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Effect of thermal and irradiation inactivation on microorganisms in spices and dried herbs

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Background

Spices and dried aromatic herbs are products of low water activity often found to be naturally contaminated with various microorganisms, including pathogenic bacteria and toxigenic moulds. Spices and dried herbs sold in the EU market are generally decontaminated either by thermal treatment or irradiation.

Objective

A meta-analysis was conducted to identify the most influential factors affecting the microbial decontamination efficacy of thermal and irradiation treatment, and to quantify global parameters for inactivation and corresponding variability.

Methods

Models for thermal inactivation according to Van Asselt and Zwietering (2006, IJFM 107: 73) and for irradiation according to Van Gerwen et al., (1999, JFP 62: 1024) were used to calculate *D* values. Mean, median, standard deviation (SD), standard error (SE) and 95% confidence and prediction interval of the thermal logD_T-values and irradiation logD_{10}-values were calculated for various groups of microorganisms. Multiple Linear Regression (MLR) assessed the influence of various factors on logD_{10}. The meta-analysis results were compared to additional experimental studies on spices and herbs, and to existing inactivation databases.

Results

Thermal robustness

Figure 1 shows the calculated 14 logD_T-values of various spore-forming bacteria (SPF) as a function of temperature (°C). The estimated logD_T-value (and variability) for SPF at 120 °C was -0.70± 0.93 log minutes. The logD_{100}-values of the dried leafy oregano steam inactivation studies of *Bacillus subtilis* spores were consistent with the meta-analysis of spore-forming bacteria. Comparison of our meta-analysis results with the models and variability from major meta-analysis in various other foods (Van Asselt and Zwietering, 2006; Den Besten et al., 2018, ARFST 9: 383) indicated that the dry matrix of spices and dried herbs provided no enhanced resistant effect on the thermal inactivation of spore-formers.

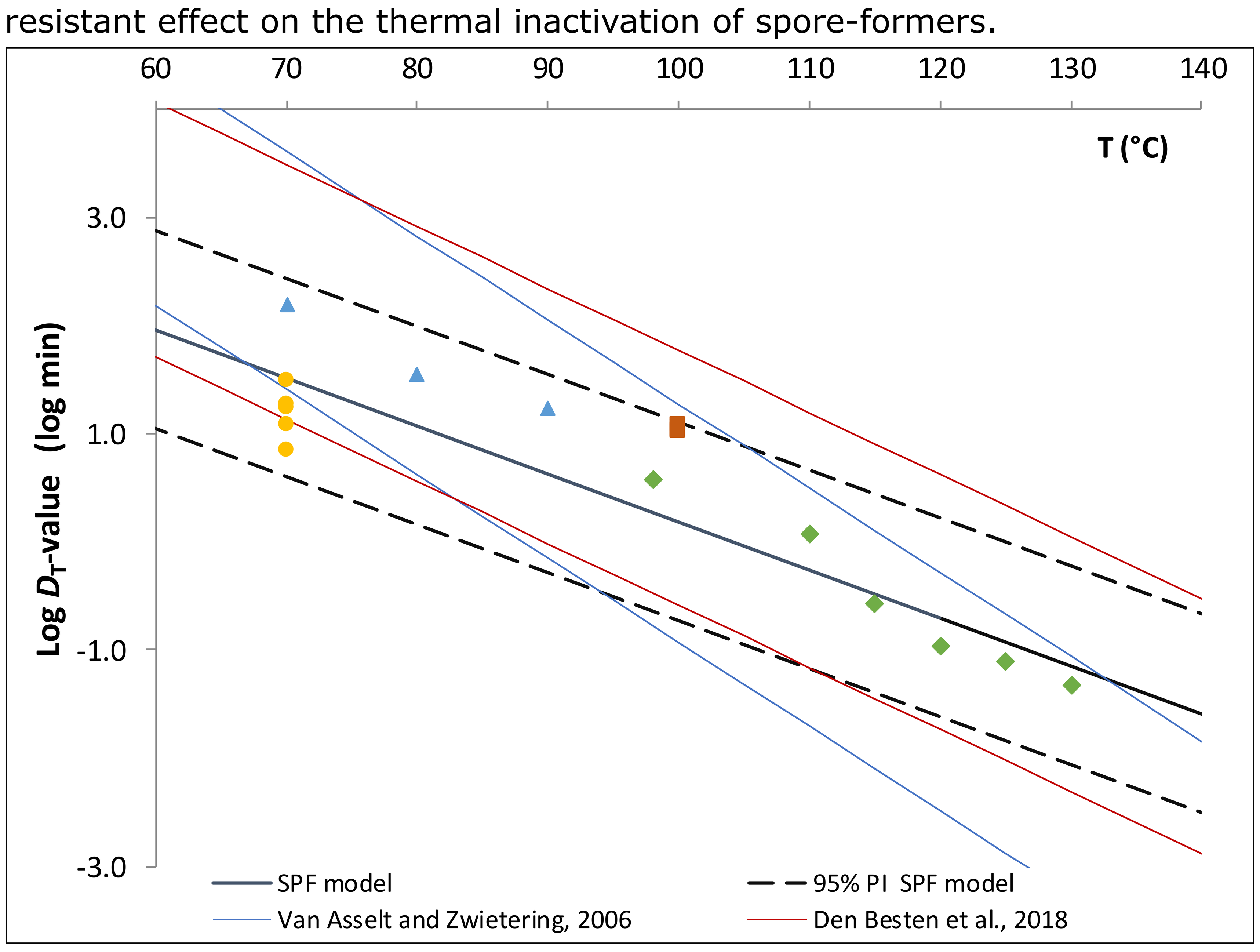

Figure 1. Effect of temperature on logD_T-values of various spore-forming bacteria. *B. cereus* spores (▲) in paprika powder, *C. perfringens* (●) in different spices, unspecified spore-forming bacteria (♦) in different spices and *B. subtilis* spores (■) in dried leafy oregano (own steam experiments). Blue lines represent 95% prediction interval from Van Asselt and Zwietering (2006) for thermal treatment of *B. cereus* spores. Red lines represent 95% prediction interval from Den Besten et al., (2018) for thermal treatment of *B. subtilis* strains.

Irradiation robustness

In total, 329 D_{10}-values (kGy) were calculated from the literature and the mean logD_{10}-values of the sub-groups of microorganisms are shown in Figure 2. MLR confirmed that spore-forming bacteria had the highest irradiation resistance, followed by total plate counts, fungi and *Enterobacteriaceae* and that microbial identity was the dominant influencing factor. Fungi and *Enterobacteriaceae* estimated mean logD_{10}-values (and variability) were not significant different.

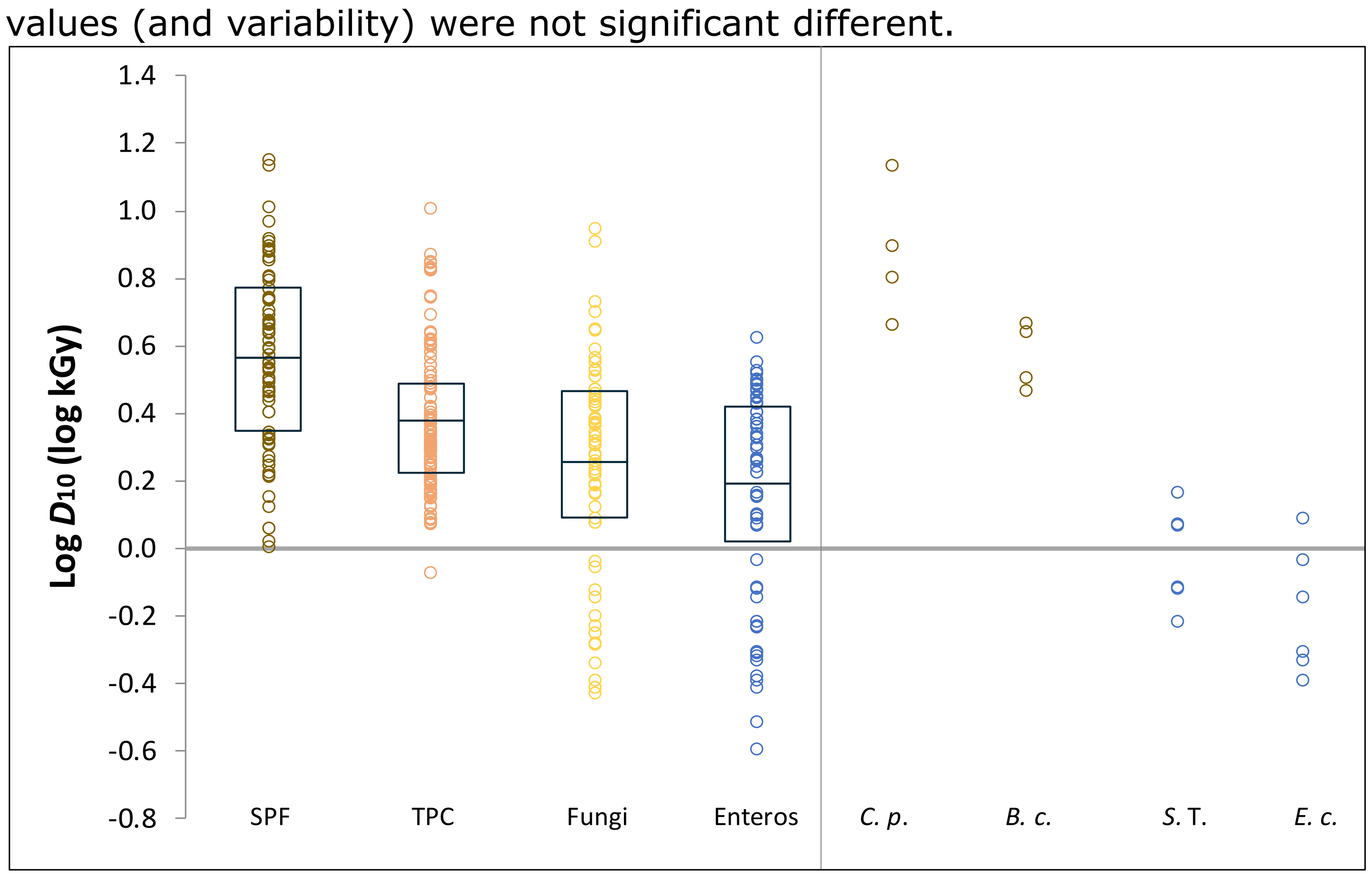

Figure 2. LogD_{10}-values of the different sub-groups of microorganisms in spices and herbs. SPF are spores and mixed cultures of spores and vegetative cells; TPC are total plate counts; Fungi are yeasts and moulds and Enteros are the *Enterobacteriaceae* family. Pathogens are *C. perfringens* (*C. p.*), *B. cereus* (*B. c.*), *S.* Typhimurium (*S.* T.) and *E. coli* O157:H7 (*E. c.*). The center horizontal line of the box plots represents the mean values, the top represents the 75th and the bottom the 25th percentile of the data range.

Comparison between spices and herbs irradiation meta-analysis and other products major meta-analysis (Van Gerwen et al., 1999) suggests that the role of food matrix in irradiation resistance is lower than that of microbial identity (Figure 3A and 3B).

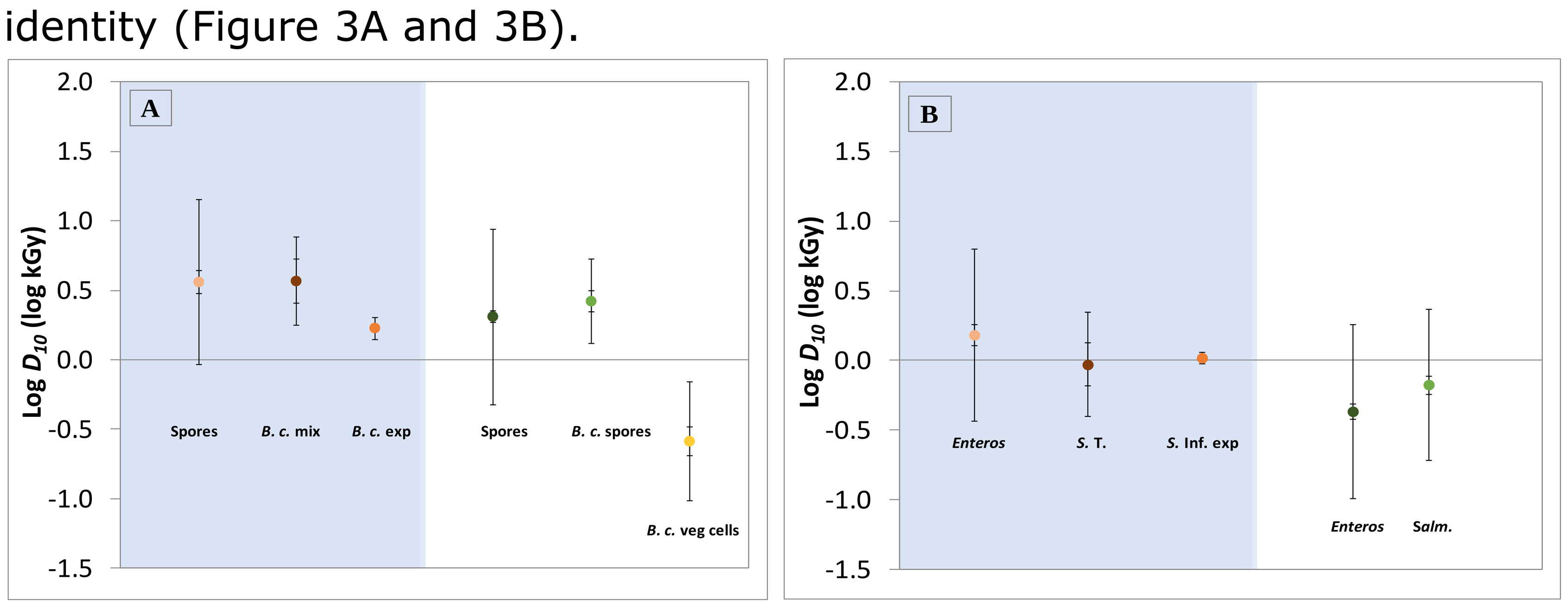

Figure 3. Comparison of logD_{10}-values in various groups of microorganisms collected in the meta-analysis in spices and herbs (blue boxes) and in the meta-analysis of Van Gerwen et al., 1999 (white boxes). Panel A: Spore-formers *Bacillus cereus* (*B. c.*); vegetative cells (veg. cells). Panel B: *Enterobacteriaceae*, *Salmonella* Typhimurium (*S.* T.); *Salmonella* Infantis (*S.* Inf.); *Salmonella* (*Salm.*). mix= mixture of spores and vegetative cells, and exp is experimental results in paprika powder. Inner error bars represent the 95% confidence intervals and outer error bars the 95% prediction intervals of the logD_{10}-values.

Conclusions

- After temperature, the next significant factor for thermal robustness is microbial identity.
- Microbial identity for irradiation robustness was the only significant factor.
- Fungi and *Enterobacteriaceae* show similar irradiation dose sensitivity.
- Inactivation by irradiation or by heat for spices and dried herbs is comparable to inactivation in other foods.

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