

# In Focus

An article by Dr. Matthias Kotthoff

The 'radio kitchen' at Fraunhofer IME:  
What is lurking in processed food?



# The 'radio kitchen' at Fraunhofer IME: What is lurking in processed food?

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A new laboratory is being set up as a 'kitchen' at the Fraunhofer IME in which foodstuffs can be processed under close-to-normal conditions and the transformation or breakdown products of their ingredients can be analyzed by means of radioactive labeling. What used to take years should now proceed faster.

Most components of foodstuffs, such as carbohydrates, fats and proteins, and also vitamins and trace elements, are desired or at least harmless. Many food ingredients occur naturally and contribute to a balanced diet

## Food safety: Processing alters material properties – revealing risks to the consumer

and well-rounded eating experience. Others, known as supplements or additives, are introduced intentionally to attain certain properties. Other substances get into foodstuffs by accident and are ingested by the consumer as contaminants and residues.

When foods are processed, however, their properties are altered. French fries become crispier; steaks become tender and give off an appetizing roasting aroma. The processing also produces new desirable ingredients while certain undesirable components are destroyed. But new and often unknown compounds may also be formed, posing uncertain risks. Thus processing procedures influence not only food quality but also food safety.

These processes are brought about by complex chemical reactions that often take years or decades to elucidate. Detailed knowledge of the reaction cascades is needed to assess the risks to consumers and to develop optimized

products and procedures. We are interested not only in the technological processes used in the food industry but also in the everyday preparation and cooking of food at home and in restaurants.

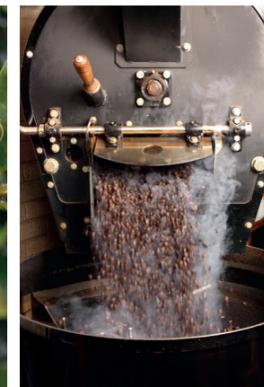
Natural ingredients can be transformed through processing into substances that are harmful to health. Acrylamide serves as a good example to illustrate the challenges encountered when striving for food safety: Acrylamide is a small, highly reactive molecule that plays a key role in the production of plastics, paints and varnishes, and is also a basic ingredient of cosmetic products. It is currently classified as 'probably carcinogenic'. Through an accident in 2002, a Swedish research team detected high concentrations of acrylamide in starchy roasted foods and discovered it was the end-product of the highly complex Maillard reaction. It is a derivative of the amino acid asparagine, which occurs naturally in almost every foodstuff.

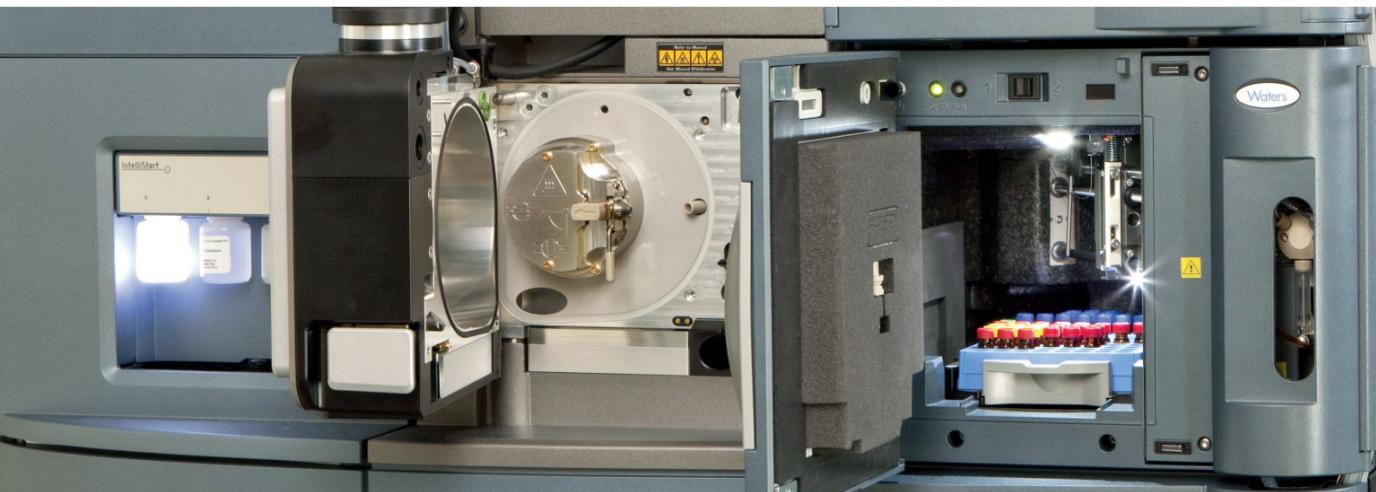
## Food quality: Processing alters aromas – optimizing recipes and procedures

Only in the last few years has it been possible to lower acrylamide levels through new procedural concepts and the modification of conditions, in particular, lowering of processing temperatures, and so improve consumer safety. Billions of euro have been invested in research and in the adaptation and supervision of processing procedures to this end.

Due to a lack of practical research approaches, there is still very little known about the behavior of chemical residues from agricultural production during food processing and the secondary metabolites produced. Critical source materials include pesticides, veterinary drugs and feed additives, as well as chemical environmental contaminants.

Coffee is a particularly interesting example for extensive chemical alterations during multi-stage processing.





Cutout of an HPLC/MS device for the analysis of metabolized components of foodstuffs (HPLC/MS: high pressure liquid chromatography coupled with mass spectrometry).

In technological processing also, many desirable substances are newly formed. Think of the aroma of freshly roasted coffee or a crisp cookie. To date, most formation pathways of these aroma-bearing substances have not been explained in detail. For optimization of recipes and procedures, however, it would be of great interest to know the exact formation pathway. Resource efficiency is currently the number one issue in food production – process changes such as lowering the temperature or process water consumption are becoming imperative, which implies that the influence on quality is known.

**Visualizing new target substances is an analytical challenge. The solution: Radioactive nuclides**

With the current technology used for food analysis it is scarcely possible to identify and quantify the metabolites of ingredients in processed foods. This is largely due to the complex matrices

of foodstuffs in which unknown target substances remain hidden and cannot be visualized with the technology available. Little is therefore known about the reaction pathways underlying food-processing procedures at the molecular level.

Radioactive nuclides – in this case, the nuclide carbon-14 ( $^{14}\text{C}$ ) – can be used to label source compounds of interest so that their fate can be determined and quantified with appropriate analytics. Their fate, be it degradation, reaction with other ingredients or a whole reaction cascade, can then be understood. Since breakdown products of the original labeled substance will also be marked, both the source compound and its residues can be tracked throughout the processing procedure and a balance taken. Our laboratory has already acquired a nickname: The 'radio kitchen' is fitted with all the key processing equipment used in the food industry as well as that of a normal domestic kitchen so as to reproduce the following technological areas:

- Fruit processing/beverage technology
- Cereal crop processing/milling/baking technology
- Meat processing technology
- Restaurant and domestic cooking

This extension of our activities into the area of food quality and safety arose from our long-term expertise in chemical analysis at the Fraunhofer

**Outlook: Simultaneous optimization of resource efficiency and food quality**

IME with a recent research focus on plant and animal metabolism. We can now cover the entire agricultural value chain – from environment to agricultural product and finally to the fork of the consumer. Thus research on animal and plant metabolism, established over many years at the IME and relevant to registration tests, can now be supported and usefully extended.

In this context, the Fraunhofer IME has since 2016 collaborated with the Fraunhofer Institute

for Process Engineering and Packaging IVV in an internal Fraunhofer research program. The aim here is to track pesticides and their transformation or breakdown products from plant cultivation through to ready-to-eat foods and finally to minimize the formation of harmful products during the manufacturing process.

In food quality research, modified food processing procedures can be geared towards the formation of specific reaction products. Thus changes can be made to the temperature profile and recipe so as to improve resource efficiency and simultaneously observe what effect this has on the reaction pathways underlying the aroma profile. At the same time, undesirable metabolites formed during processing can potentially be broken down into uncritical degradation products by longer retention times.

**AE Environmental and Food Analysis**

The process cascade from raw material to consumer is often long.

