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Modelling the Growth Inhibition of Common Food Spoilage and Pathogenic Micro-organisms in Presence of Solvent Extract from Irish York Cabbage

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Modelling the growth inhibition of common food spoilage and pathogenic micro-organisms in the presence of solvent extracts from Irish Crucifer vegetables

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Abstract

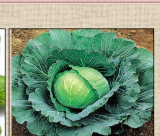
Crucifer vegetables are a rich source of phytochemicals such as flavonoids and glucosinolates and their hydrolysis products. These phytochemicals possess antimicrobial and anti-oxidant activities. In order to assess the antimicrobial potential of different members of crucifer family, Irish York cabbage, Broccoli and Brussels Sprouts, the effect of solvent extracts on the growth inhibition of common food spoilage and pathogenic bacteria was studied. Broccoli and Brussels sprouts, at a concentration of 2.8%, showed a weak inhibition in the range of 11-50% and 7-38%, respectively, against the different micro-organisms. Extracts from York cabbage were highly effective at a concentration of 2.8% resulting in 100%, 75% and 57% inhibition against *Listeria monocytogenes*, *Salmonella abony* and *Pseudomonas aeruginosa*, respectively. Growth/survival of the micro-organisms in presence of York cabbage extract was mathematically modelled using the Baranyi model. Lower concentrations of cabbage extract prolonged the lag phase and reduced both the maximum specific growth rate and final population densities.

Materials and Methods

Raw Material

Broccoli

Brussels Sprouts



York Cabbage

Extraction Procedure (Gupta et al., 2010)

5 gm sample was crushed with liquid nitrogen → Extraction with 60% methanol under nitrogen atmosphere → Shaking at 40°C and 100 rpm for 2 h → Extracts filtered and evaporated to dryness

Antimicrobial Analysis

Bacterial cultures used in the present study

- Gram Positive
  - Food Pathogen: *Listeria monocytogenes*
  - Food Spoilage: *Enterococcus faecalis*
- Gram Negative
  - Food Pathogen: *Salmonella abony*
  - Food Spoilage: *Pseudomonas aeruginosa*

Microtitre plate based analysis (Gupta et al., 2010)
Extract concentration: 5.6%

200 µL extract added in the first row of microtitre plate → Extract was serially diluted down the plate → 100 µL bacterial culture added to all wells → Plates incubated at 37°C for all bacteria and at 30°C for *Pseudomonas* → Absorbance read at 600nm (Powerwave, Biotek) every hour for 24 h

Antimicrobial activity was calculated in terms of % inhibition of growth as follows (Casey et al., 2004)

$$Percentage\ Inhibition = \frac{(C_{24}-C_0)-(T_{24}-T_0)}{(C_{24}-C_0)} \times 100$$

C_{24} is the OD_{600} of the bacteria at 24 h, C_0 is the OD_{600} of the bacteria at 0 h,
T_{24} is the OD_{600} of the organism in the presence of extract at 24 h ,
T_0 is the OD_{600} of the organism in the presence of extract at 0 h.

Analysis of Growth Kinetics

The OD values were converted into log CFU/ml by a standard curve for each bacterium. Growth kinetics in the presence of cabbage extract was described by DM-Fit program implemented in Microsoft excel (DM-Fit; Institute of Food Research, Norwich, UK, (Baranyi et al., 1993)

Kinetic parameters calculated were:

- Maximum specific growth rate (μ_m),
- Log_{10} maximum population density (γ),
- Lag time (λ)

Results and Discussion

Antimicrobial Activity

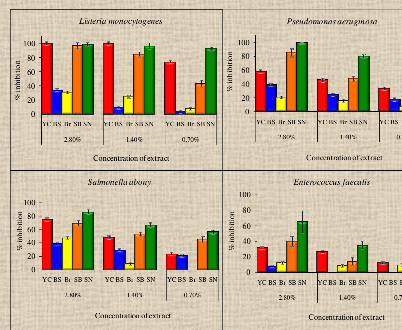


Fig 1: Comparative study of antimicrobial activities for York cabbage (YC), Broccoli (Br) and Brussels Sprouts (BS) with positive controls Sodium Benzoate (SB), Sodium nitrite (SN)

- Extracts from York Cabbage were the most effective followed by Broccoli and Brussels sprouts which had weak inhibition.
- *L. monocytogenes* and *E. faecalis* were the most sensitive and resistant organisms, respectively.
- An inhibition of 100% and 75% was observed against *L. monocytogenes* and *S. abony*, respectively, with 2.8% York cabbage extracts.
- The inactivation effect reduced with a reduction in extract concentration.
- York cabbage extracts, with an inhibition of 100%, were more potent than sodium benzoate (84.4%) and sodium nitrite (96%) against *L. monocytogenes* at a concentration of 2.8%.

Growth/Inhibition Kinetics

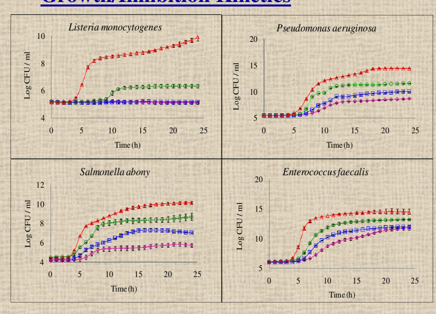


Fig 2: Growth kinetics of food spoilage and pathogenic bacteria in presence of different concentrations of cabbage extract (◊: 2.8%; □: 1.4%; ○: 0.7%; Δ: control)

- Kinetics studied with extracts from York cabbage
- A rapid and prolific growth was observed in control samples.
- An extract concentration of 1.4% resulted in complete inactivation of *L. monocytogenes* whereas 0.7% extract resulted in 76% reduction in the stationary level growth as compared to the control.
- For the other three organisms, addition of 2.8% extract resulted a reduction of 72, 64 and 32% in the stationary level growth of *S. abony, P. aeruginosa* and *E. faecalis* as compared to the control.
- Maximum specific growth rate was reduced and lag phase increased upon addition of extract.

Growth Kinetics using Baranyi Model

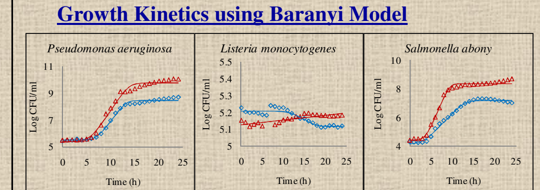


Fig 3: Fitting of the Baranyi model at an extract concentration of (◊) 2.8% and (Δ) 1.4%. (smooth lines: predicted; values; points: experimental data)

Table 1: Value of model parameters

	Conc (%)	λ (h)	μ (h^{-1})
L. monocytogenes	2.8%	11.3	-0.014
	1.4%	-	0.003
	0.7%	8.1	0.316
	control	2.2	0.685
S. abony	2.8%	4.065	0.24
	1.4%	3.07	0.31
	0.7%	3.6	-
	control	-	0.53
P. aeruginosa	2.8%	7.01	0.469
	1.4%	5.62	0.533
	0.7%	5.4	1.06
	control	3.9	1.1

- Reducing the extract concentration to 0.7% resulted in 4 and 2 times increase in λ for *L. monocytogenes* and *P. aeruginosa*, respectively.
- Addition of extract at 2.8% resulted in 57% and 55% reduction in the μ_m of *P. aeruginosa* and *S. abony*, respectively.

Conclusions

- Extracts from York cabbage have the potential of imparting microbiological safety to food products.
- Higher antimicrobial activity was seen against *L. monocytogenes* and *S. abony* as compared to typical food preservatives such as sodium benzoate and sodium nitrite.
- The present finding brings out a new insight towards the development of natural antimicrobial agents against *L. monocytogenes* from Irish York cabbage.

References

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