Dr Maria Marco discusses her research into the interactions of bacteria with their environments and the potential to exploit this knowledge to improve our health and prevent the spread of foodborne diseases.
Bacteria, food safety and health

Dr Maria Marco and her colleagues from the Department of Food Science and Technology at the University of California, Davis are transforming the way we think about bacteria with in-depth research into the varied roles they can play in food safety and health.

It is hard to understated the importance of microorganisms to food supply chains and human health. While outbreaks of pathogens can cause illness, small doses of some bacterial strains can aid digestive health: bacteria such as Lactobacillus and Bifidobacterium, for example, play a beneficial role in human digestive systems. They help to keep the immune systems healthy and facilitate the breakdown of food into useful energy and nutrients. Awareness of the health benefits of these probiotic bacteria has grown in recent years leading to their addition to food and drink products, of which the best known is perhaps probiotic yoghurt. The demand for such products is rising but our understanding of the full potential of bacteria in improving food safety and health remains limited.

Dr Maria Marco and her laboratory in the Department of Food Science and Technology at the University of California (UC), Davis are exploring the interplay between diet and food formats on the effectiveness of probiotic food products as well as investigating the roles of commensal bacteria on the safety aspects of fresh produce. The unifying theme behind the work at the laboratory is the role played by lactic acid bacteria (LAB) in food production and digestion. LAB are found on plant surfaces and in human and animal intestines. LAB are used widely throughout the food production system, particularly in the fermentation of yoghurt, cheese, olives and sourdough bread, and have an important role in shaping fermented food taste and texture. The team is exploring the beneficial effects of LAB and other commensal microorganisms in our foods to improve microbial food safety and human health.

Boosting beneficial bacteria

The general consensus among experts is that probiotic bacteria must be alive when they reach the human gut if they are to have optimal effects on our health. However, these microbes respond quickly to changes in their environment, which has important consequences for the effectiveness of probiotics both before and after consumption. For example, Lactobacillus is currently added to a number of different foods, from yoghurts and cheeses to chocolate and cereal bars; to date, little is known about how these formats affect the molecular interactions between the bacteria, food and host. As such, it is not possible to ensure the consistency of their effects on health. Moreover, LAB must be packaged, transported and stored before they even begin to negotiate the individual conditions of each human digestive system. The group has conducted an extensive review of studies in this area and found that relatively little research has been conducted into how pre-consumption factors affect the efficacy of dietary probiotic bacteria.

Another important facet to probiotic foods is the role that differences in diet have in shaping their impact on human health. Diet has major consequences on health including the development of chronic diseases (e.g. Type 2 diabetes mellitus and heart disease). Recent studies have shown how diet also shapes the composition of the indigenous microbiota residing in the intestine. These bacteria outnumber somatic cells in the human body by 10 to one. What is not known is how diet also affects the efficacy of probiotic bacteria that enter the gut through foods and beverages. Prior research has shown that probiotics adapt to utilise the nutrients available in the intestine. However it is uncertain how this will change depending on the other microbes present and the food delivery format of the probiotic. Therefore, the researchers are focusing on how diet and the delivery format of one type of LAB, Lactobacillus, affects its performance in the digestive tract. The investigations are targeting the anti-inflammatory effects of Lactobacillus, as well as how and to what extent they are shaped by host diet and food delivery matrix.

Innovative gene-targeted approaches are being used to examine these interactions and identify the specific mechanisms that generate probiotic effects. One such approach is the use of high-throughput DNA sequencing to study the intestinal microbiota before and after probiotic consumption. Marco explains why the technique of high-throughput DNA sequencing was chosen for this work: “We rely on this method because standard culturing methods are not able to accurately detect the majority of microorganisms in the intestine and DNA sequencing is a relatively rapid technique to assess the diversity of bacteria inhabiting the gut”. The efficiency of this method is particularly useful because the microbes colonising the digestive tract are distinct for every individual and therefore no two digestive systems will contain the same types and/or quantities of bacteria.

Using the groundbreaking DNA sequencing technology, it has been possible to identify which microorganisms in the intestines were most changed by diet, the delivery matrix and ingestion of Lactobacillus. This breakthrough will enable the design and production of probiotic food products which better accommodate these complex interactions. It will also improve standards of future investigations: “The findings of the research thus far show that diet should be recorded and possibly standardised in clinical studies intending to assess probiotic effects,” clarifies Marco. These results are being disseminated to the public and food science, nutrition and health industries through conferences, peer-reviewed publications and the media.

Preventing pathogens

Much like the intestinal microbiota and probiotics are important to human health, the indigenous bacteria on plants might be doing a similar function. The DNA sequencing technique is being used to establish how the biotic conditions of Romaine lettuce leaves change according to different temperatures and moisture levels both in the field and in controlled growth-chamber studies. These DNA analyses have revealed information about cell activity as well as the diversity and abundance of different microorganisms on lettuce.

This successful approach of analysing how environment affects the bacterial diversity...
and activity on a molecular level is also being applied to improve food safety, for example regarding *Escherichia coli* O157:H7, the well-known pathogen which can be transmitted through food, and can cause severe illness even in very small doses. Numerous outbreaks of *E. coli* O157:H7 have been linked to the contamination of leafy green vegetables before they are harvested. Work is underway at the Marco Lab to explore the influence of the indigenous plant microbiota and abiotic environmental variables – in particular extremes and fluctuations in moisture and temperature – on *E. coli* endurance. The upshot of this project is that farmers will be able to tailor their methods to reduce the likelihood of outbreaks of this pathogen.

**THE FUTURE OF FOOD**

The studies carried out so far have revealed a wealth of potential for further investigations into other microbiota and their influence on our health and food safety. Marco points out that the laboratory is also keen to continue expanding knowledge on probiotic bacteria: “The next steps will be to investigate whether the results of this project are transferrable to other strains and foods. Other health benefits should be investigated in light of our comparative analysis on the effects of diet on probiotic performance in the digestive tract”. There are many other strains of bacteria to investigate; studies conducted so far have only begun to scratch the surface. This also applies to using members of the indigenous plant microbiota as sentinels for human pathogens on agricultural crops. From the farm to the human body, understanding how different bacteria respond to a variety of environments at a molecular level is vital to creating healthier and safer food products, and the studies are set to contribute significant knowledge to this field.

**INTELLIGENCE**

**MICROBIOTA INFLUENCE ON FOOD SAFETY AND HEALTH**

**OBJECTIVES**

- To study the effects of native microbiota inhabiting fresh produce on human pathogens which might come into contact with those plants in the field
- To study molecular mechanisms of probiotic bacteria beneficial effects on health and the influence of diet on the bacterial residents of the mammalian gut

**KEY COLLABORATOR**

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**FUNDING**

US Department of Agriculture, National Institute of Food and Agriculture, Agriculture and Food Research Initiative Competitive Grants Program - grant nos 2012-67017-30219 (nutrition and health) and 2010-65201-20572 (food safety)

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