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The Role of Extrusion within Sustainable Food Research

Sustainability is an essential trend in the food sector, on levels of both nutrition and food production. What drives the sustainability aspect from a consumer and processing standpoint?

Sustainability is a megatrend, affecting almost every sector in business. The food sector is one of these. There are numerous factors that make up the driving forces behind the sustainability trend, and one obvious reason for its popularity can be put down to the fact that, on a near-daily basis, consumers are exposed to food-related information. Consumers are now more aware than ever that their choices have a marked impact on the environment and unfortunately, it is not always positive.

Consumers are searching for solutions to reduce the possible negative impact of their diet on the planet, and this heightened awareness has meant that the food industry has needed to undertake major concept revolutions. These changes include moving on from traditional foods that we have been consuming for a long time to more sustainable food products.

The food industry has begun to look for new alternatives and more sustainable ingredients to produce and design food products, but in replacing conventional ingredients with more sustainable ones, there can be adverse effects on a product's flavor, mouthfeel, odor, and texture.

Consider meat products. Proteins are being sourced from more sustainable areas more and more often and is an increasingly important factor in production. There is one fundamental question that comes from this practice: how can high-protein foods from more sustainable sources, such as plant proteins, micro-algae, or even insects, be produced?

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What role does extrusion play in this?

Extrusion is a method of production that has been used since the 1950s to produce meat analogs from plant proteins. To this day, it continues to be a focus for researching new meat analog formulations. The products made through this method need to resemble meat-like fibrillar textures, quality consumers looking to reduce their meat consumption do not want to give up. As such, these new products need to possess the features of meat, such as its beefy flavor and juicy mouthfeel.

Extrusion allows for a huge degree of flexibility with respect to the raw material selection and the wide range of food products that can be designed using this system. This makes extrusion very attractive for research because it can offer numerous solutions to designing more sustainable food products.

What is KIT's research focus in the field of sustainable food and what applications do you see your research having?

In designing sustainable food systems, we have been working in three different areas. The first area is the design of meat analogs, which are based on plant proteins like wheat, soy or pea proteins, or other plant proteins in general. We analyze the extrusion process, studying the mechanisms that are responsible for creating meat-like structures in products.

Another focus of our research is related to the so-called functionalization of alternative proteins, again concerning the use of extrusion technology. By functionalization, we mean that the proteins can obtain new or improved properties, from better solubility and digestibility to improved texture-giving properties, which allow them to then be used in the formulation of both traditional and innovative food products.

Our third area of research is in a promising, alternative area: the functionalization and up-cycling of food by-products for fruit and vegetable processing. In food production, there is a vast amount of food by-products, such as apple and carrot pomaces from apple and carrot juice production, and potato peel or pulp from potato production.

These raw materials are very rich in fibers and bioactives, and bioactives are very valuable. But these raw materials are not fully utilized. This is because their addition to food products can adversely affect the texture and mouthfeel of foods.

With extrusion technology, we can change the functional properties of these raw materials and allow them to be used in food formulations, not only to increase the fiber and bioactive content of these formulations, but also to create specific textures in food products such as bakery products, smoothies, or even sausages. These are the three domains that we are working on.

What are the challenges in the production of protein-based foods?

The production of protein-based foods is not a big challenge in itself. The challenges come when you have to achieve a very specific product characteristic when new or different protein sources are used.

Each protein has a different molecular structure and, as a result, they also have different properties. This means that it is not possible to use the same process to produce the same product from different proteins. Consequently, there needs to be a deeper understanding of those traditional food processes at a mechanistic level. This level of understanding is typically achieved after many years through trial and error. After that, we are able to adapt the process according to the needs of each specific protein.

For example, consider meat analog production by extrusion processing. Through this method, we are able to produce meat-like textures, but consumers demand a very exact taste profile and mouthfeel found in meat before they accept a meat substitute. Meeting these demands requires a comprehensive understanding of the process and behavior of those sustainable proteins used, which allows us to design tailor-made, meat-like structures. This is the challenge we have as the starting point for our research.

Which instruments have been helpful in conducting your research?

We use extrusion as the core technology of our research. Although extrusion is not the only technology used to design new sustainable food alternatives, it is one of very few food manufacturing processes that has seen continuous improvement since its invention.

Could you explain how and why extrusion is used in your research?

Extrusion is one of the very few processes that offers a high degree of flexibility when selecting the raw materials and process conditions necessary to produce a wide range of food products. In short, we can use one extruder to produce many different food products.

Extruders can be used as bioreactors in order to adjust the functional properties of most types of food ingredients, and it can also be used as a structuring process to give specific textures to ingredients. With meat analogs, different textures and flavors might be needed for breakfast links, ready-to-eat snacks, or even pet foods. It is very rewarding to see all the new food formats that can be realized with extrusion technology for this type of research.

You have been working with the Thermo Scientific™ Process 11 Twin-screw Extruder for your research. What are some of the benefits of using this extruder and how has it accelerated your research?

We work on an experimental level that tests the limits of the extrusion process. This can generate more technical questions that we want to explore, such as possible extensions, adaptations, and developments for the process. Because of this, responsive technical support and consulting are crucial for our success. This is one of the main reasons why we decided to work with Thermo Fisher Scientific.

The Process 11 Extruder itself is a small-scale, benchtop format, that is very easy to handle, and it is also easy to make changes to process parameters, too. This means we can perform a number of experiments in an effective and time-efficient way when testing different materials and process conditions.

The Process 11 Extruder also has technical advantages, such as its modular design, which makes it easy to change its screw configuration to adapt the process condition to the protein being used. It has different dosing locations to add ingredients along the extruder barrel, which helps in the optimization of the final formulation. It can also accommodate different throughput levels with a wide variety of screw speeds.

All of these features improve the flexibility of the extrusion process, and we can create very mild to very harsh processing conditions, depending on the application, as a result.

Yet another advantage of this extruder is the amount of material needed for the experiments, which can vary between several hundred grams per hour to two kilograms per hour. It is a particularly important feature for us, as we sometimes work with model systems to gain more fundamental information about the process.

However, these model systems are often very high in purity, making them very expensive to obtain in large amounts. But, this is not an issue with the **Process 11 Extruder**, as it allows us to work with very small amounts of raw materials for research-scale testing.

The list of advantages is long, but these are the initial benefits that we see with this system.

Where can our readers find out more about your research?

The easiest way readers can find out more is to take a look at our website. There, readers will see a log of extrusion that will direct you to **our website**, where they can see all the publications and projects that refer to the topics I have mentioned here.

Thermo Scientific Process 11 Twin-screw Extruder

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About the author

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Dr.-Ing. M. Azad Emin received his PhD degree in Process Engineering from Karlsruhe Institute of Technology (KIT) in Germany. Subsequently, in 2013, he has established the extrusion research group in the Institute of Process Engineering in Life Sciences at KIT. He is currently leading a research group of 6 PhD students focusing mainly on the analysis of extrusion processing at mechanistic level to design sustainable and functional food systems. Alternative proteins based food formulations is, therefore, one of the main topics (with the total project budget of 2M€), he has been working on. His research has been acknowledged by several awards including EFCE Food Engineering Award (2013), BBGG -Award (2015), IUFoST Young Scientist Award (2016), and ProcessNet-Food Process Engineering Award (2016).

Find out more at **thermofisher.com/process11**

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