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ORIGINAL ARTICLE

Kannurin, a novel lipopeptide from *Bacillus cereus* strain AK1: isolation, structural evaluation and antifungal activities

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Abstract

Aim: This study was performed to isolate and characterize novel antifungal lipopeptide from *Bacillus cereus*.
Methods and Results: Elucidation of its chemical structure was carried out by electrospray ionization mass spectra (ESI-MS) and Fourier transform infrared spectroscopy (FT-IR). The compound is a cyclic heptapeptide and composed of amino acids, Leu–Asp–Val–Leu–Leu–Leu–Leu. The *in vitro* activity of Kannurin against various pathogenic yeasts was assessed by CLSI M27-A and moulds by M38-A. It demonstrated broad-spectrum, fungicidal activity against clinically relevant yeasts and moulds. Kannurin exhibited low haemolytic activity and remained active over a wide pH and temperature range. In addition, Kannurin did not bind with melanin particles and was as active in inhibiting biofilms.
Conclusions: An antifungal surfactin-like lipopeptide produced by *Bacillus cereus* strain AK1 was purified and chemically characterized. We propose to name this lipopeptide compound 'Kannurin'. To our knowledge, this is the first report of *Bacillus cereus* producing surfactin-like lipopeptide antibiotic with stronger antifungal activity.
Significance and Impact of the Study: Our results provide a valuable contribution towards a better understanding of the lipopeptide of *Bacillus cereus*. Moreover, it raises the possibility of using as an alternative antibiotic in clinical medicine.

Introduction

During the past decades, there has been a concomitant increase in the incidence of mycosis and also the emergence of multidrug-resistant pathogens that has caused serious problems worldwide. Invasive fungal infections, primarily those caused by *Candida* species, *Cryptococcus neoformans* and *Aspergillus* species, constitute a major cause of morbidity and mortality in severely immunocompromised host (Silveira and Husain 2007; Antachopoulos and Walsh 2012). In this connection, much interest has been focused on novel therapeutic approaches using peptide antibiotics. Peptide antibiotics are quite diverse, amphipathic and either ribosomally or non-ribosomally synthesized (Hancock and Chapple 1999). Bacteria and fungi use non-ribosomal peptide synthetases (NRPSs) to produce broad structural and biologically active peptides. This often contains unnatural amino acids (D-amino acids or hydroxy amino acids) and other molecules, not found in ribosomally produced peptides (Ajesh and Sreejith 2009). The assets of these peptides are their diverse potential applications as single antimicrobials or in combination with other antibiotics (Marr *et al.* 2006).

The genus *Bacillus* produces a large number of peptide antibiotics representing different basic chemical structures, finding wide applications (Abriouel *et al.* 2011). Lipopeptides are produced in bacteria and fungi during cultivation on various carbon sources (Makovitzki *et al.* 2006). A prominent group of bioactive lipopeptides produced by *Bacillus* species is constituted by iturins,