Crispy jellyfish, milk mayo, and crackling vegan sausage – just a few of the specialties from the laboratory of Thomas A. Vilgis. The research group leader at the Max Planck Institute for Polymer Research in Mainz approaches cooking with scientific precision and has thus found the perfect synthesis of his two passions.

TEXT: CATARINA PIETSCHMANN

Chanterelles with dumplings, interspersed with a few diced carrots, still slightly crunchy. "It's always important to have different textures in your mouth. That makes it more interesting for the tongue," says Thomas Vilgis as he continues to dissect the mushroom dish with his fork. "The carrots are still neatly cut by hand. Beautiful irregularities. Just the way I like it!" Anyone who dines with Vilgis can't help but ask what he notices about the meal, as well as pondering their own mouthfeel. This man is neither a celebrity chef, nor a nutritional physiologist or food chemist – he's actually a theoretical physicist. But he knows exactly what he's talking about. Thomas Vilgis is in charge of the "Soft Matter, Food Physics" group at the Max Planck Institute for Polymer Research in Mainz until 2024. He and his team investigate food structures and research novel foods. But exact science is only one side to Thomas Vilgis. In addition to countless specialist publications, the 67-year-old has now written more than 20 popular books covering the science of cooking, unusual taste experiences, and – of course – recipes. Spring this year saw the publication of *Der Genussforscher (The Taste Researcher)*, adapted from his Saturday afternoon podcast on SWR, *Kochen mit Genussforscher Prof. Thomas Vilgis (Cooking with Taste Researcher Prof. Thomas Vilgis)*, complete with a recipe for download. His latest work – *Noch mehr Kochen für Angeber. Die geheimen Tricks der Sterneküche (Even More Cooking for Show-offs. The Secret Tricks of Acclaimed Cuisine)* – has just hit bookstores, and his standard work, *Aroma. Die Kunst des Würzens (Aroma. The Art of Seasoning)* is already in its fifth edition. He is also co-editor of the *Journal Culinaire,* the magazine for the culture and science of food. Professor! How did this all come about?

Thomas Vilgis laughs. "Ah, that is a strange story. I had been working with soft matter for a long time. At first it was rubber and other polymers, later colloids, then proteins. I was a typical paper-and-pencil theorist – but then computer simulations developed incredibly quickly, and this soon made it possible to explore the boundaries of theoretical physics more easily than on paper via so many approximations." He didn't want to delve into simulation himself, not least because another window had already opened: through it, he could see pots and pans from which irresistible aromas wafted, unexplored textures of food … All of which was essentially just waiting for him to analyze and understand it. Partly to blame for this was food critic Wolfram Siebeck, whose column in *Die Zeit* was regular reading for Vilgis, himself a passionate amateur chef. Once, when Siebeck excoriated a special way of baking pizza, Vilgis wrote a letter to the editor: what Siebeck had tried out in this instance was nonsensical from a physics perspective anyway, he explained, because ... And a short time later, the editor-in-chief of *Essen & Trinken* asked whether Vilgis might write a regular column on "Food and Natural Sciences" – that was back in 1999. Mussel mousse, melon caviar – molecular cooking was also making its way into Germany's haute cuisine at the time. "People were

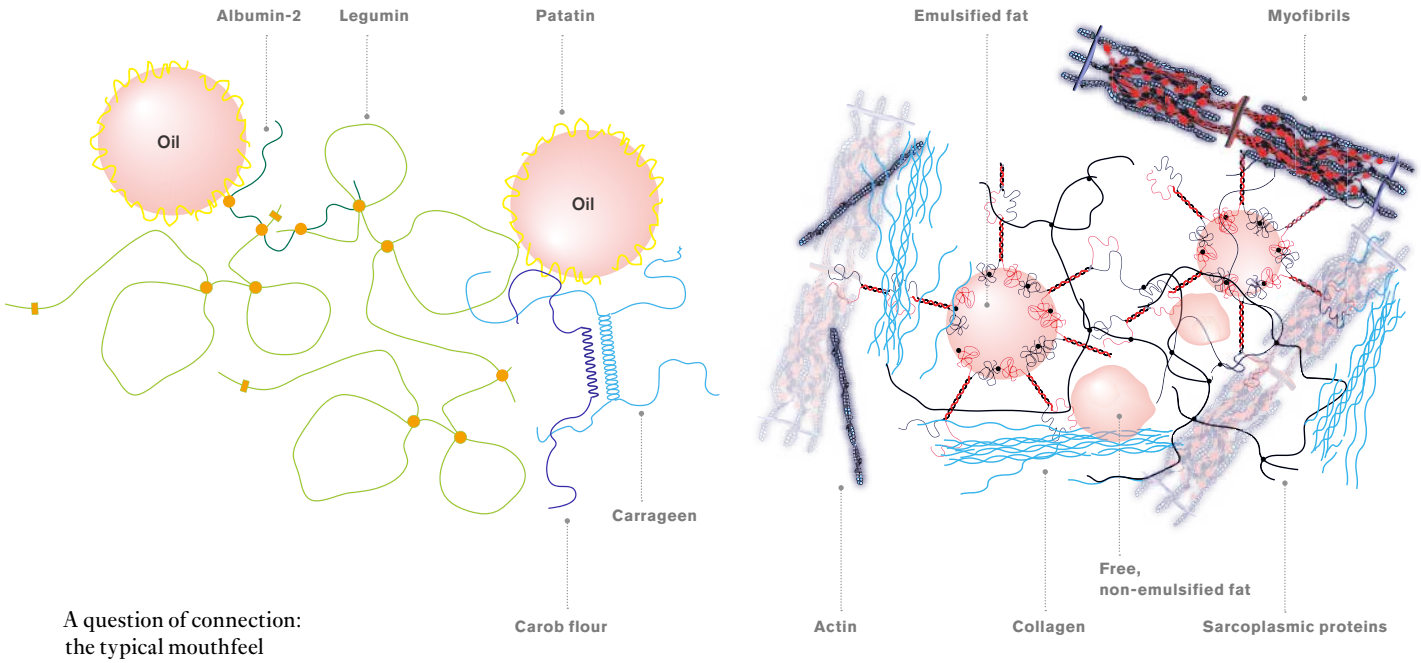
→

VISIT TO

THOMAS VILGIS

PHOTO: KATRIN BINNER FOR MPG

The tear test: Thomas Vilgis investigates the physical properties of food, including the difference in textures between Mortadella and vegan sausage.



A question of connection: the typical mouthfeel produced by meat sausage (right) results from the close-meshed linkage of myosin and sarcoplasmic proteins (black dots). The collagen also causes a partly elastic and partly viscous behavior. This effect, as well as the ability of collagen to bind water, is something researchers are trying to imitate in vegan sausage (left) using xanthan gum, carrageenan, or other binding agents. However, since the binders separate from the chemically cross-linked plant proteins due to their chemical properties, vegan sausage can generally stretch much more than meat sausage.

experimenting wildly with gelling and thickening agents – all pure polymer physics." Thomas Vilgis met the French physical chemist Hervé This, whose book *Kitchen Mysteries: Revealing the Science of Cooking* was causing a furor at the time. "We quickly became firm friends and have enjoyed many a discussion ever since."

Applying physics to analyze food and its preparation methods? Why not! "I was already at the Max Planck Institute at the time, and I mentioned it. It really sparked a fire right away. I got a budget, two lab rooms, and bought our first rheometer." The latter is a device that can be used to determine the elasticity, flow behavior, and shear forces of a material. It consists of one fixed and one movable plate, and the sample is placed between the two. "Things really took off when a manufacturer of food production machinery asked if we could investigate the flow properties of pasta dough for them," Vilgis recounts. The research project secured a postdoc position for two years. In addition to actors within the food industry, doctoral students frequently approach him with exciting ideas of their own. And he is largely driven simply by his own curiosity – for example, the question of what gives caviar its particular mouthfeel. "I got hold of some caviar and trout eggs for comparison and put both under a universal testing machine that had been temporarily converted into a texture analyzer." In it, a stamp slowly but steadily presses down on the sample from above. This is pretty much what happens between the palate and tongue as caviar is "processed" in the mouth. Initially, we see the high elasticity of the eggs' outer membrane, followed by their bursting as the force suddenly drops. "At that moment, all the flavors are released explosively in the mouth." Collagen and elastin in the tiny egg membrane form a very special network, Vilgis found. "In order to describe the tear propagation and bursting, I unpacked what I had learned some time before about the theory of rubber elasticity."

Sugar substitutes, vegetarian and vegan products, current food trends – the topics Vilgis covers are incredibly varied. Some of them are bizarre, such as the jellyfish chips he is researching together with Danish researcher Mie Pedersen. In Asia, where cnidarians are traditionally eaten, they are placed in a mixture of table salt, calcium chloride, and aluminum salts after being caught. "As the monovalent, divalent, and trivalent ions accumulate, the proteins contract, and the jellyfish is dehydrated. The result is a kind of gelatin gum, but it's quite crunchy," Vilgis explains. Aluminum salts are suspected of promoting Alzheimer's, so Mie Pedersen tried some-

GRAPHIC: MEAT, VEGETARIAN, AND VEGAN SAUSAGES: COMPARISON OF MECHANICS, FRICTION, AND STRUCTURE; PHYSICS OF FLUIDS 34, 047112 (2022); M.GHEBREMEDHIN, M. BAECHLE, T. A. VILGIS

thing new: instead of salt, she put the animals in 96-percent alcohol. Jellyfish proteins bind a large amount of water but are poorly soluble in alcohol and clump together – polymer physics par excellence. This also removes water from the animal and shrinks it into a flat disc, which is then dried out. "You get a crisp, salty chip that makes a great aperitif or provides a textural element in certain dishes."

Sometimes the Institute resembles an experimental kitchen. Mayonnaise is usually made with eggs, but milk can also be used as an emulsifier, as studied by master's student Katja Braun. "We took some milk and then slowly drizzled in the oil while stirring vigorously." Vilgis had already tried this a few times at home. But how stable does this emulsion remain? How big are the droplets of oil in the milk mayo? "For this project, we purchased transparent rheometer plates. This allowed us to see exactly at what shear rates the oil droplets become deformed and begin to fuse. In the process, the viscosity changed." It's the moment when mayonnaise suddenly becomes more liquid in the mouth. A milk mayo (without additives) remains stable in a fridge for seven days. The same principle also works in a vegan version – really well, actually – with soy milk. Oat milk, on the other hand, was a flop, for reasons of pure physics.

with minced meat sauce. "To me, it was a fascinating new taste, and that's what ended up on the table at home."

It was while the food projects at the Institute were getting underway that Stiftung Warentest asked if Vilgis could co-author a book on how best to use flavors in the kitchen – all based in science, of course! "As a physicist, I had zero idea about flavorings and fragrances, so I started by reading a lot of original literature." Somehow, Vilgis had to come to grips with thousands of different aromas. But how? Are there specific types of aroma? Apparently, yes. "Chemically, the smell you get from flowers in the spring is all down to acyclic terpenes. Although flowers smell different depending on the plant species, the basic odor is the same, and that also goes for the sulfur compounds in garlic, onion, and cabbage." Herbaceous aromas are based on cyclic terpenes. And so it goes on through eight aroma types that Vilgis color-coded. But wait, there's a ninth: for odorless substances that do not stimulate the taste buds for sweet, sour, salty, bitter, or umami – but rather the trigeminal nerve. Like the pungent capsaicin in chili or oxalic acid, which accounts for the dull, astringent mouthfeel of sorrel, spinach, and rhubarb. "One thing became clear to me: aroma chemists may laugh their heads off at my systematics, but you can put it to

"One thing became clear to me: aroma chemists may laugh their heads off at my systematics, but you can put it to good use in the kitchen."

Even as a young boy, Thomas Vilgis liked to look inside the pots and pans while his mother cooked. So what was his favorite food when he was little? "Liver sausage pate at noon and liver sausage pate in the evening," he recalls with a smile. "This phase was then replaced by chocolate loaf at lunch and dinner, but also lentil stew, Pichelsteiner stew, and sour tripe." In the late 1960s, he took part in a cooking club at school, which was led by the landlady of the Ochsenwirt, a rustic local restaurant in his birthplace of Oberkochen. "The first guest workers from Italy had already made it to small-town Baden-Wurttemberg, and so we once cooked 'baschta schutta'" – *pasta asciutta,* or spaghetti

good use in the kitchen." In 2014, however, an important publication appeared by those previously dismissive experts at the Technical University of Munich. They had been searching for primary aromas in foods and their origins and now indirectly confirmed that Vilgis had been quite right with his intuition. "Phew!"

Nature is playful and complex, and so almost every spice, herb, vegetable, or fruit combines several aroma groups. Vilgis' color code makes it easy to see which ones. It's also easy to see which spices, such as garlic and onion, are similar to each other and enhance the flavor – specialists call this food

⟶

PHOTO: KATRIN BINNER FOR MPG

There may be many cooks, but the broth stays good: Mathias Bächle, Marta Ghebremedhin, Hannah Hartge, Thomas Vilgis, and Juan Carlos Zambrano (from left) jointly develop ideas for new research projects—recently, sustainable nutrition has been a major topic.

pairing – or create exciting contrasts, referred to as food completing because they bring flavors that garlic, for example, lacks – such as lemongrass, ginger, or thyme. Flavors change with processing – and with temperature. So it can make a big difference whether something is eaten raw, boiled, fried, or fermented. Regular sugar, for example, is just sweet. When it is heated to over 150°C in a pan and melted, it becomes caramel – aromatic and crunchy. That's right, textures change, too! "Textures essentially determine the mouthfeel of a food," Vilgis emphasizes. Analyzing and changing them is part of his profession. Recently, for example, his team discovered what makes foie gras melt so delicately and how to recreate it without cruelty to animals – from livers of geese that have not been stuffed. But just how they managed it remains a secret for now.

On the subject of more sustainable foods in general, Vilgis has recently devoted his attention to sausage substitutes. Conveniently, the sausage from a well-known manufacturer is available in the refrigerated section of the supermarket in its original meat version, as a vegetarian version (with egg white), and as a vegan version (with potato and pea protein). "I wanted to know what made the difference, so I talked two PhD students into a Friday afternoon experiment." That gradually evolved into a comprehensive study published in the journal Physics of Fluids. In the rheometer, the samples behaved almost identically, but tensile experiments revealed glaring differences: while the meat sausage was initially very elastic and then quickly tore apart, the vegan one could be stretched almost endlessly. "Most manufacturers mix something together and only pay attention to whether it tastes good, but the emulsification properties of muscle proteins from animals are different to those of plants." Based on the experiments, the team developed models of the microstructure of sausage and sausage substitutes that explain how different proteins affect mechanical behavior and thus mouthfeel. Crucial to the typical feeling of biting into a sausage is the network that the proteins form. Proteins from sunflowers have a better structure for

emulating this than those from peas, and the company has since adapted the recipe for its meatless sausages accordingly. Nevertheless, Vilgis finds it almost reprehensible that pure protein is often used as a meat substitute. "Fiber, polyphenols, vitamins, bulk – everything is disposed of! That's crazy and also makes you less full."

He has no regrets about his shift to food physics. "Quite the contrary! It was the best decision of my life," says Thomas Vilgis. "Methods from physics are very suitable here; they can be applied directly— and I also directly benefit from my work." That's because at the Vilgis family home, they cook every night. "One look in the refrigerator, full power to the flavor library in your head, texture and cooking physics programs running in parallel: and so it begins." His wife takes care of the appetizer; he prepares the main course. After that, there's a tiny bit of cheese, a dessert (often fruit), and a bit of chocolate to finish. You wouldn't know it by looking at him – no wonder, then, that he confesses to doing "a bit of exercise": 100 push-ups and 100 situps almost every day after getting up, and extensive weight training on Sundays. At the Institute, meanwhile, he always moves with "excessive speed," running up and down the stairs. Even when sitting or standing, he fidgets around, sometimes tensing one muscle, sometimes another. This is good for the autochthonous dorsal musculature, says his personal physiotherapist – and longtime spouse.

was no fresh fish, so Vilgis was treated to fish fingers or "fish sticks" instead. "I loved them! Whenever we have them in the cafeteria, I stand at the front of the line and feel like I'm five again."

Thomas Vilgis generally cooks without a recipe and is always on the lookout for new, unusual taste experiences. The scientist wastes no time; food completing starts with Sunday breakfast – to the large muesli, comprising various fresh and dried fruits, are added herbs from the family's own garden. Sometimes marjoram – "the more intense, the better" – sometimes thyme, sometimes basil. Whatever's growing at the time. His favorite spice is tonka bean (hay-like, notes of vanilla, slightly bitter). "In desserts, it is often used together with vanilla. Add a pinch of nutmeg, and it's like a perfume." But he also adds the tropical spice as a "final rub" to savory things: roast potatoes, chicken, fish, and even red cabbage. "Caramelize sugar and butter with a little vanilla in the pan, briefly roast the finely chopped cabbage in it, pour some cream over it, a little tonka bean, and salt. Mmm! Perfect with game." This is likewise covered in the cookbook Der Genussforscher – as are cold fruit minestrone with Campari, heel muscle of beef flavored and trussed, and creamy celery nut vegetables, among other things. To finish, perhaps a "Cossack croissant" from the famous Loriot comedy sketch? Instead of whipped cream, Vilgis crowns the legendary dessert – a mocha truffle parfait with lemon cream balls – with a tiny meringue. That

"Convenience foods and frozen goods only make it onto my plate for scientific purposes."

The couple met in Ulm, where he was studying physics. Since then, they have been going to the weekly market together every Saturday. Vilgis' dietary principles: only fresh and seasonal food. Snacks between meals? Never! Never eat until you're completely full. Variety is what satisfies you – not quantity. "Convenience foods and frozen goods only make it onto my plate for scientific purposes." Although … there is one thing he finds hard to resist. In the past, at home in the Swabian Alb, there

makes it particularly difficult to divide exactly down the middle – a problem that ruined the friendship of two married couples in the Loriot sketch. But Thomas Vilgis, of course, is not interested in sowing discord with this variation; rather – as you might guess – in the exciting combination of textures and flavors for the sake of an exhilarating mouthfeel: cold, creamy, and crisp – bitter, sour, and sweet.

www.mpg.de/fleischfreie-wurst (in German)