Systematic and critical review on the potential use of bacteriophages on foods

Area of research interest: Foodborne pathogens
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Background

Bacteriophages are viruses (naturally present in the environment) that can kill specific host bacteria. There has been some reported interest in using these in a targeted fashion to reduce microbiological contamination of foods i.e. reduce the level of food pathogens such as *Salmonella* . Alternatively a bacteriophage could reduce spoilage bacteria on food thereby extending its shelf-life. Our previous research considered the use of bacteriophages on live animals and as such this project focussed on use on/in food.

There are currently no approved bacteriophages at European-wide level, although some European countries allow the use of bacteriophages under national rules. Additionally bacteriophages are authorised for use in other countries across the world and there is a growing interest in this area.

When bacteriophages are used to reduce surface contamination on products of animal origin (e.g. meat, fish) they may require approval under EU food hygiene legislation before they are permitted for use. If they act as preservatives with an ongoing effect in the food, then they may require approval under EU food additives legislation.

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Research Approach

This project critically reviewed information on the use of bacteriophages on food to determine where and how bacteriophages could potentially be used in food production. The work focussed on efficacy, specificity, safety and any potential issues associated with their use.

The project focused on five key pathogens responsible for the microbiological contamination of foods which can lead to food poisoning i.e. *Salmonella* spp., *Campylobacter* spp., *Listeria monocytogenes*, shiga toxin producing *E. coli*(STEC) and *Staphylococcus aureus.*

For food spoilage bacteria, two representative species were selected from the following groups: Gram negative rods, the Enterics, Gram positive spore formers, Gram positive non-spore formers and lactic acid bacteria.

The first stage of the project assessed the current applications of bacteriophages in the food industry, including information on where and how they are used, controls/guidelines and any existing risk assessments on their use.

The second stage involved a systematic and critical review of the data available from a literature search on the ability of bacteriophages to reduce food pathogens or spoilage bacteria to determine the potential use of bacteriophages in food production.

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Results

Certain bacteriophages are approved as food additives or have 'GRAS' status in the USA and can be used to reduce the amount of *Listeria monocytogenes*, *Salmonella enterica* or *E. coli* O157:H7 on a wide range of food types including poultry, red meat, ready to eat foods, fish, shellfish and processed fruits and vegetables. Specific bacteriophages used to reduce *Listeria* are also permitted in Canada, Australia and New Zealand.

Regarding the potential use of bacteriophages to reduce microbiological contamination of foods, there was a lack of published work on the use of bacteriophage against *Campylobacter* spp. on/in food as the current literature mainly related to their use on live animals, which was outside the scope of this review. There was also a lack of relevant studies on the use of bacteriophage against food spoilage bacteria.

Key conclusions from the review:

- Some bacteriophages are already approved outside the EU for use on foods to reduce microbiological contamination by food pathogens such as *Listeria, Salmonella* and *E Coli O157*.
- Additional work is required to establish the effectiveness of using bacteriophages against food spoilage bacteria as there is a lack of published studies in this area.
- Further work is needed to confirm if bacteriophages provide a one off 'kill' or whether they have an ongoing effect and so could protect against recontamination of food by the bacteria. This is important as the mechanism of action of a bacteriophage will determine whether they should be regulated as food additives or as processing aids. Additionally, if they only act as a one off 'kill' then food could be susceptible to being re-contaminated by the bacteria and so there could be an increase in the level of the food pathogen following the use of the bacteriophage.
- If bacteriophages have an ongoing effect and continue to reduce the level of bacterial contamination of food (i.e. protect against recontamination) they would be regarded as food additives, which require approval prior to use under EU food additives legislation. If they act as a one off 'kill' they may be considered to be processing aids and so would only require approval under EU food hygiene legislation if used to decontaminate the surfaces of meat or fish.
- Optimisation of the treatment process (i.e. contact time and temperature) is required to obtain the optimum results as the effectiveness of the treatment varies significantly with the type of food.
- It was considered unlikely that a single bacteriophage would be effective against all strains of a particular bacterial species. Therefore the use of a 'cocktail' of bacteriophages may be necessary to reduce bacteria levels. The use of a bacteriophage with other antimicrobial treatments (e.g. nisin) often resulted in an improved 'kill' of the target bacteria.

The impact of bacteriophages on toxin-producing bacteria and on how they may influence the human gut microflora should be investigated further.

Research report

England, Northern Ireland and Wales

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