abuse (37^{o}C). At abuse storage temperatures, a synergistic interaction was found between MAP and irradiation processing. Since it is difficult to maintain the cold chain in developing regions, the synergistic effect between MAP and irradiation processing can be regarded as beneficial with regards to extending the shelf-life of the RTE meal.

However, the sorghum porridge and spinach relish RTE meal is a low acid food product. This together with the fact that the meal was packaged in a full barrier film under MAP conditions favouring the absence of O_2, renders it potentially dangerous from a *C. botulinum* view-point. It is therefore crucial to establish the naturally occurring *C. botulinum* levels in this type of product as well as whether this micro-organism would be able to survive and proliferate under processing and storage conditions used.

At a storage temperature of 5^{o}C for 7 d there was no microbial activity (TPC was < 10 cfu/g). Implications of this includes a desirable extension of the shelf-life of the RTE meal treated with the combination of MAP and irradiation. On the other hand, the lack of any competition for *C. sporogenes* that survived the processes could lead to them proliferating unchecked in the event that the cold chain is broken, causing a health hazard, i.e. the meal could become toxic before it spoiled.

At a storage temperature of 37^{o}C for 7 d, TPC did not exceed 3 $\log_{10}$ cycles during the storage period for the combination treatment as compared to the control, MAP and irradiation treatments on their own. The implications of this could be a longer shelf-life of the RTE meal, and lack of TPC proliferation means no competition for *C. sporogenes* (which was unaffected by MAP) which go on proliferating unchecked in the RTE meal i.e. the meal becomes toxic before it spoiled.

At a storage temperature of 5^{o}C, the *C. sporogenes* counts in the meal remained more or less constant during the storage period, with MAP 1 (84.5% N_2 + 15.5% CO_2) reducing proliferation rate of *C. sporogenes* inoculated into the RTE meal beyond 5 d of storage. However, in the event of severe temperature abuse, coupled with lack of competition (TPC), the *C. sporogenes* would proliferate rapidly resulting in health hazards, if the RTE meal contains strains of the organism capable of growth and toxin production at low temperatures.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Chlorine at a concentration of 250 mg/l reduced the microbial load (TPC) on spinach by approximately 3 $\log_{10}$ cycles.

Blanching of spinach after chlorine treatment did not have an effect on microbial activity (TPC). Blanching in more than two changes of water led to a drastic loss in total solids, meaning a lower nutritional content of the product.

Initially, in Phase 1, it was found that interruptions during the irradiation processing of the RTE meal led to discrepancies in gamma D_{10}-values for *C. sporogenes* between the different MAP conditions. It is postulated that the duration of these interruptions (up to 14 h) may have been long enough for the microbes to initiate repair of the damaged DNA. Stricter control measures during irradiation processing resulted in more reliable gamma D_{10}-values.

Irradiation (alone) reduced *C. sporogenes* counts and total plate counts (TPC) in the RTE meal significantly. Neither MAP (82.3% N_2 + 15.9% CO_2 + 1.8% O_2 and 84.5% N_2 + 15.5% CO_2) conditions on their own or in combination with irradiation had an effect on *C. sporogenes* counts and TPC in the RTE meal during the first 24h of storage. Gamma D_{10}-values of the RTE meal were between 2.58 kGy and 2.60 kGy indicating an effective inactivation rate by irradiation. A target dose of 10 kGy (actual dose 11.52 kGy) resulted in a 4 $\log_{10}$ cycle reduction in *C. sporogenes* counts.

Irradiation reduced initial TPC and *C. sporogenes* in the RTE meal significantly. Modified atmosphere packaging (84.5% N_2 + 15.5% CO_2) did not have an effect on the growth of *C. sporogenes* in this particular RTE meal when stored at 37^{o}C. However, at a storage temperature of 5^{o}C MAP seems to have reduced growth rate of *C. sporogenes* inoculated into the meal beyond 5 d of storage. The effect of MAP on total plate count in the RTE meal depended on the storage temperature, at 5^{o}C, growth rate (TPC) was lower than at 37°C. MAP-irradiation combination processing is synergistic with regard to TPC in the RTE meal stored at 37 °C since irradiation inactivates a high percentage of the bacteria and MAP keeps growth of surviving bacteria to a minimum. Although this might be regarded as beneficial with regard to extending the shelf-life of the RTE meal, the elimination of *C. botulinum* and thus the safety of the meal, cannot be guaranteed.

If the microbial cut-off point of 10^5 cfu/g for TPC is used to determine spoilage of the RTE meal, then the shelf-life of the RTE meal was as follows for the following treatments:

5°C-

- Control 3 d
- -MAP Alone 5 d
- Irradiation alone At least 7 d
- MAP + Irradiation At least 7 d

37°C-

- Control Less than 1 d
- -MAP Alone Less than 1 d
- Irradiation alone 3 d
- MAP + Irradiation At least 7 d

It is possible to produce a safe sorghum porridge and spinach RTE meal with a shelf-life of at least 7 d at 5°C using a combination of MAP (84.5% N_2 + 15.5% CO_2) with irradiation at a target dose level of 10 kGy, provided the following points are adhered to:

- Low initial microbial load on the raw materials and finished product.
- No cross-contamination during processing
- Ensuring the maintenance of the cold chain throughout processing, storage distribution and final end-use.

The use of alternative hurdles to MAP (e.g. nitrites and/or a_w) in conjunction with irradiation and storage at low temperature (5°C) are recommended for the processing of the RTE meals and other low-acid foods in order to improve shelf-life and guarantee safety.

CHAPTER 7

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