PRESSURE ASSISTED THERMAL STERILIZATION: A NOVEL MEANS OF PROCESSING FOODS

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ABSTRACT

This thesis investigates a newly developed and patented technology for its ability to inactivate spore-forming bacteria and non-spore-forming microorganisms. This new technology "*Pressure Assisted Thermal Sterilization*©" (PATS) is based on the theory of the thermal expansion of liquids. The efficiency of inactivating spore-forming and non-spore-forming microorganisms by PATS was compared with the thermal treatment alone. A combination treatment consisting of high pressure processing and gaseous carbon dioxide was also investigated for its ability to inactivate bacterial spores in model and real food matrices. The structural damage caused by treatments to the spores and non-spore-forming bacteria was assessed by scanning electron microscopy.

Geobacillus stearothermophilus spores suspended in Milli-Q water, UHT milk and pumpkin soup, treated by PATS were found to have significantly lower decimal reduction times (D values) compared with the thermal treatment alone. Spores suspended in UHT milk were more heat resistant compared with those in Milli-Q water and pumpkin soup. *Bacillus cereus* spores suspended in Milli-Q water and pumpkin soup treated with PATS were more effectively inactivated compared with spores treated by the thermal treatment alone. *Clostridium botulinum* spores in saline buffer subjected to PATS treatment were inactivated more effectively compared with the thermal treatment alone. Overall, the results show that PATS was a better processing technique for inactivation of bacterial spores compared with thermal treatment alone. However, PATS had no added benefit in inactivating the non-spore-forming bacteria *Escherichia coli* and *Saccharomyces cerevisiae* cells compared with the thermal treatment.

A shelf life study showed that *B. cereus* spores in pumpkin soup retained a low spore count (<5 LogCFU/mL) for approximately 40 days in 30^{o}C storage after treatment with PATS. No additional degradation of colour pigments of pumpkin soup and model pumpkin juice was observed following PATS compared with the thermal treatment.

Spore-forming microorganisms can be resistant to pressure treatment alone, which limits the application of high pressure processing (HPP). Therefore, a combination approach was investigated. The mechanism of inactivating spores by combining HPP with other treatments is that the pressure assists in spore germination. Then a secondary treatment (thermal or CO_2 gas) can be used to

inactivate the germinated spores. A combined application of HPP and a consecutive CO_2 treatment was investigated for the efficiency of spore inactivation. Results showed that HPP (200 MPa for 30 min) followed by a CO_2 treatment inactivated *Bacillus subtilis* 168 in nutrient broth, tomato juice and liquid whole egg by 2.5, 1.0 and 1.5 LogCFU/mL respectively. These results indicated that this technique is inadequate for practical use.

Scanning electron micrographs showed that pressure processing of *B. subtilis* 168 and *B. subtilis* natto spores resulted in deformation of the spore structure. This structural deformation of spores may have been due to water absorption during HPP and subsequent release upon decompression. PATS treated *G. stearothermophilus* and *B. cereus* spores were more severely damaged compared with the same spores which underwent thermal treatment alone. However, the extent to which *E. coli* and *S. cerevisiae* cells were damaged by both PATS and thermal treatment was similar.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

A	Area
AC	Alternative Current
Ae	Arrhenius Equation (Pre exponential factor)
β	Thermal Expansion
BYE	Bacto Yeast Extract
C	Capacitative Component
CFU/mL	Colony Forming Units per Millilitre
CIE	Commission Internationale d'Eclairage
CO_2	Carbon Dioxide
Cp	Heat Capacity
D Value	Decimal Reduction Time
E	Electrode Impedance
E_t	Total Colour Change
E	Activation Energy
F	Frequency
g	G force
h	Hours
h	Heat Transfer Coefficient
HPP	High Pressure Processing
IDT	Impedance Detection Time
k	Rate Constant
κ	Compressibility
KHz	Kilohertz
LWE	Liquid Whole Egg
M	Media Impedance
m	Mass
μ	Dynamic Viscosity
mins	Minutes
μL	Microlitre
MPa	Megapascal
MPN	Most Probable Number

msec	Milliseconds
NB	Nutrient broth
NFRI	National Food Research Institute of Japan
P	Pressure
PATS	Pressure Assisted Thermal Sterilization
PB	Phosphate Buffer
Q	Heat Input
R	Ohmic Resistance
R	Gas Constant
ρ	Density
R2	Correlation Coefficient
s	Seconds
SEM	Scanning Electron Microscopy
SPC	Standard Plate Count
T	Temperature
t	Time Period
TDT	Thermal Death Time Curve
T_{eff}	Effective Mean Temperature
TGE	Tryptone Glucose Extract Agar
TPYG	Trypticase Peptone Yeast Glucose Extract
TSA	Tryptic Soy Agar
TSB	Tryptic Soy Broth
UHT	Ultra High Temperature
w/v	Weight per Volume
YPD	Yeast Extract Peptone Glucose
Z	Impedance