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Red propolis extract as an alternative to control different Salmonella serotypes, isolated from poultry production environments and chicken meat products

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Propolis is the result of a mixture of resinous and balsamic substances collected by *Apis mellifera* honeybees from buds, flowers, and plant exudates, and it has been used in folk medicine in various parts of the world due to its bioactive properties. Considering the current context of seeking alternatives for controlling foodborne pathogens, the study of propolis effects has garnered attention from researchers worldwide. Thus, the aim of this study was to determine the total phenolic content and flavonoid levels of green and red propolis extracts, subjected to different extraction protocols, and to evaluate their antimicrobial potential against *Salmonella* spp. For this purpose, green propolis and red propolis samples were collected from *Apis mellifera* beehives in mangrove regions of Northeast Brazil, and subjected to ethanolic and ultrasonic extraction protocols, to determine total phenolic content, flavonoid levels, and antioxidant activity. Additionally, the extracts were used in minimum inhibitory concentration (MIC) assays by the microdilution method, according to Clinical and Laboratory Standards Institute (CLSI), against 40 isolates of *Salmonella enterica* of different serotypes obtained from poultry production environments and chicken meat products. The phenolic content of the propolis extracts, evaluated by Folin-Ciocalteu protocol, ranged from 115.22 mg GAE/g to 281.73 mg GAE/g, with higher values obtained for red propolis extracts compared to green propolis, regardless of the extraction method used. Regarding flavonoids, determined by aluminum chloride colorimetric method, the values obtained ranged from 31 mg QE/g to 122.2 mg QE/g for the extracts, with a significant difference ($p > 0.05$) for the extraction method used, revealed by higher flavonoid levels in the ultrasonic extract of RP. Concerning antioxidant activity, determined by DPPH method, the data obtained ranged from 60.5% to 62.1%, with no significant differences observed regarding the type of propolis or extraction method employed. The results also showed that propolis extracts exhibited variable antimicrobial action, depending on the type of propolis extract and the serotype of the *Salmonella* isolates tested in the study. The lowest MIC value found was 3.1 mg/mL for red propolis obtained by ultrasonic extraction against the serotypes *Salmonella* Saintpaul, Schwarzengrund, and Senftenberg. The MIC values of green propolis extracts ranged from 6.25 to 50 mg/mL, while the MIC values of red propolis extracts ranged from 3.1 to 25 mg/mL, indicating a greater antimicrobial efficacy of red propolis, regardless of the extraction method. The results of this study demonstrate that red propolis extracts have a higher antimicrobial potential against *Salmonella* compared to green propolis extracts, possibly due to the higher content of phenolic compounds and flavonoids, and greater antioxidant activity. Additionally, red propolis extracts have technological potential for the development of more accessible and natural antimicrobials for the control of foodborne pathogens.

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