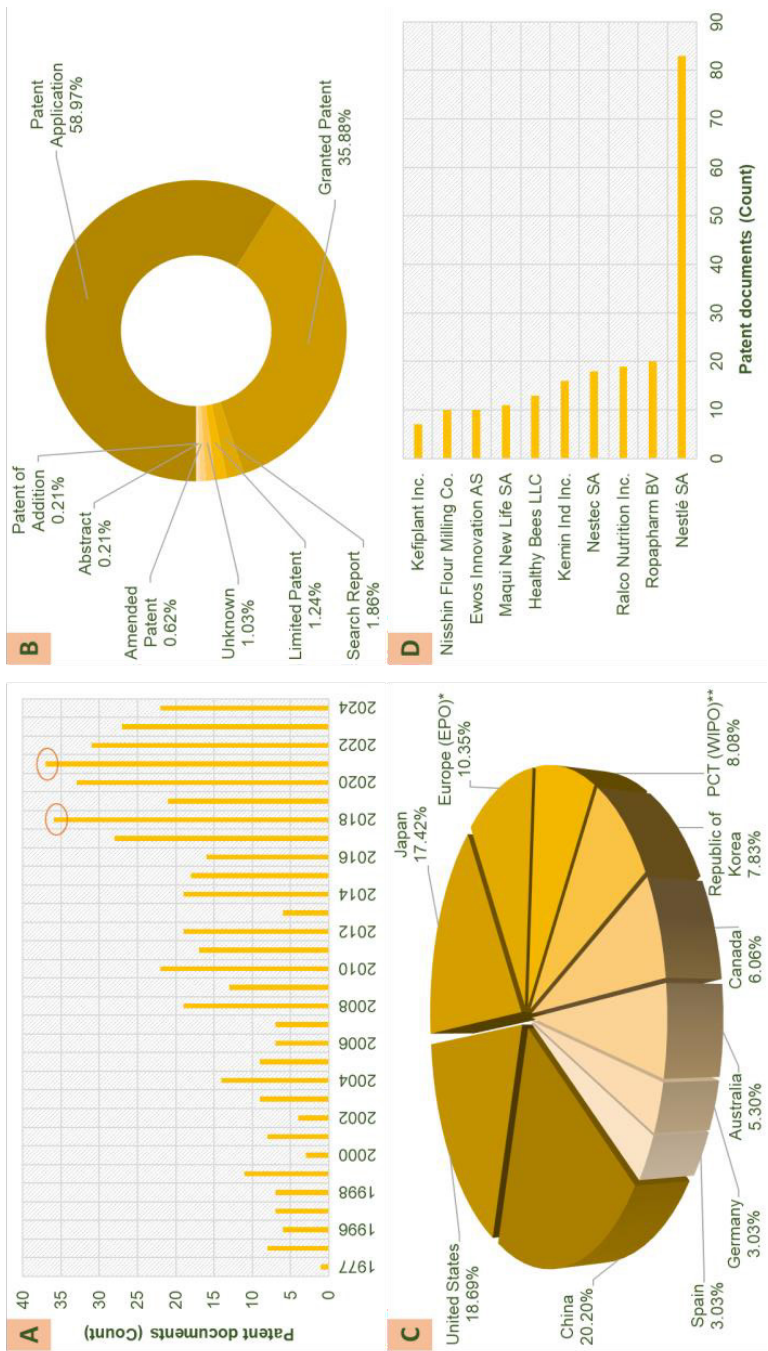


Fig. 1. Quantitative metrics focused on assessing the volume and distribution of patent documents related to innovations in feeding-stuffs and nutritional supplements formulated with Lamiaceae extracts: (A) Evolution of patent publications from 1977 to 2024; (B) Document types; (C) Top 10 patent jurisdictions (\*EPO: Regional filings in Europe via the European Patent Office (EPO). \*\*WIPO: International filings through the World Intellectual Property Organization (WIPO) under the Patent Cooperation Treaty (PCT)); (D) Top 10 patent applicants.



retrieved from the specialized patent databases consulted (Patentscope, Espacenet, and The Lens), thus making earlier data inclusion both unnecessary and non-informative.

Therefore, the comprehensive timeframe 1977-2024 allowed for an evaluation of long-term trends in innovation and patenting activity. By covering nearly five decades, the analysis provides valuable insights into the evolution of feeding-stuffs and nutritional supplements formulated with *Lamiaceae* extracts. This extensive temporal scope also highlights key periods of increased patenting activity, reflecting shifts in research priorities and market demand over time.

From 1977 to 2024, 485 patent documents were identified. A steady increase was observed, with notable peaks in 2018 and 2021. This highlights growing interest in integrating *Lamiaceae*-based formulations into feeding-stuffs.

#### **Patent family size and document types**

A simple family refers to a group of patents that are directly related to each other through priority claims, typically covering the same invention. Instead, these 485 patent documents, 197 simple families have been identified.

Figure 1B presents the distribution of 485 patent documents – as a function of document type – related to innovative use of *Lamiaceae* extracts in animal feeding-stuffs and nutritional supplementations.

The analysis of document types revealed that patent applications accounted for the majority, with 286 documents. This dominance underscores the continuous efforts in research and development aimed at formulating feeding-stuffs and nutritional supplements using *Lamiaceae* extracts. The high number of applications reflects sustained interest and investment in this area.

Granted patents, totaling 174 documents, represented a significant proportion of the dataset. These documents highlight the successful conversion of applications into legally protected innovations, indicating the maturity and commercial viability of some of the technologies developed.

In addition to these, 25 other patent documents, including search reports, limited patents, and amended filings, provided further evidence of diverse activities within the innovation landscape for animal nutrition solutions.

#### **Top jurisdictions**

Figure 1C presents the geographical distribution – top 10 patent jurisdictions – of patent documents related to innovative use of *Lamiaceae* extracts in animal feeding-stuffs and nutritional supplementations.

China, with 83 patent documents, emerged as the leading jurisdiction in the innovation landscape. This dominance reflects China's strong focus on developing alternative and natural feed formulations, likely driven by its growing demand for sustainable animal nutritional solutions to support its large agricultural sector.

The United States followed closely, with 74 patent documents. This indicates a robust interest in leveraging bioactive compounds from *Lamiaceae* plants to enhance animal

health and productivity. The U.S.'s well-established intellectual property infrastructure and thriving animal nutrition industry likely contribute to its strong position.

Other notable jurisdictions, including Japan, Europe (as regional filings via the European Patent Office (EPO)), and international filings through the World Intellectual Property Organization (WIPO) under the Patent Cooperation Treaty (PCT), demonstrate the global relevance and appeal of innovations in feeding-stuffs and nutritional supplements using *Lamiaceae* extracts. However, only the top jurisdictions are highlighted to provide a concise yet impactful overview of the key regions driving this field forward.

#### Leading applicants

Figure 1D presents leading applicants – top 10 patent applicants – of patent documents related to innovative use of *Lamiaceae* extracts in animal feeding-stuffs and nutritional supplementations.

Among the top contributors, Nestlé SA (Vevey, Switzerland) and its subsidiary, Nestec SA (Vevey, Switzerland), stood out as key players in leveraging *Lamiaceae* extracts for innovative feeding-stuffs and nutritional supplements. Their patent activity highlights a strategic focus on integrating natural bioactive compounds to enhance animal health and nutrition. As examples of innovation in this area, the granted patent concerning “Nutrition blend for health benefits in animals” with Nestlé SA as the applicant [Yu and Pan 2022] as well as its subsidiary, the applicant Nestec SA, for the patent application concerning “Pet food composition for regulating body weight and preventing obesity and related disorders in pets” [Lemaure and Darimont-Nicolau 2010].

Another contributor is Ropapharm BV (Zaandam, Netherlands) which emerged as a leading applicant. This company was the first one in the world, which developed animal feed based on oregano oil. The integration and use of *Lamiaceae* extracts in animal feeding-stuffs and nutritional supplementation have been highlighted in numerous patents. As an example, the applicant Ropapharm BV registered the patent concerning “Pharmaceutical compositions, based on etheric oils obtained from plants for use in the human and veterinary medical field” [Ninkov 2003].

Ralco Nutrition Inc. (Marshall, MN, United States) also emerged as a leading applicant, reflecting the company's commitment to advancing sustainable animal nutrition through the use of plant-based ingredients. Their emphasis on incorporating *Lamiaceae*-derived bioactives aligns with industry trends toward natural and health-promoting feed solutions. As an example, the applicant Ralco Nutrition Inc. registered a patent of addition concerning “Feed mitigant compositions for inactivating swine viruses and related methods” [Lamb and Koppien-Fox 2022].

Focusing on these key contributors provides a clear picture of corporate leadership in this field, avoiding redundancy by limiting the analysis to a select few significant players rather than expanding to a broader list of ten.



### Technological Fields

The analysis of International Patent Classification (IPC) codes provided insights into the key technological fields associated with innovations in feeding-stuffs and nutritional supplements formulated with *Lamiaceae* extracts (Tab. 2).

The most frequently occurring IPC code was A61K36/53, with 485 documents. This code pertains to medicinal preparations of undetermined constitution containing

**Table 2.** Document count and definitions of IPC codes (top 10) of key technological fields associated with innovations in feeding-stuffs and nutritional supplements formulated with *Lamiaceae* extracts

| IPC Code   | Definition                                                                                                                                                 | Technological field                                                                                     | Document count |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|----------------|
| A61K36/53  | Medicinal preparations containing material from plants in the <i>Lamiaceae</i> or <i>Labiatae</i> (i.e., mint family) (e.g., thyme, rosemary, or lavender) | Use of bioactive compounds from <i>Lamiaceae</i> plants for medicinal and health-related applications   | 485            |
| A23K10/30  | Feeding-stuffs from plant material, e.g., roots, seeds, or hay, including fungal-origin materials obtained by microbiological/biochemical processes        | Development of plant-based animal feeding-stuffs with improved nutritive or functional properties       | 213            |
| A23K1/16   | Animal feeding-stuffs supplemented with accessory food factors such as salt blocks                                                                         | Inclusion of essential additives or supplements in feeding-stuffs to support animal health              | 178            |
| A61K36/18  | Medicinal preparations containing material from plants in the <i>Magnoliophyta</i> (angiosperms)                                                           | Utilization of angiosperm plant-derived materials in health and therapeutic innovations.                | 142            |
| A61K36/00  | Medicinal preparations containing material from algae, lichens, fungi, plants, or derivatives (e.g., herbal medicines)                                     | Broad exploration of plant-based materials in traditional and modern medicinal applications             | 138            |
| A23K1/18   | Feeding-stuffs specially adapted for particular animals                                                                                                    | Formulation of specialized feed for specific animal categories to optimize health and productivity      | 131            |
| A61K36/23  | Medicinal preparations containing material from plants in the <i>Apiaceae</i> ( <i>Umbelliferae</i> ) family (e.g., dill, coriander)                       | Use of <i>Apiaceae</i> plants for their therapeutic and functional properties in medicinal applications | 116            |
| A61K36/534 | Medicinal preparations containing material from plants in the <i>Mentha</i> (mint) genus                                                                   | Innovations involving mint-based bioactives for medical, dental, or toiletry purposes                   | 116            |
| A23L1/30   | Modifying the nutritive qualities of foods, such as dietetic products with additives                                                                       | Enhancement of food or feed through the addition of health-promoting or functional additives            | 113            |
| A61K36/48  | Medicinal preparations containing material from plants in the <i>Fabaceae</i> ( <i>Leguminosae</i> ) family                                                | Applications of <i>Fabaceae</i> -derived compounds for medicinal and therapeutic innovations            | 113            |

material from plants in the *Lamiaceae* or *Labiatae* family (e.g., thyme, rosemary, lavender, etc.). In addition, it shows how important *Lamiaceae* plants are for innovation by showing their bioactive properties and potential to improve animal health. Its prevalence was expected, since this code was incorporated into the request during the collection of patent documents. However, the existence of several hundred innovations linking it to animal feed confirms the relevance of the subject at hand.

Another prominent IPC code, A23K10/30 (213 documents), focuses on feeding-stuffs derived from materials of plant origin, such as roots, seeds, or hay. This classification highlights advancements in utilizing plant-derived materials to develop targeted feeding applications aimed at improving livestock productivity and well-being.

Several other notable IPC codes included A23K1/16, A61K36/18, A61K36/00, and A23K1/18. A23K1/16 (178 documents), emphasizing animal feeding-stuffs supplemented with accessory food factors, such as salt blocks. A61K36/18 (142 documents), addressing medicinal preparations containing material from plants classified under *Magnoliophyta* (angiosperms). A61K36/00 (138 documents), a broader classification encompassing medicinal preparations containing material from algae, lichens, fungi, plants, or their derivatives, illustrating the expansive exploration of plant-based health innovations. A23K1/18 (131 documents), highlighting feeding-stuffs specially adapted for particular animals, emphasizing their targeted applications in animal nutrition.

A final list of complementary codes included A61K36/23 (116 documents), related to medicinal preparations containing material from the *Apiaceae* (*Umbelliferae*) family (e.g., dill, coriander, etc.). A61K36/534 (116 documents), covering medicinal preparations involving material from the *Mentha* genus. A23L1/30 (113 documents), which focuses on modifying the nutritive qualities of foods, such as dietetic products with additives. A61K36/48 (113 documents), relating to medicinal preparations from plants in the *Fabaceae* (*Leguminosae*) family.

This diverse range of IPC codes reflects a comprehensive exploration of bioactive compounds and their integration into advanced feeding-stuff formulations. It highlights the interdisciplinary nature of innovations in animal nutrition, encompassing medicinal, biochemical, and agricultural advancements.

#### **Granted patents highlighting innovative use of *Lamiaceae* extracts in animal feeding-stuffs and nutritional supplementations**

**Justification of patents selection.** Based on simple family size, 10 granted patents have been selected as relevant among others (Tab. 3). These concern granted patents with 7 top jurisdictions (i.e., Europe, China, Australia, Republic of Korea, United States, Japan, and Canada) and 9 top applicants (i.e., Ewos Innovation AS, Ropapharm BV, Nestlé SA, Cargill Inc., Healthy Bees LLC, Maqui New Life SA, Hill's Pet Nutrition Inc., Bartlett Grain Pty. Ltd., and Delacon Biotechnik GmbH).

The choosing granted patents based on simple family size helps to focus on inventions with the highest potential for technological influence, market relevance, and innovation impact (Tab. 4).

**Table 3.** Selection of granted patents highlighting innovative use of *Lamiaceae* extracts in animal feeding-stuffs and nutritional supplementations

| Patent         | Publication  | Title                                                                                                                                                | Applicant                 | Family | Reference                            |
|----------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|--------|--------------------------------------|
| EP2946672B1    | Aug 1, 2018  | Composition comprising sulfide compounds for masking the odor of a fish semiochemical                                                                | Ewos Innovation AS        | 36     | [Wadsworth <i>et al.</i> , 2018]     |
| CN1124855C     | Oct 22, 2003 | Pharmaceutical compositions, based on etheric oils obtained from plants for use in the human and veterinary medical field                            | Ropapharm BV              | 29     | [Ninkov, 2003]                       |
| AU2002325281B2 | Jan 24, 2008 | Pet food composition for regulating body weight and preventing obesity and related disorders in pets                                                 | Nestlé SA                 | 24     | [Lemaure and Darimont-Nicolau, 2008] |
| KR102570195B1  | Aug 23, 2023 | Method of feeding an animal                                                                                                                          | Cargill Inc.              | 21     | [Hilbert <i>et al.</i> , 2023]       |
| US11376297B2   | Jul 5, 2022  | Nutrition blend for health benefits in animals                                                                                                       | Nestlé SA                 | 16     | [Yu and Pan, 2022]                   |
| US10925920B2   | Feb 23, 2021 | Nutritional powder compositions with acaricide activity for apiculture and their use for the prophylaxis and treatment of <i>Varroa</i> infestations | Healthy Bees LLC          | 12     | [Del Vecchio, 2021]                  |
| US11439680B2   | Sep 13, 2022 | Veterinary composition of marine algae and <i>Andrographis</i> sp. extracts, which can be used to treat infections in fish                           | Maqui New Life SA         | 12     | [Campos and Jeraldino, 2022]         |
| JP7422234B2    | Jan 25, 2024 | Pet food compositions                                                                                                                                | Hill's Pet Nutrition Inc. | 9      | [Jackson and Jewell, 2024]           |
| CA2362953C     | Oct 1, 2013  | Animal feed supplement for the nutritional enrichment of animal produce                                                                              | Bartlett Grain Pty. Ltd.  | 8      | [Bartlett and Wingate, 2013]         |
| US10688145B2   | Jun 23, 2020 | Poultry feed additive                                                                                                                                | Delacon Biotechnik GmbH   | 8      | [Mueller, 2020]                      |

**Review of selected relevant patents.** The granted patent EP2946672B1 with 36 simple families concerns the composition comprising sulfide compounds for masking the odor of a fish semiochemical [Wadsworth *et al.*, 2018]. In this invention, Wadsworth *et al.* propose a dual approach to mitigate ectoparasite infestations in aquaculture by combining plant-based strategies and bioactive compounds. Extracts from *Lamiaceae* plants, such as lavender (*Lavandula* spp.) and rosemary (*Salvia rosmarinus*), along with bog myrtle (*Myrica gale*), were tested for their ability to mask salmon odor by reducing the detectability of semiochemicals like isophorone and 1-Octen-3-ol. These extracts inhibited sea lice (*Lepeophtheirus salmonis*) attraction and settlement. Additionally, the invention utilizes diallyl sulfide (DAS), a bioactive compound, applied directly to water or integrated into nutritional feed compositions for Salmonidae species, such as Atlantic salmon and rainbow trout. The feed incorporates DAS at optimal concentrations (0.01-0.5% by weight) along with

**Table 4.** Relevance of patents of patents based on simple family size

| Aspect               | Advantages                                                                                                                                                                                | Expected strategies                                                                                                                                                                       |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Patent Coverage      | Patents within a larger simple family often indicate more significant innovation and potentially higher commercial value                                                                  | Patents within larger simple families can represent more comprehensive protection, indicating that the invention has reached a stage where the assignee is confident in its marketability |
| Influence on Market  | Patents with large simple families may indicate technologies that have a broader or more immediate impact on the market                                                                   | The larger the family, the more likely it is that the technology is pivotal within its field. This can be useful in identifying key patents that could drive trends in the industry       |
| Innovation Indicator | A higher simple family size may indicate that the inventor or assignee is actively protecting various aspects of the technology in multiple regions, suggesting significant innovation    | The larger the simple family, the more likely the patent covers novel and valuable technological advancements, which might contribute to shaping the direction of the industry            |
| Patent Strategy      | Companies often focus on filing more patents within a simple family when they anticipate a strong competitive advantage from their invention, or when they seek to cover multiple markets | This can indicate a deliberate strategy to expand their intellectual property portfolio, which is relevant to the analysis of trends and innovation                                       |
| Regional Importance  | Selection of patents based on how many of them are filed in major patent jurisdictions such as the US, Europe, and Asia                                                                   | Patents with large simple families could reflect strategic importance in these key markets, making them more relevant to patent analysis                                                  |
| Technology Focus     | The patents with large simple families may cover fundamental or essential technologies in a specific field of interest                                                                    | This relevance ensures that the patents selected are the most influential in the specific domain                                                                                          |

essential nutrients. Together, these solutions provide an eco-friendly and sustainable method for reducing parasite-fish interactions, advancing aquaculture practices while enhancing fish welfare [Wadsworth *et al.* 2018]. As applicant, the company Ewos Innovation AS (Dirdal, Norway) emerge among top leading in this area. Founded in 1975, this company provides research and development services focused on the fish feed and aquaculture industry.

The granted patent CN1124855C with 29 simple families concerns pharmaceutical compositions, based on etheric oils obtained from plants for use in the human and veterinary medical field [Ninkov 2003]. In this invention, Ninkov utilizes essential oils derived from *Lamiaceae* family plants to formulate a pharmaceutical composition for preventing and treating animal microorganism gastroenteropathy. Key plants include *Origanum vulgare*, *Thymus vulgaris*, *Mentha piperita*, *Thymus serpyllum*, *Satureja hortensis*, *Satureja montana*, and *Salvia officinalis*. Essential oils from *Adeps Bovis seu Bubali* (*Origanum vulgare*), *Herba thymi vulgaris* (*Thymus vulgaris*), and *Mentha piperita* are particularly emphasized for their efficacy. These oils are incorporated as active carriers in concentrations ranging from 1-15% by weight, complemented by natural carriers like honey and starch products. The inclusion of tannins (0.5-2.5% by

weight) enhances antimicrobial and gastrointestinal therapeutic effects. This approach highlights the potential of *Lamiaceae* plants for sustainable veterinary healthcare solutions [Ninkov 2003]. As applicant, the company Ropapharm BV (Zaandam, Netherlands) is within top 10 patent applicants in this area. It develops animal feed products based on natural ingredients.

The granted patent AU2002325281B2 with 24 simple families concerns Pet food composition for regulating body weight and preventing obesity and related disorders in pets [Lemaure and Darimont-Nicolau, 2008]. In this invention, Lemaure and Darimont-Nicolau propose the development of a nutritionally complete pet food composition designed to prevent and manage obesity and related disorders in pets. The composition includes plant-based bioactives capable of stimulating  $\beta$ 3-adrenergic receptors, which are key in regulating lipolysis, glucose homeostasis, and energy metabolism. Active ingredients are derived from plants such as *Medicago sativa* (seeds), *Capsicum* species (leaves), *Cyperus* species (leaves or tubers), *Iris pallida* (tubers), and *Coleus* species (roots). These plant extracts may be used alone or in combination with other bioactives like antioxidants and milk hydrolysates. Results demonstrate improved pet activity, mobility, and stamina, alongside enhanced metabolic health [Lemaure and Darimont-Nicolau, 2008]. As applicant, the company Nestlé SA (Vevey, Switzerland) is the top leading in this area. As already confirmed this Swiss multinational corporation and its subsidiary, Nestec SA (Vevey, Switzerland), are specializing in development and innovation of food and drink processing.

The granted patent KR102570195B1 with 21 simple families concerns a method of feeding an animal [Hilbert *et al.*, 2023]. In this invention, Hilbert *et al.* outline a method to enhance reproductive and offspring performance in avian animals using a feed composition containing vitamin E and a polyphenol blend derived from grape seed and skin, onion, and rosemary extract. Administered as part of their feed ration, this composition improves key metrics such as hatchling weight, daily gain, feed conversion rate, and antioxidant status. By partially replacing vitamin E with polyphenols at a 1:1 ratio, it achieves significant performance improvements. The inclusion of rosemary, a member of the *Lamiaceae* family, underscores the potential of its bioactive compounds in enhancing antioxidant activity and promoting animal health [Hilbert *et al.*, 2023]. As applicant, the company Cargill Inc. (Wayzata, MN, United States) is global food industry leader that produces grains and oilseeds while offering farmer services and risk management solutions.

The granted patent US11376297B2 with 16 simple families concerns a nutrition blend for health benefits in animals [Yu and Pan 2022]. In this invention, Yu and Pan present a nutrient-rich composition designed to deliver health benefits to animals by leveraging the synergistic effects of bioactive compounds. The composition includes a significant proportion of walnut (60.61-83.33%) as a core ingredient, providing essential fatty acids and antioxidants. Complementary ingredients include maitake mushroom extract (0.0017-0.076%) for immune support, epigallocatechin-3-gallate (EGCG) (0.167-1.52%) for its potent antioxidative properties, turmeric root powder

(16.67-24.24%) for its anti-inflammatory effects, and lycopene (0.0167-0.033%) as a natural antioxidant. Additionally, taurine (0.833-1.52%), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) (each 0.833-6.06%) contribute to cardiovascular, neurological, and overall metabolic health. In some embodiments, botanicals like peppermint, cloves, parsley, and ginger are included for their antimicrobial, anti-inflammatory, and refreshing properties. Finally, the formulation claimed targets enhanced immunity, reduced inflammation, and improved general wellbeing. [Yu and Pan, 2022]. As applicant, the Swiss multinational corporation Nestlé SA (Vevey, Switzerland) confirms again its leadership in this area.

The granted patent US10925920B2 with 12 simple families concerns a nutritional powder compositions with acaricide activity for apiculture and their use for the prophylaxis and treatment of *Varroa* infestations [Del Vecchio 2021]. In this invention, Del Vecchio provides a nutritional powder composition designed for bee nourishment and the prophylaxis or treatment of acariosis, particularly *Varroa destructor* infestations. The formulation includes nutritional components such as powdered milk, algae proteins, brewer's yeast, sugars (dextrose, glucose, fructose), organic acids (acetic, citric, tartaric), and glycerin. It incorporates natural antioxidants and antiseptics from essential extracts of *Origanum vulgare*, *Pelargonium graveolens*, *Crocus sativus*, *Myristica fragrans*, *Origanum majorana*, and *Monarda citriodora*. Medicinal elements include thymol, *Thymus vulgaris*, oxalic acid, *Aloe vera*, geraniol, and *Beta vulgaris* cv. *altissima*. This composition improves bee health, combats parasites, and promotes sustainable apiculture practices [Del Vecchio 2021]. As applicant, the company Healthy Bees LLC (Miami, FL, United States) emerges among top leading in this area. It is a leader developer of honeybee supplement technology designed to enhance the immunity and physiology of honeybees.

The granted patent US11439680B2 with 12 simple families concerns a veterinary composition of marine algae and *Andrographis* sp. extracts, which can be used to treat infections in fish [Campos and Jeraldino, 2022]. In this invention, Campos and Jeraldino introduce an immunostimulant composition for fish to enhance immunity and combat infections caused by intracellular microorganisms. It includes an extract of *Andrographis* sp. containing andrographolide and a seaweed extract containing fucoidan, derived from brown algae such as *Fucus vesiculosus* and *Macrocystis pyrifera*. The extracts are combined at a 100:450 ratio. The composition, formulated as a fish food additive, incorporates bioactive compounds from algae with specific glycosidic and sulfated groups. It can be mixed with fish feed at 0.5-2.5 kg per ton, promoting sustainable aquaculture by improving fish health and preventing infections effectively [Campos and Jeraldino 2022]. As applicant, the company Maqui New Life SA (Santiago, Chile) is within top 10 patent applicants in this area. It focused on research and development of standardized natural products for human and animal health applications.

The granted patent JP7422234B2 with 9 simple families concerns different pet food compositions [Jackson and Jewell, 2024]. In this invention, Jackson and Jewell



describe a pet food composition tailored to improve health outcomes in companion animals, particularly canines and felines. The composition includes 15-25% neutral detergent fiber (NDF), 10-20% crude fiber, 15-20% protein, and 10-14% fat, with an NDF-to-crude fiber weight ratio of at least 3:2. It incorporates fiber sources such as pecan fibers, beet pulp, or cranberry pomace, and anti-inflammatory agents like rosemary extract, rosmarinic acid, curcumin, ginger, and blueberries. Benefits include inducing satiety, reducing inflammation, increasing anti-inflammatory cytokines (e.g., IL-10), and managing obesity-related symptoms such as joint pain and metabolic endotoxemia. This innovative approach enhances animal wellness and dietary management [Jackson and Jewell, 2024]. As applicant, the American pet food company Hill's Pet Nutrition Inc. (Topeka, KS, United States), that is a subsidiary of Colgate-Palmolive (New York, NY, United States), produces dog and cat foods.

The granted patent CA2362953C with 8 simple families concerns an animal feed supplement for the nutritional enrichment of animal produce [Bartlett and Wingate 2013]. In this invention, Bartlett and Wingate describe a livestock feed supplement designed to enrich meat products with omega-3 fatty acids, particularly docosahexaenoic acid (DHA), prior to slaughter. The supplement includes stabilized tuna fishmeal (5-15% of total food intake), antioxidants (both synthetic and naturally occurring), and agents to prevent biological contamination. One of the antioxidants is a naturally-occurring antioxidant selected from the group consisting of rosemary oil, thyme white oil, peppermint oil, and jasmine tea. The supplement also contains an oil-based premix, a dry mix premix, and a water-based green tea extract. This formulation enhances DHA incorporation into meat, without imparting a fishy taste. It is suitable for livestock such as pork, poultry, lamb, beef, or farmed fish, improving the nutritional quality of the meat for human consumption [Bartlett and Wingate 2013]. As applicant, the company Bartlett Grain Pty. Ltd. (West Chatswood, Australia) specializes in grain merchandising and supplies commercial patent flours, various classes of wheat, food-grade corn, and soybeans.

Finally, the granted patent US10688145B2 with 8 simple families concerns a poultry feed additive [Mueller 2020]. In this invention, Mueller describes a method for improving feed conversion efficiency in antibiotic-free poultry production by administering a feed additive composition that combines phytogetic compounds. The key ingredients are microencapsulated essential thyme oil (oil component) and dried quillaja bark powder containing saponin (saponin component). The composition contains at least 0.5% saponin and at least 0.2% thyme oil per saponin. This mixture is effective in improving poultry feed conversion, enhancing nutrient digestibility, and supporting weight gain. The composition is formulated to be storage-stable, pelletable, and can be included in a poultry feed product to improve production efficiency, particularly in laying and breeding poultry [Mueller, 2020]. As applicant, the company Delacon Biotechnik GmbH (Engerwitzdorf, Austria) develops and manufactures phytogetic feed additives for poultry, swine, ruminants, and aquaculture industries.

## Conclusion

This study highlights the innovative application of *Lamiaceae* extracts in animal nutrition, showcasing a convergence between bioactive compound research and practical applications. The increasing trend in patent publications reflects the growing recognition of *Lamiaceae* plants as a valuable source of bioactive compounds for feeding-stuffs and nutritional supplements. The dominance of jurisdictions like China and the United States aligns with their broader focus on sustainable agricultural technologies, emphasizing their leadership in this field.

The prevalence of patent applications over granted patents suggests an active pipeline of ongoing innovation, signaling continued interest in exploring the potential of *Lamiaceae*-based formulations. Leading applicants, including major corporations, have demonstrated a commitment to enhancing animal health through natural, eco-friendly feeding solutions.

The findings also underscore the importance of IPC codes in tracking technological progress and identifying emerging trends in this domain. Specifically, the data reveals a strong focus on sustainable practices and the integration of plant-based additives into advanced feeding-stuff formulations. Future studies could further investigate the synergistic effects of combining *Lamiaceae* extracts with other natural additives and validate these formulations through field trials, paving the way for novel, sustainable feeding solutions for the agricultural industry.

**Acknowledgments.** The authors acknowledge the WIPO (Geneva, Switzerland), EPO (Munich, Germany), and Cambia Institute (Canberra, Australia) for their invaluable contributions to the patent databases (Patentscope, The Lens, and Espacenet, respectively) utilized in this study.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data presented in this study are available within this manuscript.

**Conflicts of Interest:** The authors declare no conflicts of interest.

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