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# Functional and ultrastructural changes in *Pseudomonas aeruginosa* and *Staphylococcus aureus* cells induced by *Cinnamomum verum* essential oil.

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## Abstract

**AIMS:** To study cellular damage induced by *Cinnamomum verum* essential oil in *Pseudomonas aeruginosa* ATCC 27853 and *Staphylococcus aureus* ATCC 29213.

**METHODS AND RESULTS:** The effect of cinnamon bark essential oil on these two strains was evaluated by plate counts, potassium leakage, flow cytometry and transmission electron microscopy (TEM). Exposure to this oil induced alterations in the bacterial membrane of *Ps. aeruginosa*, which led to the collapse of membrane potential, as demonstrated by bis-oxonol staining, and loss of membrane-selective permeability, as indicated by efflux of K(+) and propidium iodide accumulation. Thus, respiratory activity was inhibited, leading to cell death. In *Staph. aureus*, cells treated with the oil entered a viable but noncultivable (VNC) state. The oil initially caused a considerable decrease in the metabolic activity and in the replication capacity of these bacterial cells. The loss of membrane integrity appeared later, as indicated by bis-oxonol and Propidium iodide (PI) staining. Data provided by TEM showed various structural effects in response to cinnamon essential oil. In *Ps. aeruginosa* cells, coagulated cytoplasmic material was observed, and intracellular material was seen in the surrounding environment, while oil-treated *Staph. aureus* showed fibres extending from the cell surface.

**CONCLUSIONS:** Cinnamon essential oil damages the cellular membrane of *Ps. aeruginosa*, which leads to cell death. There is evidence of VNC *Staph. aureus* after exposure to the oil.

**SIGNIFICANCE AND IMPACT OF THE STUDY:** Cinnamon essential oil shows effective antimicrobial activity and health benefits and is therefore considered a potential food additive. To use this oil as a natural food preservative, especially in combination with other preservation methods, a thorough understanding of the mechanism through which this oil exerts its antibacterial action is required.

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