MANAGING INTERACTING MICROBIAL POPULATIONS

THE ECOLOGY OF MICROBIAL POPULATIONS

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- Fresh meat will have a variety of microbe populations.
- The varietal proportions on the meat will depend on the relative proportions in the plant.
- The different populations will interact through competition, synergy and changes in the environment (pH, water activity) induced by each other.
- These interactions will be dependent on external variables e.g. temperature.

Can we manipulate these interactions to optimise shelf life of the product?

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- Interacting microbe populations represent a complex system with considerable outcome variation.

- The conceptual tool for complex systems is Probability. This gives the frequencies for different outcomes and is the basis for designing efficient strategies - e.g. to minimise spoilage.

- The proper description of a system of interacting microbial populations is that of a multivariate probability distribution evolving in time.

- If we know this probability distribution we can devise optimal strategies!

PRACTICAL QUESTIONS

- Are there conditions where an (undesirable) population can be driven out, or suppressed to low levels by the other populations?

- What are the relative initial population sizes that ensure an undesirable microbe will fail to reach a ”problem” size with high probability?

- What are the uncertainties in the controls that can be tolerated to achieve a particular desirable outcome

In applications we want to know the “Long run” behaviour of the interacting populations

When there are 2 interacting populations then

- Both can die out
- One can die out and the other dominate
- Both can reach an equilibrium populations size and coexist.

The long – term fate of 2 interacting microbial populations depends on:

The maximum population size (K)

The strength with which one population suppresses the other (the interaction coefficient, α).

Populations can coexist if

$$\alpha_x < \frac{1}{K_x} \quad and \quad \alpha_y < \frac{1}{K_y}$$

Population y outcompetes population x if

$$\alpha_x < \frac{1}{K_x} \quad and \quad \alpha_y < \frac{1}{K_y}$$

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BROCHOTHRIX THERMOSPHACTA AND *LACTOBACILLUS SAKEI* GROWN TOGETHER

Temperature	Microbe	r	K	α
-1.5 C	Brochothrix	0.085 ± 0.017	6.78	0.085 ± 0.013
	Lactobacillus	0.030 ± 0.017	7.5	0.020 ± 0.011
0 C	Brochothrix	0.08 ± 0.017	6.78	0.100 ± 0.013
	Lactobacillus	0.07 ± 0.017	7.5	0.080 ± 0.011
7 C	Brochothrix	0.13 ± 0.017	6.78	0.127 ± 0.013
	Lactobacillus	0.06 ± 0.017	7.5	0.0 ± 0.011

Brochothrix and Lactobacillus coexist at -1.5 C and 2 C, but Lactobacillus drives out Brochothrix at 7 C.

Same result when parameter variation is considered.

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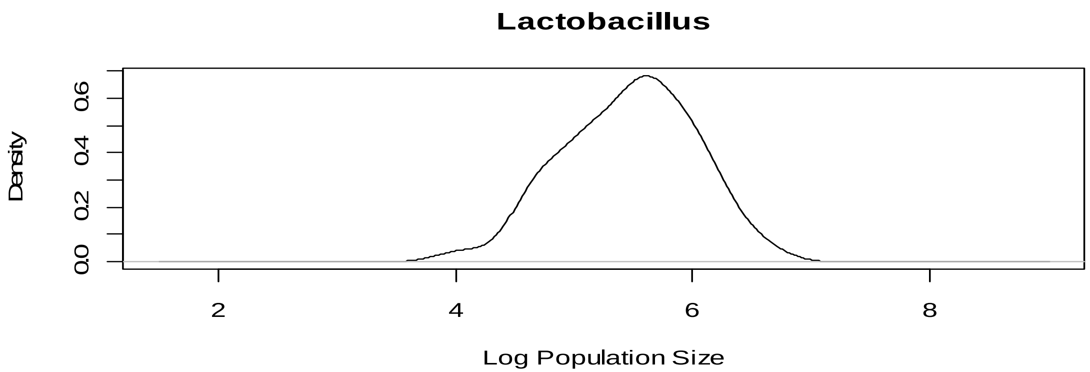
INTERACTING PROBABILITY DISTRIBUTIONS

At -1.5 C and identical initial populations sizes interacting Brochothrix and Lactobacillus populations present these probability (frequency) distributions at 60 days.



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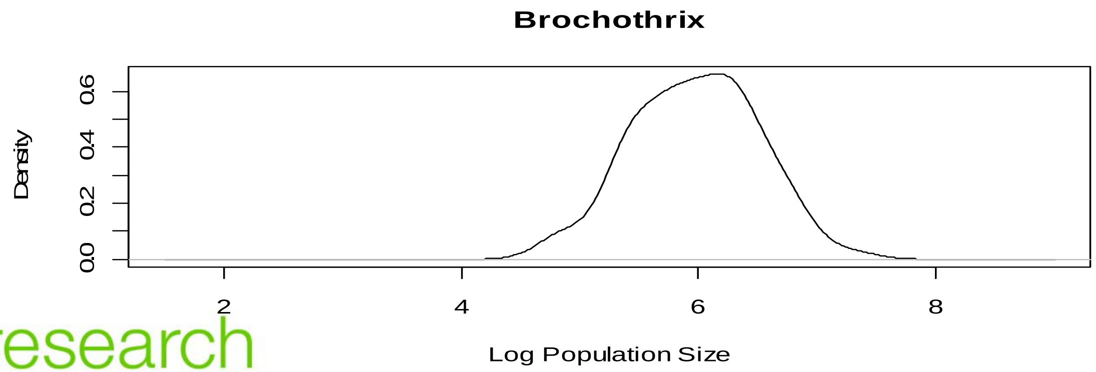

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OTHER MEASURED INTERACTIONS

- Ls200(MRS) drives Wv12706(M5) to extinction at temperatures of 2 C and below.
- Ls200(MRS) coexists with Ha25(Entero) and Ra23 at all temperatures
- Cm88(TY 9) drives Wv12706(M5) to extinction at temperatures of 0 C and below, and to a low equilibrium at a temperature of 2 C.
- Cm88(TY 9) drives Ha25(Entero) to extinction at -1.5 C, but coexists at higher temperatures.
- Cm88(TY 9) coexists with Sp26, Bt20 and Ra23 at all temperatures

Thus, interaction coefficient α is temperature dependent (possibly pH dependent ?).

We can find the functional relationship of this parameter to temperature.

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WORK IN PROGRESS

- Derive probability distributions for other species of interacting microbes.

- Investigate the effect of transients on different starting conditions and under varying temperature profiles

- Investigate optimal strategies for managing mixed microbe populations under uncertainty of population size and environmental conditions. E.g. what degree of control is necessary to achieve a desirable outcome with high frequency.

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THE FUTURE

- Results to be coded into FoodQSM™ or MeatQSM.
- The model updating procedures of FoodQSM™ will be adapted to deal with interacting microbial populations.
- The updating procedures will provide information about how different microbial species interact in a particular supply chain.
- The unique database management capabilities of FoodQSM™ will provide the basis for analysis of these interactions.
- This analysis will be the basis for optimisation and improved management of food spoilage

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