Sonodynamic bactericidal activity of curcumin against foodborne bacteria

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KEY MESSAGES

1. Sonodynamic treatment with curcumin could eradicate *Bacillus cereus* and *Escherichia coli*, with *Bacillus cereus* being more sensitive to treatment.
2. The production of reactive oxygen species, including singlet oxygen and hydroxyl radical, increased significantly after sonodynamic treatment with curcumin.

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Introduction

Treatments for foodborne disease do not reduce levels of foodborne pathogens in environmentally contaminated sources, and most disinfectants have potential genotoxicity and/or carcinogenicity.[1] There is a need to develop alternative strategies to eradicate foodborne pathogens. This study aimed to evaluate the sonodynamically bactericidal efficacy of curcumin on foodborne bacteria such as *Bacillus cereus* and *Escherichia coli* and the reactive oxygen species (ROS) production of foodborne bacteria after sonodynamic treatment using flow cytometric analysis.

Methods

This study was conducted from 1 February 2013 to 31 March 2014. Non-pathogenic strains of Gram-positive *Bacillus cereus* 14579 and Gram-negative *Escherichia coli* 35218 were used. To evaluate the bactericidal effect of curcumin-mediated sonodynamic treatment, treated bacterial suspensions were spread on Mueller-Hinton agar and incubated for 24 hours. The growth of treated bacteria was indicated in terms of colony-forming units per mL ($\log_{10}$). The bactericidal effect of the treatment in anaerobic conditions was assessed in terms of production of ROS measured by flow cytometry with 2',7'-dichlorodihydrofluorescein diacetate staining. The specific detective probes and quenchers of free radicals and singlet oxygen were used to determine the types of ROS produced. The ultrasound exposure system was used as described in our previous study.[2]

Results

Sonodynamic treatment with curcumin had significant bactericidal activity, with reduction in colony-forming units for *Bacillus cereus* and *Escherichia coli* by 5.6 and 2.0 log units, respectively (Fig 1). Bacterial survival was higher without oxygen than with oxygen (Fig 2). Compared with the control condition, sonodynamic treatment with curcumin significantly increased production of ROS, singlet oxygen, and hydroxyl radicals, but bactericidal efficacy was significantly reduced by all three kinds of quenchers (Fig 3).

Conclusions

Sonodynamic treatment with curcumin significantly inactivated foodborne bacteria, especially Gram-positive *Bacillus cereus*. Significant production of ROS, including singlet oxygen and hydroxyl radicals, may result in important bactericidal activity.

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Results of this study have been published in: Wang X, Ip M, Leung AW, et al. Sonodynamic action of curcumin on foodborne bacteria Bacillus cereus and Escherichia coli. Ultrasonics 2015;62:75-9.

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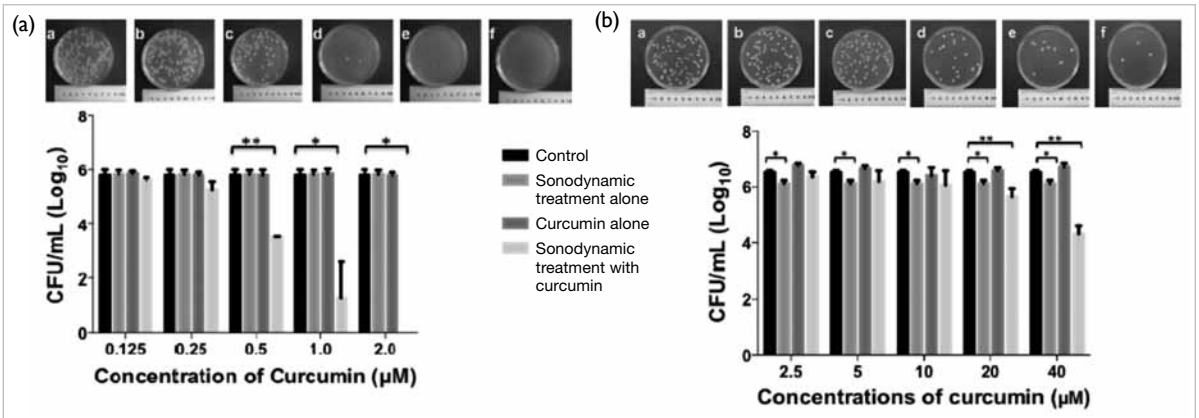

FIG 1. Colony-forming units (CFU) per mL after sonodynamic treatment with curcumin against (a) *Bacillus cereus* and (b) *Escherichia coli*

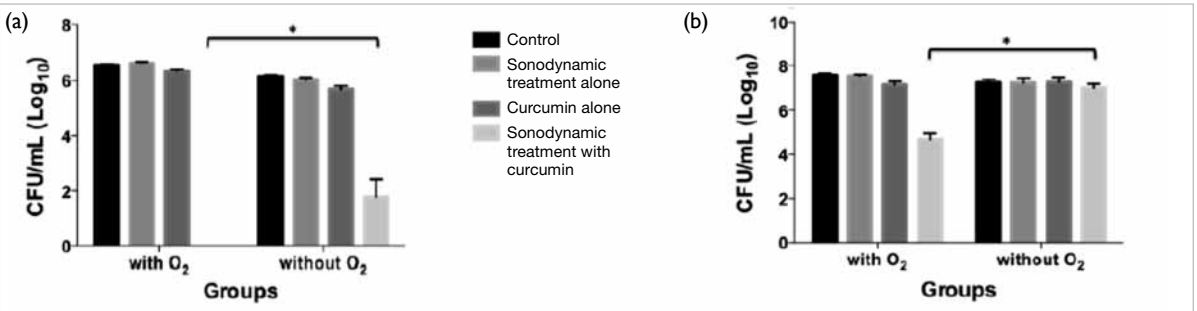

FIG 2. Bacterial survival in terms of colony-forming units (CFU) per mL for (a) *Bacillus cereus* and (b) *Escherichia coli* after curcumin-mediated sonodynamic treatment with or without O_2

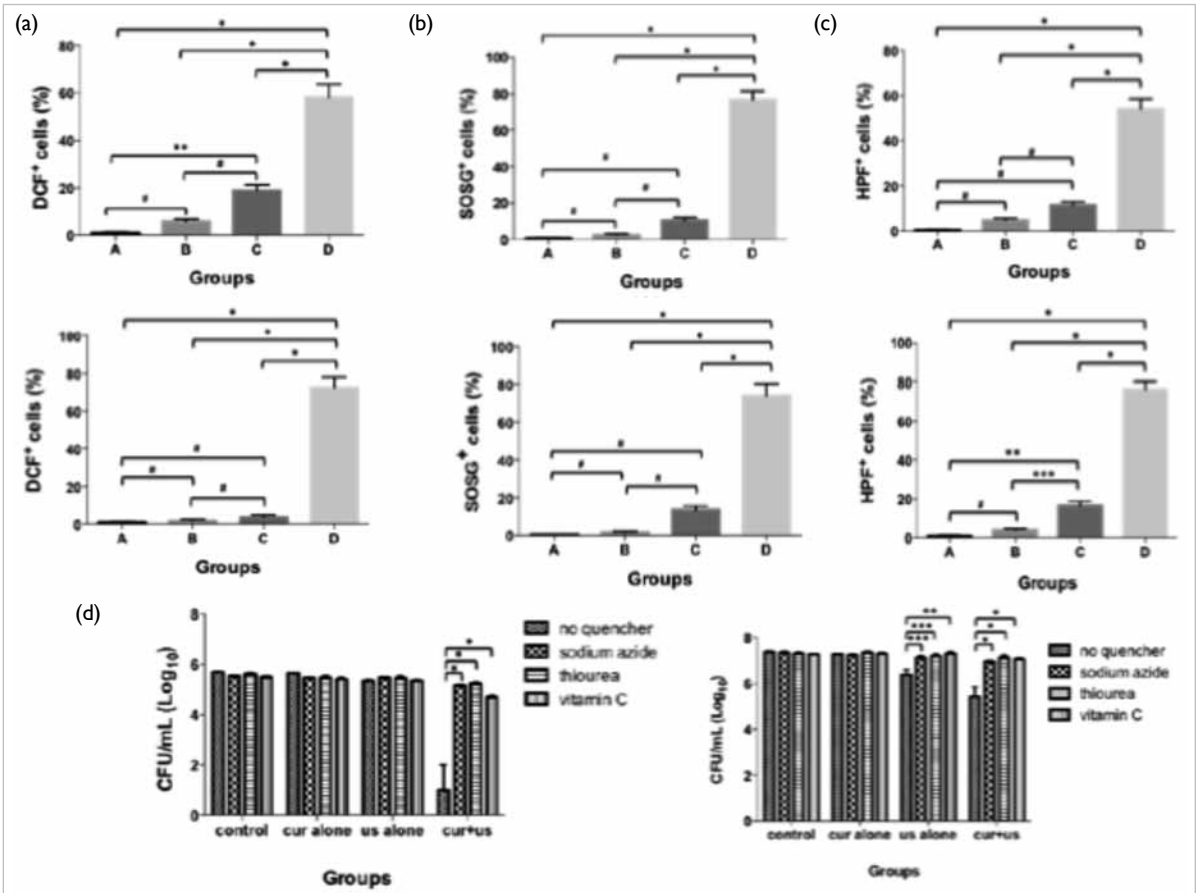

FIG 3. Production of (a) reactive oxygen species, (b) singlet oxygen, and (c) hydroxyl radical after sonodynamic treatment with curcumin against *Bacillus cereus* and *Escherichia coli*. (d) Bacterial viability after sonodynamic treatment with curcumin with or without different quenchers (sodium azide, thiourea, and vitamin C) against *Bacillus cereus* and *Escherichia coli*