



Use of essential oils as natural preservatives in the meat industry

Uso de aceites esenciales como conservantes naturales en la industria cárnica

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Abstract

Essential oils, due to their antimicrobial, antioxidant, and organoleptic properties, are presented as a natural alternative to synthetic preservatives in the food industry. The objective of this study was to conduct a documentary review on the use of essential oils as natural preservatives in the meat industry. To achieve this, the SALSA method modified by Gunnarsdottir was employed, which includes an exhaustive search, critical evaluation, synthesis, and analysis of the literature, complemented by the snowball technique. The results revealed 21 essential oils derived from various plants, which exhibit antioxidant, antimicrobial, and preservative properties. These characteristics position them as key resources in the preservation of meat products, with doses ranging from 0.5 to 2 mL·kg⁻¹ of oil, depending on the species used. In conclusion, it was determined that essential oils are effective in optimizing the quality, safety, and shelf life of meat products and their derivatives, establishing them as a valuable tool in the industry.

Keywords: decomposition, documentary film, product, effect, review, can.

Resumen

Los aceites esenciales, debido a sus propiedades antimicrobianas, antioxidantes y organolépticas, se presentan como una alternativa natural a los conservantes sintéticos en la industria alimentaria. El objetivo de este estudio fue realizar una revisión documental sobre el uso de aceites esenciales como conservantes naturales en la industria cárnica. Para ello, se empleó el Método SALSA modificado por Gunnarsdottir, el cual incluyó una búsqueda exhaustiva, evaluación crítica, síntesis y análisis de la literatura, complementado con la técnica de bola de nieve. Los resultados obtenidos revelaron 21 aceites esenciales derivados de diversas plantas, los cuales exhibieron propiedades antioxidantes, antimicrobianas y conservantes. Estas características los posicionan como recursos clave en la conservación de productos cárnicos, con dosis que varían entre 0,5 y 2 mL·kg⁻¹ de aceite, dependiendo de la especie utilizada. En conclusión, se determinó que los aceites esenciales son eficaces en la optimización de la calidad, seguridad y vida útil de los productos cárnicos y sus derivados, consolidándose como una herramienta valiosa en la industria.

Palabras clave: descomposición, documental, producto, efecto, revision, poder.



Introduction

In recent decades, innovations in food production and a growing interest in food safety have motivated consumers to demand products to have less synthetic additives and pose less strain on the environment. Although chemical preservatives have been used for many years to control microbial growth, they are very controversial for their effects in human health (Reische et al., 1998). Essential oils from aromatic plants have strong anti-microbial and anti-oxidant potential, which justifies their use as natural preservatives that can fulfill the growing demand for safe, healthy and nutritional food.

Due to its great potential, these oils can contribute to fighting pathogenic microorganisms that cause illness to consumers, extending the foods' useful life and keeping their quality (Enríquez et al., 2023). Some essential oils and other plant extracts exhibit anti-bacterial, anti-fungal and anti-viral properties, which makes them potential sources of anti-microbial compounds. These compounds are explored as alternatives for food preservation and the treatment of infectious diseases (Rodríguez, 2019).

Food preservation is defined as the set of treatments that extend the shelf life of food while maintaining, as much as possible, its quality attributes such as color, texture, flavor, and especially nutritional value (Salgueiro et al., 2000). This definition encompasses a wide range of preservation methods, from short-term techniques such as household cooking and cold storage, to long-term methods like freezing and dehydration in strictly controlled industrial processes (Leistner, 2006).

The current trend among consumers shows a preference for quick-to-prepare foods that meet quality standards, are natural, safe, minimally processed, and have a longer shelf life (Sauceda, 2014). Food preservation technologies face the challenge of producing perishable products while minimizing the loss of their original nutritional and sensory characteristics (Gómez, 2024).

The use conditions of preservatives are strictly regulated in all countries worldwide, with established limits for the amount of a specific preservative and the total amount of permitted preservatives (Zelada, 2019). At authorized concentrations, food preservatives generally do not eliminate microorganisms but simply prevent their proliferation. Therefore, they are only effective when used with high-quality raw materials (Ibañez, 2013).

Essential oils are complex mixtures of organic compounds, including terpenes, phenols, esters, and aldehydes, which are responsible for the characteristic aromas of the plants from which they are extracted. Their volatility and

ability to release aromatic molecules into the air make them easily perceived by olfactory receptors, granting them a key role in various applications (Enríquez, 2023).

In the cosmetic industry, essential oils are vital in the formulation of perfumes and aromatic products due to their high concentration of natural aromatic compounds, allowing for the creation of complex and long-lasting fragrances (Dufort, 2017). In the food industry, their organoleptic properties make them ideal as flavorings and condiments, as they enhance the aroma and taste of food, improving the sensory experience (Ayala, 2024).

According to Montoya (2010), they are identified by their physical appearance and fat-like consistency, and are widely distributed throughout the plant kingdom, especially in phanerogams. Essential oils can be found in different parts of the plant—leaves, roots, bark, and fruits—and their quantity and composition vary between species and even within the same genus. They are also known as biopreservatives or green chemicals, and are now considered potential alternatives to synthetic preservatives (Diaz and Martínez, 2013).

Essential oils are a natural alternative to synthetic preservatives in the meat industry thanks to their antimicrobial properties, which help control pathogens such as *Salmonella* spp., *Escherichia coli*, and *Listeria monocytogenes*, as well as inhibit fungi responsible for spoilage (Bautista and Barrado, 2023). They help preserve freshness, delay lipid oxidation, and improve sensory quality with their unique aromas and flavors. Their use allows for a reduction in synthetic additives, responding to consumer demand for more natural foods.

Recent innovations include the use of nanoemulsions and coatings for the controlled release of active compounds. Their implementation must comply with food regulations, highlighting their potential to enhance both safety and sustainability in the sector. The objective of this study was to conduct a literature review on the use of essential oils as natural preservatives in the meat industry.

Materials and methods

The research conducted was specifically a literature review, and the SALSA methodology—an acronym for Search, Appraisal, Synthesis, and Analysis—was used in its modified form. The traditional SALSA method for systematic reviews involves four steps: search, evaluation, synthesis, and analysis; however, Gunnarsdottir et al. (2020) added an additional step known as the snowballing technique, as shown in Figure 1.



Figure 1. Diagram of the SALSA method created by Gunnarsdottir et al., 2020.

1. Search

An exhaustive search was conducted on the use of essential oils in the preservation of meat products, focusing on their antimicrobial and antioxidant activity, as well as their impact on shelf life and sensory quality. Sources included scientific articles, theses, books, and technical documents, using academic databases such as Web of Science, Scopus, PubMed, Science Direct, and Scielo, in addition to search engines like Google Scholar. Keywords were defined as: “essential oils”, “meat industry”, “natural preservatives”, “antimicrobial properties”, and “sensory quality”. Inclusion criteria were established to prioritize recent research and studies with a strong methodological design.

2. Appraisal

The collected studies were critically reviewed to assess their relevance, methodological quality, and scientific validity. This process included an analysis of experimental design, sample size, methods of essential oil extraction and application, and their impact on the microbiota and organoleptic properties of meat products. Exclusion criteria were also applied to eliminate studies with incomplete information or poorly detailed methodologies.

3. Synthesis

The results were organized to identify patterns and trends related to the effects of essential oils in meat preservation. The results are classified as such: type of essential oil; mechanism of action (anti-microbial or anti-oxidant), and method of application (marinades, coatings, direct incorporation). Likewise, the results were compared considering the type of meats in the analysis and the storage conditions.

4. Analysis

The data was synthesized to answer the key research questions, highlighting the benefits of essential oils as an alternative for meat preservation. The practical implications for the meat industry were evaluated, including the perception of the consumer, adherence to the norms, and sustainability. Furthermore, the limitations were analyzed, such as variability of effectiveness depending on the type of oil and meat, and future research lines were proposed to optimize its use.

Results and discussion

Essential oils are widely used in the meat industry due to their antimicrobial and antioxidant properties, making them key tools for food preservation (Martínez, 2022). These oils act similarly to synthetic preservatives, preventing the spoilage and deterioration of meat products. They are composed of over 70 components, including terpenes, hydrocarbons, alcohols, and ketones (Nadinic et al., 2016). Based on their origin, they are classified as natural, artificial, or synthetic, with natural oils being the most expensive due to their low yield.

Synthetic oils, which are more affordable, are commonly used as flavorings and aromatic agents (Lascano, 2020). From a chemical perspective, essential oils can also be classified according to their major components: monoterpenes, sesquiterpenes, and phenylpropenes. This classification is useful for analyzing the phytochemical aspects of these oils in the context of their application in processed meats (Zambrano, 2024).

Essential oils have also demonstrated antimicrobial activity against various strains, including *L. innocua*, *Staphylococcus aureus*, *Bacillus subtilis*, *Yersinia enterocolitica*, *Salmonella enteritidis*, *S. typhimurium*, *Proteus mirabilis*, *E. coli*, and *Klebsiella oxytoca* (Maldonado and Rico, 2013).

Uses of essential oils for meat preservation

Table 1 presents a summary of various plant species used in the preservation of meat products, highlighting their bioactive properties and the beneficial effects they contribute to food preservation. Each species was analyzed based on its primary effect (antimicrobial, antioxidant, preservative, among others), the part of the plant used, the recommended dosage, the biochemical compounds responsible for its preservative properties, and the food products in which it is applied.

Table 1 showcases a wide range of essential oils derived from plants used in the food industry, characterized by their antioxidant, antimicrobial, and preservative properties. These qualities position them as strategic ingredients for the preservation and improvement of meat products and their derivatives, reinforcing their significance within the food sector. The analysis reveals a notable diversity of plant species, including *Allium sativum*, *Ocimum basilicum*, and *Origanum vulgare*. These plants exhibit specific properties, with antioxidant and antimicrobial activities being predominant—both of which are essential for the preservation of food, particularly those of animal origin.

Table 1. Essential oils and their use in preserving meat products

Species	Effect	Part of the plant it comes from	Dosage	Biochemical composition and role in preservation	Used in	References
Garlic (<i>Allium sativum</i>)	Anti-bacterian, anti-oxidant, preservative	Fruit	1-2 mL·kg ⁻¹	It contains allicin, a compound with antimicrobial and antioxidant properties that helps preserve meat products.	Processed and cured meats	Hidalgo (2018)
Basil (<i>Ocimum basilicum</i>)	Antioxidant, antimicrobial, improves test and aroma	Leaves	0.5-1 mL·kg ⁻¹	Contains eugenol, which acts as an antimicrobial, inhibiting the growth of fungi and bacteria in meat products.	Processed meats, fresh meats	Hilvay (2015)
Caraway (<i>Carum carvi</i>)	Expectorant	Fruit	1-2 mL·kg ⁻¹	Carvone, the main compound in caraway oil, has antimicrobial and antioxidant properties.	Processed and cured meats	Stashenko et al. (2014)
Anise (<i>Pimpinella anisum</i>)	Aroma, antiseptic properties	Seeds	0.5-1 mL·kg ⁻¹	Contains anethole, which has antimicrobial and antioxidant properties, contributing to food safety.	Mortadella	Piñon et al. (2015)
Bergamot (<i>Citrus bergamia</i>)	Antimicrobial, preserves aroma	Rind of the fruit	0.5-1 mL·kg ⁻¹	Contains limonene and linalool, providing antimicrobial properties and helping to maintain the freshness of products.	Cured meats, seafood	Dosoky y Setzer (2018)
Cajeput (<i>Melaleuca cajuputi</i>)	Antiseptic, anti-inflammatory	Leaves	1-2 mL·kg ⁻¹	Contains cineole and alpha-terpineol, which inhibit the growth of pathogenic microorganisms in meat products.	Fresh sausages	Medina (2022)
Cilantro (<i>Coriandrum sativum</i>)	Antioxidant and antimicrobial	Leaves	1 mL·kg ⁻¹	Contains coriandrol and linalool, which are antioxidant and antimicrobial, helping to maintain product freshness.	Processed meats	Valles et al. (2014)
Cumin (<i>Cuminum cyminum</i>)	Antioxidant	Seeds	1 mL·kg ⁻¹	Contains cuminaldehyde and terpenes with antioxidant effects, preventing fat oxidation in meat products.	Vacuum-sealed fish	Rea (2012)
Dill (<i>Anethum graveolens</i>)	Tonic, aromatic agent, antispasmodic, diuretic	Fruits and leaves	1 mL·kg ⁻¹	Anethole and limonene have antimicrobial properties, contributing to food preservation.	Processed meats	Castro et al. (2017)
Eucalyptus (<i>Eucalyptus citriodora</i>)	Antibacterial, antimicrobial, refresher	Leaves	1 mL·kg ⁻¹	Contains eucalyptol, which has antimicrobial and refreshing properties, enhancing preservation.	Fresh meats	Guapulema, (2015)
Guaviduca (<i>Piper carpubya</i>)	Antioxidant, antimicrobial	Leaves	1 mL·kg ⁻¹	Contains bioactive compounds that inhibit microbial growth and reduce oxidation.	Paisa-style chorizo	Enríquez, (2022)
Spearmint (<i>Mentha spicata</i>)	Antioxidant and antimicrobial activity	Leaves	1 mL·kg ⁻¹	Menthol and carvone are responsible for its antimicrobial properties, preventing the proliferation of pathogens.	Fresh meats, processed meats	Idrovo (2018)
Huacatay (<i>Tagetes minuta</i>)	antimicrobial and analgesic	Leaves	1 mL·kg ⁻¹	Contains active compounds with antimicrobial and anti-inflammatory properties.	Processed and fresh meats	Chappa et al. (2023)

Tabla 1. Essential oils and their use in preserving meat products. Continuation ...

Lavander (<i>Lavandula angustifolia</i>)	Stimulant, antimicrobial and preservatives	Leaves and flowers	0.5-1 mL·kg ⁻¹	Contains linalool, which has antimicrobial and antioxidant properties, contributing to the preservation of quality.	Processed meats	Ruiz (2014)
Laurel (<i>Laurus nobilis</i>)	Antioxidant, antimicrobial and preservative	Leaves	1 mL·kg ⁻¹	Contains eugenol, which has antimicrobial and antioxidant properties, protecting products from oxidation.	Cured meats	Correa (2010)
Peppermint (<i>Mentha piperita</i>)	Stimulant, antimicrobial	Leaves	0.5-1 mL·kg ⁻¹	Menthol and menthone have antimicrobial and antioxidant properties that help maintain food freshness.	Cured meats	Guerrero et al. (2015)
Orange (<i>Citrus sinensis</i>)	Antioxidant, antimicrobial, refresher and aromatic agent	Rind of the fruit	1 mL·kg ⁻¹	Contains limonene, which provides antimicrobial properties, enhancing flavor and aroma.	Processed meats	Guerrero (2015)
Oregano (<i>Origanum vulgare</i>)	Antioxidant and antimicrobial agasint <i>Salmonella, Escherichia coli, Staphylococcus.</i>	Leaves	0.5-1 mL·kg ⁻¹	Carvacrol and thymol are known for their potent antimicrobial and antioxidant effects, protecting food products.	Cured products	Armenteros (2012)
Rosemary (<i>Salvia rosmarinus</i>)	Antioxidant, antimicrobial, taste enhancer	Leaves	1 mL·kg ⁻¹	Contains rosmarinic acid and carnosol, which have antioxidant and antimicrobial properties.	Cured meats	Guerrero (2015)
Sage (<i>S. officinalis</i>)	Antioxidant, antimicrobial	Leaves	0.5-1 mL·kg ⁻¹	Contains rosmarinic acid and sclareol, which provide antioxidant and antimicrobial effects.	Fresh chorizo	García (2006)
Wild garlic (<i>Allium sativum</i>)	Antimicrobial and antioxidant properties	Leaves	1 mL·kg ⁻¹	Has a similar composition to garlic	Cured products	Amaguay (2020)

Regarding the plant parts used, leaves and fruits were most commonly identified, as seen in rosemary, oregano, caraway, and dill. In exceptional cases, bark is used, such as in the essential oils of orange and bergamot. This suggests that these parts contain significant concentrations of bioactive compounds responsible for their functional effects.

From a biochemical perspective, several key compounds stand out for their contribution to the properties of these oils. Eugenol, found in basil and bay leaf, is well known for its antimicrobial properties, while rosmarinic acid, present in rosemary and sage, acts as a potent antioxidant. Likewise, limonene (present in orange and bergamot) and the combination of carvacrol and thymol (oregano) have shown strong efficacy against microorganisms such as *Salmonella* and *E. coli*.

In terms of application, these oils are mainly used in the production of sausages, cured meats, and fresh meats, highlighting their role in the preservation of animal-based products. Additionally, certain oils such as cumin have more specific uses—for example, in vacuum-packed fish—demonstrating their versatility across different food categories.

The doses of essential oils applied, generally between 0.5–2 mL·kg⁻¹, are designed to be effective in food preservation without

compromising sensory characteristics. These compounds not only extend the shelf life of food products but also contribute to food safety by inhibiting the growth of pathogenic microorganisms.

The use of essential oils in the food industry has gained considerable attention due to their functional properties and potential as natural alternatives to synthetic preservatives. Previous studies have demonstrated their antimicrobial and antioxidant effectiveness, supporting the observations described in Table 1. For instance, Burt (2004) reported that essential oils rich in compounds such as carvacrol, thymol, and eugenol exhibited high efficacy against common foodborne pathogens such as *L. monocytogenes* and *E. coli*. This is consistent with the effects attributed to plants like oregano, basil, and bay leaf.

Regarding dose optimization, Farbood et al. (2016) emphasized that essential oil concentrations must be carefully adjusted to maximize antimicrobial activity without compromising the organoleptic properties of the product. This finding supports the concentrations indicated in Table 1, which ranged from 0.5 to 2 mL·kg⁻¹. As a sustainable and natural alternative, essential oils represent a promising solution for improving food preservation while meeting consumer demand for clean-label and minimally

processed products; Dorman and Deans (2000) highlighted that essential oils can be derived from agricultural by-products, such as orange or bergamot peels, thereby contributing to the circular economy. This approach not only reinforces their usefulness in food preservation, but also promotes the valorization of agro-industrial waste.

The specificity of essential oils in food matrices is another relevant aspect. Hyldgaard et al. (2012) noted that compounds such as menthol from peppermint oil were particularly effective in fresh products, while garlic-derived compounds proved ideal for cured meats. Finally, Zhang et al. (2020) investigated the synergy between essential oils and other natural preservatives. Combinations such as rosemary and oregano showed enhanced effects in inhibiting microorganisms and preventing lipid oxidation, highlighting their versatility and effectiveness.

Conclusions

These compounds represent a viable and effective alternative for the preservation of animal-based foods. Their effectiveness lies in their antioxidant and antimicrobial properties, which position them as strategic tools to optimize the quality, safety, and shelf life of meat products and their derivatives. Eugenol, rosmarinic acid, carvacrol, and limonene, present in certain plant-derived essential oils, have demonstrated antimicrobial action against pathogenic microorganisms, including *Salmonella* and *E. coli*. These components are versatile, as they are used in various raw, cooked, and cured meat products. The doses commonly used range from 0.5 to 2 mL·kg⁻¹, which allow for a balance between preservative efficacy and the maintenance of the food's sensory characteristics, thus ensuring consumer acceptance.

Conflict of interests

The authors declare no conflicts of interest regarding this publication at any stage.

References

- Amaguay Terán, D. I. (2020). *Evaluación de 3 niveles de aceite de sacha culantro (Eryngium foetidum), como agente antioxidante en la elaboración de salchicha Frankfurt* (Bachelor's thesis, Universidad Estatal Amazónica).
- Armenteros, M., Ventanas, S., Morcuende, D., Estévez, M. y Ventanas, J. (2012). Empleo de antioxidantes naturales en productos cárnicos. *Eurocarne*, 207, 63-73.
- Ayala Sheron, D. (2024). *Caracterización química de las hojas comestibles de la ruda de río (Porophyllum ruderale) y evaluación de los parámetros de extracción de aceite esencial para su aplicación en los alimentos*. Universidad Nacional de San Cristóbal de Huamanga. Perú. 244 p.
- Bautista, G. y Barrado, A. (2023). Aplicaciones de aceites esenciales en la industria cárnica. *Journal of Food Preservation*, 37(4), 110-119.
- Burt, S. (2004). Essential oils: Their antibacterial properties and potential applications in foods—a review. *International Journal of Food Microbiology*, 94(3), 223-253.
- Castro, D. V., Pantoja, A. y Gomajoa, H. A. (2017). Evaluación *in vitro* de la capacidad antimicrobiana del aceite esencial de eneldo-*Anethum graveolens*-como inhibidor del crecimiento de *Staphylococcus aureus*, coliformes y hongos presentes en la carne de trucha. *Revista de la Facultad de Medicina Veterinaria y de Zootecnia*, 64(2), 44-51.
- Chappa, M. Y., Quintana, S. C., Angeles, W. G., Gomez, H. S., Servan, D. M., Alcantara, R. B. y Mas, M. L. (2023). Efecto de aceites esenciales de huacatay (*Tagetes minuta* L.) y mariasacha (*Tagetes elliptica* Sm.) como conservante en la carne de cerdo. *Revista Científica Dékamu Agropec.*, 4(2), 17-28.
- Correa Padrón, F. E. (2010). *Extractos vegetales y aceites esenciales como inhibidores de Listeria monocytogenes en productos cárnicos* (Bachelor's thesis, Universidad del Azuay).
- Diaz, M. y Martínez, V. (2013). Aceites esenciales como biopreservantes en la industria alimentaria. *Revista Latinoamericana de Tecnología Alimentaria*, 29(3), 80-88.
- Dorman, H. J. D. y Deans, S. G. (2000). Antimicrobial agents from plants: antibacterial activity of plant volatile oils. *Journal of Applied Microbiology*, 88(2), 308-316.
- Dosoky, N. S. y Setzer, W. N. (2018). Actividades biológicas y seguridad de *Citrus* spp. Aceites esenciales. *Int. J. Mol. Sci.*, 19(7), 1966.
- Dufort, J. (2017). *El uso de aceites esenciales en la formulación de productos cosméticos y perfumes*. Editorial Aromática.
- Enríquez-Estrella, M. Á., Poveda-Díaz, S. E. y Alvarado-Huatatoca, G. I. (2023). Bioactivos de la Hierba Luisa utilizados en la industria. *Revista Mexicana de Ciencias Agrícolas*, 14(1), 1-11.
- Enríquez, M. Á., Villafuerte-Mera, F., Figueroa, A. y Mariño, J. (2023). Efectos de los componentes bioactivos de frutas, vegetales, lácteos y plantas medicinales en la

- nutrición humana. *Revista de Ciencias Agropecuarias ALLPA*, 6(11), 2-24.
- Enríquez Estrella, M. Á. (2022). *Efecto del extracto de guaviduca (Piper carpubya Ruiz & Pav), sobre la estabilidad y propiedades funcionales del chorizo parrillero* (Master's thesis, Universidad Estatal Amazónica).
- Farbood, A., Heidari, H., Nayebzadeh, K. and Rezaei, H. (2016). Antimicrobial and antioxidant activity of essential oils in food preservation. *Journal of Food Processing and Preservation*, 40(6), 1234-1242.
- García, M. E. (2006). *Desarrollo de nuevos transformados cárnicos cocidos a partir de carne, hígado y grasa de cerdo Ibérico con antioxidantes naturales* (Doctoral dissertation, Universidad de Extremadura).
- Gómez, M. (2024). *Desafíos actuales en la conservación de alimentos y el uso de aceites esenciales como alternativa natural*. Editorial Nutrición y Salud.
- Guerrero, A., Carvalho, A., Madrona, C. B., Cestari, G. S., Scapin, L. A. y Prado, I. N. (2015). Envases alternativos biodegradables y activos con aceites esenciales para productos cárnicos. *Eurocarne*, 238.
- Guapulema Solórzano, M. A. (2015). *Utilización del aceite de coco aromatizado a base de eucalipto aromático, cedrón, cilantro, hierbaluisa, y romero para usos culinarios* (Tesis doctoral, UNIBE).
- Gunnarsdottir, I., Davidsdottir, B., Worrell, E. and Sigurgeirsdottir, S. (2020). Review of indicators for sustainable energy development. En: renewable and sustainable energy reviews. *Renewable and Sustainable Energy Reviews*, 133, 1-22. <https://doi.org/10.1016/j.rser.2020.110294>
- Hidalgo Núñez, D. R. (2018). *Evaluación de la actividad antioxidante y antimicrobiana del ajo sacha Mansoa alliacea (Lam.) Ah Gentry y su uso potencial en la conservación de la carne de pollo* (Master's thesis, Universidad Estatal Amazónica).
- Hyldgaard, M., Mygind, T. and Meyer, R. L. (2012). Essential oils in food preservation: mode of action, synergies, and interactions with food matrix components. *Frontiers in Microbiology*, 3, 12.
- Hilvay Gómez, L. R. (2015). *Efecto de los aceites esenciales de limón (Citrus limon), albahaca (Ocimum basilicum L.) y orégano (Origanum vulgare), en la conservación de la carne de cuy (Cavia porcellus)* (Bachelor's thesis, Universidad Técnica de Ambato. Facultad de Ciencia e Ingeniería en Alimentos. Carrera de Ingeniería en Alimentos).
- Ibañez, L. (2013). El papel de los conservantes en la industria alimentaria. *Revista de Innovación Alimentaria*, 15(3), 71-80.
- Idrovo Encalada, A. M. (2018). *Extracción de aceites esenciales y aplicación como inhibidores del crecimiento microbiano en productos cárnicos* (Bachelor's thesis, Univesidad del Azuay).
- Lascano, M. (2020). Clasificación y aplicaciones de aceites esenciales sintéticos en la industria alimentaria. *Revista de Química y Alimentación*, 21(4), 101-110.
- Leistner, L., (2000). Aspectos básicos de la conservación de alimentos mediante tecnología de barrera. *Int. J. Food Microbiol.*, 55, 181-186. [https://doi.org/10.1016/S0168-1605\(00\)00161-6](https://doi.org/10.1016/S0168-1605(00)00161-6)
- Maldonado, J. y Rico, J. (2013). Actividad antimicrobiana de aceites esenciales contra cepas patógenas comunes en alimentos. *Journal of Microbiological Research*, 27(5), 88-96.
- Martínez, J. (2022). El uso de aceites esenciales en la conservación de productos cárnicos. *Revista Internacional de Ciencia Alimentaria*, 50(4), 112-118.
- Medina Tierres, C. A. (2022). *Actividad repelente e insecticida de aceites esenciales de plantas medicinales* (Bachelor's thesis, Universidad Técnica de Ambato. Facultad de Ciencia e Ingeniería en Alimentos y Biotecnología. Carrera de Ingeniería Bioquímica).
- Montoya, C. (2010). *Los aceites esenciales: Propiedades y aplicaciones en la industria*. Editorial Aromaterapia. Universidad Nacional de Colombia. 174 p.
- Nadinic, R., Puchalski, A. y Vidrih, R. (2016). Composición y propiedades de los aceites esenciales utilizados en la conservación de alimentos. *International Food Research Journal*, 23(6), 1982-1992.
- Piñón, J. R. G., Monterrubio, A. L. R., Meléndez, L. A. D., Martínez, A. C., Rojo, A. D. A., Palma, N. G. A., & Vázquez, R. S. (2015). Efecto del aceite esencial de orégano en el rendimiento y las propiedades fisicoquímicas y microbiológicas de la carne de pollo. *Investigación y Ciencia*, 23(66), 5-11.
- Rodríguez, A. (2019). Los aceites esenciales como alternativas naturales en la conservación de alimentos. *Revista de Biotecnología Alimentaria*, 12(3), 43-52.
- Rea Varela, V. G. (2012). *Evaluación de la actividad antimicrobiana del aceite esencial de comino (Cuminum cyminum) como potencial bioconservador en la carne de trucha* (Bachelor's thesis, Escuela Superior Politécnica de Chimborazo).
- Reische, D., Lanza, M. y Silvagni, D. (1998). Efectos secundarios de conservantes químicos en la salud humana. *Food Safety Journal*, 6(2), 44-49.



- Ruiz Navajas, Y. (2014). *Caracterización de aceites esenciales de plantas aromáticas mediterráneas y su aplicación a films de quitosano para la conservación de productos cárnicos*. Universidad Miguel Hernández. Escuela Politécnica Superior de Orihuela. Alicante, España. 166 p.
- Salgueiro, L., y Silva, J. (2000). *Conservación de alimentos y su impacto en la calidad nutricional y sensorial*. Editorial Alimentaria.
- Sauceda, M. (2014). Preferencias actuales de los consumidores sobre alimentos naturales y seguros. *Revista de Comportamiento del Consumidor*, 32(1), 26-35.
- Valles, M. V., Salinas, P. A., Haro, I. R., Sevilla, W. S., Lázaro, W. R. y Huamán, A. V. (2014). Efecto del aceite esencial de *Origanum vulgare* en la supervivencia de *Staphylococcus aureus*, *Salmonella thypi*, *Salmonella paratyphi* y *Salmonella enteritidis* en carne de cerdo pasteurizada y refrigerada. *REBIOL*, 34(1), 57-68.
- Zelada, L. (2019). Regulaciones sobre el uso de conservantes en la industria alimentaria. *Food Regulatory Journal*, 21(2), 67-75.
- Zambrano Santillán, Á. R. (2024). *Evaluación del efecto antimicrobiano de la adición de aceite esencial de albahaca morada (Ocimum sanctum) en embutido de cerdo* (Bachelor's thesis, Babahoyo: UTB).
- Zhang, Y., Liu, X., Wang, J. and Zhu, L. (2020). Synergistic effects of essential oils and natural compounds on food preservation and quality improvement. *Food Chemistry*, 327, 126945.

Author Contributions Statement according to CRediT taxonomy:

Miguel Ángel Enríquez Estrella: methodology, investigation, formal analysis, writing – original draft, writing – review & editing. **Luis Andrés Torres Caicedo:** review & editing. **Armando Vinicio Paredes Peralta:** conceptualization, formal analysis, methodology, investigation, writing – original draft, writing – review & editing.