Phytochemical determination and antimicrobial activity of plant extracts from *Cinnamomum amoenum* (Ness) Kosterm. (Lauraceae) against *salmonella* spp. of poultry importance

Determinação fitoquímica e atividade antimicrobiana de extratos de plantas de *Cinnamomum amoenum* (Ness) Kosterm. (Lauraceae) contra *Salmonella* spp. de importância para a aves

DOI: 10.55905/revconv.16n.12-017

Recebimento dos originais: 27/10/2023
Aceitação para publicação: 30/11/2023

Camila Vogt dos Santos
Master in Conservation and Management of Natural Resources
Institution: Universidade Estadual do Oeste do Paraná
Address: Cascavel – PR, Brasil
E-mail: cami_vogt@hotmail.com

Mayara Maria de Souza
Graduated in Biological Sciences
Institution: Universidade Estadual do Oeste do Paraná
Address: Cascavel – PR, Brasil
E-mail: mayaramariaa.s@hotmail.com

Amanda Janaina Gonsatti Feitosa
Graduated in Biological Sciences
Institution: Universidade Estadual do Oeste do Paraná
Address: Cascavel – PR, Brasil
E-mail: amanda00gonzatti@hotmail.com

Debora Marina Bandeira
Master in Conservation and Management of Natural Resources
Institution: Universidade Estadual do Oeste do Paraná
Address: Cascavel – PR, Brasil
E-mail: dm-bandeira@hotmail.com

Andressa Guarnieri Canton
Graduated in Biological Sciences
Institution: Universidade Estadual do Oeste do Paraná
Address: Cascavel – PR, Brasil
E-mail: guarnieriandressa12@gmail.com
ABSTRACT
Salmonellosis is a zoonotic disease that affects commercial birds and causes major economic and productivity losses in the poultry sector. Belonging to the Enterobacteriaceae family, the Gram-negative bacillus of the genus *Salmonella* has presented itself as a health problem in recent years, as there has been a considerable increase in bacterial resistance, due to the indiscriminate use of antimicrobials as growth promoters. Given this context, bioactives from Brazilian flora, considered one of the most abundant in biodiversity, emerge as an alternative to the use of synthetic products. Thus, this work aimed to determine the chemical compounds of the native species *Cinnamomum amoenum* (Ness) Kosterm, as well as evaluate the antimicrobial activity of aqueous, ethyl acetate, hexane and ethanolic extracts against different serovars of the genus *Salmonella*. To obtain the extracts, the plant leaves were dried at 40°C and ground in a knife mill. Subsequently, sterilized by vacuum filtration and roto-evaporated, to completely remove the solvent. The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (CBM) were performed using the broth microdilution method, with serial concentrations ranging from 200-0.09 mg/mL of the extract. As a positive control, gentamicin was used at a concentration of 200 mg/mL. Phytochemical tests revealed the presence of flavonoids, steroids and tannins, the latter present only in the aqueous and ethanolic extracts. Regarding antimicrobial activity, the ethanolic, hexane and ethyl acetate extracts showed inhibitory/bactericidal activity for all tested serotypes and the aqueous extract showed no activity on the tested serotypes. The ethanolic extract and ethyl acetate presented MIC ranging between 25 and 50 mg/mL and MBC ranging between 50 and 100 mg/mL. The hexane extract presented MIC ranging between 50 and 100 mg/mL and MBC with 100 mg/mL. The most susceptible serotypes for the ethyl acetate extract were *S. Newport*, *S. Gallinarum*, *S. Montevideo*, while for the ethanolic extract the most susceptible serotypes were *S. Typhimurium*, *S. Mbandaka*, *S. Infantis*, *S. Heidelberg* and *S. Enteritidis*. The results suggest that *C. amoenum* extracts have antimicrobial potential and could be a viable alternative to be used in poultry farms, thus being a more sustainable and less harmful approach to the consumer, who will be free from overdoses of synthetic antimicrobials that are commonly used. Furthermore, it is essential that new studies regarding the biological activities of *C. amoenum* are carried out, in order to validate its use in the control of poultry *Salmonella*.
Keywords: *Cinnamomum amoenum*, microdilution in broth, minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC), plant extracts, *Salmonella*.

RESUMO

A salmonelose é uma doença zoonótica que afeta aves comerciais e causa grandes perdas econômicas e de produtividade no setor avícola. Pertencente à família Enterobacteriaceae, o bacilo Gram-negativo do gênero *Salmonella* tem se apresentado como um problema sanitário nos últimos anos, pois houve um aumento considerável da resistência bacteriana, devido ao uso indiscriminado de antimicrobianos como promotores de crescimento. Diante desse contexto, os bioativos da flora brasileira, considerada uma das mais abundantes em biodiversidade, surgem como uma alternativa ao uso de produtos sintéticos. Assim, este trabalho teve como objetivo determinar os compostos químicos da espécie nativa *Cinnamomum amoenum* (Ness) Kosterl, bem como avaliar a atividade antimicrobiana dos extratos aquoso, acetato de etila, hexânico e etânolico contra diferentes sorotipos do gênero *Salmonella*. Para obter os extratos, as folhas da planta foram secas a 40°C e moídas em um moinho de facas. Posteriormente, foram esterilizadas por filtração a vácuo e evaporadas por rotogravura, para remover completamente o solvente. A concentração inibitória mínima (CIM) e a concentração bactericida mínima (CBM) foram realizadas usando o método de microdiluição em caldo, com concentrações seriadas variando de 200-0,09 mg/mL do extrato. Como controle positivo, a gentamicina foi usada em uma concentração de 200 mg/mL. Os testes fitoquímicos revelaram a presença de flavonoides, esteroides e taninos, estes últimos presentes apenas nos extratos aquoso e etânolico. Com relação à atividade antimicrobiana, os extratos etânolico, hexânico e de acetato de etila apresentaram atividade inibitória/bactericida para todos os sorotipos testados e o extrato aquoso não apresentou atividade nos sorotipos testados. O extrato etânolico e o acetato de etila apresentaram MIC variando entre 25 e 50 mg/mL e MBC variando entre 50 e 100 mg/mL. O extrato hexânico apresentou MIC variando entre 50 e 100 mg/mL e MBC com 100 mg/mL. Os sorotipos mais suscetíveis para o extrato de acetato de etila foram *S. Newport*, *S. Gallinarum* e *S. Montevideo*, enquanto que para o extrato etânolico os sorotipos mais suscetíveis foram *S. Typhimurium*, S. Mbandaka, S. Infantis, S. Heidelberg e S. Enteritidis. Os resultados sugerem que os extratos de *C. amoenum* têm potencial antimicrobiano e podem ser uma alternativa viável a ser usada em granjas avícolas, sendo assim uma abordagem mais sustentável e menos prejudicial ao consumidor, que ficará livre de overdose de antimicrobianos sintéticos que são comumente usados. Além disso, é essencial que novos estudos sobre as atividades biológicas de *C. amoenum* sejam realizados para validar seu uso no controle de *Salmonella aviária*.

Palavras-chave: *Cinnamomum amoenum*, microdiluição em caldo, concentração inibitória mínima (CIM), concentração bactericida mínima (CBM), extratos vegetais, *Salmonella*.

1 INTRODUCTION

Brazilian poultry farming has grown in recent decades due to innovations in production technology, new methods in processing chicken meat and the large external commercialization of cuts, determining an increase in productivity and a reduction in production time and costs (BARROS; GERALDO JUNIOR, 2023). In Brazil, poultry farming has been the leader in the
export of chicken meat since 2011, in addition to being one of the largest producers in the world, always remaining in the top positions. In 2022 alone, it produced a total of 14.524 million tons (ABPA, 2023).

Due to the rapid expansion of the poultry industry, birds began to receive antimicrobial additives in their feed. These products are not only used to treat diseases, but also improve the performance of animals, leading to rapid weight gain, thus reducing production time. They are commonly referred to as growth promoters. However, due to the high productivity in this sector, the infection rate of birds increased, making chicken meat an important means of transmitting bacteria of the genus Salmonella (RIZZO et al., 2010; MALLMANN et al., 2021).

Salmonellosis in birds is distributed throughout the world, is considered one of the most important zoonoses and results in severe economic losses due to high mortality, low productivity, high medication costs, worsening quality and large expenses in its eradication and control. These infections are caused by several different serovars and typically do not cause any clinical symptoms in birds (ANSARI et al., 2017; NIRMALA et al., 2018).

More than 2,600 different serovars of the genus have been reported and the predominance of each of them varies depending on the region, time of year and species, and in Brazil the serovars with the highest incidence are Enteritidis, Typhimurium, Heidelberg, Agona and Mbandaka. The use of antimicrobials in feed has contributed to increasing the distribution of resistant Salmonella present in poultry. Furthermore, resistance levels indicate that such products should be used in poultry farms with caution, aiming to minimize the spread of resistant strains (PANDINI et al., 2015; CARDOZO et al., 2021). As the resistance of Salmonella strains decreases, there will be a lower risk of foodborne illnesses (FDIs) in humans caused by this bacteria. DTA’s have been the focus of discussions in recent years, due to global concern with strategies that allow their control and, consequently, guarantee the supply of safe products to the consumer market (MAJOLO et al., 2014).

In 2006, the use of antimicrobials for the purpose of improving performance was abolished by the European Union and, in order to remain a reference in the international marketing of chicken meat, Brazil needed to adapt to new requirements from importing countries, one of the solutions being found was the use of alternative products, such as enzymes, organic acids, probiotics, prebiotics, among which plant extracts and essential oils stand out (SANTANA et al., 2011).
Essential oils and plant extracts are a natural choice, with lower toxicity and more effective against the resistance of pathogenic microorganisms, representing a form that is less harmful to the consumer, who will be free from antimicrobial dosages and possible damage to health (PANDINI et al., 2015; GOMDIN; SILVA; SILVA, 2023).

Research with plant extracts shows that some plants, in addition to producing substances in their secondary metabolism with the ability to inhibit the activity of bacteria, have a molecular diversity much greater than those derived from chemical products. Therefore, it has become an important object of study in relation to its various medicinal properties. In plants, secondary metabolism would be responsible for the synthesis of a large part of plant compounds that have biological activity, increasing interest in their healing properties (CORDEIRO, 2014).

Among the secondary metabolites such as tannins, flavonoids and coumarins are anthocyanins, present in the Lauraceae family. Anthocyanins make up the largest group of water-soluble pigments in the plant kingdom, and are responsible for tones ranging from red to blue in many fruits, vegetables and greens (LOPES et al., 2007).

In the search for native plants, we highlighted the Lauraceae family, one of the best represented, both in terms of number of species and individuals, it has around 3,000 species, within its 49 genera. Typical of tropical and subtropical forests, around 24 species occur in Brazil, which are distributed especially in the Atlantic forest and in forests in the southern region. It is a well-known family due to its economic importance, its species are widely used in the perfumery, food and pharmaceutical industries. The use of *Cinnamon*, as most species of this family are generally called, should also be highlighted (MARQUES; BARROS; COSTA 2004; SANTOS; ALVES, 2013; DAMASCENO et al., 2019).

Among the genera of the Lauraceae family, the *Cinnamomum* genus is known as one of the most economically valuable, due to the fact that its species are used in landscaping, traditional medicine, the food and pharmaceutical industries. According to Sharifi-Rad et al. (2021) several studies demonstrate that the genus has several pharmacological properties in vitro, including antimicrobial, antioxidant, insecticidal and acaricidal. *Cinnamomum amoenum* (Ness and Mart) is popularly known as “canela-alho-miuda”, its leaves are widely used as a seasoning, in addition to also providing essential oil, and its alkaloids are used in perfumery and in the manufacture of pharmaceuticals. However, no research is found in the literature regarding the biological
activities and compounds present in plant extracts from the leaves of this species (WANG et al., 2020).

In this context, aiming at the importance of studies with native species, this research aimed to evaluate the antimicrobial activity of plant extracts from the leaves of the species *C. amoenum* against *Salmonella* of poultry importance, intending in particular to evaluate the susceptibility of these bacterial strains to substances bioactives of these extracts.

2 MATERIAL AND METHODS

2.1 COLLECTION, IDENTIFICATION AND STORAGE OF PLANT MATERIAL

The leaves of *C. amoenum* were collected in the Paulo Gorski ecological park, located in Cascavel – PR, between the months of April and June 2016. An exsiccate of the plant was sent to the Herbarium of the State University of Western Paraná (UNOP) for identification botany being deposited under registration UNOP 1803. After collection, the leaves were dried in an air oven at 40º C for between 72 and 96 hours. Subsequently, they were ground in a Willye knife mill, with a 0.42 mm membrane particle size. Then, the plant material was stored in a glass bottle and protected from light, until its use to produce the plant extract.

2.2 OBTAINING EXTRACTS

The methodology for obtaining the aqueous extract was carried out according to Scur et al. (2014). To prepare the aqueous extract, ten grams of crushed plant material were added to 100 mL of distilled water, this mixture was kept for 24 hours in a shaker-type rotary shaker at 220 rpm. After this period, the solution was filtered using Whatman nº 1 filter paper and subsequently centrifuged at 5000 rpm for 15 minutes. Finally, the supernatant obtained was the extract at a concentration of 100mg/mL, which was stored at 4ºC until use.

The preparation of organic extracts was carried out according to the methodology proposed by Pandini et al. (2015), with modifications. The dried plant material (10 g) was subjected to extraction with different solvents (100 mL): 95% Ethanol, Hexane (P.A) and Ethyl Acetate (P.A). These liquid preparations were kept on a rotary shaker at 220 rpm for 24 h. They were then filtered using Whatman nº 1 filter paper and centrifuged at 5000 rpm for 15 min. The supernatant was collected and subjected to rotary evaporation, with the exception of the aqueous
extract, which was stored at 4º C. In the end, the crude organic and aqueous extracts were obtained, which were stored protected from light and under refrigeration at 4º C.

2.3 PHYTOCHEMICAL PROSPECTING

The tests relating to the phytochemical prospecting of the different plant extracts of *C. amoenum* were carried out according to the methodology described by Matos (1997) with modifications. These tests were based on colorimetric visualization and/or precipitate formation after the addition of specific reagents. The classes of secondary metabolites identified were: saponins from the reaction with distilled water and P.A. hydrochloric acid; steroids and triterpenoids through the Liebermann-Burchards reaction; alkaloids using Dragendorff’s reagent; anthocyanidins, anthocyanins, aurones, chalcones, flavonols, flavones, flavonols and xanthones from changes in pH in the medium; coumarins through a fluorescence reaction with potassium hydroxide and tannins through a reaction with ferric chloride.

2.4 DETERMINATION OF ANTIMICROBIAL ACTIVITY

2.4.1 Microorganisms used and inoculum preparation

The antimicrobial activity of *C. amoenum* plant extracts was evaluated following the methodology proposed by Scur et al. (2014) with modifications from Bandeira et al. (2022). Different serotypes of *Salmonella enterica* were used: *Salmonella enterica* Enteritidis, *Salmonella enterica* Tiphymurium, *Salmonella enterica* Heidelberg, *Salmonella enterica* Mbandaka, *Salmonella enterica* Orion, *Salmonella enterica* Gallinarum, *Salmonella enterica* Newport, *Salmonella enterica* Agona, *Salmonella enterica* Montevideo and *Salmonella enterica* Infantis. The microorganisms were recovered in Brain and Heart Infusion (BHI) broth for 24 hours at 36º C, then seeded on a plate containing Muller-Hinton (MH) agar and incubated for 24 hours at 36º C. To carry out the experiments, the concentration of microorganisms was adjusted in 0.85% saline solution to 1x10^5 CFU/mL.

2.4.2 Determination of Minimum Inhibitory Concentration (MIC)

The tests were carried out according to the broth microdilution methodology described by Weber et al. (2014) with modifications from Laskoski et al. (2022). *C. amoenum* plant extracts were solubilized in methanol. In 96-well microdilution plates, 150 µL of Mueller-Hinton (MH)
broth was distributed in all wells. The first well received another 150 µL of the plant extract at an initial concentration of 200 mg/mL. Then, serial dilution was carried out, obtaining concentrations ranging from 200 to 0.09 mg/mL. Finally, 10 µL of inoculum was added to each well and the plate was incubated at 36º C for 24 h. For the positive control, the commercial antibiotic Gentamicin (200 mg/mL) was used. As a negative control, the inoculum was added to the MH broth, without the presence of the extract to verify the viability of the microorganisms tested. Methanol diluent control was also carried out to check for possible interference in the assay. To interpret the results, 20 µL of 0.5% triphenyltetrazolium chloride (TTC) was added, acting as a colorimetric developer, the wells that showed red color were considered negative for inhibition of bacterial growth. The MIC was performed in triplicate, making it possible to determine the lowest concentration of plant extract capable of inhibiting microbial growth.

2.4.3 Determination of Minimum Bactericidal Concentration (MBC)

Before adding 0.5% TTC to determine the MIC, 2 µL aliquots were removed from each assay well and transferred individually to petri dishes containing MH agar, which were incubated for 24 hours at 36º C. To determine CBM, or that is, the lowest concentration of plant extracts capable of causing the death of the microorganism, in this method the presence/absence of microbial colony growth on the plate is verified at different concentrations of extracts in the MIC assay. The assays were performed in triplicate.

3 RESULTS AND DISCUSSION

The phytochemical profile of *C. amoenum* extracts revealed the presence of compounds such as: flavonoids, steroids and tannins, the latter present only in the aqueous and ethanolic extract. The presence of alkaloids and coumarins was not found in any of the extracts, and the presence of triterpenoids was identified only in the aqueous extract (Table 1).
Table 1: Classes of secondary metabolites present in the aqueous extract, ethyl acetate, hexane and ethanolic extracts of *Cinnamomum amoenum* leaves.

<table>
<thead>
<tr>
<th>Metabolite classes</th>
<th>Extracts</th>
<th>Ethyl Acetate</th>
<th>Hexane</th>
<th>Ethanolic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tannins</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Coumarins</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Anthocyanin</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Triterpenoids</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Steroids</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

+: presence of metabolite; -: absence of metabolite

Source: the authors

There are no reports found in the literature that identify the metabolites of *C. amoenum*, but the results obtained in this study agree with the data described for bioactive substances from plants of the same genus. We evaluated the composts present in the ethanolic extract of *Cinnamomum zeylanicum*, identifying secondary metabolites such as flavonoids, steroids and tannins, while the aqueous extract was verified to contain only tannins (HUAMÁN et al., 2003). The ethanolic extract of the *Cinnamomum zeylanicum* peel also identified tannins (ADARSH et al., 2020) and flavonoids (YASEEN; MOHAMMED, 2023). No ethanolic extract of *Cinnamomum burmannii* also detected composts such as flavonoids, steroids and tannins (PARISA et al., 2019). The species *Cinnamomum verum* and *Cinnamomum camphora* foram identified in the presence of flavonoids (ABDALLA; ABDELGADIR, 2016; SOBHY et al., 2023).

The extracts of *Cinnamomum tamala*, being ethanolic, ethyl acetate, aqueous and hexanic, present secondary metabolites such as tannins, alkaloids and flavonoids (GOYAL; CHAUHAN, KAUSHIK, 2009).

In this sense, there are differences in the metabolites found in the secondary metabolism of each plant, which must be related to environmental factors such as seasoning, temperature, water availability, altitude, circadian rhythm, atmospheric pollution and protection against pathogens. These factors can alter the entire metabolic pathway by promoting the biosynthesis of different composts in different seasons of the year (GOBO-NOETO; LOPES, 2007; DE MORAIS, 2009).

In relation to antimicrobial activity, it was verified that among the 4 extracts tested, either ethanolic or ethyl acetate, presented greater inhibitory/bactericidal activity with MIC and CBM varying between 25-50mg/mL and 50-100 mg/mL, respectively. Já the hexânico extract
presented low activity on the tested sorovars, with MIC varying between 50-100mg/mL. For the aqueous extract, the antimicrobial activity was not verified on any of the strains tested (table 2).

The sorovars *S.* Montevideo and *S.* Gallinarum are more susceptible to the ethyl acetate extract, meanwhile, more resistant in relation to the hexânic extract. Among the most susceptible to ethanol extract, *S.* Enteritidis, *S.* Typhimurium and *S.* Heidelberg stand out, for presenting the highest incidence of infection in birds. In this way, it is verified that there is no standard physiological behavior for *Salmonella* strains, and this can be explained by the wide variety of strains found in the poultry chain and the differences between them in terms of susceptibility to different antimicrobials and also to plant extracts (BONA et al., 2012).

The antimicrobial potential of ethanolic, ethyl acetate and hexanic extracts can be justified by the presence of secondary metabolites, such as flavonoids and tannins (table 1) (DUARTE et al., 2006; FURTADO et al., 2015).

The antimicrobial activity of flavonoids can occur through three mechanisms: plasma membrane (perforation and reduction of its fluidity), inhibition of nucleic acid synthesis (inhibition of topoisomerase) and inhibition of energy metabolism (CUSHNIE; LAMB, 2011). Furthermore, it can, through the formation of protein complexes between the cell wall, cause a rupture in the bacterial wall (WEBER et al., 2014).

### Table 2: Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) two different extracts of *Cinamomum amoenum* on the serovars of *Salmonella*.

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>MIC/MBC (mg/mL)</th>
<th>Ethyl Acetate</th>
<th>Hexane</th>
<th>Ethanollic</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>S.</em> Enteritidis</td>
<td>50/100</td>
<td>50/100</td>
<td>25/50</td>
<td></td>
</tr>
<tr>
<td><em>S.</em> Heidelberg</td>
<td>50/100</td>
<td>50/100</td>
<td>25/50</td>
<td></td>
</tr>
<tr>
<td><em>S.</em> Infantis</td>
<td>50/100</td>
<td>50/100</td>
<td>25/50</td>
<td></td>
</tr>
<tr>
<td><em>S.</em> Mbandaka</td>
<td>50/100</td>
<td>50/100</td>
<td>25/50</td>
<td></td>
</tr>
<tr>
<td><em>S.</em> Newport</td>
<td>25/50</td>
<td>50/100</td>
<td>50/100</td>
<td></td>
</tr>
<tr>
<td><em>S.</em> Orion</td>
<td>50/100</td>
<td>100/100</td>
<td>50/100</td>
<td></td>
</tr>
<tr>
<td><em>S.</em> Typhimurium</td>
<td>50/100</td>
<td>100/100</td>
<td>25/50</td>
<td></td>
</tr>
<tr>
<td><em>S.</em> Gallinarum</td>
<td>25/50</td>
<td>100/100</td>
<td>50/100</td>
<td></td>
</tr>
<tr>
<td><em>S.</em> Montevideo</td>
<td>25/50</td>
<td>100/100</td>
<td>50/100</td>
<td></td>
</tr>
<tr>
<td><em>S.</em> Agona</td>
<td>50/100</td>
<td>100/100</td>
<td>50/100</td>
<td></td>
</tr>
</tbody>
</table>

* The aqueous extract did not show antimicrobial activity against the microorganisms tested; 
Source: the authors

In addition to the presence of flavonoids, the ethanolic extract presented tannins, and its antimicrobial potential may be related to the presence of this compound, which has proven antimicrobial activity. This secondary metabolite acts directly on the cell wall of
microorganisms, inhibiting microbial growth (DOSS; MUBARAK, DHANABALAN, 2009). Furthermore, tannin prevents the transport of nutrients to the cell, and this is caused by the formation of complexes between the organism and the cell wall, also resulting in the inhibition of bacterial growth (MCSWEENEY et al., 2001).

Although it presents secondary metabolites such as tannins and flavonoids (Table 1), the aqueous extract did not show antibacterial activity on the microorganisms tested, which can be justified by the assumption that these compounds are present in low quantities, sufficient to be detected in phytochemical tests, but insufficient to inhibit the growth of the tested bacteria, as observed by Pandini et al. (2014).

The results of antibacterial activity found in this study agree with those reported for the species *Cinnamomum tamala*, with ethyl acetate and ethanolic extracts from this plant showing activity against the *Salmonella* Typhimurium serovar. The aqueous extract was only effective against *Bacillus cereus* and *Staphylococcus aureus*, which are Gram positive bacteria. This is due to the different composition of the bacterial wall of Gram-positive bacteria when compared to Gram-negative bacteria. Gram positive bacteria are more susceptible due to their wall having only one major component, peptidoglycan, which is not as effective a permeability barrier as the outer membrane of Gram negative bacteria, which have an external phospholipid wall, and thus makes making the cell impermeable to certain antimicrobial chemicals (GOYAL; CHAUHAN; KAUSHIK, 2009; TADEG et al., 2005).

The hexane extract of *C. amoenum* showed antimicrobial activity for the strains tested, however at high doses, this can be explained by the methodology used in this work, with microdilution in broth being a quantitative and more sensitive method. Goyal; Chauhan; Kaushik (2009) observed that the hexane extract of *C. tamala* was completely inactive for the Gram negative strains tested. This lack of activity may be attributed to the method used by the authors, with disk diffusion being a preliminary and qualitative test, in addition that the components present in the extract may not be able to completely diffuse into the solid culture medium, thus making it difficult to evaluate the activity of the extract (NASCIMENTO et al., 2007).

Although present in all extracts, no reports were found in the literature on the antimicrobial potential of anthocyanins, which after chlorophyll are the main group of pigments of plant origin (LOPES et al., 2007).
According to the results obtained, the *C. amoenum* extracts tested, except for the aqueous extract, exerted antimicrobial activity on the different *Salmonella* serovars tested. This study should serve as a basis, highlighting the importance of carrying out new research to determine the compounds present in these extracts, which can contribute to their future application in the manufacture of alternative products to be used in poultry farming.

### 4 CONCLUSION

In phytochemical prospecting, two groups of compounds with proven antimicrobial potential were identified, namely tannins and flavonoids. The ethanolic, ethyl acetate and hexanic extracts of *C. amoenum* leaves showed antimicrobial activity against the different serovars of *Salmonella enterica*. The most susceptible serotypes for the ethyl acetate extract were *S. Newport*, *S. Gallinarum*, *S. Montevideo*, while for the ethanolic extract, the most susceptible serotypes were *S. Typhimurium*, *S. Mbandaka*, *S. Infantis*, *S. Heidelberg* and *S. Enteritidis*.

*Cinnamomum amoenum* (Ness) Kosterm. exhibits properties that make it suitable for applications in the poultry industry, standing out for its proven antimicrobial activity against *Salmonella enterica* serovars. This characteristic makes it a viable option as a raw material, which can be incorporated directly into products or used in the development of new antimicrobial agents.
REFERENCES


DE CAMARGO BARROS, Thiago Arcoverde; JÚNIOR, Edvaldo Geraldo. DIFICULDADES DA AVICULTURA NA REGIÃO OESTE DO PARANÁ. *Arquivos Brasileiros de Medicina Veterinária FAG*, v. 6, n. 1, p. 91-100, 2023.


GONDIM, Renata Freire Alves; DA SILVA, Jaqueline Damos; DE SÁ SILVA, Claudileide. Aplicação de essencial de tea tree (melaleuca alternifolia) e óleo bálsamo de copaíba (copaifera officinalis) no controle de staphylococcus aureus em carne de frango cozida. CONTRIBUCIONES A LAS CIENCIAS SOCIALES, v. 16, n. 5, p. 2531-2550, 2023.


