Everyday food science as a design space for community literacy and habitual sustainable practice

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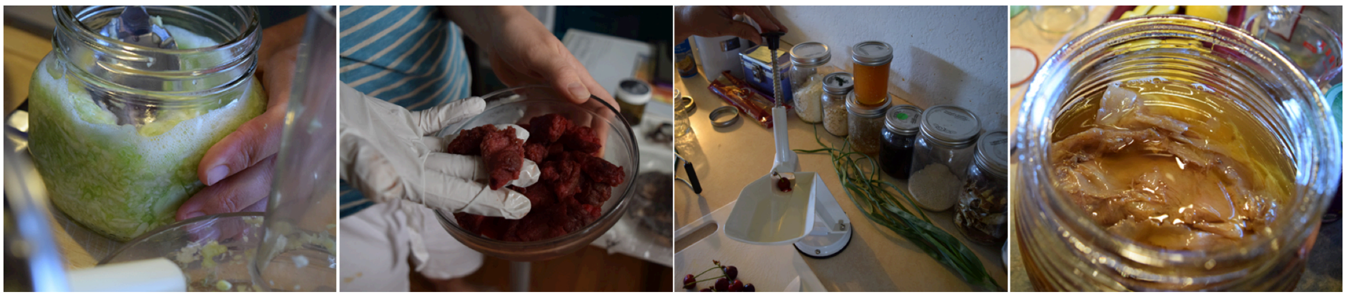

Figure 1: Example of food science projects from our fieldwork: sauerkraut, placenta encapsulation, cherry canning, kombucha.

ABSTRACT

Focusing on food as a platform for everyday science, this paper details our fieldwork with practitioners who routinely experiment with preserving, fermenting, brewing, pickling, foraging for, and healing with food. We engage with these at-home science initiatives as community-driven efforts to construct knowledge and envision alternatives to top-down modes of production. Our findings detail the motivations, challenges, and workarounds behind these practices, as well as participants' hybrid lay-professional knowledge, and the iterative mechanisms by which their expertise is scaffolded. Our paper contributes to CHI's amateur/citizen science research by examining how social, digital, and physical materials shape scientific literacy; and to sustainable HCI by presenting habitual practice as an alternative (bottom-up) form of food production and preservation.

Author Keywords

Food, amateur science, sustainable HCI, slow technology

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Amateur science has been widely studied by the CHI community, both in terms of how people participate and construct expertise outside of professional settings, as well as the broader socio-political impacts of bottom-up science [e.g., 1, 12, 14, 45]. In this paper, we consider a special case in this area: at-home food science as a site of everyday experimentation, community-driven knowledge production, and habitual sustainable practice. We broadly define food science as the selection, flavoring, preservation, storage, or distribution of food. The at-home practices in our fieldwork range from raising, fermenting, brewing, canning, or pickling edible materials, to foraging and using food for medicinal purposes (Fig. 1). As the world's population surpasses 9 billion in the next 40 years [52], focusing on alternative systems of food production and preservation is both timely and critical for sustainability and citizen science research. On the most basic level, our work examines sustainable food practices as a form of amateur science, and asks how is everyday expertise scaffolded, and how are these practices positioned as a deliberate alternative to top-down systems?

To answer these questions, we conducted *in-situ* fieldwork with 15 practitioners who routinely experiment with homemade beer, fermented vegetables and fruit, foraged grasses, kombucha and kefir, livestock, and human placenta (as a dietary supplement), to name a few. Our findings reveal a host of materially-driven practices motivated by personal health and medicine, social and cultural tradition, reducing waste, and avoiding mass-production. Throughout their work, participants draw upon diverse sources of information—from professional research and schooling, to community apprenticeships, as well as personal trial and error, amounting to a hybrid body of professional-lay knowledge. We thus view their work as a form of "amateur science" not as a reflection on their expertise, but to emphasize the iterative, bottom-up mechanisms by which

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their knowledge is acquired. The processes by which this information is gathered and understood, as well as how habitual, science-oriented practice relates to professional science and mainstream food production, are at the heart of our work.

Research contributions and goals

We focus on everyday food science as a lens for examining alternatives to top-down production of both food and information. Within CHI, we contribute to the domains of citizen science [e.g., 1,24,55]—by examining how social, digital, and physical materials shape scientific literacy; and to sustainable HCI [e.g., 5,13,39]—by presenting practices that counter mass-consumption and work around mainstream food systems. More broadly, our paper can be contextualized within the long-standning body of work on alternative food systems, including the politics of localism [e.g., 15]; the historical background of food counter-cultures [e.g., 4]; or popularized reflections on eating only native plants and organisms [e.g., 35]. We continue with an overview of related literature and detail our research methods. We then present findings in regards to 1) food science materials and motivations, 2) participants' knowledge and expertise, 3) the mechanisms by which expertise is scaffolded, and 4) barriers and workarounds for these practices. We conclude with opportunities for interaction design to scaffold community-driven scientific literacy and support sustainable practices around food production and beyond.

WHAT IS AMATEUR SCIENCE?

Broadly speaking, non-professional participation in science might range from high school lab experiments to ecosystem monitoring or DIY (do it yourself) genetic testing. To what extent are these practices and the underlying knowledge scientific, and how are these types of 'science' studied within HCI? To better orient our paper, we present a modest overview of related HCI research in citizen science, including studies of existing practices; platforms for volunteer-driven data collection; tools for scaffolding expertise; and approaches for enabling broader impact. Although these areas are by no means exhaustive or exclusive, they help contextualize (and perhaps re-ignite a discussion around) CHI's framing of amateur science work.

Studies of existing practices

Prior work investigated a range of existing amateur science communities. Studies of online platforms examined weather reporting [17], ecological monitoring [42], protein folding and neuron mapping [22], and multi-domain research [50], to name a few. In parallel, examples of *in-situ* fieldwork include a study of bio-monitoring groups [27], DIYbio (Do It Yourself Biology) initiatives [28], and the culture of bird monitoring [5]. Throughout this HCI work, amateur science has been discussed in terms of a range of practices—from observing local organisms and ecosystems, to analyzing online data, to performing DNA extraction at home.

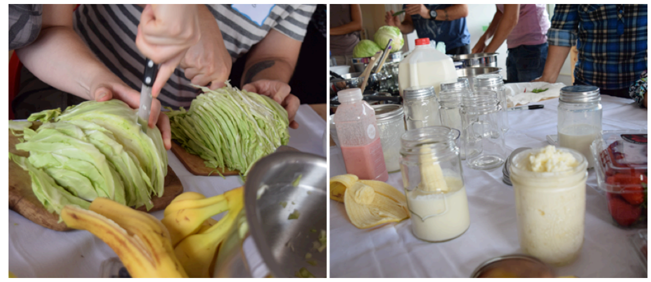

Figure 2. Learning from practitioners at a hands-on workshop: collaborating on flavored sauerkraut and milk keffir.

Platforms for citizen-driven data collection

In addition to empirical studies, HCI has developed systems for bottom-up data collection. Examples include a mobile phone application to document local water sources [25]; acoustic sensing to monitor rare cicadas [34]; a system for gathering transportation data [32]; or handheld community-based air quality monitors [55]. Environmental sensors have also been deployed on bicycles, street sweepers, and taxis [1, 16, 21]. These and many other projects leverage low-cost sensing and social media to support volunteer-driven data collection and sharing.

Systems for scaffolding scientific expertise

Increasingly, HCI is trending towards empowering volunteers as active collaborators in the scientific process. Scaffolding tools—particularly interactive tabletops—support novice learning of bioinformatics [45], chemistry [47], phylogenetics [44], or environmental data analysis [53]. Other platforms enable people without programming experience to create their own science applications [24], digitally augment environments to facilitate learning about ecosystems [41], or teach outdoor observation skills [43]. These systems promote scaffolding across diverse scientific domains (genetics, biology, environmental science, etc.).

Approaches for enabling broader impact

Finally, HCI has explored the broader impacts of bottom-up science, including changes to policy, healthcare, or environmental practices. For example, political computing literature emphasized supporting collective action [14] and "conjoint practices" [10] for environmental sustainability, and detailed how scientific measurements can bias social and political outcomes [40]. Participatory design research also involved stakeholders in the development of scientific tools and democratic technologies [12, 29] and systems to express concerns [7], to name a few.

To summarize, prior HCI work—empirical studies, digital tools, and socio-political framings—has broadly understood citizen science in terms of diverse domains, from biology, to DIY, and environmental monitoring. This suggests an exigency for studying food science as an over-looked, albeit highly related form of amateur science. Our work reveals the mechanisms by which practitioners build expertise and enact broader impact through their work with food.

STUDY METHODS

Drawing on prior sustainability research that examines everyday practices [e.g., 37,39,48], our fieldwork focused on practitioners who routinely work on food science projects in and around a large southwestern city in the US. We conducted twelve interviews with fourteen participants (two couples; ages early 20's-late 60's; 4 males) who routinely work with food beyond simple meal preparation by experimenting with selection, preservation, storage, and nutrition. Participants were recruited through local food communities (e.g., foraging, fermenting, gardening, beer-brewing groups) and via flyers posted at local coffee shops, gardens, and brew stores. The interviews were conducted at participants' place of work (kitchens, garages, farms, yards, foraging areas, etc.). We asked participants to walk us through their routines in regards to food experimentation and to demonstrate a project of their choice. These demos—which often invited researchers to participate in hands-on work—ranged from foraging for edibles, to making kefir or sauerkraut, encapsulating placenta, making beer, or caring for domestic animals. Additionally, open-ended questions probed participants' backgrounds, motivations, and challenges. Finally, the work culminated in two workshops in our design studio (Fig. 2): a hands-on workshop whereby participants and researchers collaboratively made kefir, kombucha, and flavored sauerkraut; as well as a co-authoring workshop, which resulted in a journal publication co-authored by the researchers and participants [withheld].

We audio recorded all interviews and workshops and took field notes, documentary photographs, and select videos. The audio was transcribed and analyzed along with the field materials. Open coding was used to create conceptual models and affinity diagrams, which revealed themes and unexpected connections in the data.

ABOUT THE PARTICIPANTS

Participants specialize in diverse areas, from fermenting and canning fruit and vegetables, to brewing drinks such as kombucha, kefir, or beer, foraging for local edibles, raising and slaughtering animals, prescribing herbal remedies and dietary changes to clients, and placenta encapsulation (dehydrating, grinding, and placing placenta into capsules as a supplement for mothers). However, to some degree, participants' practices also overlap: for example, almost all participants dabble in fermentation projects such as kombucha or sauerkraut, and many share interests in herbal medicine and foraging. For the purposes of this work, we reference participants by their primary line of work, and cite data owing to individuals from each area as follows:

- Fermentation (foods and non-alcoholic drinks) [FE1-5]]
- Small-scale livestock farming and aquaponics [F1, F2]
- Beer brewing [B]
- Health and nutrition coaching [HC]
- Herbal and holistic medicine [H1, H2]
- Foraging (botany-informed identification of plants) [FO]
- Chicken and turkey keeping and veterinary care [C]
- Placenta encapsulation [P]
- Canning [CA]

All participants have worked in their domina for several years and many have been involved for decades. All of the participants, except C, orient their practice towards making a living, whether by selling their homemade fermented, brewed, canned, or pickled foods (FE1-5; F1, F2, CA, B, P), consulting clients and teaching nutrition classes (HC, H2, F1, P), or by prescribing and selling herbal remedies (HC, H1-2, FO). While several participants (B, FE4, F2) also hold jobs outside their food domains, they intend to transition into food-related work as a primary source of income. For this reason, almost all participants brand or market their work by blogging about their projects, sharing through social media, creating physical brands (e.g., bottling logos), or by hosting workshops and events.

Materially-oriented practice

Physical materials—from tools and containers to the food products themselves—play a key role in participants' day-to-day routines with regard to food work. These materials range from high end, professionally-purchased equipment (e.g., an aeroponics system for soil-less gardening [H2]), to appropriated and modified tools (*e.g.*, a cooler converted into a mash tun to ferment beer at a particular temperature [B]; a blender used to turn dehydrated placenta into powder [P]; glass containers re-used to store food products [all participants]), as well as food materials that were bartered, shared, hand-harvested, or foraged (apricots grown in backyard [CA]; kefir grains acquired from a friend [P, HC]; fruit picked from a tree in a public park [FO], etc.).

With their work deeply rooted in material engagement, the availability of materials (or lack thereof) often determines participants' course of action. For example, an abundance of certain foods leads participants to experiment with different methods of preserving: FE1 sun-dried extra apples from her tree; FE3 fermented 50lbs of strawberries because they were seasonal and on sale; F1 and F2 make sour cream with extra milk from their farm. In parallel, materials also inspire certain recipes: FO forages and eats plants that taste better in season (e.g., Queen Anne's lace tastes milder in the spring); FE3 flavors kombucha based on what produce is in season. These and many other examples illustrate how materials shape the types of projects participants take on and how they proceed with their work.

Motivations

Participants cited a range of motivations for working with food, which sometimes evolved as their practices matured. For most, health was the initial reason for starting out: all participants except B and C described turning to food science for health reasons, whether to address particular concerns with herbs, fermented foods, or changes in diet, or to be more healthy in general by increasing biodiversity in gut flora or eating fewer processed foods. All participants noted that home-prepared foods had more health benefits than their store-bought counterparts (e.g., more control over ingredients, less sugar, or more probiotics because homemade foods were unpasteurized or canned at lower temperatures). However, as they became more versed in their practice, all participants continued working on food projects because they had fun (in fact, fun is the primary reason why B and C became involved in beer brewing and at-home chicken/turkey keeping, respectively):

They're [chickens] so much fun. We'll sit back here, and they all have little personalities. C

It's fun. It [foraging] brings me back to being a kid. FO

I just dumped milk in this jar with these slimy grains, and then, the next morning, it's thick kefir. That's so cool. P

These quotes illustrate how participants describe their work as being fun and derive joy from aspects of their practice.

In addition, participants discussed a host of community, family, and cultural values. For instance, all participants emphasized sharing food—ingredients, starters, or the final products themselves—as a motivation (e.g., "*I love sharing ferments and whatever I can with my friends*", FE1; "*That's the way I share my love is through making food for people"*, FE2). All participants also placed their practice in a historic context, whether by discussing how their work was passed down their family line (H1), or by more broadly describing how their practice carried cultural meaning:

I mean, it's kind of like—"doula" is a Greek word, and it literally just means a woman supporting another woman. P

As you begin to learn [about herbs], there's a generation of generation of generation of people teaching these things. FO

[kimchi] is like a culture thing. It's passed on to generations. It's kinda cool how people keep traditions alive. HC

These passages demonstrate how participants associate food science with tradition and culture and value these ties to motivate their work. Finally, participants also cited sustainability as a motivation, specifically to reduce waste (e.g., *It's not being discarded, thrown away, or anything like that. Instead, you're using it, and you're creating the canned items,* CA); as well as to save money (*It's a cheap—it's easy [kombucha]. It's almost free to make. Where like live enzymes and probiotics are crazy expensive.* FE3)

To summarize, our participants are experts in their domains, yet their practices operate outside of the mainstream food systems. Their work is diverse, materially-driven, and motivated by values spanning health, fun, community, culture, and sustainability.

KNOWLEDGE AND EXPERTISE

In this section, we detail the types knowledge our participants drew upon as part of their practice. Expertise included conventional scientific information, fluency with specialized instruments, appropriation of everyday tools, and highly nuanced use of the human senses, as well as specialized language to describe aspects of the practice.

Conventional science knowledge

To varying degrees, all participants relied on concepts from professional science to orient their work. Sterilization, for instance, was commonly-discussed and performed in a variety of ways: by increasing pressure in canning (CA), boiling placenta encapsulation tools (P), or cleaning equipment with reagents (B). Similarly, participants discussed concepts from modern nutrition, including the links between immunity and gut flora (HC, H1, FE1-3), cinnamon as a supplement to regulate insulin intolerance (H1), high vitamin B and iron content of placenta (P), or sprouting as a mechanism to break down enzymes that inhibit nutrient absorption (H2). Several people also referenced botany and microbiology throughout their work, including a discussion of how chlorophyll porphyrin rings are similar to the molecular structure of hemoglobin (FO); or the harvesting of probiotic strains in fermentation (FE2). The practices of drawing on professional knowledge can be seen as parallel to information seeking practices in more widely studied communities (e.g., non-experts seeking information in DIY or genomics communities [45, 51]).

Fluency with scientific instruments

Participants also rely on highly specialized tools to achieve precision throughout certain procedures (Fig. 3). For example, B uses a spectrometer to measure alcohol content during brewing: "*I just wanna make sure I hit these specific numbers. This one is 6.7%."*. Likewise, CA cans different foods at particular pressures by setting the pressure canner: "*The extra air's coming out of here. You decide how much pressure you need, if you need 5 pounds, 10 pounds, or 15.*" CA also appropriates a soil pH meter to measure the acidity of her spaghetti sauce. Similarly, FE3 relies on a Berkley filter to remove specific compounds (traces of arsenic and fluoride) from her water. These food science instruments

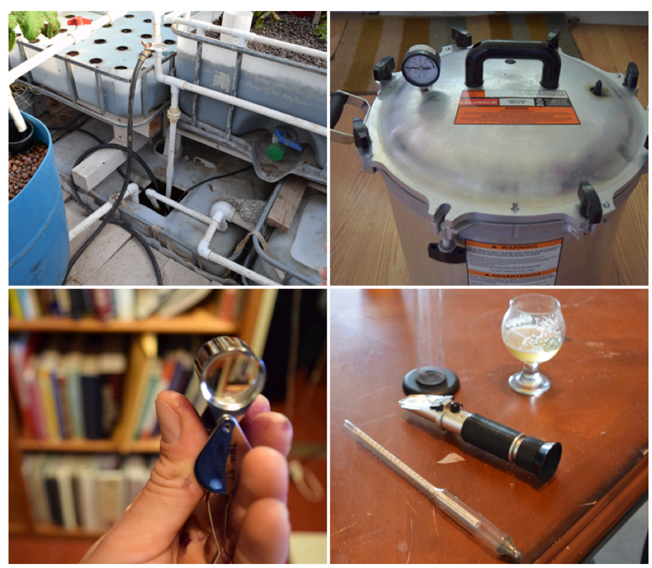

Figure 3. Scientific instruments and everyday tools: DIY aquaponics system, pressure canner, monocle for foraging, and spectrometer and thermometer for beer brewing.

can be framed as technologies. Indeed, HCI work has reflected on the use of highly-specialized tools in parallel DIY domains as a form of technoscientific literacy [30, 54].

Specialized use of everyday tools

In addition, participants appropriate everyday tools to perform highly-specialized steps within their workflows (Fig. 3). Examples include a food dehydrator and blender, which were adopted to dry and grind up placenta, before packaging it with a capsule maker (P), or a bathtub and pool as part of an aquaponics system (FE1-2). Similarly, a monocle is used to distinguish between features of edible and poisonous plants while foraging: *Magnifying to look at the plants very closely when you're identifying. Flowers are how you identify plants. Dissecting the flower.* (FO)

Expert use of human senses

Finally, the human senses themselves serve as a form of expertise. Before citing specific examples, it is important to note that the participants themselves describe their senses as highly trained or different from other people's:

It's [food fermentation] just trained my taste buds in a different way as it is for most people. FE1

Taste it [kombucha] a little bit first. I think you kind of develop a taste for it. HC

That the smell [of fermentation] is always there. It just becomes a part of your life. You really do just, as bad as it sounds, you just get over it. FE3

All grass is edible pretty much. Tastes different. Some are gross. Wheatgrass is really gross to people. FO

These quotes exemplify how food practice led participants' senses to adapt to particular flavors and smells. Our findings reveal that, once developed in this way, the human senses are used to 1) understand processes within participants' work; and 2) to troubleshoot projects.

In regards to the first, we found many cases of human senses being used to infer the progress of certain processes: the color of kombucha indicating how far along the fermentation is (HC); a "ping" sound confirming that canning was successful (CA); or the flavor and aroma indicating when hops should be added to a batch of beer (B). Similarly, human senses were used to distinguish between ingredients, including size, flavor, and texture differences between chicken and turkey eggs for C; brightly colored foods being associated with higher antioxidant content for FE2; or 'hair legs' being used to distinguish between the edible wild carrot and the poisonous hemlock plants (FO). As for troubleshooting, participants routinely relied on their senses to identify potential problems and correct aspects of their work:

If I could smell it [sauerkraut], and it smelled really funky and weird, then I just—it's you just know it's not good, and taste-wise as well, that musky taste. FE1

It'll be blue [kombucha starter]. Have you ever seen like moldy cheese? It'll look really obvious. HC

If it's too sour [beer], it's a bacteria problem. If it's too like a yeasty flavor, you didn't let it ferment for long enough. B

In the above, participants discuss examples of smell, sight, and taste being used to troubleshoot problems in certain processes and iterate on procedures to avoid these.

Specialized language and terminology

Not unlike professional science, a highly-specialized language was often used to convey aspects of the work. Examples include terms that refer to particular procedures, including water bath canning (boiling a jar of ingredients as part of the canning processes, CA); clabbering (letting milk sour at a particular temperature, FA1-2); media-based aquaponics (a floating or deepwater system, FA1); or cold crashing (rapidly cooling beer before it is bottled, B). In addition, participants used specialized language to refer to ingredients and products: SCOBY—symbiotic culture of bacteria and yeast to brew kombucha (HC); second ferment—water kefir or kombucha ferment for the second time with ingredients such as berries, ginger, lemon, etc. for flavoring (FE3, HC and others); salve—olive oil infused with herbs for medicinal purposes (H1).

This section presented the types of expertise that was drawn upon to inform practice, including conventional science, professional and everyday tools, human senses, and domain-specific language to describe the work.

SCAFFOLDING EXPERTISE

The next section details the mechanisms by which participants came to acquire their skills and expertise. Our findings reveal a hybrid system of resources, ranging from classes and professional research, to social media, in-person interactions, hands-on experimentation, and failure.

School and classes

All participants have taken formal classes in their respective fields, whether through community organizations such as the Permaculture Alliance, or at larger institutions such as the Institute for Integrative Nutrition at a state university. Examples of formal education in participants' domains include HC's bachelor's degree in exercise science or C's Animal Emergency Medical Technician training from the Humane Society. Other participants are certified within their fields (e.g., H1 and H2 are certified herbalists; FE1 received a yoga and nutrition certification; FO is working towards becoming a certified herbalist). In addition, many participants also taught workshops and courses, either with clients (H2, HC, P) or through community centers (*e.g.*, the Permaculture Alliance, H1, FA1).

Professional sources

Participants often rely on professional science research to acquire expertise. With Google being a popular starting point, some participants then turn to peer-reviewed sources:

I'll go online and find where those articles are in peer review journals, that way when I have clients who come to me that are under a doctor's care, I can adequately write out an *explanation for why I am suggesting a change in diet and how that's going to interact with medication they're taking.* H1

In the above passage, H1 discusses the importance of professional research within her practice. In addition, nearly all participants reference books: FO uses botany textbooks to identify local edibles; P has checked out "*every book on birth*" from the library; and FA1 and FA2 use publication standards to evaluate the reliability of information in books.

Online communities and forums

In addition, participants turn to online forums, which tend to aggregate novices and expert contributions. Aquaponics forums exemplify this hybrid knowledge sharing:

My bell siphon isn't draining. What could be wrong with it? That's when the engineers will pop in [on the forum] and starts analyzing it and figuring out what's going on. FA1

Other resources—Facebook pages and online groups such as Fermenting Fodder (C) and Cultured Food Life (FE2) coalesce around specific practices (fermentation, brewing, foraging, etc.). These online groups offer concrete assistance in the form of recipes and specific techniques (C1), photographs (FO), and links to vetted articles (H1), as well as emotional support and connection (B). Virtual communities also help locate physical resources, such as in the case of P, a "midwife's office" and "breastfeeding meeting." Not surprisingly, the participants also circulate their own expertise online, e.g., a "placenta-centric blog" (P1), or personal YouTube channels (HC). The reliance on social media tools for information can be placed within a broader HCI context, particularly relating to work that examines online food communities and communication (e.g.. studies of social networks for recipe, resource, and event sharing [20, 26]).

In-person interactions

In-person interactions—from learning by sharing the food materials, to collaborative hands-on work and longer-term mentorships—all serve as a means for acquiring expertise.

Sharing materials. Our findings show instances where sharing materials facilitated sharing expertise. For example, F2 followed a craigslist ad to "*look at a dairy cow*" and, as a result, encountered "*a gal*" who "*showed us a bit of the process*"; P "*got grains from a friend*" who "*just showed me her little process*"; H1 learned about kefir from "*the gal that handed grains off to me to do my own, she taught me her method"*; and HC teaches people how to make kombucha when she gives them the starter. Participants describe these interactions as a gift economy in which a network of people delights in sharing both knowledge and materials.

Working together. Collaborating on projects was seen as another resource for scaffolding expertise:

It's something that people do better to see hands on. If you hear about it or you research it, it's overwhelming. It's almost like the Amish bread, the friendship bread. You can tell someone how to do it, but when you show 'em and do it, it builds that relationship. FE3

Here, FE3 discusses how hands-on work with other people is both an antidote to information overload and a catalyst for building relationships. Likewise, CA tends to "*reach out to friends*" to compare processes and troubleshoot the work. Other examples include FA1 and C, who toured other people's setups for aquaponics and chicken coops.

You can see all the way from $4,000 coops that an architect designed that have electricity and water, then to things that are just from found objects. It's really interesting. C

The above reflects several participants' emphasis on seeing other people's projects as a way of learning the practice.

Longer-term mentorships. Finally, many participants also rely on longer-term mentors—individuals whom they routinely turn to for advice, and who advise them as their work becomes more complex. Examples include an elder (e.g., H1's "*friend's grandmother*"), a friend (B, CA, FA1), or well-known experts in the field (H2, P, FO). Throughout the interviews, all participants highlighted the value of learning from these relationships with expert practitioners:

If you do have somebody that can show you - because I made simple and stupid mistakes [on my own], but it took longer to learn. FE1

Here, FE1 notes that mentors play a unique role in advancing skills, which compliments trial and error.

Experimentation

Last but not least, participants discussed many forms of experimentation as way of learning. Examples range from changing flavors (e.g., flavoring kombucha, HC, FE3), to trying new ferments (e.g., salsa, FE1), identifying best methods (e.g., choosing jars for sauerkraut, H2), or adapting practices to their routines (once-a-day cow milking, FA1-2). Other experiments involve the human body itself, as in, for instance, H1's adjustments in her clients' diets and herbal supplements; or FE1's self-experimentation:

If I feel that I need to have some meat [even though I am a vegetarian], I still play around with it. I'm always using my body as an experiment. FE1

Participants thus embraced trial and error, which was fueled by their imagination (B), willingness to question tradition (FA1), and ability to set expectations aside (FE1).

Most the stuff I come up with myself, in my head. Just brew it up and see how it tastes. B

The most creative people respect tradition, but then question it, and then try different things. FA1

I like to expect that it's gonna work, but I don't really know. A lot of times I'm just trying it. FE1

In each case, it is also clear that participants manage a set of risks (i.e., discomfort, stress, time and resources) and a keen flexibility or willingness to experiment to acquire expertise.

Failure. As a result of their willingness to experiment, all participants experienced unsuccessful—yet still highly informative—outcomes. Examples include canning mishaps (jars breaking because they were not boiled, C1), foods tasting strange (olive oil-based mayonnaise, P; dehydrated green beans, FA1); killing plants (i.e., duckweed in an aquaponics system FA1); or unsuccessful dyes (hair dyed with lemons, H1). Even though such failures can represent a stopping point (e.g., "*I did a cornmeal mash. It was a mess. I'll never do that again*", B), more often, failure was seen as generative: participants adapted their materials or processes to succeed. Over time, all participants learned to anticipate and/or accept food failures and even frame them as opportunities for learning and developing expertise.

Records of practice. To varying degrees, all participants (and even some of their clients) keep highly-detailed records to aid experimentation. These records serve to change old or develop new habits, as well as to keep track of variables in the work. Formats range from "*notes on the fridge*" or "*on my tablet*", B; to "*a big folder with all my recipes in it*", CA; as well as "*some pretty extensive spreadsheets that I would dedicate for months at a time, just documenting everything and seeing the trends*", H; and "*food journals, just documenting every food I've eaten, and then documenting how am I sleeping",* H2. Indeed, it was not uncommon to observe participants using mobile phones and cameras to document their work during our hands-on workshops and activities. Participants tended to share images and descriptions of their work across social media sites, for fun, inspiration, or to troubleshoot problems; as well as to reach broader audiences (e.g., online branding).

Confidence and intuition. Finally, participants noted that the experience gained from hands-on experimentation led them to be confident in their abilities and in their practice.

I wasn't confident making that starter, but once it worked, then I was. You just have to try stuff… You have to just get over yourself. A lot of it is you're afraid to fail. P

There's a difference with hands on for sure, because once you get in there and do it, you're more confident, and you're more willing to get in the kitchen and do it. H

Furthermore, participants also noted that they developed a particular intuition to aid decisions in their work.

A lot of times, I take a lot of this information, and I come back to common sense. I feel like I just have a natural knack for what is Mother Nature telling us. H2

It seems like [chemistry background] *really helped me to personally decipher some things, but at the same time I really trust and rely a lot on my intuition with things.* FE1

These quotes reflect how many participants developed tacit knowledge or intuition to inform their practice.

To summarize, this section detailed the various mechanisms by which participants acquired expertise. Schooling and professional resources were drawn upon alongside interactions other practitioners and personal trial and error.

BARRIERS AND WORKAROUNDS

Participants discussed a range of challenges for their work. On a higher level, these fall into two categories: negative public perceptions of food science products and materials; and time and habit as barriers for becoming involved with the work. Below, we present these in more detail and discuss participants' workarounds.

Negative perceptions of food science materials

To varying degrees, all participants experienced some negative reactions in response to their work, including their own initial adverse perceptions of the materials. Kombucha scoby (starter), for instance, tended to elicit a bit of fear or disgust from people who are not familiar with the brewing processes (as discussed by FE1-3, HC, H1-2, and others). Other materials that were noted as off-putting include placenta ("*When you first tell a random person [about placenta encapsulation], sometimes the response is not so nice. It's like, "That's disgusting*", P); bone broth ("*I do bone broth as well. I get a lot of, "Eww"*", FE2); and fermentation more generally, which might be associated with "*rotten*" produce, as noted by HC.

When discussing these negative perceptions of food science materials, participants often referenced mass media and mainstream production as the root cause:

When you get fruit off a tree, everybody wants it to look like the grocery store. They went it to be perfect. Well, fruit doesn't always grow perfectly. CA

We're so taught to think anything that's moldy-looking or hairy or whatever, then it's oh, that's inedible now. FE1

I realized how lied to I had been, as a woman, about birth, that birth is just this horrible, bloody— It's a horrible thing that you just have to get through to get a baby. P

In the above, participants describe how at-home food science and materials can be at odds with mainstream standards or ideals of perfection. In other words, people may have reacted negatively to participants' work in part due to the expectations set by the mainstream food system.

Nurture and care. While even the participants themselves admitted to initially being intimidated by the appearance, smell, or texture of some of the ingredients, over time they developed deep and even nurturing attachments to their materials. In particular, many participants tended to anthropomorphize the materials they worked with, and it was not uncommon to hear live foods such as starters being described as feeding, eating, breeding, or even having names (Fig. 4).

Treating things as like living things more, then I feel like it's made it more open for me to just kind of experiment and create more new things or whatever. FE1

Every week, it (scoby) creates a baby. Yes, it becomes like a child in your family. The whole family talks about the kombucha. What are we brewing today. FE3

It's [placenta] a really amazing organ that just knows what the baby needs and goes and takes it from the mom's body, and the *mom's blood and the baby's blood never mix. It filters all the waste for the baby, and dumps it into the mom's system so she can excrete it. It's just like, wow.* P

The excerpts above show how participants attributed living and even human qualities to the materials they worked with. By anthropomorphizing materials, participants incorporated nurture and care into their practice, and overcame initial hesitations about the materials being strange or "imperfect".

Time and habits

By participants' own admission, their work can be time-consuming since many processes operate on the scale of hours, days, or weeks. Brewing a batch of beer takes over four hours, sauerkraut is flavored over the course of a week, while spaghetti sauce changes over the course of eight months. Time therefore deterred certain projects: CA does not work with longer canning processes, P and FE4 choose not to raise meat chicken because of the tedious slaughtering process, and F1 will not use recipes with too many steps. Not surprisingly, time was discussed as a factor that barred both the participants and the general public from starting food science projects:

That's the biggest challenge, is people think eating healthy is too time consuming. It's much easier to go through the drive-thru, or to pop a hot pocket in the microwave, you know what I mean? H2

Similar to H2's comment, other participants referenced public reliance on fast food and "*instant gratification culture*" [H1] as deterrents for at-home food science.

Slow transition. To overcome these challenges, all participants discussed their transition into food science as a slow and gradual process. In fact, most participants began with projects that were as simple as experimenting with one ingredient in a familiar recipe or removing one item from their diets. Over time, their projects became more and more complex, and it was not uncommon to hear participants describe their transition as a maturing *process*:

It's a slow evolution. This week, we make our own mayonnaise. Next week, it might be something else that we had been buying that we'll decide, "Oh, this is actually pretty easy to make, too." P

The above quote reflects how participants gradually shifted their food-related practices towards more complex projects and became more involved with their craft over time.

Habitual practice. Slow transition enabled participants to naturally integrate food science work into their lives: many steps and procedures became part of habitual, everyday routine. Examples include FE3 and her family's week-long cycle of fermenting, flavoring, and drinking kombucha; H2's practice of soaking seeds overnight and then sprouting them over the course of several days; C's morning ritual of feeding and checking on the chickens.

Then I'll add the fruit for the second ferment, and then I put it in the fridge, right after I brush my teeth, and stuff like—that you have to work it into your life, if that makes sense. P

The quote above illustrates how P (and many others) were able to co-evolve their practice with their lifestyle. In a way, this served to demystify food science work and reduce the perceived complexity of the projects:

They [other people] just assume that it's a lot more complicated than it is, which I understand. They don't understand the full process yet… It's very surprising how easy it is, really simple. You just have to find the flow. FE1

Here FE1 points out that while outsiders may find her practice complicated and time-consuming, for her, the work has flow that parallels other habitual activities and demystifies the craft.

To summarize, this section detailed two major barriers for food science practice: perceptions of the materials and time. Participants worked around these challenges by developing deep and sometimes nurturing bonds with their materials, as well as by slowly transitioning into complex practices and adopting food science as a habitual, everyday practice.

DISCUSSION

Thus far, we detailed findings from our ethnographically-informed fieldwork with practitioners who routinely work on food science projects such as fermenting, preserving, flavoring, foraging for, or healing with food. While initially motivated by health concerns, participants deepened their involvement with food science because they found the work to be fun, socially and culturally valuable, and sustainable (e.g., by operating outside of the mainstream food system, reducing waste, etc.). All of the practices we examined revolve around physical materials, which shape both the kinds of projects participants take on, and the types of knowledge they acquire. In the remainder of this section, we want to more carefully consider two themes that emerged from our work: participants' attachment to and

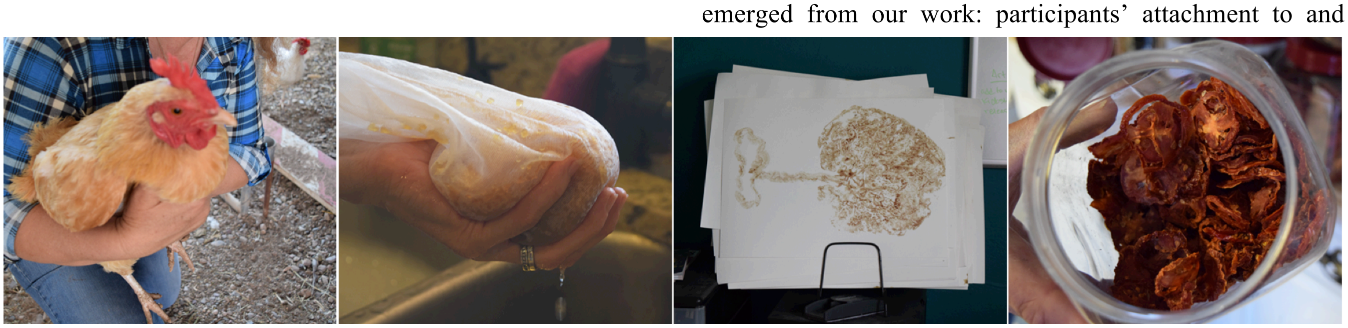

Figure 4: Examples of deep care for food science materials: chicken petted by participant, kefir grains rinsed before brewing, an artistic print made from placenta, and sun-dried tomatoes to preserve excess produce.

slow transition into their work as a habitual practice, and the resulting community-driven scientific literacy.

Attachment and slow transition

Interestingly, physical materials served as both a barrier to entry and a reason for persistent engagement with food science. While many of the starters, cultures, and final products were initially seen as off-putting even by the participants themselves, over time, practitioners developed deep relationships with the systems they worked with. Most significantly, participants perceived many materials as living entities to be fed and cared for, and in some cases even nurtured as pets or extensions of their families. This attachment was sometimes communal: people shared the physical materials and meals, worked on projects together, and shared materially-oriented knowledge.

Time likewise played a complex role: while participants were deterred from taking on some time-consuming experiments, they also, as P best put it, *worked their practice into their lives*. The integration of complex practice into everyday routine did not occur overnight: initial forays into food science were often as simple as fermenting a vegetable, foraging for a berry, or supplementing their diet with a particular herb. Gradually, as the projects turned more complex—flavoring second ferment, canning large quantities of surplus foods, or relying on foraging as sustenance—they also, in a way, became more simple, as they evolved into habitual, everyday practice.

Scientific literacy

Throughout their practice, participants draw on diverse knowledge, spanning concepts from conventional science (*e.g.,* the biology behind fermentation or herbal medicine); fluency with scientific instruments (pH meter, spectrometer, *etc.*); appropriation of tools (*e.g.,* blender for placenta encapsulation, pool as part of an aquaponics system); and a specialized language to describe processes and procedures (water bath canning, salve, clabbering, *etc.*) Moreover, participants rely on their highly-developed senses as a form of expertise: taste, smell, and sight are routinely drawn upon to understand and troubleshoot aspects of the work.

Rather than a top-down delivery of expertise, the mechanisms by which participants acquire knowledge are iterative and hybrid. Classes and professional research, as well as online communities, in-person collaborations and apprenticeships, hands-on experimentation, and first-hand successes and failures all serve to advance expertise. Most importantly, participants demonstrated that, over time, they developed an ability to fluidly navigate across these diverse sources and make sense of complex and often conflicting information. What has evolved, then, is a highly-skilled community, centered around scaffolding a literacy of lay-professional science. This literacy, which spans the domains of food science, biology, and medicine, among others, serves to support participants' intuition about and confidence in their practice.

DESIGN IMPLICATIONS

Our study provides a platform for future HCI interventions, similar other literature that relies on fieldwork to uncover new directions for food and sustainability systems [e.g., 18, 31]. We conclude by suggesting two trajectories for future interaction design systems: supporting habitual sustainable practice and scaffolding community literacy.

Supporting habitual sustainable practice

Everyday food science presents an alternative to the world's increasing reliance on mass-produced and mass-processed foods, and by operating outside of the mainstream system, parallels other areas within sustainable HCI (e.g., water consumption [46], reuse of materials [37, 39] or energy conservation [38]). Above all, our findings depict at-home projects not as single-point interventions, but as habitual and integrated practices. These insights echo trends in sustainable HCI, which argue for moving beyond technologies that reward or punish certain behaviors, and towards designing for shifts in habitual practice, contexts, or values [6]. We suggest two concrete trajectories for this: supporting attachment to physical materials and enabling slow integration of practices into everyday life.

Attachment to materials. The live food materials often elicited participants' curiosity and care, which led them to overlook any potential imperfections and persist in their practice. This suggests applying interaction design to nurture deep connections between people and materials. In the context of our research, new technologies might enable people to create narratives around their materials, by, for instance, documenting the histories, origins, and even 'personalities' of the starters, cultures, ferments, and brews they work with. With sharing—of both food and knowledge—being essential to practitioners, design can explore rich media for expressing the stories and experiences associated with food (e.g., how might a system express a practitioners' attachment to a kombucha scoby?). This direction is particularly intriguing considering the ephemeral nature of some of the food projects: how do relationships with and narratives around food science shift when the materials are physically consumed by the 'scientists' and their friends and families? As a starting point, work might leverage ludic design [e.g., 19] to inspire play and curiosity around food experiments. More broadly, design can explore attachment to 'living' materials in other domains, including: everyday technologies (e.g., phones) that mimic the qualities of biological systems by being more reliant on our care; or design artifacts that materialize intangible concepts such as energy, pollution, or shortages within a particular watershed, similar to [38].

Facilitating slow transition. By slowly transitioning into food science one project at a time, participants were able to integrate their work into their routines and merge their lives with their practice. Here, we highlight opportunities for technology to support gradual adoption of sustainable behavior as a *habitual practice*. As an alternative to encouraging certain actions in isolation (e.g., reducing food waste in trash cans [49] or purchasing healthier products [23]), design could shift the way people approach food preparation, preservation, and storage more systemically. One on hand, popular technologies (e.g., calendars, tasks lists, reminder systems) could help users incorporate sustainable food selection and preparation within their current routines. In parallel, new systems might help people gradually change their routines to adapt to more complex food science processes (e.g., by showing how to prepare seasonal or local produce or preserve excess foods instead of throwing them away). Both approaches would reflect the Slow Technology agenda of embedding systems in people's lives for prolonged engagement [e.g., 36].

Scaffolding community literacy

Finally, we turn to our initial inquiry into what constitutes amateur science. As we discussed earlier, HCI research broadly examines amateur science—from environmental sensing, to biology, and crowd-sourced data analysis—through empirical studies, via technical interventions, and in terms of broader political impacts. Widely framing scientific practice as systematic activity that produces knowledge, we have shown that our participants' work is generative. Drawing on professional research and education, as well as mentorships, hands-on experiments, and trial and error, at-home food scientists develop highly nuanced expertise in regards to bottom-up food production. We thus see at-home food science as a form of citizen science, and insights from our work reveal avenues for scaffolding community literacy through design.

In-situ documentation. Our participants gain significant expertise and confidence through trial and error—whether by experimenting themselves or by learning from the outcomes of others' projects. Coupled with the fact that most practitioners rely on personal devices and social medial to keep detailed records of their practice, these findings suggest design opportunities for *in-situ* documentation and sharing technologies. Tools that enable participants to document their processes along with project outcomes, challenges, and workarounds present unique questions for interaction design. How can the material qualities of the work (taste, smell, biological activity, etc.) be captured and communicated; what physical forms might technologies for everyday science take on to aesthetically and functionally fit into the home; and how can information about habitual practice be captured and visualized without disrupting routine. As a starting point, future work might reflect on tools for hybrid data collection in professional settings [e.g., 56], which gather practitioners' annotations as well as sensor data (in the context of food: video, photographs, or measurements such as pH, temperature, carbonation levels, etc.). Research supporting habitual practices in other domains (e.g., slow and reflective use [36] or ludic engagement [19]) might further inform the design of artifacts for at-home food science.

Aggregating hybrid knowledge. Our participants leverage scientific, social, and personal knowledge to inform, troubleshoot, and orient their work. This suggests opportunities to aggregate hybrid information and assist practitioners in making sense of diverse and sometimes conflicting sources. Interaction design might examine approaches for presenting individual and community food science projects alongside related professional research. For example, a system might contextualize fermentation experiments within professional research that details the underlying microbial reactions or potential health effects; people's experiences with herbal remedies might be visualized alongside related publications from medical journals; GPS-enabled tools might show foraging locations, including areas suggested by local communities alongside botany literature for identifying edible plants.

Presenting diverse sources poses unique design challenges as noted by HCI literature on pluralism [2]: how can hybrid information be communicated to support "*different ways of knowing*" and resist an authoritarian point of view [3]? As a starting point, systems might embrace *agonistic pluralism* [11] to enable productive conflict. For instance, design artifacts might support exploration of competing theories by allowing communities to formulate new hypotheses, conduct experiments, and evaluate results. More broadly, new social sharing mechanisms might allow practitioners to discuss and validate or critique professional research within the context of their practice (e.g., how mainstream medicine relates to herbal treatments). Such systems would support "oppositional discourse" [8]—an alternative, though not necessarily opposing, perspective to conventional science.

CONCLUSION

Our paper focused on everyday food science as a lens for examining scientifically-oriented sustainable practices. Our findings reveal the mechanisms behind community-driven knowledge scaffolding and insights into bottom-up food production and preservation. We highlight that materials and time play a key role in both the adoption and rejection of food science projects, and suggest these themes as productive touchpoints for interaction design. Above all, we hope to have shown that through its long tradition of experimenting and tinkering, at-home food science engages with many issues that are critical for sustainable HCI: food preservation and security, human health and nutrition, and everyday scientific literacy, among others. It was therefore critical for the success of our project to work with our participants as expert practitioners, project collaborators, and co-authors. Building on our design implications, our follow-up work is conducting co-design workshops with practitioners to envision and develop technologies for alternative food systems. These strategies from everyday food science can be applied to other interaction design practices, particularly in co-designing future systems for habitual sustainability and community literacy.

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