

Reduction of *C. botulinum* spores at the meat surface using C-band microwaves

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INTRODUCTION

To reduce the risk of *C. botulinum*, FSA [1] recommends a heat treatment of 90°C for 10 minutes or a time and temperature combination sufficient to achieve a 6 log reduction of *C. botulinum* spores in vacuum-packed meat. For semi-processed meat, a shelf life of more than 10 days at 5°C is expected. On whole meat roasts, the bacteria flora only occur at the surface [2]. By using microwaves at a specific frequency, only the surface of the meat is heated, resulting in a preservation of a red and juicy centre and an inactivation of the spores at the surface.

OBJECTIVE

The objective was to test if a surface treatment with C-band microwaves was able to inactivate *C. botulinum* spores faster than a heat treatment at 90°C for 10 minutes.

MATERIALS AND METHODS



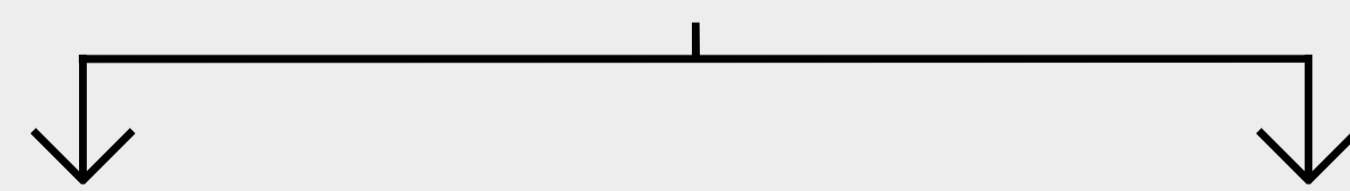
STRAINS AND PREPARATION OF SPORES

- The inoculation cocktail contained four non-toxicogenic and gas-producing strains of psychrotrophic *C. botulinum*.
- The spores were cultivated in Tryptone Peptone Glucose Yeast and Cooked Meat Medium.



MEAT PIECES

- Bovine top sides were cut into cubes (4.5×4.5×4.5 cm) ~ 100 g
- The spore suspension was added to the surface (10⁵ spores per cm²).
- The meat pieces were vacuum-packed.



WATER BATH TREATMENTS:

- 90°C for 0, 2, 4 or 7 minutes
- 95°C for 0, 0.5, 1 and 2 minutes
- 97°C for 0, 0.5, 1 and 1.5 minutes
- 99°C for 0, 0.5, 1, 2 and 4 minutes



MICROWAVE TREATMENTS:

- C-band microwaves (5.8 GHz)
- Exp. 1# Full power for 1, 2, 3 or 4 minutes.
- Exp. 2# Full power for 1 minute + 25% of full power for 1, 2 or 2.5 minutes.



ANALYSIS

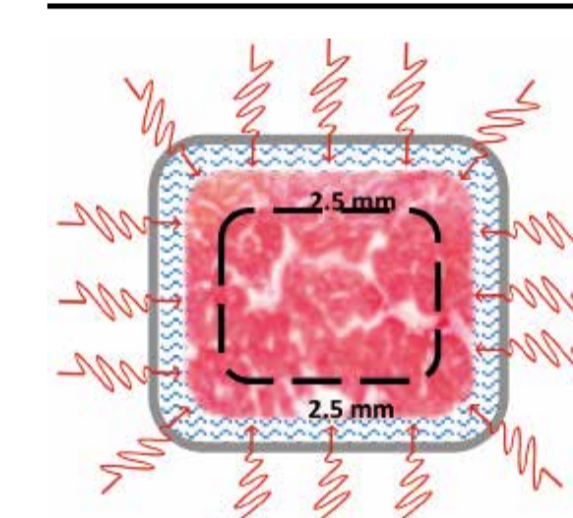
- Numbers of spores and vegetative cells of *C. botulinum* were analysed on SFP-agar and incubated for 3 days at 30°C.
- Samples for the spore analysis were heat treated at 75°C for 20 minutes before analysis on SFP-agar.
- The D-value and regression coefficient (R²) for each treatment was determined by linear regression from the plot of the logarithm of spore and vegetative counts against time.

RESULTS

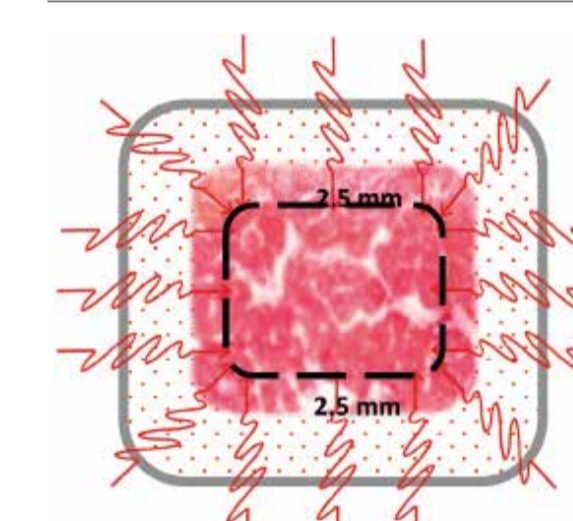
Table 1. D-values for *C. botulinum* spores treated in a microwave oven and a water bath at different temperatures.

| Exo. No | Equipment | Temperature (C°) | D-value (minutes) | R ² reg. | Time to 6 log red. (minutes) |
|---------|------------------------|------------------|-------------------|---------------------|------------------------------|
| 1 | Water bath | 90 | 3.99 | 0.816 | 23.94 |
| 1 | Water bath | 95 | 3.64 | 0.330 | 21.84 |
| 1 | Water bath | 97 | 2.22 | 0.588 | 13.32 |
| 2 | Water bath | 99 | 1.67 | 0.625 | 10.02 |
| 1 | Microwave ¹ | – | 0.68 | 0.864 | 4.08 |
| 2 | Microwave ² | – | 0.94 | 0.912 | 5.64 |

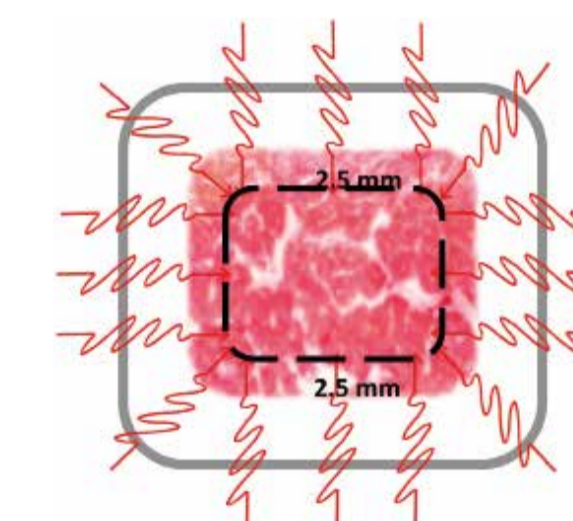
- The D-values for the water bath treatment decreased with increasing temperature as expected.
- The time to achieve 6 log reduction of *C. botulinum* was reduced 4-6 times by using C-band microwaves compared to water bath treatment at 90°C.
- Steam formation was observed during the microwave treatment, indicating that the temperature was 100°C (see figure 1).



Step 1. Microwave energy is absorbed in the liquid column between the meat and the packaging film.



Step 2. When the temperature at the surface of the meat reaches 100°C, the liquid column begins to boil, and steam fills the gap between the meat and the packaging film. The subsequent steam condensation results in the release of an enormous amount of heat directly at the meat surface.



Step 3. When the column evaporates, the steam facilitates direct absorption of microwave energy by the meat surface, as microwaves do not experience any essential energy loss as they do in the water. The direct access of microwaves to the meat surface sustains the decontamination process after the initial shock and further improves its efficacy.

Figur 1. The principle of microwave treatment

CONCLUSION

- The advantage of using microwaves is that the thin water film at the meat surface is immediately heated to 100°C
- The advantage of the microwave method is that the sterile red coloured centre is preserved during the fast decontamination of the surface on whole muscles, meaning that a subsequent heat treatment at temperatures in the range from 55-63°C can be applied without affecting the food safety.

REFERENCES

1. Anonymous (2008) Food Standards Agency guidance on the safety and shelf life of vacuum-packed and modified atmosphere packed chilled foods with respect to non-proteolytic *Clostridium botulinum*. July 2008
2. Baldwin, D. E. (2012). Sous vide cooking: A review. Int. J. of Gastronomy and Food Science 1, 15-30



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