Innovative Food Science and Emerging Technologies 36 (2016) 128–149

Contents lists available at ScienceDirect

Innovative Food Science and Emerging Technologies

journal homepage: www.elsevier.com/locate/ifset

Inactivation of *Staphylococcus aureus* by high pressure processing: An overview

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ARTICLE INFO

Article history:
Received 11 April 2016
Received in revised form 1 June 2016
Accepted 13 June 2016
Available online 16 June 2016

Keywords:
High pressure processing
Staphylococcus aureus
Staphylococcal food poisoning
Inactivation

ABSTRACT

Food safety is a major concern of consumers, food industry and governments, with 25 million foodborne diseases occurring annually worldwide. *Staphylococcus aureus*, is an extremely versatile opportunistic pathogen being responsible for staphylococcal food poisoning due to enterotoxic strains. With increasing demands for safer food, new food preservation technologies are increasingly gaining interest. In the last two decades, high pressure processing (HPP) appeared as an alternative non-thermal food preservation method promoting inactivation of some spoilage and pathogenic microorganisms, while maintaining food characteristics. Factors that modulate its efficiency will be revised, firstly based on the state-of-the art described for bacteria in general and afterwards, when studies exist, for *S. aureus* specifically. *S. aureus* inactivation by HPP, like in other microorganisms, is conditioned by cell structures and biomolecules, matrix, HPP processing conditions, the use of antimicrobials and is also dependent of the strain and growth phase. Cell membrane is the most pressure sensitive structure of *S. aureus*, being the lipids and proteins the most important target molecules. However, monomeric proteins such as staphylococcal enterotoxins (SE) are not affected by HPP, and strains with SE appear to be more efficiently inactivated than those without. Other phenotypic and genotypic characteristics of *S. aureus* strains, such as pigmentation and the presence of σ^B factor are extremely important factors determining the efficacy of HPP treatments. Inactivation of *S. aureus* by HPP to ensure food safety still remains a current challenge regarding the understanding of its particular barotolerance and its inactivation kinetics profile that often deviates from the simpler first order decay. Thus, this review provides state-of-the-art information for researchers interested in studying HPP inactivation of *S. aureus*.

Industrial relevance: This review gives an insight on the importance of *Staphylococcus aureus* as a foodborne versatile opportunistic pathogen and its importance from the food safety point, its barotolerance and the main reasons for this resistant behavior to high pressure processing and the mechanisms of *S. aureus* inactivation by HPP.

Contents

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http://dx.doi.org/10.1016/j.ifset.2016.06.008
1466-8564/

1. Introduction

Gastrointestinal diseases are responsible for 25 million infections each year, with diarrheal diseases as second leading cause of death in the world (Forbes, Sahm, & Weissfeld, 2007). In fact, foodborne diseases along with waterborne diseases, are responsible for the death of approximately 1.8 million people every year, most of whom are children, and accountable for economic losses in food industry, health systems, tourism and also for the consumer (WHO, 2008). Sets of norms and rules have been developed over the years, such as HACCP (Hazard Analysis and Critical Control Points), in order to guarantee safe food for the consumer.

Although food contamination with foodborne pathogens might be avoided through the development and implementation of such procedures, food preservation methods are extremely important to control food contamination by pathogenic microorganisms and also to control microorganisms responsible for food deterioration. These methods have been used *since antiquity* and include heating, salting, freezing, drying, freeze-drying, irradiation, fermentation, canning, the addition of antimicrobials and chemicals and more recently, ionization radiation, pulsed electric fields, UV decontamination, pulsed high intensity light, high intensity laser, pulsed white light and high pressure processing (HPP) (Devlieghere, Vermeiren, & Debevere, 2004). Nowadays HPP progressively appears as a commercially viable alternative food preservation method in order to answer consumer demand for safes but also fresher and nutritious food (Lado & Yousef, 2002; Rastogi, Raghavarao, Balasubramaniam, Niranjan, & Knorr, 2007).

Despite considerable efforts to improve food safety, foodborne diseases outbreaks linked to the presence of pathogenic bacteria at harmful levels in food has been well documented, highlighting the need for technological interventions in order to address food safety risk posed by these pathogens in the final food products. Among these pathogens is *Staphylococcus aureus*, which is responsible for one of the main foodborne diseases, staphylococcal food poisoning (SFP) (Kadariya,

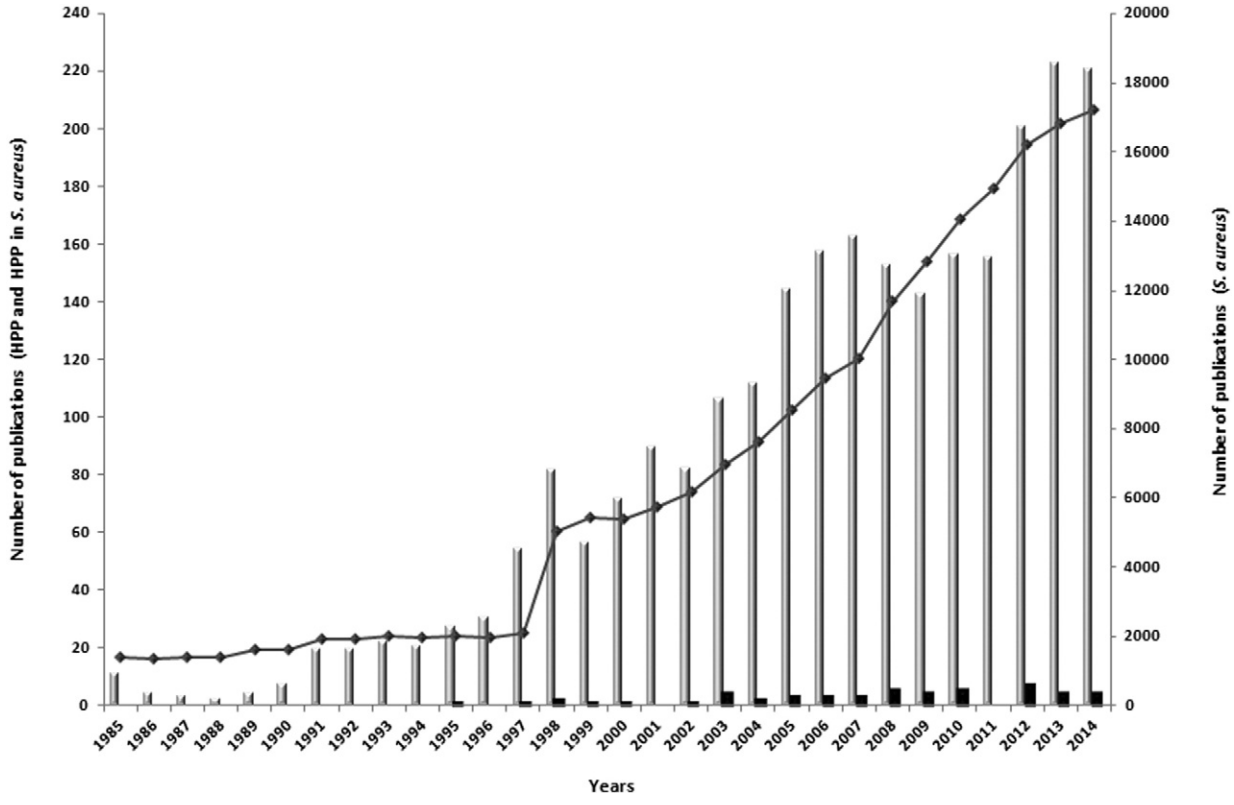

Fig. 1. Literature survey of published research articles using a search query in the field topic with the keywords "*Staphylococcus aureus*" for *S. aureus* publications (dark grey line; secondary y axis), "high pressure processing" or "high hydrostatic pressure" for HPP publications (light grey bars) and "high pressure processing" or "high hydrostatic pressure" in combination with "*Staphylococcus aureus*" for *S. aureus* inactivation by HPP publications (black bars) in topic; from 1985 to 2014 via Web of Science™.