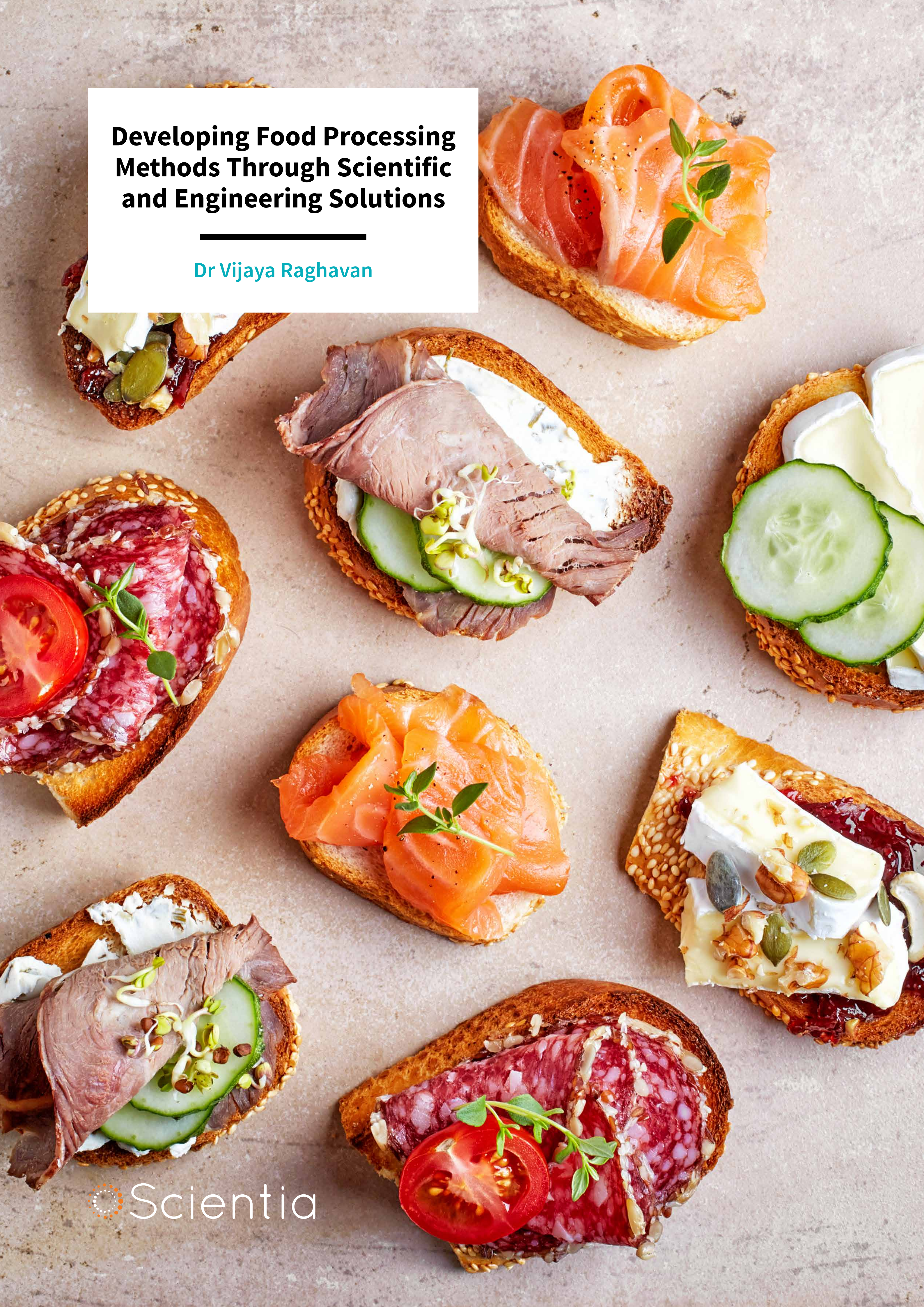
# Developing Food Processing Methods Through Scientific and Engineering Solutions

Dr Vijaya Raghavan



Scientia

# DEVELOPING FOOD PROCESSING METHODS THROUGH SCIENTIFIC AND ENGINEERING SOLUTIONS

The food processing industry generates enormous quantities of waste every year. On top of this, the way that food is processed can have negative impacts on the health of consumers. Therefore, it is vitally important to develop new food processing methods that consider human health while producing minimal waste. **Dr Vijaya Raghavan** and his research group at McGill University, Montreal, have been applying their expertise in chemistry and engineering to develop and optimise food processing techniques, to ensure the future health of people and the environment.

**Food Processing**

Today, almost all of the food we consume has been processed in some way. Food processing methods offer a range of important benefits, such as extending shelf life, and providing foods that are more palatable or edible than their unprocessed counterparts.

For instance, the various processing steps involved in converting wheat crops into loaves of bread – from harvesting and milling, to kneading and baking – unlock the nutrition contained within the raw grain, converting it into an edible form. Additionally, fish processing often involves gutting, deboning and washing, to obtain fresh meat that can be either transformed into safe and palatable products, or frozen or smoked to preserve the meat for months, or even years. Such preservation techniques allow consumers to enjoy fish well beyond the harvest season and far from where the fish were caught.

Without food processing, the needs of urban populations would be difficult to fulfil, and our selection of foods would be extremely limited, particularly in winter. However, certain aspects of food processing raise concerns over both environmental sustainability and the health of consumers.

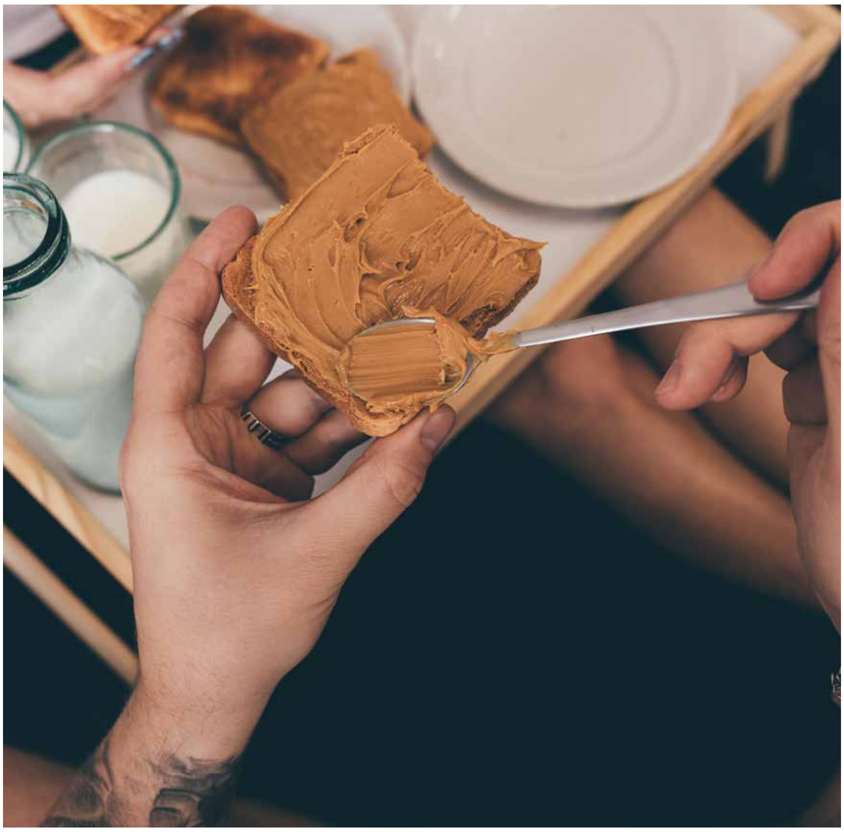
For example, the food processing industry generates a phenomenal amount of waste each year, both in terms of packaging materials and wasted food. On top of this, different processing methods can alter food on a chemical level, which can lead to negative health impacts. To address these issues, Dr Vijaya Raghavan and his research team at McGill University have been investigating various aspects of the food processing industry, in order to develop and optimise methods.

**Converting Seafood Waste into Useful Products**

Seafood makes up a huge proportion of the food consumed worldwide. However, as seafood is particularly perishable, much work goes into

maximising its shelf life. During processing, the less desirable parts of fish, such as the head, scales, fins and bones, are typically discarded. Studies have shown that almost half of harvested seafood is wasted. Most of this seafood waste ends up in landfill, or is simply dumped back into the ocean – causing serious environmental problems.

Dr Raghavan and his colleagues have been working to address this problem



by developing methods that transform this waste into useful materials. In a recent study, they explored a technique known as hydrothermal carbonisation. This method, which converts biomass into useful carbon-rich materials, has been widely used to convert plant matter into a coal-like biofuel called hydrochar. However, it is far less commonly used for treating animal waste.

Typically, hydrothermal carbonisation is performed by raising the temperature of a material to around 200°C under high pressure and in the presence of water. Dr Raghavan and his team employed a modified version of this method, which uses microwave radiation for heating. Microwaves can heat an object by causing water molecules to rapidly rotate inside the object, which generates heat directly inside the material.

The team started the process by mashing fish waste in a blender and treating it with a cocktail of enzymes, to further break down the different components of the waste. Then, they placed the mixture in an enclosed container and heated it using microwave radiation. With heating, the pressure in the container increased, and under these conditions the waste became converted into hydrochar. The researchers collected and dried the hydrochar, and took samples for analysis.

They found that their hydrochar was of similar quality to that obtained from plant waste. This was very promising, as it meant that the team's seafood-derived hydrochar could be used as a sustainable, biofuel-based alternative to coal. Additionally, Dr Raghavan suggests that the hydrochar would make a good fertiliser for soil, extending its useful applications further. Liquid derived from the process is also valuable for several other applications.

The team's approach could revolutionise the fish processing industry, significantly cutting down on the amount of waste produced worldwide, while also providing new sustainable sources of energy, fertiliser and other products.

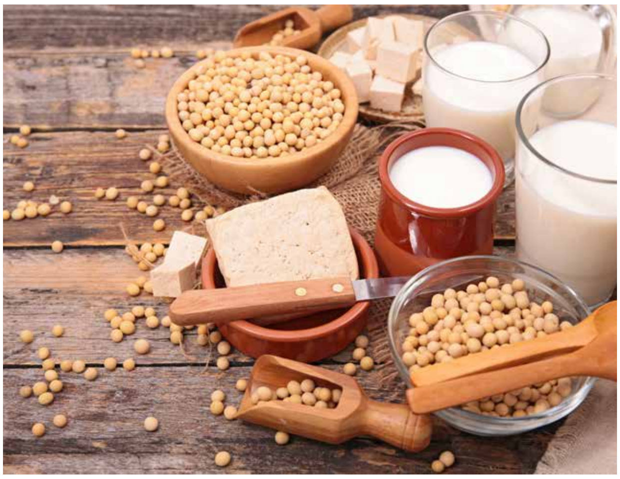
**Reducing Risks for Allergy Sufferers**

About 3% of the global adult population suffers from at least one type of food allergy, which represents a significant threat to their health. Peanut allergies are particularly serious, affecting roughly 1% of the US population. The prevalence of peanut allergies is largely because there are several different proteins in peanuts that can cause a dangerous immune response in affected people.

To add to this complexity, food processing can lead to structural changes in these proteins, making them more difficult to understand. In fact, certain structural changes to peanut proteins have been shown to reduce digestibility, and even increase the likelihood of triggering a severe allergic reaction compared to the unaltered protein. As peanuts are almost always processed before they reach the consumer, it is crucial to better understand the structural changes induced by different processing conditions.

Dr Raghavan and his colleagues have been investigating the nature of one particular peanut protein, called ARA-h-6. Through computational simulations, the team exposed this protein to different electric field strengths and various temperatures, to explore their effects on its structure. They found that while electric fields had a minor effect, increased temperatures did indeed have a large impact on the structure of the protein.

The team's work provides useful insights into how exactly this protein changes under various different processing conditions. Such computational simulations reveal far more structural detail compared to lab-based experiments, which only show the protein's structure before and after processing, without demonstrating what happens during the process. With further insights into the digestibility of different structures of ARA-h-6, and the forms that are likely to trigger an allergic



response, the team's insights could be used to develop new methods of processing peanuts to ensure healthier and safer foods.

**Improving Digestibility of Soy-based Foods**

In another study, Dr Raghavan and his team used computational simulations to explore structural changes in a protein found in soybeans. Specifically, they studied the effects of processing on the 'soybean trypsin inhibitor protein', which is known to block the action of enzymes that help us to digest other nutritional proteins. By better understanding how to change or destroy this protein's structure, its impact could be reduced, leading to soy-based foods that are more easily digested, and thus healthier.

In their study, Dr Raghavan's team found that the soybean trypsin inhibitor protein is unusually stable, and did not change much when exposed to different electric fields and elevated temperatures. Their research reveals the chemical and structural reasons behind this protein's stability, which may help scientists to develop ways of destroying it in a targeted way.

Hopefully, the insights gleaned in this study will inform the development of new methods for processing soybeans, to maximise the digestibility and nutritional value of soy-based foods. As soybeans are considered a more sustainable and ethical source of protein than meat, such methods would help to ensure the future sustainability of our food supply.

**Drying Carrots with Microwaves**

When it comes to preserving food, drying is a simple and effective processing method. It does not require any chemical additives and is often energy efficient. Therefore, much research goes into developing the best drying methods that do not sacrifice food quality.

One of the prominent methods used in this field is microwave drying. This works by heating the substance with microwaves, causing internal water to be driven to the surface where it evaporates. This process can also cause channels to open in the material as the water is removed, which in turn can lead to even faster drying times.

In order to achieve the most efficient drying using this method, the centre of the food needs to be much hotter than the surface, to optimise the movement of water. However, if the temperature difference is too large, heat-sensitive nutrients can be degraded and lost from the food. Therefore, Dr Raghavan has been investigating microwave drying, to better understand how it can be optimised.

His team uses carrots as a test food in their studies. The researchers began by cutting carrots into cubes with precise dimensions, which were submerged in hot water and then rapidly cooled. They then used a microwave drying unit that they had assembled using a microwave oven and a hot air generator. Using this setup, they performed a series of trials to monitor the internal and external temperatures of the cubes, as well as how much they decreased in size, and changes in their moisture content.

Through this, the team was able to determine the optimal conditions for drying carrot pieces, while maintaining the highest level of vitamin C. They were also able to identify the conditions that lead to the highest rehydration capacity, which is another important factor to consider.

Overall, the team's technique shows a lot of promise as a method for preserving carrots and other root vegetables, while also maintaining their nutritional value.

**The Future of Food Processing**

Dr Raghavan and his team have utilised their expertise in food chemistry and engineering to optimise various aspects of the food processing industry. Hopefully, their research and methods will soon be used by the food industry towards ensuring a more sustainable, safer and healthier future for all.

# Meet the researcher

**Dr Vijaya Raghavan**
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Dr Vijaya Raghavan earned his BEng at Bangalore University, before obtaining his MSc in Agricultural Engineering from the University of Guelph, Ontario. He then pursued and completed his PhD at Colorado State University, before moving to a teaching position at McGill University, Quebec, where he holds his current position as a professor in the Department of Bioresource Engineering. Here, his research focuses on the methodology used in food processing, including storage and waste management, with a view to enhancing food security and sustainability. He has directed several projects funded by the Canadian Government and was recently made a Director of the Royal Society of Canada. In 2019, he was awarded with the Lifetime Achievement Award from the Society of Tropical Agriculture for significant contributions to the field.

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