Crafting the perfect bite of meat: Engineers develop metamaterials that mimic muscle and fat architecture

January 8 2025

Lamb Chop – Wood. Credit: Hebrew University

In a new publication in *Nature Communications*, Israeli and Palestinian engineers from The Hebrew University of Jerusalem pioneered the use

of metamaterials to create whole cuts of meat. The work leverages cutting-edge materials science to overcome the long-standing challenges of replicating the texture and structure of traditional meat while offering a scalable and cost-effective production method that surpasses 3D printing technology.

Metamaterials are composite materials whose properties arise from their structure rather than their composition. By adopting principles typically used in the aerospace industry, the team, led by Dr. Mohammad Ghosheh and Prof. Yaakov Nahmias from Hebrew University, developed meat analogs that mimic the intricate architecture of muscle and fat. These analogs are produced using injection molding, a high-capacity manufacturing process borrowed from the polymer industry, marking the first time this technology has been applied to alternative meat production.

Central to the innovation are two novel metamaterials: a low-temperature meat analog (LTMA) that replicates the fibrous texture of muscle tissue, and proteoleogel (PtoG), a plant-protein-stabilized oleogel that emulates the structural integrity and cooking behavior of animal fat. Together, these materials allow the creation of complex meat cuts, such as steaks, chops, and T-bones, with remarkable precision and sensory fidelity.

The implications of this technology extend beyond culinary innovation. Unlike existing 3D printing methods for meat analogs, which are slow and expensive, injection molding offers a transformative leap in scalability and affordability. At large-scale production, this method reduces costs to $9 per kilogram, nearly a quarter of the cost of 3D printing, making sustainable meat alternatives accessible to a broader audience.

Blind taste tests conducted as part of the study revealed the sensory appeal of these products, with participants seemingly unable to

distinguish between steak analog and traditional meat. This milestone signifies a major step forward in consumer acceptance of sustainable protein alternatives, particularly for whole cuts, which represent over half of global meat consumption.

MetaFat. Credit: Hebrew University

"Our work demonstrates the untapped potential of metamaterials in food technology," said Prof. Nahmias. "By harnessing their unique structural properties, we have developed a solution that is not only sustainable but also scalable, addressing the growing global demand for meat while mitigating its environmental impact."

The study represents a convergence of materials science and gastronomy, offering a blueprint for the future of food production. With livestock farming accounting for over 30% of global freshwater use, innovations like this are crucial for building a sustainable food system. By introducing new metamaterials into the culinary landscape, this research opens new possibilities for designing food products that are as appealing as they are sustainable.

More information: Mohammad Ghosheh et al, Metamaterial-based injection molding for the cost-effective production of whole cuts, *Nature Communications* (2024). DOI: 10.1038/s41467-024-54939-y

Provided by Hebrew University of Jerusalem

Citation: Crafting the perfect bite of meat: Engineers develop metamaterials that mimic muscle and fat architecture (2025, January 8) retrieved 9 January 2025 from https://phys.org/news/2025-01-crafting-meat-metamaterials-mimic-muscle.html

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