Structure analysis of plant-based meat

While the global demand for plant-based meat continues to grow at a rapid pace, many consumers still lack variety in marketed products, especially in terms of meat types and protein sources. To cope with this demand, food companies continue to develop new ingredients and products with the goal to mimicing the taste and texture of meat. (1)

Structural properties of plant-based meat

Twin-screw extrusion is considered a key technology for producing plant-based meat. It utilizes a continuous process with a range of adjustable parameters that enables the production of different textures. To obtain plant-based products with a texture perception similar to that of muscle meat, the extrusion aims to impart an anisotropic, fibrous and gel-like structure into plant proteins. An exemplary product with a typical, meat-like texture is shown in Figure 1.

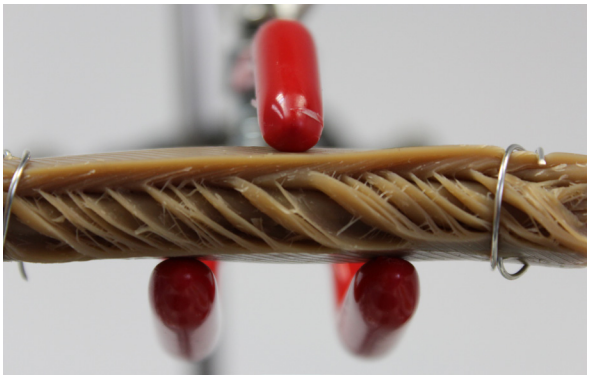

Figure 1: Plant-based meat extrudate made from pea protein isolate with Process 16 Twin-screw Extruder.

It is nowadays assumed that the fibrous characteristic of plant-based meat derives from the presence of a multiphase system. (2) The anisotropic nature of these structures is imparted into the final product by the specific flow pattern in the extruder die. It is therefore necessary during product development to understand the formation of these distinct structural elements in extrusion processing.

SEM as the ideal tool for structural analysis

Scanning Electron Microscopy (SEM) has proven to be a suitable method to visualize and evaluate these characteristic structures in a relevant size range. (3) In particular, the Thermo Scientific™ Phenom™ XL G2 Desktop SEM is a powerful tool for assessing the structure of plant-based meats. With its unparalleled ease-of-use and speed, results can be obtained effortlessly. The large sample capacity and low vacuum capabilities allow many extrusion products to be imaged simultaneously without any sample preparation. Examples of structure analysis using Phenom XL G2 Desktop SEM in development of plant-based meats are given below.

Figure 2: The Phenom XL G2 Desktop SEM has the fastest time to data: < 1 minute to SEM image. No sample preparation or coating is required.

Assess influence of process and formulation

Figure 4 shows the SEM image of the plant-based meat product displayed in Figure 1. The SEM image reveals that the structure of the sample consists of a gel-like matrix with further embedded elements, which can be identified as dispersed phases. While food scientists are still exploring the nature and composition of the dispersed phases by different analytical techniques, (3) the image allows one to qualify the orientation and anisotropy of the structural elements contributing to the texture perception of the final product.

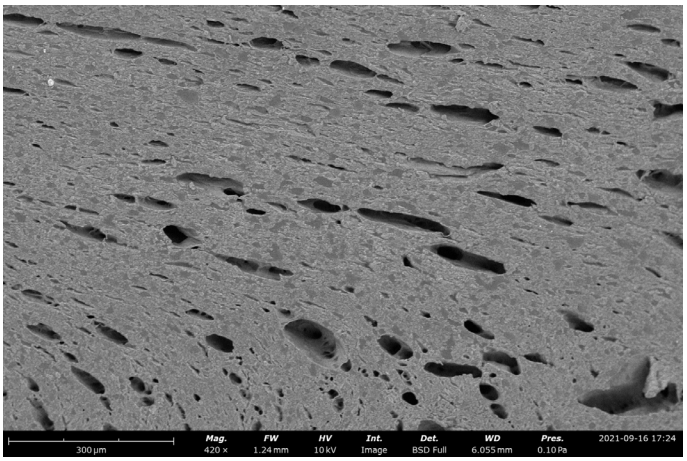

Figure 3: SEM image of plant-based meat extrudate made with Phenom XL G2 Desktop SEM. Comprehensive overview via Automated Image Mapping.

The Phenom User Interface includes automated software that scans large areas, as shown in Figure 4. These samples were retrieved from varying extruder die lengths. The image indicates that varying the die length imparted different flow patterns into the extruded samples. Putting these images in relation to the visual sample appearance and texture analysis (4) allows product developers to define decisive process conditions that need to be controlled to obtain specific textures. The results shown in Figure 4, for example, indicate that homogeneity of product texture results from varying velocity gradients in the flow profile, which can be controlled via die length.

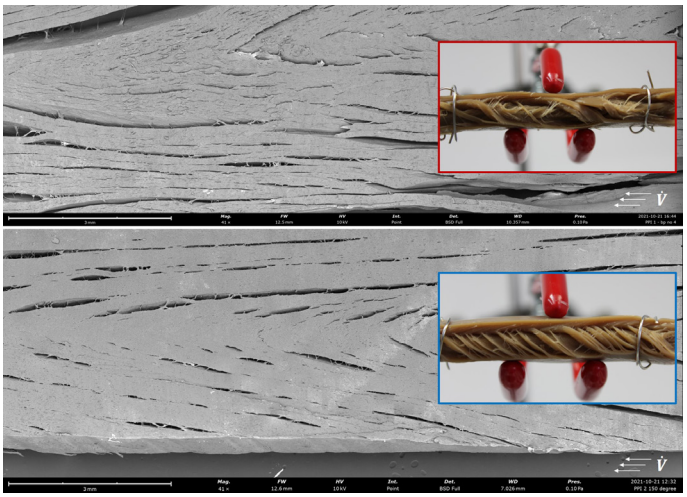

Figure 4: Stitched large area scan of plant-based meat extrudates, red: die length = 270 mm; blue: die length: 360 mm.

Compare animal to plant-based meat

Figure 5 shows an SEM image of muscle meat. The image depicts the layering of muscle and connective tissue, which define the main structural elements that need to be mimicked in plant-based meat. When looking at Figure 3 in comparison, the structure of the selected plant-based meat sample only resembles to a certain degree the fibrous nature of muscle tissue. Thus, SEM analysis can be applied to study differences in the structural composition of animal and plant-based meat. These results can give product developers guidance how to obtain structures more comparable to various meat types.

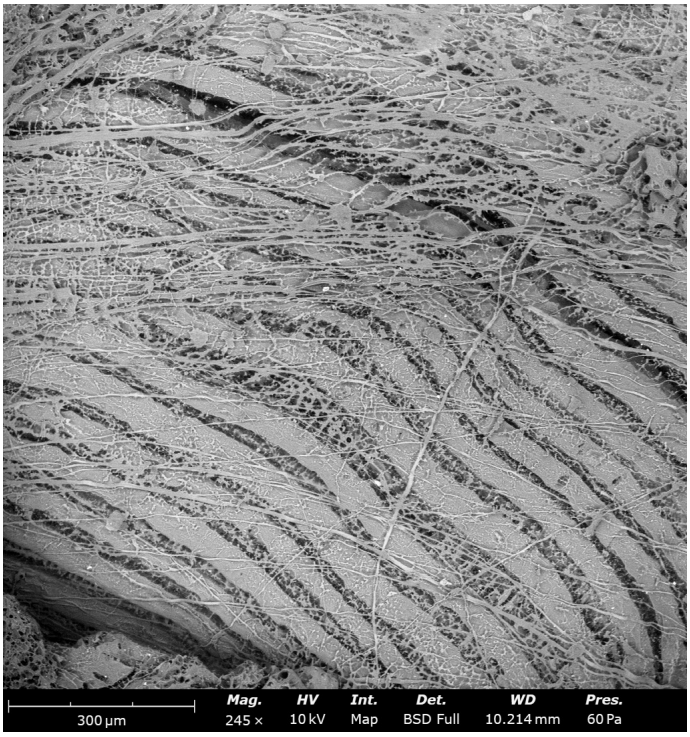

Figure 5: Beef muscle tissue, image made with Phenom XL G2 Desktop SEM.

Complete your workflow

Together with Scanning Electron Microscopy, lab-scale extrusion and further advanced analytical equipment, Thermo Scientific broad technology portfolio provides state-of-the art equipment that can be used along multiple points of the workflow in the plant protein-based meat industry.

References

1. Plant-Based Protein: Global Markets, BCC Publishing Staff, Report Code: FOD092B, July 2022.
2. Dekkers, et al. (2018). Structuring processes for meat analogues. Trends in Food Science & Technology. 81.
3. McClements, et al. (2021). Methods for Testing the Quality Attributes of Plant-based Foods: Meat- and Processed-Meat Analogs. Foods, 10, 260.
4. Pietsch, et al. (2020). White Paper WP04 0320, Combining extrusion, electron microscopy and rheology to study the product characteristics of meat analog products.

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