Taste-Shaping-Natures

Making Novel Miso with Charismatic Microbes and New Nordic Fermenters in Copenhagen

Joshua Evans and Jamie Lorimer

Taste shapes evolution, microbes make tasty food, and humans and microbes have been shaping each other for a long while. Yet anthropological accounts of evolution and domestication have given little consideration to taste, microbes, or fermentation. In this paper we develop the concept of "taste-shaping-natures"—natures shaping and shaped by taste—to highlight these multispecies interactions, based on practices of translated fermentation in the New Nordic Cuisine. Here, chefs combine Japanese microbes and fermentation techniques with Scandinavian substrates to create new products and flavors. Focusing on novel misos made with the kōji fungus (*Aspergillus oryzae*), we illustrate how chefs sense their microbes through smell and taste, and identify the sources of kōji's exceptional microbial charisma. We situate the rise of kōji's allure in the context of New Nordic Cuisine, framed as a high-end response to anxieties about globalization and subsequent nationalisms, a reworking of the scientism of molecular gastronomy, and a postpastoral mobilization of different natures for the reconstruction of regional identity. The analysis traces the natural history of kōji's taste-shaping powers through the biogeographical, ecological, and evolutionary consequences of New Nordic fermentation experiments. The conclusion reflects on how this nascent microbiology of desire revises prevalent understandings of domestication.

Fermentation is domesticated decomposition—rot rehoused. (Sheldrake 2020:229)

It is high summer in Copenhagen, July 2018, and Jason White, deputy head of fermentation at a renowned restaurant called Noma, is showing Evans how they make their yellow pea miso, or "peaso." Miso is a fermented paste consisting of soybeans, rice or other grains, and salt. It is rich in umami (discussed later) and has been used for centuries in Japanese cuisine as a savory base for soups, sauces, glazes, and other applications. Making miso starts with making *kōji*—the Japanese word for the filamentous fungus *Aspergillus oryzae*.[1] Kōji describes these organisms and the ecology formed when they are grown on rice, barley, soybeans, or other starchy or proteinous substrates for use in fermentation.[2] The kōji fungus produces many enzymes that break down larger molecules, facilitating microbial metabolism that enhances the flavor, healthfulness, and preservation of many foodstuffs. Kōji is a cornerstone of Japanese cuisine, used to produce sake, soy sauce, and many other traditional products including miso. For this reason, the Brewing Society of Japan designated kōji the country's "national fungus" (Lee 2019).

Aspergillus oryzae is closely associated with the rice plant (*Oryza sativa*), and as rice does not grow in Scandinavia, it is unlikely there are any indigenous populations of *A. oryzae*. Yet this fungus has found a home in restaurant kitchens across Copenhagen. At Noma, White and his team in the fermentation lab (fig. 1) grow around 75 to 100 kilos per week. White takes us through their process.

White shows Evans through their process, as Evans describes in his field notes:

> First we soak pearled barley overnight and steam it in the oven. When the grains are cooked, we don latex gloves and use dough scrapers to scoop them into a stainless steel tray. Cleanliness is of paramount importance to minimize the chance of unwanted colonization by other faster-growing or more opportunistic microbes. We stir the grains to cool and break up clumps, and when they reach approximately 37°C, we use sugar shakers to dust them with pure white spores of *A. oryzae* purchased from Japan (fig. 2).[3]

1. Kōji may also refer to other *Aspergilli*, such as *A. sojae*, *A. awamori*, and *A. luchuensis*, and even a non-*Aspergillus* fungus such as *Monascus purpureus*, or "red rice kōji."

2. Japanese distinguishes between different states of the fungus: *kōji* refers to the fungus with substrate before sporulation (while it is white and fluffy and ready to ferment with); *tane-kōji* refers to the sporulated fungus with or without substrate (as with pure spore powder or spores on whole dried rice grains); and *kōji-kin* refers to the fungus itself, without substrate. In English kōji seems to be used by most fermenters to refer both to the fungus itself and the fungus grown on substrate. Thanks to Shinya Shoda for this clarification.

3. This albino strain of kōji was purified from a mutation in older black-sporulating kōji near the start of the twentieth century. It became

Joshua Evans is a DPhil student in the School of Geography and Environment of the University of Oxford (Oxford OX1 3QY, United Kingdom [joshua.evans@ouce.ox.ac.uk]) and visiting PhD student in the Section for Evolutionary Hologenomics of the GLOBE Institute of the University of Copenhagen. **Jamie Lorimer** is Professor of Environmental Geography in the School of Geography and Environment of the University of Oxford (Oxford OX1 3QY, United Kingdom [jamie.lorimer@ouce.ox.ac.uk]). This paper was submitted 6 VI 20, accepted 18 II 21, and electronically published 23 VIII 21.

Current Anthropology, volume 62, supplement 24, October 2021. Published by The University of Chicago Press for The Wenner-Gren Foundation for Anthropological Research. https//doi.org//10.1086/714851

Figure 1. The Noma fermentation lab. Photo by Joshua Evans.

Figure 2. David Zilber, then head of the Noma fermentation lab, inoculating a sheet of cooked barley with spores of *Aspergillus oryzae*. Photo by Joshua Evans.

We pack these grains into perforated steel trays lined with damp-wrung linen cloths, slide them into a wheeled rack, and place them in one of the three kōji rooms that are outfitted with temperature and humidity controls and sensors to maintain a warm, humid environment. We set the room to 32°C and 75% relative humidity.

The following day we pull back the linen cloth. Tiny filaments of fluffy white mycelia have begun to sprout and hold the grains together. We mix the kōji to redistribute the growing mycelia and dissipate the heat produced by the fungus's growth and metabolism. The small kitchen space grows fragrant with kōji's smells: flowers, ripe tropical fruits, raw mushroom. We drop the temperature in the room to 28°C to keep the grains from overheating, and we return the racks to allow the kōji to continue growing.

Meanwhile, we shift our attention to preparing the peas.

Yellow peas are a classic Danish ingredient, traditionally cooked until soft, often with pork. Noma chefs have developed misos with many Nordic varieties of protein-rich, leguminous substrates that function in a similar way to soybeans in a traditional Japanese miso. This novel approach to fermentation, of deliberately combining microbes and techniques from other parts of the world with raw materials from the Nordic region—what we will call "translated" fermentation—has emerged within the larger culinary movement known as the New Nordic Cuisine, which has aimed to explore the biodiversity and cultural identity of the Nordic region through cooking.

We leave our dried yellow peas to soak overnight in the refrigerator.

The following morning, the kōji is ready, a relatively rapid fermentation. The mycelia have bound the grains into a spongy white cake (fig. 3). They have penetrated the substrate,

Figure 3. The finished barley kōji. Photo by Joshua Evans.

popular because it did not leave black marks on the clothing of kōji growers and sake producers. Black kōji has since made a resurgence due to its distinctive flavors.

Figure 4. Cooked yellow peas, barley kōji, and salt, mixed and packed into a bucket to ferment into miso. Photo by Joshua Evans.

excreting enzymes that break down starches into simple sugars, proteins into amino acids, and fats into fatty acid chains. The kōji can be used immediately or refrigerated to halt fermentation before it sporulates.

Our kōji ready, we cook the soaked peas, boiling them in a large pot. This is the easiest way to monitor their progress. We must cook the peas to a specific texture: cooked through but still firm. Too much cooking can make the peas too mushy, introducing too much water to the miso such that it will quickly sour from increased bacterial activity. Too little cooking will not cook the peas through, limiting the nutrients available to the microbes and yielding a dry, crumbly texture. Jason bites into one, showing me how to feel with his teeth when the peas have reached the perfect point.

We then use a meat grinder to break up the cooked peas and barley kōji. We combine three parts cooked peas to two parts kōji, add 4% of the total weight in salt, and mix everything together thoroughly. We then take large handfuls of this mixture and tamp it down into ethanol-sterilized, white plastic buckets or large glass jars, as firmly as possible to avoid air pockets (fig. 4). This creates an anaerobic environment that selects for desired bacteria and yeasts and against unwanted molds.[4]

From here, White will frequently taste the miso to ensure that it is fermenting as desired, developing its umami taste and fruitiness, and not going too sour too quickly. After three months, if all goes well, it will reach the desired balance of sweetness, sourness, and umami, at which point it will be used or frozen for later use.

White shapes the microbial ecology of the fermentation as it goes, adjusting temperature, humidity, surface weight, and exposure to oxygen to steer the miso's taste toward Noma's desired balance. Similarly, White is steered by microbes, whose metabolisms shape his sensory and bodily responses through pleasure and disgust, and structure his time and labor, ordering his tasks and often forcing him to stay extra hours or come in on weekends. No one is in full control, nor is this a symmetrical collaboration; but through these intimate, taste-based relations, humans and microbes come to shape each others' lives and livelihoods, in more profound ways than they might suspect.

Taste-Shaping-Natures

Through Evans's time spent making miso at Noma, we learned how White and his colleagues were drawn to kōji and other fermentation microbes for their taste-making properties, how they "learned to be affected" by their visual, haptic, olfactory, and gustatory charisma (Despret 2004; Latour 2004), and how they have influenced their global distribution and natural history (Gan, Tsing, and Sullivan 2018). Bringing kōji cultures from Japan to Denmark and growing them for the first time on Scandinavian grains and pulses creates a novel microbial biogeography. This globalized miso making also generates new microbial ecologies, and these new environments and growth conditions may in turn encourage new trajectories of microbial evolution. Kōji, we argue, is a "taste-shaping-nature," a nature shaping and shaped by taste (we use hyphens to indicate this two-way relation).[5] Its gustatory allure has long entangled humans and other organisms, shaping cultural ecologies and coevolutionary relationships through the transformations of fermentation. Against the backdrop of rising concerns about the loss of microbial diversity (Flandroy et al. 2018; Hanski et al. 2012), in this paper we explore how taste shapes microbes and how microbes shape taste, and with what consequences.

Taste is an important material-semiotic phenomenon that conjoins physiological and social dimensions. It mediates sustenance and satiety, pleasure and survival, and it has world-shaping powers. Taste also means many things. In the scientific literature, "taste" or "gustation" refers strictly to the sensation of chemicals in contact with chemoreceptors on the tongue and in the mouth, in contrast with "smell" or "olfaction," which refers to the sensation of airborne chemicals through contact with olfactory receptors in the nose (Dunn and Sanchez 2021; Shepherd 2013). Taste and smell together are often referred to as flavor. While some social scientists have recently advocated for distinguishing taste and smell in this way (Watson and Cooper

4. Yeasts are unicellular fungi; "molds" generally refers to multicellular fungi. Kōji is also a mold but a desirable one.

5. Taste-shaping-natures do not only or even necessarily involve humans tasting. The preferential grazing of fields by livestock is but one common example of a taste-shaping-nature where nonhumans do the tasting.

2019), we wish to maintain taste's multivalence, as not only gustation but "degustation": the multisensory, considered apprehension of substances ingested by mouth, including the experience of texture or mouthfeel (Spence 2017; Spence, Piqueras-Fiszman, and Blumenthal 2014).

Whether as gustation, degustation, or in even broader aesthetic terms, most work in the social sciences has figured taste as preference and judgment (e.g., Bourdieu 1984 [1979]), including classic anthropological texts that focus mainly on the implications of certain taste preferences (Mintz 1986; Mintz and Du Bois 2002) rather than the perception of how things taste. More recent work on the "anthropology of the senses" (Sutton 2010) and "sensory ethnography" (Pink 2010) has begun to approach taste as perception (Ingold 2000). This "sensory turn" helps capture the material-semiotic character of degustation as an activity that emerges in practice (Teil and Hennion 2002), whose different functions are enacted in different circumstances rather than as fixed, preexisting states (Mol 2011, 2012), and whose performances are highly trainable (Majid et al. 2017). Recent ethnographies illustrate this material-semiotic malleability (Besky 2020; Counihan and Højlund 2018), while related work on the political ecology of food has shown how consumer tastes come to shape organisms, breeds, and ecologies (Guthman 2019). Rather than try to sort out once and for all what taste "really" is, this article attends to how invocations of taste flip between and blend these dimensions.

Anthropologists concerned with tracing taste's world-shaping powers build on established literatures documenting how agriculture, food, and cooking have shaped human history (Laland, Odling-Smee, and Myles 2010; E. Russell 2011; Scott 2017; Wrangham et al. 1999). Domestication is a central—and contested—concept in this work. Prevalent accounts index domestication to anthropocentric control and focus on the human tailoring of plants and animals to the Neolithic agricultural domus (e.g., Bökönyi 1969; Clutton-Brock 1989, 1992; Ducos 1978, 2016 [1989]). Alternative accounts challenge the anthropocentrism (e.g., Anderson 1997; Payne and Evans 2017; N. Russell 2002) and human exceptionalism (Leach 2003) of this work, shifting attention to the mutualistic agencies of plants and animals in domesticating people, entangling humans in relations of mutual benefit (Cassidy and Mullin 2007). But taste as a driver of domestication figures only on the margins of these discussions, found in pioneering writings by figures like Gary Nabhan (2006) and Michael Pollan (2002, 2018) on the selection and dispersal of, for example, apples, potatoes, chili peppers, and certain fungi.

In this modest literature on taste-shaping-natures, moreover, most examples focus on familiar plants and animals. To date there is very little work on tasty microbes as agents of historical change.[6] This is surprising, as hominids have been interacting with microbes for millennia, knowing them not through microscopes or DNA sequences but through the senses, particularly in fermentation. Long before the emergence of *Homo sapiens*, our primate ancestors collected and enjoyed consuming fermenting fruit (Amato et al. 2021*a*, 2021*b*; Carrigan et al. 2015). Subsequently, alongside other preservation methods such as salting, smoking, drying, and more recently pasteurization, fermentation has played a key role in making food safe, long-lasting, and nourishing (Katz 2012). It has also created objects for economic and cultural exchange and for the construction of cultural identities (Jasarevic 2015; Yamin-Pasternak et al. 2014). Fermentation foodways are older than human society, and their geography is overwhelmingly varied and nuanced (Carrigan et al. 2015; Steinkraus 1995). The primacy, ubiquity, and diversity of microbes on Earth past and present suggest that compelling stories of taste-driven entanglements with microbes are also there to be told.

6. For a few exceptions, see Flachs and Orkin (2019), Gibbons and Rinker (2015), Gibbons et al. (2012), Money (2018), and Nabhan (2010).

Translated Fermentation in Copenhagen

The specific taste we investigate emerged in a particular time and place. Noma (a conjunction of "Nordisk mad," or "Nordic food" in Danish) was founded in Copenhagen in 2003 by head chef René Redzepi and gastronomic entrepreneur Claus Meyer. It had risen to global renown by 2010, when it was named the Best Restaurant in the World by the World's 50 Best Restaurants list, an authoritative voice in the industry.[7] Noma also played a central role in the creation of the New Nordic Cuisine, a culinary ideology that, in the words of its founders' manifesto, aimed to "express the purity, freshness, simplicity and ethics" they associated with the region (Risvik et al. 2008). The aesthetic and ethos promulgated by the New Nordic Cuisine have since suffused the elite culinary world. Perhaps not coincidentally, 2010 was also the year in which fermentation began to play a key role in the ongoing construction of Noma's culinary style.

Noma's translated approach to fermentation is based on a mixture of principles. For raw materials it has explicitly constrained itself to what can grow in the Nordic region.[8] For techniques, however, it has drawn on traditions across the world, such as ancient Roman *garum* (a salty, savory, fermented fish sauce), Italian balsamic vinegar, and East Asian kombucha (a sour fermented tea) and black garlic, to name but a few. This combination has yielded flavors such as hare garum, black currant leaf kombucha, quince balsamic vinegar, and blackened parsnip that are unlikely to have existed before (Johnson and Williams 2016).

Japanese culinary traditions have been especially formative in this globalization, particularly for Noma's pursuit of umami taste. Umami (旨味) means "delicious taste" in Japanese, coined at the start of the twentieth century to refer to the

7. www.theworlds50best.com.

8. The area stretching from Greenland to Finland, including Iceland, the Faroe Islands, Norway, Sweden, and Denmark in between. In recent years, Noma has somewhat relaxed this constraint.

savoriness triggered by glutamic acid (the receptor was only discovered much more recently). Developing new, regionally appropriate sources of umami was one of Noma's main goals for their early experiments with fermentation. Kōji became a key collaborator in this pursuit because of its enzymatic power: breaking down proteins yields amino acids, some of which stimulate umami taste.

Chefs and culinary researchers at Noma, and simultaneously at a New York restaurant group called Momofuku, began combining traditional applications of kōji with local raw materials and fermentation techniques from other places and times, translating techniques like miso and shoyu/soy sauce from one biogeographical lexicon into another.[9] While mobilities and mixings have certainly been central to the development of fermentation traditions over centuries and millennia, these would have been largely slow and gradual compared with the rapidly combinatorial, geographically discontinuous, deliberate, and flavor-oriented experiments being undertaken by fermenters today. And while pockets of fermenters have been practicing such novel mixings for some decades (Katz 2012; Katz and Morell 2008; Shurtleff and Aoyagi 1983), Noma's global success, its focus on flavor and culinary application, and its concurrence with the contemporary "microbial moment" (Paxson and Helmreich 2014) have contributed to its authoritative position in contemporary fermentation (Redzepi and Zilber 2018), shaping the practices and taste of chefs and home cooks around the world.

Noma's preeminence has also made it a top destination for ambitious cooks, some just starting out and some already with their own restaurants, who apply for three-month unpaid internships known as stages. Completing a stage at a restaurant such as Noma can prove invaluable in building one's culinary career, for the affiliation, network, and knowledge of products and techniques acquired. *Stagiaires* comprise the majority of the production kitchen workforce where prep is completed, while the paid chefs run the service kitchen.[10] Meanwhile, access to dining is limited by price. At the time of writing (summer 2019), the cost of a meal was 2,500 Danish kroner (US$370), with about 1,500 kroner (US$220) for paired wine.[11] Waiting lists run into the thousands.

From 2012 to 2016, Evans was an employee of the Nordic Food Lab, a nonprofit established in 2008 by Noma to investigate the edible diversity of the Nordic region and share the results with the restaurant and food industries, academia, and other publics. From July 2018 to June 2019, he conducted fieldwork at Noma and at a distillery in Copenhagen called Empirical Spirits. Founded in 2017 by two Noma alumni who had been involved for many years in the restaurant's creative, research, and development areas, Empirical employs similar fermentation techniques as Noma, such as extensive and novel use of kōji, kombuchas, and vinegars, to produce free-form spirits and other products. Our research questions required a methodology that combined techniques for sensing taste and microbes across disciplines. Evans pursued a multisensory approach to ethnography, attending to how Noma and Empirical team members experience and articulate taste and smell and how these modalities shape their work. With this sensory focus, he combined ethnographic techniques of participant observation of fermentation, interviews, and textual analysis with structured fermentation experiments, sensory analyses with participants, and DNA sequencing and analysis to investigate possible changes in the microbial ecology of Noma's novel misos and the evolution of kōji at Noma and Empirical.

Taken together, these data illuminate some key features of the taste-shaping-natures of novel fermentations in Copenhagen. We begin with an analysis of how kōji has shaped the material practices of taste. We then explore how the taste of and for kōji and the fermentations it facilitates are distinguished in the New Nordic Cuisine, before focusing on the effects of these entanglements on the fungus and its associated ecologies.

Microbial Charisma and the "Pursuit of Deliciousness"

Copenhagen's New Nordic fermenters have developed a highly influential gastronomic epistemology in their experimental pursuit of novel flavors. In interviews our participants frequently explained how they primarily sense their microbes' presence and agency through smell and taste. Learning how to make kōji and miso for the first time, in particular, required both relying on and recalibrating their already highly refined palates to recognize sensory experiences they knew only by description.

Lars Williams is an R & D chef who built up Noma's fermentation research before founding Empirical Spirits. It was Williams who developed the original peaso recipe. At that time, around 2010, he had not been to Japan as an adult. He had never tasted freshly made kōji. He had tasted many misos, but

9. To ensure safety, all of Noma's fermentations produced for service have HACCP plans, approved and controlled by the Danish Health Authority. HACCP stands for Hazard Analysis and Critical Control Points, a systematic preventive approach to food safety.

10. Recent years have seen growing debate in the restaurant industry concerning *stagiaires*, as it is an existential issue for restaurants of a certain level. On the one hand, while still legal, *stagiaires*' unpaid labor appears increasingly unjust, however much nonmonetary capital they might gain (Danish *stagiaires*, if studying to become a chef, are paid by the state). On the other hand, in an industry with already notoriously thin margins, *stagiaires* make fine dining economically possible. Like public fine arts institutions in Denmark, Noma cannot survive without "subsidy"; yet unlike these other institutions, Noma does not receive public or private funding. Until a structural solution is found for the industry generally, especially at the upper end, having stages is difficult for ambitious restaurants to avoid.

11. A reduced rate of 1,500 kroner (US$240) for the menu with wine was available for students, a rather rare offer for such restaurants.

he had never visited any Japanese miso producers. He explained how he developed his kōji and miso skills through a combination of trawling Google Patents for technical insights and his own taste-based experimentation. Having never smelled or tasted fresh kōji before, however, and not being able to deduce exactly how it should smell and taste only from a description, Williams judged when his experiments worked largely by how much they appealed to his palate: "I wasn't under the illusion that I was making brilliant perfect kōji, but . . . the ones that weren't wrong were, I think, very different than the ones that were. When it's healthy it's very . . . delicious; when it's passable, it still . . . looks healthy, it looks happy, it smells floral and sweet . . . and when it's gone bad it's clearly disgusting, it smells off. It's just sensory analysis."

Williams and other participants made frequent reference to this "chef's intuition" in guiding their inductive discovery of "deliciousness."[12] Though Williams first encountered kōji outside a social context where he could be sure what "good kōji" should smell and taste like—among expert Japanese kōji makers, for example—his chef's palate, developed and sensitized over years of training in the intensely socialized environments of ambitious kitchens, guided his visceral response (Hayes-Conroy and Hayes-Conroy 2010). This gastronomic imperative, combined with conceptual but not embodied knowledge, gathered from afar, of what sorts of flavors and growth behaviors he should look for, is what enabled him to navigate the many hiccups of learning to make kōji without knowing the exact goal.

Once he figured out the kōji, Williams then had to decide how to make his first miso. He proceeded with yellow peas, mainly because they had the highest protein content of all the Danish legumes he researched. He settled on a fairly traditional ratio of three parts legume to two parts kōji. The salt is where he made quite a departure. Most misos in Japan range from 5.5% to 13% salt (Shurtleff and Aoyagi 1983:31–32). Williams aimed to develop the lowest-salt miso he could, because "having something that's lower in sodium just allows you to use it in a wider spectrum of products in the kitchen, [but] anything below 4% [salt] . . . goes lactic very, very fast, and the proteins start to, like, decay instead of [ferment]."

One beneficial feature of this lower salt concentration was that it enabled the growth of tasty salt-intolerant yeasts. Williams knew these yeasts were there not from culturing them in petri dishes or sequencing their DNA but through a combination of microbiological principle and smell. He knew from reading and experience that salt inhibits most fungi, so lowering the salt concentration would allow more yeasts to prosper. The increase in fruity esters, which his flavor chemist colleague had told him were produced when the yeasts' alcohols react with the acids produced by bacteria, confirmed his expectation. By knowing which smells and tastes signal the presence and activity of which microbes, Williams and other fermenters can deduce a detailed "flavorscape" of their fermentations, in turn allowing them to shape the flavor and the ecology in different directions.

As their iterative experiments proliferated, these New Nordic fermenters developed progressively more intimate relationships with the microbial species and communities that made these different smells and tastes possible. Williams's thoughts are illustrative here:

> I definitely feel like they have their own, not to anthropomorphize them, but to anthropomorphize them [laughs]—they definitely seem to have their own personalities and quirks. Like the kombuchas that we actually still have [at Empirical], which are from the same mothers I grew at the Nordic Food Lab, are super robust and happy. You know we talk to other people doing kombucha, they're like, oh yeah it takes two weeks, and these guys, like, four days they're [done]. . . . And each microbe kind of has its, you know, amount of care, and certain things that you really need to look after. I guess the ones I like the most are the kombuchas and the kōjis.
>
> *Why is that?*
>
> I mean, the different strains, like awamori,[13] and also the temperature curves, cause I think the thing that's really interesting about kōji is it's one of the microbes I've worked with that has the most variation in terms of how it changes given the environment you put it in. So, whether pushing it toward creating more amylase or creating more protease [by increasing or decreasing temperature], it actually looks and smells very different. In the case of something like awamori the taste becomes wildly different, because you have to let the temperature fall off to then create the acid.

Microbes do not have faces or fur; we cannot do "fingery eyes" with them as individual cellular bodies (Hayward 2007). Especially in fermentation, microbes invite us to know them and interact with them as populations and communities, primarily through smell and taste, sometimes through sight and touch (as with kōji), and always through pleasure and disgust. But not all microbes do this in the same way. Different microbes—species like kōji and communities like kombucha—have differing degrees of "charisma" (Lorimer 2007): the physiological and aesthetic properties of an organism that configure to what extent, and in what ways, they are sensed by other species and invite their attention. Most work on charisma has explored its visual and haptic dimensions. Touch and sight are important here as well; but this charisma also features an especially olfactory-gustatory dimension, emerging from the production and consumption of tasty molecules.

Fermenters at Noma and Empirical consistently drew attention to how this microbial charisma shaped their

12. A word frequently used by Noma affiliates.

13. *Aspergillus awamori*, a black species of kōji that produces citric acid, used in the production of *awamori*, a traditional alcoholic beverage of Okinawa in southern Japan.

relationships with different microbes, and they identified kōji as an exceptionally charismatic one. The charisma of kōji emerges from its long taste-oriented coevolutionary history with humans; New Nordic fermenters further shape kōji's charisma by modulating and enhancing its flavor by how and on what the kōji grows. Kōji's charisma also stems from its ability to enable ecological interactions among other microbes to produce further tasty molecules, for example, once it is made into miso. And, unlike many other fermentation microbes, which cannot be easily seen or touched, kōji exerts a particular charisma over its fermenters because its relatively rapid growth can be witnessed without technological mediation and because it demands frequent and laborious physical contact in order to grow properly. This care led many fermenters to describe kōji with terms of endearment such as one's "baby," which they perceived as "communicating" with them through its smells, tastes, appearances, and textures. It is in part this exceptional, multisensory charisma that has led to kōji being enrolled, internally and publicly, as the "delicious microbe" of the New Nordic Cuisine.

The Cultural Economy of the New Nordic Cuisine

Fermentation microbes may have the charisma to make history, but they do not gain it in a social vacuum. To understand the proliferation of kōji and why it has been translated into Scandinavia as it has, we need to know a little more about the evolving cultural economy of the New Nordic Cuisine. Redzepi, White, and Williams work at the cutting edge of contemporary cooking, in a global and highly competitive industry. This is an economic world marked by high capital costs, low margins, and a dependence on reading and shaping consumer trends and preferences, contributing to chefs' all-consuming drive to generate new, consistently executed dishes (Tan 2020). Our Danish fermenters have had to frame the taste of microbes in this context. In this section we focus on three dimensions of the recent history of the New Nordic Cuisine that help contextualize the evolution of taste-based translated fermentation experiments: the postpastoral mobilization of wild natures for the construction and reconstruction of regional identity; the reworking of molecular gastronomy's overt scientism; and responses to anxieties about globalization, subsequent nationalism, and the politics of cultural "exchange."

Fermentation and the Shifting Natures of the New Nordic Cuisine

The emergence of the New Nordic Cuisine in the early 2000s tapped into a deep hunger among consumers for "a connection to time and place" (Redzepi 2010). It offered a move toward regional distinction, one example of the well-documented reaction to the perceived homogenizing effects of placeless globalization and the rapid extinction of many locally specific ways of life (Appadurai 1996; Petrini 2003). Nature—or rather, an idealized naturalism (Paxson 2012)—features heavily in this reaction. This naturalism saw New Nordic chefs assemble a wide range of rare and forgotten breeds; ancient techniques; local, seasonal, organic, and biodynamic products; and lots of "wildness" to produce a highly wrought experience of a diverse, bountiful world to which humans might be restored in timeless balance.

In the early days of Noma, this naturalism was prominently expressed through a narrative around foraging—obtaining ingredients from sources other than cultivated ones. The "wild" featured heavily in how these landscapes and ingredients were described, even if for the most part they were sourced from managed places like parks, hedgerows, fields, and forests. This narrative of foraging as a reconnection with nature became central to the Noma identity and shaped their discovery of fermentation, as Williams explained in an interview:

> Before [industrialization] you had more interest in foraging, smoking, pickling, curing, which were a lot of fermentation-based ideas. We wanted to be able to go back to some of those ideas about food which were dictated by the climate and the landscape. In the old days people had to ferment because you had a very short season where things were available, and you had to be able to keep them in an edible state for six or nine months. . . . But broadening the scope of that was the idea [to] take a look at fermentation styles from different parts of the world and then apply those techniques and traditions through the lens of a Scandinavian culinary tradition.

As their interest in fermentation grew, Noma's public storytelling shifted from foraging for wildness "out there" to fermenting wildness "in here." These wildnesses are related but not identical. In foraging, "wild" is often contrasted with "cultivated" or "domesticated," while in fermentation, it is contrasted with "inoculated" or "backslopped." "Wild" fermentations are begun without any deliberate starter culture added, though the built environment, the utensils, and the producer seed the microbial ecology, as with lactoferments like sauerkraut or kimchi. Inoculated fermentations begin with an existing microbial culture, often a "pure" culture such as with kōji or some cheeses, while backslopped fermentations begin with some of the previous batch of the finished product, like kombucha or vinegar, or a backslopped starter culture like a sourdough.

Many of the earliest fermentations at Noma were "wild" lactoferments, for example, of plums or ceps.[14] This was partly because they were rather straightforward: simply add a small amount of salt (often 2%), keep the product in its own brine, and wait, tasting as it goes to reach the desired balance of sourness. But these fermentations also played directly into the New Nordic Cuisine's narrative of wildness and allowed chefs at Noma to link their practices with the emerging

14. Mushrooms also known as porcini or edible boletes (*Boletus edulis*).

discourse of "microbial terroir" (Felder, Burns, and Chang 2012): the notion that any site, and the products from it, had a distinct community of bacteria and fungi that would uniquely shape the flavor of its "wild" fermentations.

The New Nordic Cuisine's naturalistic storytelling speaks to what Heather Paxson (2012) terms a "postpastoral" imaginary, in which largely urban citizens recreate a pre-industrial countryside inhabited by wholesome, rooted laborers attuned to seasonal and ecological rhythms and adhering to low-intensity, nonextractive foodways. This beguiling ecological vision could largely accommodate foraged produce and wild lactoferments, but it had to be reworked as more complicated fermentations like kōji and miso were developed. As we have seen, these products involve inoculation, strict hygiene practices, and sophisticated technologies for the atmospheric control of temperature and humidity—features harder to reconcile with a primitivist aesthetic.

Technoscience in the New Nordic Cuisine

To understand the ways in which Noma practices and narrates the science of miso making and other translated fermentations, we also need to understand how the New Nordic Cuisine was shaped by the growing dissatisfaction in some influential circles with the then-dominant ideology of culinary modernism, sometimes dubbed "molecular gastronomy." This movement, whose epicenter from the 1990s through the late 2000s was a celebrated restaurant named El Bulli in northern Spain, emphasized technique and unfettered human creativity. It aimed to surprise and misdirect the diner through the abstraction of raw materials, notably through radical transformations of texture into gels, foams, and exploding spheres of liquid. This cuisine could implicitly be practiced anywhere in the world, with the provenance of the ingredients a less primary concern (El Bulli's commitment to product quality notwithstanding). Molecular gastronomy was premised on the human genius of the chef, over and above the agency of any tasty nonhumans like microbes.

In its public self-presentation through cookbooks, interviews, and the dining experience, Noma found in culinary modernism a useful counterpoint for the naturalistic methods they were developing; but under the hood, in the kitchen and the fermentation lab, Noma and the New Nordic Cuisine have always retained certain key principles of this scientism. In practice, we must understand the shift to Nordic naturalism and the celebration of microbial agency not as a simple reactionary move against culinary modernism but as a subtle "post-Pasteurian" (Paxson 2012) reworking of its neophilic, high-tech identity. For example, Williams, White, and other fermenters all described how the technologies for monitoring and conditioning their fermentations were vital, not only for achieving consistently optimal results but sometimes, as with kōji, for achieving successful results at all. While the New Nordic Cuisine employs many techniques of the modernist canon, it has co-opted them into a new model, narrating the role of technoscience in its ideology in quite different terms: less as a means of uncovering universal culinary principles and physical and chemical techniques, and more as a way of developing specific regional microbiological articulations of flavor impossible to reproduce elsewhere—even if one followed the same recipe exactly.

Globalization, Nationalism, and Politics of Cultural Exchange

If this embrace of science and technology might be seen to conflict with the traditionalist naturalism of terroir, so the pursuit of global microbial cultures like kōji might seem antithetical to a valorization of the local. The shift from regionalism to what some might call a "glocalism" (Robertson 1995) in the New Nordic Cuisine happened in the context of larger changes in the political climate of Scandinavia from around 2014. The refugee crisis in Europe and the rise of the political Right led to the amplification of historic but previously marginal discourses that construct exclusive regional identities by naturalizing ethnic or national connections with landscape. Any appeal to a natural, native, and national Nordic cuisine quickly became obviously and uncomfortably politically charged.[15] For a fine dining restaurant like Noma, in the business of selling narrative just as much as food to affluent cosmopolitan consumers, the story of Nordic purity rapidly became untenable.

This was likely one reason why Noma began to look for "new" culinary horizons overseas. While Redzepi has frequently explained that Noma's three "pop-ups" in Japan (2015), Australia (2016), and Mexico (2017) were all part of the "pursuit of deliciousness," keeping the team on its toes and constantly learning about new cultures and flavors, these endeavors also helped rebrand Noma as outward looking, cosmopolitan, and global in perspective—on top of maintaining their preeminence through relentless innovation. Projects like these gesture to an evolving agenda that is now definitively more than regional (Evans 2015; Leer 2016), even while their success is predicated on their skill in packaging the "Nordic" for a global audience.

Yet this story of cosmopolitan glocalization does not fully explain why Japan has been a particularly prominent source of inspiration. In interviews, chefs and fermenters offered a range of responses to this question, which they recognized as their own speculations rather than self-evident truths, but which nonetheless illuminate popular conceptions. Many identified certain values often associated with Japanese culture, such as exceptional craftsmanship, carefulness, and attention to detail, as well as the cuisine's deeply integrated relationship with seasonality and devotion to umami taste. Others invoked explicitly essentialist constructions, such as an image of Japan as

15. The New Nordic Cuisine was accused of fascistic tendencies somewhat earlier (Holm 2011), but at that point this position was more marginal. The New Nordic Cuisine has also been subject to critical discussion with respect to gender (Leer 2019), nationalism (Neuman and Leer 2018), race (Andreassen 2014), and historicity (Leer 2016).

a mythical source of a sophistication not fully accessible to or comprehensible by a Western person, or a lauded superiority born of its ability to take practices from elsewhere and further refine them into something their own (e.g., French patisserie or electronics). While such contemporary popular constructions of Japan are overwhelmingly positive, admiring, and aspirational, they still tend to reify "Western" versus "Eastern" dichotomies and cultural stereotypes (Borggreen 2016).

Observed correspondences between Japanese and Scandinavian aesthetic minimalism and a preference for natural materials and forms were also frequently cited. These are not coincidental, however, but the result of a historical dialogue extending back at least 160 years. The emergence of what today is recognized as distinctively Scandinavian aesthetics and its relation to the contemporaneous emergence of Scandinavian national identities has been deeply shaped by the Japonisme of the second half of the nineteenth century (Gelfer-Jørgensen 2013; Guth 2004, 2015; Johnson 2016; Larsen 2016; Wagner 2016, 2017).[16] While Japan's charisma waned in Western cultures during World War II, it gradually returned over the final decades of the twentieth century with the rise of "Cool Japan," a national marketing campaign to enhance the country's soft power through cultural exports (Abel 2011; McLelland 2017; Valaskivi 2013). This recent history makes Japan both a chic and relatively "safe" choice for inspiration: it is not contemporarily controversial in the way that countries recently or currently at war with or historically colonized by Western countries might be.

The rise of Japanese food outside of Japan occurred in relation to this general aesthetic-cultural history.[17] Japanese ingredients, including fermented products, have been used in elite Western cuisines at least as early as France's nouvelle cuisine in the 1960s and 1970s (Rao, Monin, and Durand 2003, 2005). Japanese dishes, including but not at all limited to sushi, had already become well-known and widely enjoyed in the United States by the late nineteenth and early twentieth century—long before the commonly cited craze beginning in Los Angeles in the 1980s (Miller 2015). The cuisine has since become widespread, from takeout and fast-casual to ultra-high-end (Bestor 2000; Cwiertka 2005; Cwiertka and Walraven 2001; Milligan 2006). The inspiration Noma found in Japanese aesthetics in general, and cuisine specifically, is thus far from new—even if its translation of fermentation techniques into the Nordic biogeographical lexicon may have few if any precedents.[18]

In this section we have seen how the microbial charisma of kōji came to prominence at Noma as a result of three broad cultural shifts in New Nordic taste: a postpastoral, naturalistic turn to the local; a post-Pasteurian reworking of culinary modernism; and a movement beyond the simple regional identity formation of the early New Nordic Cuisine, toward glocal cosmopolitanism (e.g., in its celebration of Japan) and away from rising right-wing ethno-nationalism. The result is a specific type of taste for a specific type of microbe and its fermentations. We can understand this taste as one highly rarefied and tightly curated example of a wider "probiotic turn" (Lorimer 2020) that is underway in Western diets, with broad implications for biogeography, ecology, and evolution.

A Natural History of Microbial Taste

In this final section we reflect on how the multispecies, taste-based experiments at Noma and Empirical have led to changes in the natural history of charismatic fermentation microbes like kōji and its ecologies like miso. Where possible, we draw on some preliminary results of our own microbiological experiments, but we raise more questions than we can answer here, our aim being to make proposals for future research on the natural history of microbial taste. We focus on actual and potential changes in microbial biogeography,[19] microbial ecology, and microbial and human evolution.

Humans have a history with kōji that goes back thousands of years. The benign *Aspergillus oryzae* was likely domesticated from the more dangerous wild *Aspergillus flavus* by intoxication-fixated humans selecting for the saccharification of rice as a necessary step for the subsequent production of ethanol by yeasts (Gibbons and Rokas 2013; Gibbons et al. 2012; Machida, Yamada,

16. Japonisme is a Western enthusiasm for Japanese art and aesthetic principles stoked by the forced opening of and subsequent trade with Japan in the 1850s, after more than two centuries of near-complete economic and cultural isolation imposed by the Tokugawa shogunate.

17. It should also be noted that Japanese cuisine, as any cuisine, is of course also historically emergent. It has accreted and developed through cultural imports from China from at least the seventh century AD and subsequent exchanges and circulations with various cultures. This cuisine and the aesthetics described above are also bound up with Japanese ethno-nationalisms.

18. We are mindful of concerns that Noma may be involved in a project of cultural and economic appropriation: commodifying microbes and culinary practices sourced from other parts of the world with unjust distributional consequences. We found little evidence to support such a critique. Noma chefs and restaurateurs draw on commercially available spores and substrates, acknowledge their sources, and work to distribute their intellectual property through their cookbooks and social media. Noma may be symptomatic of an unequal food economy, but it is not exceptional in this regard.

19. Williams was not the first person to take kōji out of Japan. The fungus was first brought commercially to the United States and Europe in the 1890s by Jokichi Takamine, a Japanese entrepreneur who saw it as a promising biotechnology for industrial whiskey production (Shurtleff and Aoyagi 2012). Over the twentieth century the *Aspergillus* genus became one of the best-characterized fungal genera, many of its species becoming model organisms for laboratory research, workhorses for the production of enzymes, acids, and aromas (Goffeau 2005), or intensively studied for their pathogenicity (Gibbons and Rokas 2013). The spores of *Aspergillus oryzae* and other *Aspergilli* used for fermentation can now be bought online and are posted worldwide. The genus has thus developed a global anthropogenic biogeography, beyond that of its own mobilities (Tsing 2014), by virtue of its mutualistic utility and gustatory allure.

and Gomi 2008; Machida et al. 2005).[20] In other words, kōji emerged because it helped our recent human ancestors enjoy the pleasures and powers of inebriation. These selections for enzyme production and atoxigenicity were also shaped by preferences for the production of desirable secondary metabolites, including aromas (Galagan et al. 2005; Gibbons et al. 2012). Williams and other fermenters thus come to know kōji not just through their individual chef's palates but also through robust and long-standing learned preferences for fruity and floral aromas and largely innate preferences for sweet and umami tastes (Dunn and Sanchez 2021): features of the kōji flavor that have developed in tandem with ancestral human preferences and more recent selections.

Kōji's history and diversification have also come to shape many other microbes, such as those in misos—lactic acid bacteria, salt-tolerant yeasts, and others that benefit from, succumb to, and direct each other's appetites and adaptability. To explore these relationships Evans conducted a series of experiments on the ecology of translated misos at Noma. We analyzed the relative abundance of bacterial and fungal taxa, using 16S and ITS amplicon sequencing, in misos varied by substrate: yellow pea, nixtamalized yellow pea, lupin seed, Ureta pea, grey pea, and Gotland lentil (figs. 5, 6).[21] We were interested in how their different tastes correlated with their ecological composition.

There are clear differences in the relative abundance of bacterial taxa in communities, even at the taxonomic level of families. These bacterial taxa are capable of different metabolic functions, and so they may be associated with differences in the levels of tasteable molecules such as lactic acid (produced by Lactobacillaceae) or glutamic acid (a prominent source of umami). Further bioinformatic analysis of these data may allow us to resolve these differences to genus or species, and further sampling could clarify the origins of bacterial taxa commonly associated with the human body (such as Staphylococcaceae and Enterobacteriaceae). While no sequencing studies of traditional miso microbial ecology seem to exist in English at this point, there exists some precedent for human-related taxa found in Asian kōji-based fermentations (Yan et al. 2013).

For the fungal communities, though *Aspergillus* spp. dominate, as one might expect (the *A. flavus* reads likely belong to *A. oryzae*, as they are so similar), there are also differences among the samples in their proportions of *Erysiphe pisi*, a common plant pathogen causing powdery mildew, that might tell us something about the agroecologies of the various Nordic legumes used to produce the misos. While these amplicon genetic data are limited—for example, they do not allow us to compare relative abundances of bacterial and fungal taxa with each other, as they are based on different genes—they are a starting point for characterizing these taste-shaping-natures. Future metagenomic sequencing, metabolomics, and further sensory analysis will allow us to describe in more detail how the pursuit of specific tastes shapes the ecologies of these novel misos, perhaps even linking strains, genes, metabolites, and flavors.[22]

While it is clear that the charisma of kōji has expanded its biogeography, drawing human enthusiasts into creating hospitable conditions that have led to variations in associated ecological communities such as those in novel misos, our ultimate interest in this paper is how the taste of microbes might have evolutionary consequences—for both microbes and humans. This is a big theme, starting to be taken up by other researchers, whose work makes clear that taste-based experiments such as Williams's are situated within a long evolutionary history of human-microbe interaction (Gibbons and Rinker 2015). This evolutionary thinking becomes performative in the New Nordic Cuisine when Williams outlines an explicit desire to facilitate evolutionary change in kōji, explaining how he "really liked the idea of having something that would evolve being in Scandinavia," hoping that it would "slowly become something quite different, in its own right." Further developing the idea of microbial terroir, he envisioned place as an assemblage of factors that might drive the variation of individual microbial lineages and not just ecologies.

Evans undertook a second set of experiments, extending Williams's early attempts to facilitate evolutionary change in kōji. He grew kōji recursively to see whether and how it might change, through mutation, symbiogenesis, and/or ecological shifts. Starting with the same commercial spore of albino kōji produced by Bio'c in Japan, Evans grew parallel populations at Noma and Empirical following their respective protocols, as well as a control set in a laboratory on barley agar plates. He grew one generation in triplicate at each site per week for 25 generations,[23] documenting temperature, humidity, and any changes in morphology, color, and smell. While the rates of change varied, all populations at Noma and Empirical gradually turned from white spores to green between generations 6 and 10, and then to black between generations 14 to 16. At approximately generation 20, they became much furrier. Meanwhile, in the laboratory they remained white, with perhaps some slight increase in the length of the conidiophores (the spore-bearing stalks that grow up from the mycelia) leading to a slightly

20. The estimated timing of the domestication of *A. oryzae* ranges from approximately 9,000 years ago (McGovern et al. 2004) to between 3,000 and 700 years ago (Watarai et al. 2019).

21. These preliminary samples were taken in December 2017, prior to Joshua Evans's main fieldwork, from misos already made by the team in the Noma fermentation lab. As such, they have no replicates. Results from a more structured experiment designed and conducted by Evans at the Noma fermentation lab involving similar misos varied by proteinous substrate and in triplicate are forthcoming.

22. This goal would require significantly more time and resources than were available for this project.

23. Similar laboratory experimental evolution studies with fungi have exhibited hereditary change after 20 to 27 propagation cycles (de Crecy et al. 2009; Jeon et al. 2013; Schoustra et al. 2006, 2007).

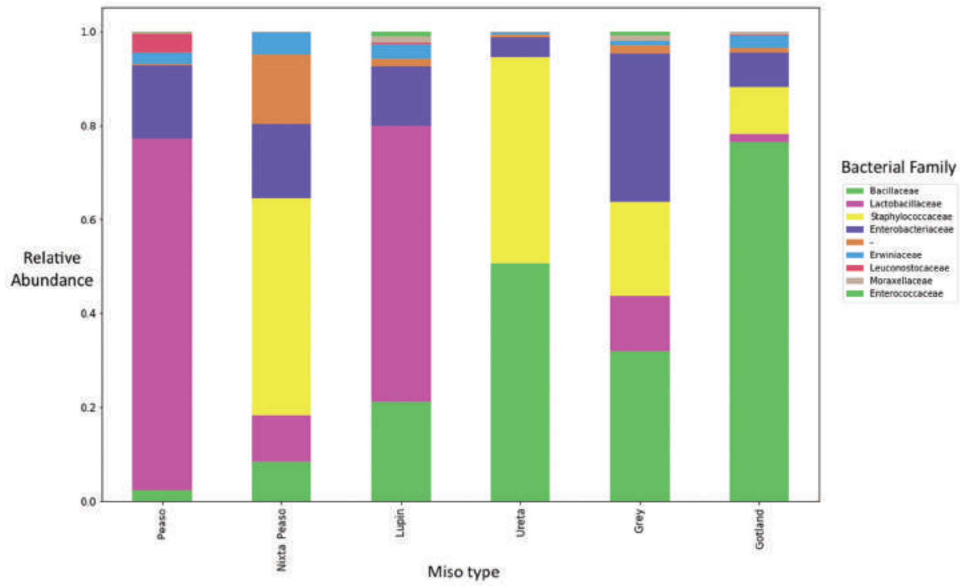

Figure 5. Relative abundance of bacterial families in translated miso ecologies.

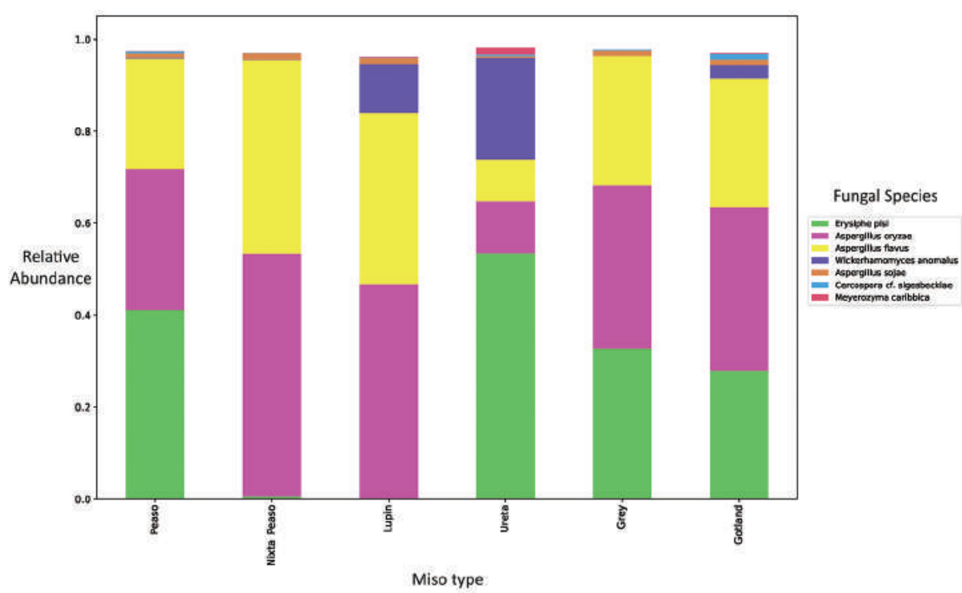

Figure 6. Relative abundance of fungal species in translated miso ecologies.

furrier appearance once sporulated. The results from Noma and Empirical corroborated Williams's earlier experiences, in which the kōji seemed to become "increasingly strong" until its appearance changed after a few generations.

The observed shift in spore color from white to green to black seems to mirror, in reverse, the evolutionary history of kōji, in which the albino mutation was selected for from populations of green-sporulating kōji, which in turn was previously selected for from the earliest forms of kōji, such as *Aspergillus awamori*, which are black. The results of genomic analyses may reveal the possible genetic signature of the changes Evans observed,[24] but we can assume that, as long as fermenters continue to revert to using commercial frozen spores every few generations, their kōji is not yet undergoing evolutionary change. While this experiment may come to yield only modest evolutionary findings, it nonetheless offered a participatory mode of microbiology (Lorimer et al. 2019) that prompted Williams and other fermenters to talk and think differently about the liveliness and robustness of kōji and to change what they might try to do with it in the future.

24. These analyses will appear in Evans's forthcoming PhD dissertation.

The ecological and evolutionary impact on the microbiome of those eating Noma's misos is currently unknown. We might speculate that Noma's customers, and perhaps most significantly Noma's chefs, will experience some changes as a result of their exposure to these organisms and due to their increased consumption of fermented food. We do not yet know if kōji comes to live on or in us, or what novel misos do to the gut microbiome, but we might anticipate, supported by our ethnographic data, that a signature of this taste-shaping-nature is by now just as likely to be found in certain people as it is in their foodstuffs.

Conclusions: Domestication in Light of the Tasty Microbiome

In this paper we have developed the concept of a taste-shaping-nature through an analysis of making kōji and miso in Copenhagen. We identified the charisma of kōji and explored how it is sensed and desired by fermenters. We followed how kōji came to prominence as part of the New Nordic Cuisine, and how the latter's constructions of nature, engagements with technoscience, and politics of globalization have shaped the cultural economy of translated fermentation. Finally, we opened a conversation about the natural history of microbial taste, highlighting the ways in which kōji's charisma has configured its biogeography, its ecology, and possibly its evolution.

In reflecting a range of contemporary developments associated with the recent fermentation revival, the story of kōji at Noma invites us to speak more generally about the implications of our discussion of microbial taste-shaping-natures for understanding domestication in the Anthropocene. While recent scholarship has aimed to develop more-than-human accounts (Lien 2017; Swanson, Lien, and Ween 2018), neither taste as a driver of these processes nor microbes as nonhuman counterparts in them have featured prominently. Thinking with tasty microbes like kōji allows us to begin to address these gaps and to make three general observations: that taste is an important but neglected aspect of how humans—and nonhumans—shape ecologies and evolutionary trajectories; that domestication need involve neither human deliberation nor domination; and that kitchens and fermentaries are particular, significant, and understudied components of the domus.

We have presented taste as a perceptual and aesthetic experience that is shaped by nonhumans such as microbes and configured by past coevolutionary encounters. This approach helps expand existing (and somewhat anthropocentric) accounts of the evolution of taste that can excessively rationalize disgust, distaste of bitterness, and the pleasure of sweetness and umami according to the instrumental benefits they confer on the consumer of obtaining nutrition and avoiding poison (Breslin 2013; Dunn and Sanchez 2021). In foregrounding taste as its own reward, we sketch a microbiology of desire akin to Pollan's "botany of desire" that is primarily shaped not by human intention and mastery but instead by mutual multispecies interest (see Hustak and Myers [2012] and Stengers [2010:35–36] for related notions). Here domestication becomes a process of mutually interested hereditary change rather than one shaped mainly by human interests and intentions (cf. Anderson 1997:493). This model fits with an emerging position in scientific research that also conceives domestication on a continuum of entangled agencies, with or without intentions (Irving-Pease et al. 2018).

Thinking with microbial charisma raises questions of microbes' historical agency. Charismatic fungi like kōji are making history in Copenhagen. Drawn by their potential to catalyze delicious tastes, high-profile chefs have driven a probiotic turn in food preparation. They are making new spaces for novel ecosystems (Hobbs, Higgs, and Hall 2013), enhancing plant, animal, and microbial diversity while generating new sources, forms, and quantities of economic and cultural value. Kōji and its charismatic microbial kin are domesticating more people as chefs translate domus-sharing relations long established in East Asia. This glocal probiotic turn represents a new chapter in the history of human-microbial relations and likely, at some point, of microbial evolution. Now armed with scientific tools for microbial identification, industrial techniques for microbial propagation, and marketing techniques for microbial popularization, chefs like Williams and White have become agents of microbial proliferation. Kōji is taking over the world in a new global domus of fermentation (Landecker 2015).

With its topology of nodes and networks and its flows of highly mobile chefs, cookbooks, and spores, this domus is far from the Neolithic hearth. And yet, as with that hearth, kitchens and fermentaries of all kinds remain key spaces of emergent coevolutionary novelty among humans and microbes—as with gardens for plants and enclosures for animals. These microbial spaces of the domus not only facilitate fermentation. They also break down domestication processes into timeframes and spatial scales humans can experience rather than infer only from artifacts and bones. Fermentation thus offers a particularly tractable system for studying domestication processes experimentally, experientially, and ethnographically. It is not only, per Sheldrake (2020), "domesticated decomposition"; it is also, enticingly, domestication decomposed.

Acknowledgments

We would like to thank Jason White, David Zilber, Lars Williams, René Redzepi, and the rest of the teams at the Noma fermentation lab and Empirical Spirits who welcomed Joshua into their work spaces for participant observation and experiments and offered their insights during interviews. Considerable thanks go to the Gilbert Group in the Section for Evolutionary Hologenomics, GLOBE Institute, University of Copenhagen, for hosting Joshua for his lab work and specifically to Sarah Mak for receiving, preparing, and submitting the miso samples for DNA sequencing, Jacob Agerbo Rasmussen for analyzing the data and producing the graphs, and Tom Gilbert for facilitating assistance throughout and covering the sequencing costs. Many thanks to the organizers of the Wenner-Gren symposium "Cultures of Fermentation," from which this paper emerged, to the other authors in this special issue who made the symposium such a productive event, and finally to our two reviewers who offered numerous helpful comments on the manuscript.

References Cited

Abel, Jonathan E. 2011. Can cool Japan save post-disaster Japan? on the possibilities and impossibilities of a cool Japanology. *International Journal of Japanese Sociology* 20(1):59–72.

Amato, Katherine R., Óscar M. Chaves, Elizabeth K. Mallott, Timothy M. Eppley, Filipa Abreu, Andrea L. Baden, Adrian A. Barnett, et al. 2021*a*. Fermented food consumption in wild *nonhuman* primates and its ecological drivers. *American Journal of Physical Anthropology* 175(3):513–530.

Amato, Katherine R., Paula Maia, Elizabeth K. Mallott, Maria Luisa Savo Sardaro, and Yan Zeng. 2021*b*. Pre-digestion as an evolutionary impetus for human fermented food use. *Current Anthropology* 62(suppl. 24):SXXX–SXXX.

Anderson, Kay. 1997. A walk on the wild side: a critical geography of domestication. *Progress in Human Geography* 21(4):463–485.

Andreassen, Rikke. 2014. The search for the white Nordic: analysis of the contemporary New Nordic kitchen and former race science. *Social Identities* 20(6):438–451.

Appadurai, Arjun. 1996. *Modernity at large: cultural dimensions of globalization*. Public Worlds. Minneapolis: University of Minnesota Press.

Besky, Sarah. 2020. *Tasting qualities: the past and future of tea*. Atelier: Ethnographic Inquiry in the Twenty-First Century. Oakland: University of California Press.

Bestor, Theodore C. 2000. How sushi went global. *Foreign Policy* 121:54–63.

Bökönyi, Sandor. 1969. Archaeological problems and methods of recognizing animal domestication. In *The domestication and exploitation of plants and animals*. P. J. Ucko and G. W. Dimbleby, eds. P. 607. London: Taylor & Francis.

Borggreen, Gunhild. 2016. Crazy about Japan: Japonisme in Nordic art and design on display. *Orientaliska Studier* 147:171–192.

Bourdieu, Pierre. 1984 (1979). *Distinction: a social critique of the judgement of taste*. Richard Nice, trans. Cambridge, MA: Harvard University Press.

Breslin, Paul A. S. 2013. An evolutionary perspective on food and human taste. *Current Biology* 23(9):R409–R418.

Carrigan, Matthew A., Oleg Uryasev, Carole B. Frye, Blair L. Eckman, Candace R. Myers, Thomas D. Hurley, and Steven A. Benner. 2015. Hominids adapted to metabolize ethanol long before human-directed fermentation. *Proceedings of the National Academy of Sciences of the USA* 112(2):458–463.

Cassidy, Rebecca, and Molly Mullin, eds. 2007. *Where the wild things are now: domestication reconsidered*. Oxford: Berg.

Clutton-Brock, Juliet, ed. 1989. *The walking larder: patterns of domestication, pastoralism and predation*. London: Unwin Hyman.

———. 1992. The process of domestication. *Mammal Review* 22(2):79–85.

Counihan, Carole, and Susanne Højlund. 2018. *Making taste public: ethnographies of food and the senses*. London: Bloomsbury Academic.

Cwiertka, Katarzyna Joanna. 2005. From ethnic to hip: circuits of Japanese cuisine in Europe. *Food and Foodways* 13(4):241–272.

Cwiertka, Katarzyna Joanna, and Boudewijn Walraven. 2001. *Asian food: the global and the local*. ConsumAsiaN Book Series. Honolulu: University of Hawaii Press.

de Crecy, Eudes, Stefan Jaronski, Benjamin Lyons, Thomas J. Lyons, and Nemat O. Keyhani. 2009. Directed evolution of a filamentous fungus for thermotolerance. *BMC Biotechnology* 9(74).

Despret, Vinciane. 2004. The body we care for: figures of anthropo-zoo-genesis. *Body and Society* 10(2–3):111–134.

Ducos, Pierre. 1978. Domestication defined and methodological approaches to its recognition in faunal assemblages. In *Approaches to faunal analysis in the Middle East*. R. H. Meadow and M. A. Zeder, eds. Pp. 53–56. Cambridge, MA: Peabody Museum.

———. 2016 (1989). Defining domestication: a clarification. In *The walking larder: patterns of domestication, pastoralism, and predation*. Juliet Clutton-Brock, ed. Pp. 28–30. Routledge Library Editions: Archaeology. London: Routledge.

Dunn, Rob, and Monica Sanchez. 2021. *Delicious: the evolution of flavor and how it made us human*. Princeton, NJ: Princeton University Press.

Evans, Joshua. 2015. Beyond "New" Nordic. Nordic Food Lab. https://nordicfoodlab.wordpress.com/2015/05/18/2015-5-18-beyond-new-nordic.

Felder, Daniel, Daniel Burns, and David Chang. 2012. Defining microbial terroir: the use of native fungi for the study of traditional fermentative processes. *International Journal of Gastronomy and Food Science* 1(1):64–69.

Flachs, Andrew, and Joseph D. Orkin. 2019. Fermentation and the ethnobiology of microbial entanglement. *Ethnobiology Letters* 10(1):35–39.

Flandroy, Lucette, Theofilos Poutahidis, Gabriele Berg, Gerard Clarke, Maria Carlota Dao, Ellen Decaestecker, Eeva Furman, et al. 2018. The impact of human activities and lifestyles on the interlinked microbiota and health of humans and of ecosystems. *Science of the Total Environment* 627:1018–1038.

Galagan, James E., Sarah E. Calvo, Christina Cuomo, Li-jun Ma, Jennifer R. Wortman, Serafim Batzoglou, Christina C. Spevak, et al. 2005. Sequencing of *Aspergillus nidulans* and comparative analysis with *A. fumigatus* and *A. oryzae*. *Nature* 438(December):1105–1115.

Gan, Elaine, Anna Tsing, and Daniel Sullivan. 2018. Using natural history in the study of industrial ruins. *Journal of Ethnobiology* 38(1):39–54.

Gelfer-Jørgensen, M. 2013. *Influences from Japan in Danish art and design, 1870–2010*. Copenhagen: Danish Architectural Press.

Gibbons, John G., and David C. Rinker. 2015. The genomics of microbial domestication in the fermented food environment. *Current Opinion in Genetics and Development* 35:1–8.

Gibbons, John G., and Antonis Rokas. 2013. The function and evolution of the *Aspergillus* genome. *Trends in Microbiology* 21(1):14–22.

Gibbons, John G., Leonidas Salichos, Jason C. Slot, David C. Rinker, Kriston L. McGary, Jonas G. King, Maren A. Klich, David L. Tabb, W. Hayes McDonald, and Antonis Rokas. 2012. The evolutionary imprint of domestication on genome variation and function of the filamentous fungus *Aspergillus oryzae*. *Current Biology* 22(15):1403–1409.

Goffeau, André. 2005. Genomics: multiple moulds. *Nature* 438(7071):1092–1093.

Guth, Christine. 2004. *Longfellow's tattoos: tourism, collecting, and Japan*. Seattle: University of Washington Press.

———. 2015. *Hokusai's Great Wave: biography of a global icon*. Honolulu: University of Hawai'i Press.

Guthman, Julie. 2019. *Wilted: pathogens, chemicals, and the fragile future of the strawberry industry*. Critical Environments. Oakland: University of California Press.

Hanski, Ilkka, Leena Von Hertzen, Nanna Fyhrquist, Kaisa Koskinen, Kaisa Torppa, Tiina Laatikainen, Piia Karisola, et al. 2012. Environmental biodiversity, human microbiota, and allergy are interrelated. *Proceedings of the National Academy of Sciences of the USA* 109(21):8334–8339.

Hayes-Conroy, Jessica, and Allison Hayes-Conroy. 2010. Visceral geographies: mattering, relating, and defying. *Geography Compass* 4(9):1273–1283.

Hayward, Eva. 2007. Envisioning invertebrates and other aquatic encounters. PhD dissertation, University of California, Santa Cruz.

Hobbs, R. J., Eric Higgs, and Carol M. Hall. 2013. *Novel ecosystems: intervening in the new ecological world order*. Chichester: Wiley-Blackwell.

Holm, Ulla. 2011. Noma er fascisme i avantgardistiske klær [Noma is fascism in avant-gardist clothes]. *Politiken* (Copenhagen), May 8.

Hustak, Carla, and Natasha Myers. 2012. Involutionary momentum: affective ecologies and the sciences of plant/insect encounters. *Differences* 23(3):74–118.

Ingold, Tim. 2000. *The perception of the environment: essays in livelihood, dwelling, and skill*. London: Routledge.

Irving-Pease, Evan K., Laurent A. F. Frantz, Naomi Sykes, Cécile Callou, and Greger Larson. 2018. Rabbits and the specious origins of domestication. *Trends in Ecology and Evolution* 33(3):149–152.

Jasarevic, Larisa. 2015. The thing in a jar: mushrooms and ontological speculations in post-Yugoslavia. *Cultural Anthropology* 30(1):36–64.

Jeon, Junhyun, Jaeyoung Choi, Gir Won Lee, Ralph A. Dean, and Yong Hwan Lee. 2013. Experimental evolution reveals genome-wide spectrum and dynamics of mutations in the rice blast fungus, *Magnaporthe oryzae*. *PLoS ONE* 8(5).

Johnson, Annika K. 2016. "An aesthetic experience: Japonisme in the north": framing Japanomania; Japanomania in the Nordic countries, 1875–1918. *Journal of Japonisme* 1:211–226.

Johnson, Arielle, and Lars Williams. 2016. *A field guide to fermentation*. Copenhagen: Noma.

Katz, Sandor Ellix. 2012. *The art of fermentation: an in-depth exploration of essential concepts and processes from around the world*. Hartford, VT: Chelsea Green.

Katz, Sandor Ellix, and Sally Fallon Morell. 2008. *Wild fermentation: the flavor, nutrition, and craft of live-culture foods*. Hartford, VT: Chelsea Green.

Laland, Kevin N., John Odling-Smee, and Sean Myles. 2010. How culture shaped the human genome: bringing genetics and the human sciences together. *Nature Reviews: Genetics* 11(2):137–148.

Landecker, Hannah. 2015. Antibiotic resistance and the biology of history. *Body and Society* 22(4):1–34.

Larsen, Peter Nørgaard. 2016. New approaches to nature: Japonisme in Danish visual art, 1880–1910. In *International Symposium: Modern Art and Japonisme in the North*. Pp. 108–115.

Latour, Bruno. 2004. How to talk about the body? the normative dimension of science studies. *Body and Society* 10(2–3):205–229.

Leach, Helen M. 2003. Human domestication reconsidered. *Current Anthropology* 44(3):349–368.

Lee, Victoria. 2019. Wild toxicity, cultivated safety: aflatoxin and kōji classification as knowledge infrastructure. *History and Technology* 35(4):405–424.

Leer, Jonatan. 2016. The rise and fall of the New Nordic Cuisine. *Journal of Aesthetics and Culture* 8. https://doi.org/10.3402/jac.v8.33494.

———. 2019. New Nordic men: cooking, masculinity and Nordicness in René Redzepi's *Noma* and Claus Meyer's *Almanak*. *Food, Culture and Society* 22(3):316–333.

Lien, Marianne Elisabeth. 2017. Unruly appetites: salmon domestication "all the way down." In *Arts of living on a damaged planet: ghosts and monsters of the Anthropocene*. Anna Tsing, Heather Swanson, Elaine Gan, and Nils Bubandt, eds. Pp. 107–124. Minneapolis: University of Minnesota Press.

Lorimer, Jamie. 2007. Nonhuman charisma. *Environment and Planning D: Society and Space* 25(5):911–932.

———. 2020. *The probiotic planet: using life to manage life*. Minneapolis: University of Minnesota Press.

Lorimer, Jamie, Timothy Hodgetts, Richard Grenyer, Beth Greenhough, Carmen Mcleod, and Andrew Dwyer. 2019. Making the microbiome public: participatory experiments with DNA sequencing in domestic kitchens. *Transactions of the Institute of British Geographers* 44:524–541.

Machida, Masayuki, Kiyoshi Asai, Motoaki Sano, Toshihiro Tanaka, Toshitaka Kumagai, Goro Terai, Ken-Ichi Kusumoto, et al. 2005. Genome sequencing and analysis of *Aspergillus oryzae*. *Nature* 438(7071):1157–1161.

Machida, Masayuki, Osamu Yamada, and Katsuya Gomi. 2008. Genomics of *Aspergillus oryzae*: learning from the history of kōji mold and exploration of its future. *DNA Research: An International Journal for Rapid Publication of Reports on Genes and Genomes* 15(4):173–183.

Majid, Asifa, Laura Speed, Ilja Croijmans, and Artin Arshamian. 2017. What makes a better smeller? *Perception* 46(3–4):406–430.

McGovern, Patrick E., Juzhong Zhang, Jigen Tang, Zhiqing Zhang, Gretchen R. Hall, Robert A. Moreau, Alberto Nuñez, et al. 2004. Fermented beverages of pre- and proto-historic China. *Proceedings of the National Academy of Sciences of the USA* 101(51):17593–17598.

McLelland, Mark J. 2017. *The end of cool Japan: ethical, legal, and cultural challenges to Japanese popular culture*. Routledge Contemporary Japan Series. London: Routledge.

Miller, H. D. 2015. The great sushi craze of 1905, parts 1 and 2. An Eccentric Culinary History. https://eccentricculinary.com/the-great-sushi-craze-of-1905-part-1. https://eccentricculinary.com/the-great-sushi-craze-of-1905-part-2.

Milligan, Lee. 2006. Japanese cuisine and the Japanisation of Europe. *Kontur* 13:1–10.

Mintz, Sidney W. 1986. *Sweetness and power: the place of sugar in modern history*. New York: Penguin.

Mintz, Sidney W., and Christine M. Du Bois. 2002. The anthropology of food and eating. *Annual Review of Anthropology* 31:99–119.

Mol, Annemarie. 2011. Tasting food: tasting between the laboratory and the clinic. In *A companion to the anthropology of the body and embodiment*. Frances E. Mascia-Lees, ed. Hoboken, NJ: Blackwell.

———. 2012. Layers or versions? human bodies and the love of bitterness. In *Routledge handbook of body studies*. Pp. 119–129. London: Routledge.

Money, Nicholas P. 2018. *The rise of yeast: how the sugar fungus shaped civilisation*. Oxford: Oxford University Press.

Nabhan, Gary Paul. 2006. *Why some like it hot: food, genes, and cultural diversity*. Washington, DC: Island.

———. 2010. Ethnobiology for a diverse world: microbial ethnobiology and the loss of distinctive food cultures. *Journal of Ethnobiology* 30(2):181–183.

Neuman, Nicklas, and Jonatan Leer. 2018. Nordic cuisine but national identities: "New Nordic Cuisine" and the gastronationalist projects of Denmark and Sweden. *Anthropology of Food* 13.

Paxson, Heather. 2012. *The life of cheese: crafting food and value in America*. California Studies in Food and Culture, vol. 41. Berkeley: University of California Press.

Paxson, Heather, and Stefan Helmreich. 2014. The perils and promises of microbial abundance: novel natures and model ecosystems, from artisanal cheese to alien seas. *Social Studies of Science* 44(2):165–193.

Payne, Charlotte L. R., and Joshua D. Evans. 2017. Nested houses: domestication dynamics in human-wasp relations in contemporary rural Japan. *Journal of Ethnobiology and Ethnomedicine* 13(13).

Petrini, Carlo. 2003. *Slow food: the case for taste*. William McCuaig, trans. Arts and Traditions of the Table: Perspectives on Culinary History. New York: Columbia University Press.

Pink, Sarah. 2010. *Doing sensory ethnography*. London: SAGE.

Pollan, Michael. 2002. *The botany of desire: a plant's-eye view of the world*. New York: Bloomsbury.

———. 2018. *How to change your mind: what the new science of psychedelics teaches us about consciousness, dying, addiction, depression, and transcendence*. New York: Penguin.

Rao, Hayagreeva, Philippe Monin, and Rodolphe Durand. 2003. Institutional change in Toqueville: nouvelle cuisine as an identity movement in French gastronomy. *American Journal of Sociology* 108(4):795–843.

———. 2005. Border crossing: bricolage and the erosion of categorical boundaries in French gastronomy. *American Sociological Association* 70(6):968–991.

Redzepi, René. 2010. *Noma: time and place in Nordic cuisine*. London: Phaidon.

Redzepi, René, and David Zilber. 2018. *The Noma guide to fermentation*. New York: Artisan.

Risvik, Einar, Claus Meyer, Eivind Hålien, and Patrik Edman. 2008. *New Nordic cuisine*. Copenhagen: Nordic Council of Ministers.

Robertson, Roland. 1995. Glocalization: time-space and homogeneity-heterogeneity. In *Global modernities*. Mike Featherstone, Scott Lash, and Roland Robertson, eds. Pp. 25–44. London: SAGE.

Russell, Edmund. 2011. *Evolutionary history: uniting history and biology to understand life on Earth*. New York: Cambridge University Press.

Russell, Nerissa. 2002. The wild side of animal domestication. *Society and Animals* 10(3):285–302.

Schoustra, S. E., A. J. M. Debets, M. Slakhorst, and R. F. Hoekstra. 2006. Reducing the cost of resistance: experimental evolution in the filamentous fungus *Aspergillus nidulans*. *Journal of Evolutionary Biology* 19(4):1115–1127.

———. 2007. Mitotic recombination accelerates adaptation in the fungus *Aspergillus nidulans*. *PLoS Genetics* 3(4):648–653.

Scott, James C. 2017. *Against the grain: a deep history of the earliest states*. Yale Agrarian Studies. New Haven, CT: Yale University Press.

Sheldrake, Merlin. 2020. *Entangled life: how fungi make our worlds, change our minds and shape our futures*. London: Penguin Random House.

Shepherd, Gordon. 2013. *Neurogastronomy: how the brain creates flavor and why it matters*. New York: Columbia University Press.

Shurtleff, William, and Akiko Aoyagi. 1983. *The book of miso*. Berkeley, CA: Ten Speed.

———. 2012. *History of kōji*. Lafayette, CA: Soyinfo Center.

Spence, Charles. 2017. *Gastrophysics: the new science of eating*. London: Penguin.

Spence, Charles, Betina Piqueras-Fiszman, and Heston Blumenthal. 2014. *The perfect meal: the multisensory science of food and dining*. EBL-Schweitzer. New York: Wiley.

Steinkraus, Keith. 1995. *Handbook of indigenous fermented foods*. 2nd edition. Food Science and Technology. Boca Raton, FL: Taylor & Francis.

Stengers, Isabelle. 2010 (1997). *Cosmopolitics*, vol. 1 of *Cosmopolitics*. Robert Bononno, trans. Minneapolis: University of Minnesota Press.

Sutton, David E. 2010. Food and the senses. *Annual Review of Anthropology* 39(1):209–223.

Swanson, Heather Anne, Marianne Elisabeth Lien, and Gro B. Ween. 2018. *Domestication gone wild: politics and practices of multispecies relations*. Durham, NC: Duke University Press.

Tan, Vaughn. 2020. *The uncertainty mindset: innovation insights from the frontiers of food*. New York: Columbia University Press.

Teil, Geneviève, and Antoine Hennion. 2002. Discovering quality or performing taste? a sociology of the amateur. In *Qualities of food*. Pp. 19–37. Manchester: Manchester University Press.

Tsing, Anna Lowenhaupt. 2014. Strathern beyond the human: testimony of a spore. *Theory, Culture and Society* 31(3):221–241.

Valaskivi, Katja. 2013. A brand new future? cool Japan and the social imaginary of the branded nation. *Japan Forum* 25(4):485–504.

Wagner, Malene. 2016. Eastern wind, northern sky. *Journal of Japonisme* 1 (1):41–65.

———. 2017. Exhibition traces Danish designers' indebtedness to Japan. *Journal of Japonisme* 2(2):170–179.

Watarai, Naoki, Nozomi Yamamoto, Kazunori Sawada, and Takuji Yamada. 2019. Evolution of *Aspergillus oryzae* before and after domestication inferred by large-scale comparative genomic analysis. *DNA Research: An International Journal for Rapid Publication of Reports on Genes and Genomes* 26(6):465–472.

Watson, Duika L. Burges, and Chris M. Cooper. 2019. Visceral geographic insight through a "source to senses" approach to food flavour. *Progress in Human Geography*. https://doi.org/10.1177/0309132519890913.

Wrangham, Richard W., James Holland Jones, Greg Laden, David Pilbeam, and NancyLou Conklin-Brittain. 1999. The raw and the stolen: cooking and the ecology of human origins. *Current Anthropology* 40(5):567–594.

Yamin-Pasternak, Sveta, Andrew Kliskey, Lilian Alessa, Igor Pasternak, and Peter Schweitzer. 2014. The rotten renaissance in the Bering Strait: loving, loathing, and washing the smell of foods with a (re)acquired taste. *Current Anthropology* 55(5):619–646.

Yan, Yin Zhuo, Yu Lin Qian, Feng Di Ji, Jing Yu Chen, and Bei Zhong Han. 2013. Microbial composition during Chinese soy sauce kōji-making based on culture dependent and independent methods. *Food Microbiology* 34(1):189–195.