Doufu, Rice Wine, and 面饼: Supporting the Connections between Precision and Cultural Knowledge in Cooking

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ABSTRACT

The digital codification and measurement of food preparation has made strong contributions to HCI food research, whether through ingredient manipulation, workflow management, or recipe interaction. But prior work has shown that technical developments that emphasize precise gourmet practices tend to overlook the importance of cultural knowledge. Drawing on an integrative autobiographical design approach, we describe an open-source hardware toolkit that we developed to examine the process of integrating precision techniques with ritual cooking practices across three recipes: flour skin, rice wine, and doufu. Our work points to the importance of understanding precision as a cultural process with roots in personal and familial experience. We end with a reflection on the particular knowledge-forms that come from cultivating cultural relationships to fabrication processes and their implications for reading digital fabrication processes as meaningfully relational.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in interaction design**; **User centered design**; Systems and tools for interaction design.

KEYWORDS

design theory, maker culture, critical making, techno-culinary innovation

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1 INTRODUCTION

On the first day of spring, Danli was living nearly 6000 miles away from her family in Beijing, the Chinese city she grew up in. As her family members gathered to prepare and eat special food, she longed to celebrate this traditional Chinese holiday that marks the beginning of a new year. Seeing the winter end and agricultural activities resume, she yearned to prepare dishes like 素春卷 (a type of vegan spring roll) that signify abundance for the incoming year. But without her family nearby, Danli struggled to repeat the particular techniques that would remind her of home.

During a period in which many adults live away from their families and home countries, food has come to play a vital role in cultivating feelings of kinship and belonging for millions of people across the globe [45]. Experiences like Danli's (above) speak to this condition: a desire for building culinary connections when few other opportunities exist [80]. Cultural anthropologists have shown how home cooking and food consumption often comprise a set of mundane activities grounded in cultural knowledge [40]. Informed by strands of cultural anthropology [22, 80], we refer to cultural knowledge of food as the forms of expertise, awareness, and comprehension associated with culinary traditions. These traditions come from experiences within particular mealtime customs, arts, social institutions, and achievements, often associated with a particular region or social group [45]. Within food preparation, cultural knowledge emphasizes forms of ritual such as the customs, performances, and ceremonies associated with the identity of individuals and groups in relation to culinary practices. We define ritual in food preparation (in line with [22, 80]) as the repeated actions that organize culinary activity over time within a culturally significant setting [46]. Prior work has shown how these actions help sustain cultural legacy: by performing cooking techniques which are passed down between generations in the form of recipes and embodied practices, food rituals reinforce connections within particular domestic settings [52].

But preparing culturally-meaningful dishes, as Danli experienced, requires particular skill sets and cultural knowledge that can be difficult to acquire, adapt, and integrate. To prepare a dish, people draw not only from familial memory, but also techniques, tools, and training that can be hard, if not impossible to find [46]. While providing essential nourishment, these activities both contribute to social connections (forming an integral part of cultural norms) and rely on those connections for their reproduction [40, 46], presenting new challenges when the connections fade or become difficult to maintain. A range of HCI scholarship has tried to address this challenge by examining what happens when people lack access to these critical cultural linkages and training [56, 59]. This work has focused on how technology development might carry forward antiquarian and ancestral processes [24, 62] as well as support and expand existing food rituals [26, 43, 49, 64]. Documenting the limits to passing-down embodied routines and inherited habits, scholars both embrace and resist technical codification and enumeration

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as a means of scaffolding knowledge transmission [59]. Whether connected with food [26, 63] or otherwise [60, 61, 66], these studies have acknowledged the importance of celebrating existing making practices as a primary mode of sustenance and cultural production. They have also noted the tricky nature of instrumentation—as HCI scholars Charlotte Nordmoen and Andrew McPherson [51] remind us: "This symbol of sensor data as clean, reliable and precise has been shaped by the culture around the technology, a culture that strives for and values precision."

Separately, a robust body of HCI scholarship has leveraged the increasing ubiquity of technology such as sensors and controllers to enable widespread access to precision, including in the areas of cooking and food preparation at home. Consumer-grade appliances such as Instant Pot and bread makers designed to execute recipes with a press of a button focus on the automation of cooking tasks and adherence to recipes. Building on this trend, HCI researchers have developed systems for highly precise food preparation that scaffold engineering novelty, creating new types of food and food presentation activities in rarefied contexts such as gourmet restaurants [8, 49, 78, 79]. While offering technical insights and intervention into food preparation, presentation, and consumption, this research tends to focus on exceptional conditions that take place far from everyday food preparation settings. A parallel body of work focused on such everyday contexts has argued for elevating cultural aspects of food and eating, rather than "solving" food "problems" [26]. This work has proposed an agenda in human-food interaction wherein users can celebrate positive interactions with food [26], and playfully support challenges like engaging restless children at the table [15]. Although this work has foregrounded important forms of togetherness and familial significance around food, it has only begun to explore the technological mechanisms that might support and sustain cultural knowledge around cooking. We see an opportunity to apply precision tools to support culturally meaningful food preparation practices. In the potential connection between these precision developments and cultural knowledge, we ask: how might we use our access to technology and precision to uplift and support diverse and personal food cultures in the home, especially for dish preparation? And what new ideas of and relationships to precision come from an approach to sustaining culturally significant food knowledge and practice?

This paper examines these questions through the development of a lightweight open-source toolkit which supports the integration of technological measurement with culturally-meaningful domestic food traditions. Our toolkit comprises modular components including sensors and actuators that can be used in multiple configurations and for different ingredients. Our toolkit prioritizes lightweight implementation to support reconfigurability instead of optimizing for a particular application with custom enclosures and settings. Our toolkit is open-source and freely available to support further customization. We implement this toolkit to automate precision-oriented tasks such as measuring, counting, and timing so that the cook can focus on connecting to the food traditions embedded within the cooking process. This connection can involve remembering a loved one, trying out a cooking task associated with a cultural ceremony, or performing an action with specific significance towards a holiday. Instead of providing comprehensive functionality, being lightweight and open-source makes this toolkit accessible, extensible, and easy to share.

To better understand the situated experience of cooking culturally-meaningful dishes, we draw on first-person methods that reflect on the creation of three recipes that have a cultural and familial association to Danli [1]. Each requires precision in both measurement and process. With sensitivity to traditional knowledge, we describe our experiments in performing these dishes and our emergent design insights based on those experiments.

In the study that follows, we make two main contributions to HCI scholarship. First, we expand conversations on precision control to emphasize the importance of overlapping concerns for cultural knowledge and precision. This insight calls for HCI studies that take advantage of industrial processes to do so without abandoning attention to processes historically associated with culture, family, and cooking in the home. Second, we contribute a lightweight open-source hardware toolkit for precision control in cooking. Our toolkit negotiates the tension between the stigmatization of cultural knowledge and skills associated with home cooking practices. In particular, we discuss how our toolkit helps shed light on approaches to technological support that refuse the reproduction of harmful feminized and racialized stereotypes associated with domestic culinary work.

2 BACKGROUND AND RELATED WORK

To explore the potential of precision control in cultural food preparation, we examine prior HCI scholarship on food fabrication, the democratization of food ritual and craft knowledge, and the particular forms food preparation takes as they shift into a codified register.

2.1 HCI, Food, and Precision

Informed by science and digital fabrication scholarship, we define precision as how consistent repeated measurements are to one another [10]. In food preparation, precision refers to a standard that people follow to ensure that repeated measurements accurately follow instructions [67]. Precision has enabled new forms of control in cooking and food preparation, including allowing for highly precise recipe description and controlling mouthfeel with fabricated structures [67, 69]. HCI food studies have embraced the possibilities these forms of precision enable, contributing new and wondrous dishes [19, 28, 48, 49, 75, 76]. These contributions focus on the precision of the dish's presentation, often relying on computer-controlled processes to create delicate and intricate forms. These food preparations follow in a lineage of molecular gastronomy, a trend in food culture that has been criticized for denying cultural bases of food and eating, and instead refashioning cuisine as something that can be explained and improved with scientific thinking [57]. Related HCI research uses the control over food presentation to introduce corrective methods for modifying behaviors [36, 37, 42]. Central to this theme is an increasing awareness of one's own eating behavior, sometimes veering on normative orientations toward body fitness and wellness [25]. While this body of work values understanding people in different social contexts, human-food interaction in HCI so far has largely dismissed the cultural representation of cuisine

[1]Details on our positionality are in Section 3.2.

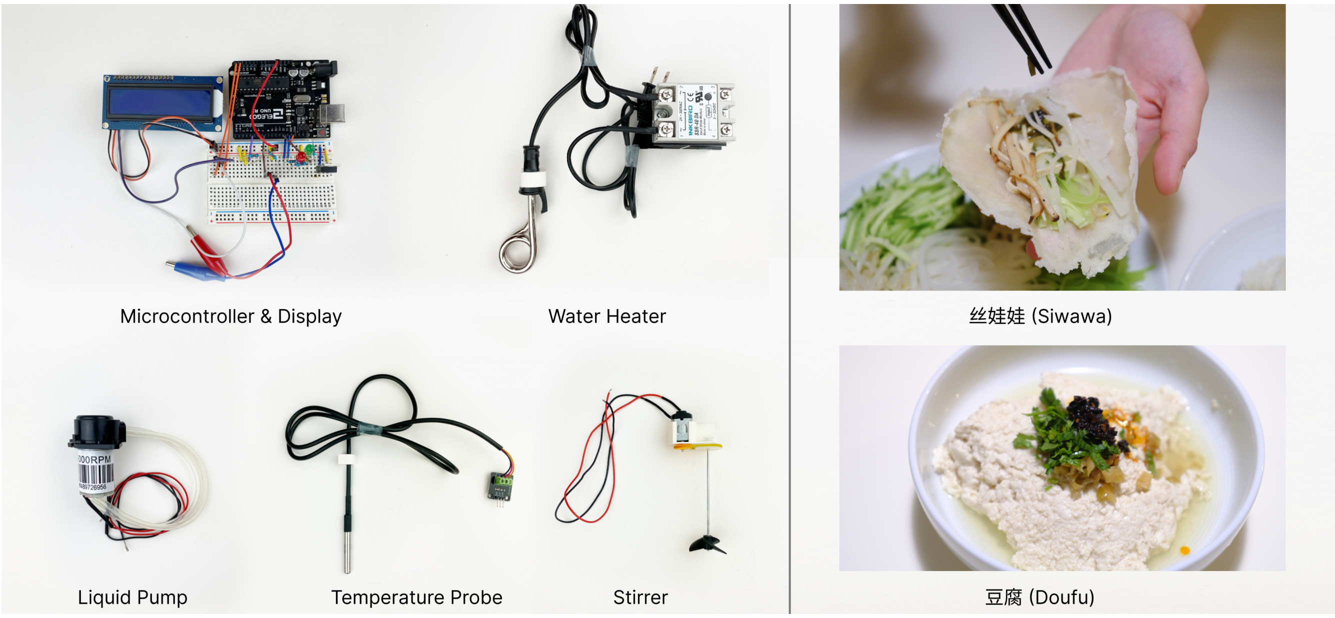

Figure 1: Left: sensors, actuators, and controllers used in our lightweight toolkit including submersible temperature probes, heaters, and stirrers. Right: culturally meaningful food we cooked using this toolkit.

that is fundamental to many communities [22]. We argue that precision in human-food interaction can go beyond rarefied presentation and as a tool for behavior change to celebrate and uplift existing food cultures and rituals.

2.2 Cooking and Sharing

Computational technology allows people to rapidly share information around food practices [59]. A significant body of work within HCI has assessed the role such technology plays in revisiting traditional knowledge to inform digital tools and practices [24, 51, 62]. The Tortellini X-perience museum exhibition [56], for example, uses computer vision to teach visitors how to create the delicate Bolognese pasta forms called tortellini, playing or pausing an instructional video depending on how far a person has gotten in the preparation process. Other work has focused on the appropriation of digital platforms such as YouTube to share food-related information and step-by-step instructions [71]. This care for human agency draws from studies of traditional sharing practices in the format of recipes [70] that frame cooking as a collective activity, wherein people express their intention and willingness to help each other, demonstrate techniques, and coordinate [52]. Emphasizing this collective character, Thomas David DuBois, a historian of East Asia, has documented not only the techniques and skills of preparing food but also the cultural significance and material embodiment of food in a specific cultural setting [22]. Informed by these insights, HCI scholars have realized digitized cookbooks that emphasize cultural and familial significance [18].

Despite the promise of digitization for cooking, designers struggle to make the rich combination of work, skills, and context shareable beyond the recipe or step-by-step format [59]. Instructions grounded in improvisation, creativity, and cultural nuance also tend to involve material processes that require precision and measurement. Whether the goal is to elucidate the historical significance of making [60, 66], support the development of tacit knowledge required to conduct food preparations [3], or support the playful, ineffable, hedonic qualities of cooking experiences [26], precision plays an important but under-explored role in celebrating inherited food traditions.

2.3 Domestic Labor and Traditional Knowledge

The automation of food preparation has increasingly informed contemporary domestic food preparation [59]. From bread-making machines to rice cookers, such technology selectively integrates cultural knowledge already at play in the food preparation process, leading HCI scholars to map the challenges of knowledge sharing as well as fruitful technical developments [26, 56]. Following a pancake recipe, for example, Devendorf and colleagues use a laser that traces a pre-loaded 3D model to create novel edible sculptures [21]. Hertafeld et al. implemented a multi-material 3D food printing technique with simultaneous infrared cooking and demonstrated a variety of examples from sweet to savory dishes [28]. These forms of novel tooling cast the home as a site of technical reinvention: using numerically controlled machines to help standardize and recreate recipes with the precision of instrumentation, creatively augmenting home cooking.

Other work has sought to trouble the separation of elite engineering culture from everyday forms of creative practice [13, 14, 72]. From IKEA hacking to embroidery [58], scholars have shown that routine acts of creativity and making exhibit skillful forms of innovation with significant implications for HCI design and development [5, 23, 54]. Scholars have pointed out, for example, that when women built the Apollo code that sent people to the moon and back, male managers called them "little old ladies," effectively feminizing their work to undermine their contributions [61]. These studies build on decades of scholarship in feminist STS that have noted the influence of patriarchy, coloniality, racism, and ageism on historically under-valued forms of labor (e.g. [1, 33]). Tracing associations drawn between the feminine and domestic, they show how innovation cultures tend to express and reinforce cultural stratifications that position women, and particularly women of color, as less important and skillful, emphasizing their contributions as manual and rote rather than cognitive and unique [32, 38].

We look across these varied bodies of work to bring an analysis of the particular forms of labor and knowledge that computing cultures tend to overlook and under-value. Drawing from Danli's familial dishes, we continue to trouble conventional stratifications of expertise by taking seriously the forms of appropriation that underlie techno-culinary innovation and their hidden origins.

3 METHODS

To pursue our research, we employ first-person research methods grounded in autoethnographic inquiry and autobiographical design. In this section, we detail our methods and our own positionality.

3.1 First Person Research

First-person research refers to a mode of empirical investigation based on the primary analyst's own experiences, feelings, reflections, and ideals [39, 44]. While autoethnography focuses on the varying degrees of written documentation and description [16], autobiographical design is another first-person research method in HCI which addresses design-based development and speculation [50]. Autoethnography is a widely practiced qualitative research method that involves the written documentation of events, experiences, and other empirical phenomena based on the analyst's own lived account, often interpreted through its relationship to larger bodies of theory and knowledge. Bringing a greater focus to technology development, autobiographic design refers to an emergent design research approach outlined by HCI scholars Carman Neustaedter and Phoebe Sengers as "drawing on extensive, genuine usage by those creating or building a system" [50, p. 514]. Underlying both lineages are not only under-examined tensions [30] but also important questions of positionality and complicity [9]. Scholars examine whose voice autoethnographic and autobiographical design approaches center, and what comes of a method of centering that lacks critical engagement with historicity, identity, and power [9, 23]. Our work builds on these studies of positioning to explore our own relationship to the practices we engage in and augment these practices with computational processes.

3.2 Positionality

To situate our own relationships to food preparation and our study approach, we briefly describe our own positionality. All authors identify as women and are the children of people who have immigrated and/or have themselves immigrated. Danli self-identifies as a woman of Chinese descent and the selected recipes in this research correspond to foods she grew up cooking, eating, and experiencing within her childhood home. As a counterpart to this cultural connection, this study draws on Danli's formal training in materials science in which she has experimented with developing materials and processes for additively fabricating food artifacts. We argue that this mix of materials science training and cultural connection to the food described in this study provides a unique lens to examine the forms of practice and knowledge embedded in cooking.

Before selecting recipes for this study, we conducted a reflective exercise wherein each of the authors recorded and shared one or more stories of recipes that had been passed down to us through familial and cultural relationships. In sharing these recipes, we considered the ways we took up the recipes in our daily lives, the reasons we had for wanting to recreate them, and our methods for realizing their connection to the past. Through discussion we decided to focus on Danli's recipes due to their primary role in driving the research questions and experiments.

3.3 Our Approach

Danli prepared the recipes sequentially and iteratively developed the toolkit to support increasingly complex recipes. While the first recipe relied on a precision scale and a commercial stove, the second recipe required temperature control and precise timing. To support this range of needs, the kit includes 3D-printed modular mounts for a digital temperature probe and an immersive water heater which we controlled using custom firmware and circuitry. With these mechanisms, Danli could provide highly consistent timed temperature control through a closed-loop system wherein the sensor data controls the heat. Beyond temperature and timing, the third recipe relied on accurate ingredient dosages. To achieve accurate dosages, Danli developed a peristaltic liquid pump module to augment our toolkit. It similarly relied on modular 3D printed mounts, and we extended our firmware and circuitry to control the pump. With this extension, Danli could introduce accurate quantities of liquid ingredients with precisely controlled temperatures.

The toolkit is open-source and shared on our Github repository[2]. Our repository includes all the off-the-shelf components we used in a bill of materials, the 3D models, and the microcontroller firmware. It is licensed CC-BY 4.0.

To collect data, Danli kept a range of media, including notes, photographs, and videos that documented each of the recipes, as well as her reflective journaling about the cooking and toolkit implementation process. She then shared this data with Daniela and Nadya during weekly meetings. All authors then reflected on the journals and associated media and consumed the cooked food. This process helped develop sensitizing and synthetic concepts and questions from successive rounds of analysis in the tradition of close reading [4]. Through discussion and reflection, we surfaced opportunities and tensions relating to precision in culturally-meaningful cooking practices. In the next section, we elaborate on our process and trace how bite-sized bursts of recognizing, problem-solving, and enjoying cooking brought us new insights and engagement with technology-supported food practices.

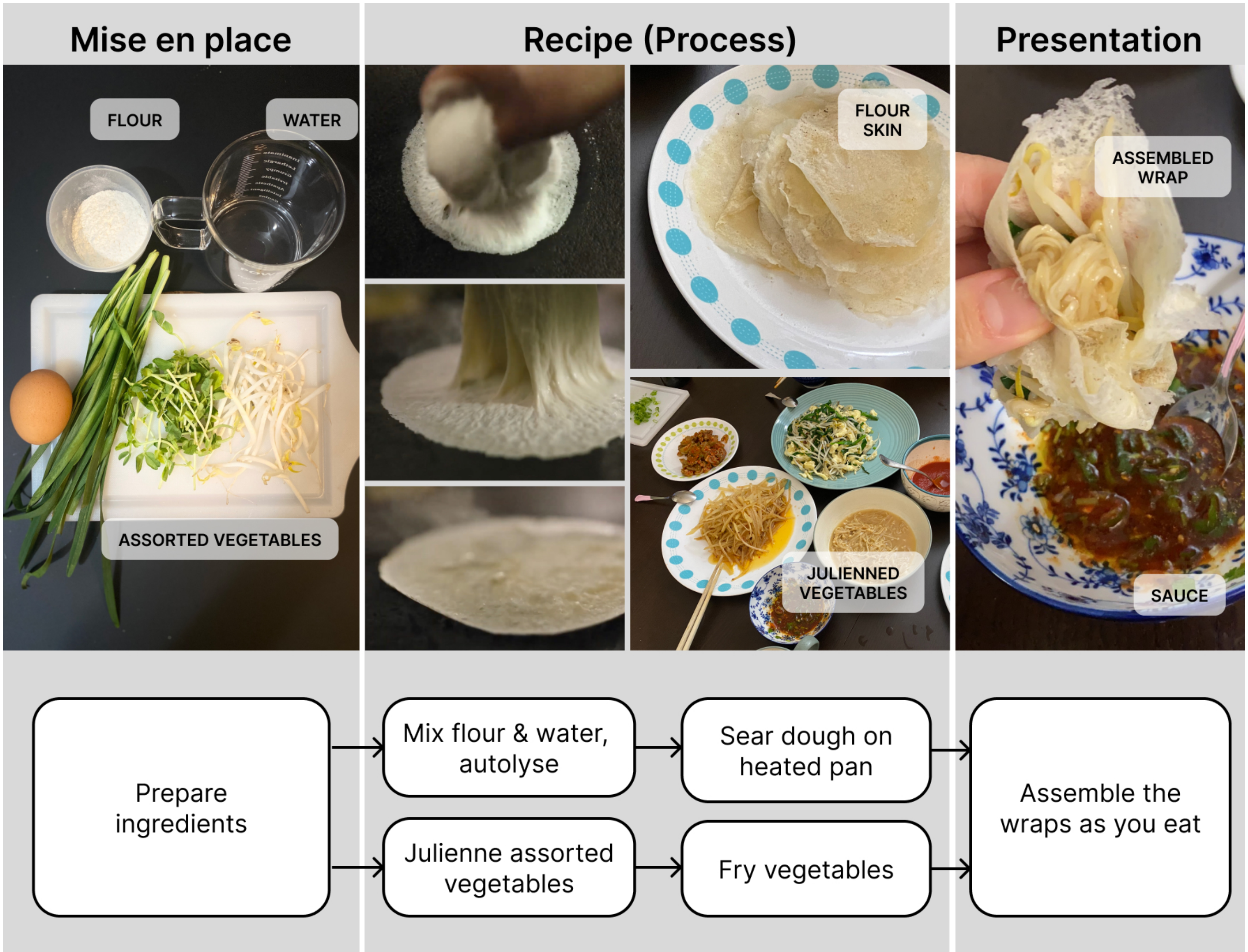

Figure 2: Workflow of making flour skin. This dish relies heavily on ancestral knowledge and only uses a digital balance in the first step of the process to weigh the flour and water. Searing the dough requires temperature control, yet the temperature depends on many factors such as the gluten content in the flour, the hydration of the dough, and the time which the dough has been rested for. The types of vegetables are simply based on individual preferences and availability. Left recipe photos from [31].

4 COOKING EXPERIMENTS AND TOOLKIT DEVELOPMENT

In this section, we describe our findings from creating three dishes and iteratively developing our toolkit. The three dishes have particular cultural relevance for Danli: flour skin (面饼), rice wine (酒酿), and doufu (豆腐). Where doufu is known to many with its Japanese-derived spelling tofu, the other two dishes may be less familiar: flour skin is a delicate and pliable pancake eaten as a wrap around a range of fillings, and rice wine is an alcoholic beverage that ranges in color from clear to yellowish-brown and can be used as a drink or for cooking. We included the Chinese names of each dish as they are more specific than their English translations. The original recipes for the three dishes are in the Appendix.

[2]https://github.com/machineagency/toolkit_for_cultural_cooking

4.1 面饼, flour skin

To set the scene for the first dish, Danli shared reflections on the importance particular recipes and flavors have played in her shifting sense of place:

> *Growing up in a family with working parents, I have little memories of childhood homemade food. As I entered adulthood I traveled to and lived on different continents. The affection for food, especially culturally meaningful food, grows with time and distance away from home.*

> *Food is an outlet of emotion, an anchor to someone's origin, and a tie to our ancestors. Recreating these cultural recipes and nuancing the minute alteration in the process gives me, a Chinese diaspora woman, confidence in touching my roots and discovering ancestral knowledge.*

Danli is describing the mix of memories—festivities, blended familial encounters, and knowledge of her family heritage—that she associates with ritual food practices. Since she did not grow up eating food made by family, she drew particular inspiration from recreating dishes she ate on special occasions. One such recipe is 丝娃娃, a type of vegan spring roll wrapped in flour skins.

Flour skin is a thin pancake made of glutinous wheat flour and water. Recalling her experience with the dish, Danli drew connections between the recipe and specific smells, tastes, and spaces:

> *In my culture, we celebrate the first day of spring, 立春 (Lichun), as the start of a new year. On this day, we prepare spring rolls or spring flour skins. Albeit having slightly different preparation processes, the essence of this type of food is julienned vegetables wrapped inside of a flour skin. I did not grow up with this, but the 丝娃娃 ('Siwawa', translated to julienne baby wrap) is a traditional and popular street food from my father's hometown. The name comes from the shape of the roll which looks like an 'infant", made of julienned vegetables, in a 'swaddle', a thin flour skin. The most special ingredient in the julienne baby is 木姜子油, litsea oil. As a processed and refined food, litsea oil exists in my memory in the form of its scent.*

In the above excerpt, we learn how Danli situates the flour skin in an array of sensory memories and experiences—her father's hometown, the smells of litsea oil, the marking of spring. Each of these associations builds a particular connection to a moment that is physically distant, but emotionally near.

For Danli, returning to the flour skin with her materials science experience meant exploring what role precision instrumentation might play in recreating these memories. As an initial step, she used an iterative trial-and-error process. Her early attempts revealed the impossibility of learning to make the dish from a recipe. Although the skin relied on only two ingredients, she found it very difficult to achieve. She also knew no one locally who might teach her. Given these constraints, she looked online. Seeking out video footage from a Chinese documentary [31], she quickly learned that the dish relies on an unusual and almost inexplicable technique of searing (Fig. 2, Recipe).

> *When I started making the flour skin, the gluten network of the dough suddenly became very tangible as I manipulated it in my hand, as done by the woman in the video.*

From her experiments, Danli learned the unique aspects of the technique of making that thin flour skin. She needed to sear a flour skin in a hot pan without oil by flapping the wet dough onto the pan, leaving a round stain of the dough that would then peel off as it cooks. In this careful work, she required precision along two axes: the consistency of the dough and the temperature of the pan. The consistency determined the elasticity of the dough, how thin a layer it will leave on the pan, and the final texture of the flour skin. The elasticity depended on the duration of time the material had rested—or in materials science terms, the degree of cross-linking of the gluten network. She explained:

> *I added more water to the dough after failing the first few flour skins as I yielded only thick flour skins. In my recollection, they ought to be thinner. I also had to adjust the heat setting on the stove multiple times to find the balance.*

In this excerpt, we find Danli had to grapple with differences between two material states: the traditional form of this dish (thin) and its current condition (thick). To grapple with this difference, Danli had to adjust the water amount and pan temperature. These actions were guided by her personal memory of the desired thin state. With time, she found that the temperature of the pan determines how fast the flour skins get cooked and how thick a layer of dough will stick to the pan. The temperature needed to be maintained in a range where the dough seared on the surface and stuck to the pan. Just when she thought she was done, she realized the chemical reaction had not ended. As the flour skins cooled down, they wicked the moisture in the air, making them chewy and pliable and ready for wrapping:

> *To consume Siwawa, we laid assorted vegetables on plates and put out a bowl of sauce to complement the flavor. The ritual of assembling one's own wrap according to one's own taste is a very important part of a family meal. The litsea oil was in the sauce. As we ate, we drizzled the sauce over the wrap that we assembled with vegetables we liked.*

In her intermingling of the dish with additional dining rituals, Danli illustrates the degree to which the technique of making flour skins relies heavily on cultural practices. The recipe relied only lightly on advanced kitchen technology such as a precision electric range, as making flour skins poses many variables depending on the physical environment. Understanding the chemistry helped Danli manipulate the dough. Yet, the indirect control of and the feedback from the low-level cookware resulted in the inconsistency of outcomes. In traditional recipes [31], authors tend to separate the textual description of the dough-searing process from the technique itself, calling for on-the-fly judgment and tuning of the cookware. With the next dish, we reflected on this experience of iterative exploration and how it shaped Danli's design of custom hardware.

4.2 酒酿, rice wine

Rice wine is both a drink and an ingredient brewed from rice and water. Unlike flour skin, which required precise pan temperature and water amount, we learned from the below experiments that the rice wine relies on a more complex set of interventions.

In her initial preparation for the rice wine, Danli noticed its unique place in her memory:

> *As I grew up, I abode by the law not to drink alcoholic beverages when I was still a minor. There is one exception which is fermented rice wine. The alcohol content is too low to be classified as an alcoholic drink, yet its sweet and refreshing flavor makes it suitable for dessert. A variety of crops can be used as the source of starch,*

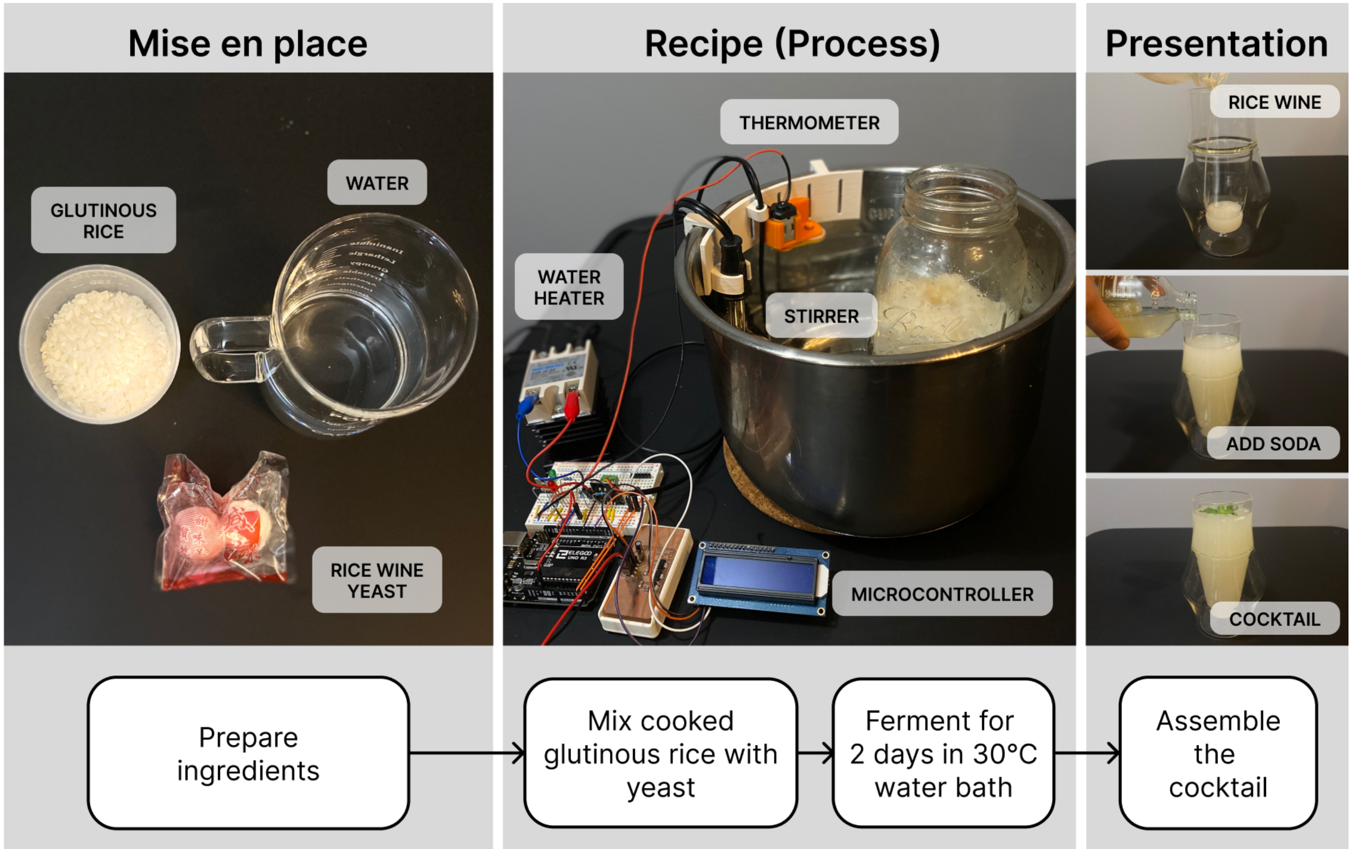

Figure 3: Workflow of making rice wine cocktail. Making rice wine requires three ingredients: glutinous rice, water, and rice wine yeast. The toolkit includes cookware equipped with a temperature probe, a motor-driven stirrer, and an immersive water heater. Once the rice one is ready, add soda and mint leaves to make a cocktail drink.

> *among which glutinous rice is the most common choice. Drinking rice wine reminds me of cocktails, in which occasionally some herbs are added to spice up the flavor. I thought of* 薄荷*, mint, which is a signature seasoning in my father's hometown. Mint is usually added to red meat in his family cuisines. It counteracts the greasy mouthfeel of animal fat while elevating the flavor with a strong aroma.*

In the above excerpt, it is the connection of the wine to specific herbal tastes and smells that first informed Danli's experiments. She quickly learned that the recipe for rice wine includes an unusual ingredient: the rice wine yeast. Using this ingredient required a prolonged trial-and-error period to ferment the alcohol. To control the temperature during fermentation, authors of various recipes originally used a bulky blanket wrapped around the container. But Danli noted that temperature sensors and heating coils could more precisely control the fermentation process than the wrapped blanket. She developed 3D-printed modules to hold the temperature sensor, immersion water heater, and motor-driven stirrer in place, connecting them to a custom circuit for which she wrote control firmware. To aid reconfigurability, she designed custom modular 3D-printed fixtures which allowed her to array the modules on a panel hanging on the edge of the container she used for brewing. In her firmware, she set her control loop to maintain a temperature close to 30°C with the stirrer constantly running to ensure even heating. The program contained a simple feedback loop where the water heater was powered on when the temperature dropped below 29°C and powered off when the temperature went above 31°C. The temperature range ensured that the water heater did not constantly switch states. Her firmware also displayed the time elapsed and alerted her after 48 hours on a connected LCD panel.

With these techniques for monitoring and controlling fermentation temperature, Danli replaced a cumbersome warming system replete with errors. In this process, Danli used her training in materials science to understand the chemical processes happening in rice wine making: the amylolytic process produces sugar from starch, which makes the rice wine sweet, and another fermentation process produces alcohol from starch [41]. The correct temperature ensures the production of sugar is promoted while the production of alcohol is lightly suppressed, creating a balance of flavor. Danli introduced precision control to better conduct and monitor the fermentation experiment of rice wine [35] (Fig. 3).

> *The temperature fluctuated between 29°C and 31°C during the operation, and I heard the stirrer turning on*

> *and off. After two days of waiting, I finally tasted my first batch, and it was sour and tingling – I have made vinegar. In retrospect, I noticed two factors that I have neglected. First, I had no control over or ways of knowing the exact chemical composition of the glutinous rice and the yeast compound I used. In practice, people just trial-and-error to yield desired results. Second, I did not take into account the heat generated by the chemical reaction, which will slightly increase the temperature of the rice-yeast mixture but is undetectable by the temperature probe sitting outside of the mixture. I should lower the water bath temperature to accommodate the exothermic effect. I repeated the experiment with a temperature setting between 28°C and 30°C and yielded a successful batch of sweet, lightly alcoholic rice wine.*

Following this recipe has led her to failure in the first trial. She recalled that in her training as a materials scientist, following recipes from literature did not always guarantee success as there are always variables in the process such as using different sources of ingredients, environmental factors, and implicit techniques that are not described in the recipe. Danli noted some tradeoffs in her approach. She found that delegating the temperature control to electronics requires a translation between traditional recipe languages such as *'a warm place (e.g., near a furnace or under a thick blanket)'* to scientific description and further automation control. Eventually, precisely controlled temperatures increased the chance of successfully replicating the rice wine recipe. Moreover, knowing the temperature during fermentation resolved Danli's frustration with ambient temperature fluctuations and better informed the next iteration.

4.3 豆腐, doufu

Doufu is a form of bean curd made by coagulating soy milk and then draining the mixture such that only white solids remain. Although a solid food, doufu has different consistencies ranging from silky to firm depending on the amount of coagulant, a mixture of chemical salts that cross-links protein molecules, added to coagulate soy milk. The consistency also depends on the final pressing that removes water from the curdled soy milk. In English, the word "tofu" comes from the Japanese, who in turn took on the Chinese 豆腐, or *dòufu*. Making doufu requires both precision control and a cook's judgment from experience. First, for precision control, the chemical reaction of doufu curdling occurs at a specific temperature. A temperature higher or lower than the required temperature will result in an overly firm consistency or uncurdled soy milk [27]. Second, the cook needs to control the interdependent variables of temperature and coagulant amount, identifying visual cues based on past experience. Danli's Chinese ancestors created a recipe for turning liquid into solid with different textures. Thinking about the texture of doufu, Danli started to recall a traditional dish from her culture.

> *I began thinking about the most famous Chinese doufu dish, which is perhaps Mapo doufu. It originated in Sichuan, China. I learned that 花椒, Sichuan pepper, is a native Chinese plant, while 辣椒, chili pepper, is exotic as it was imported from North America hundreds of years ago. The use of chili pepper has rapidly spread in Southeastern China, where my parents grew up. A burnt smell of chili pepper flakes or chunks is signature to the cuisine in my father's hometown. My young palate, as a child, could not bear the stimulating sensation until I grew up to appreciate its significance in my father's culture.*

To connect with her father's culinary culture, Danli decided to make the doufu for Mapo doufu. Originating from Sichuan province, Mapo doufu is made with simmered tofu set in a sauce containing fermented bean paste, ground beef, chili pepper, and Sichuan pepper which give the dish its spicy and tingly flavor. For this dish, she had found a medium doufu easier to handle. She needed to fix the ratio between the three ingredients in this food — soy beans, water, and coagulant (a mixture of chemicals derived from seawater) — to achieve a medium firmness. She first boiled the soy milk and removed the container from the stove followed by curdling. Here, she used the same 3D-printed panel to hold the peristaltic liquid pump and the temperature probe with custom fixtures (Fig. 4). The program on the microcontroller used temperature probe readings as triggers. When the temperature dropped below the set temperature at 80°C, the program activated the peristaltic pump, transferring the exact amount of *nigari* (a mixture of magnesium chloride and traces of other salts) by controlling the motor run time. The soy milk started to coagulate within a few minutes, turning into a cloudy solution with white chunks. She then manually transferred this mixture to the mold with weights on top to drain excessive water.

What Danli found in this process is a striking shift in her own experience. Using the custom instrument, she succeeded in reproducing the doufu dish. However, arguably, she lost the fun part of homemade doufu: observing the curdling and adjusting the addition of coagulant on-the-fly. She knew that experienced doufu makers would use a ladle to gently disturb the surface and decide whether more coagulant and heating are needed [73]. In an industrial workflow, all the parameters—temperature, amount of coagulant, time—are decided prior to the production and require no further alteration. From the lack of interaction with the coagulated soy milk, Danli noticed a disconnection between the material and its form.

As dosage, temperature, and timing for adding the coagulant are all well controlled by the custom cookware, Danli managed to spare the complexity in executing the doufu recipe. The act of following steps, observing the curdling reaction, and moving it to a mold with the right amount of pressure, remains on a ritualistic register. She could only gauge these steps through experimentation. As she iteratively repeated the recipe three times, she yielded different results in the firmness of doufu.

We have so far seen that the conditions for preparing food with computational support varied across time and recipes. At first, each process seemed to require a particular degree of process and measurement precision, often involving many small adjustments: tuning the temperature of the stove while searing the flour skin dough; monitoring the temperature of the rice wine bath as it fluctuated with the surrounding air temperature; and adding a precise amount of coagulant to the doufu to make sure it was neither too soft nor stiff. But with time, Danli noticed that each

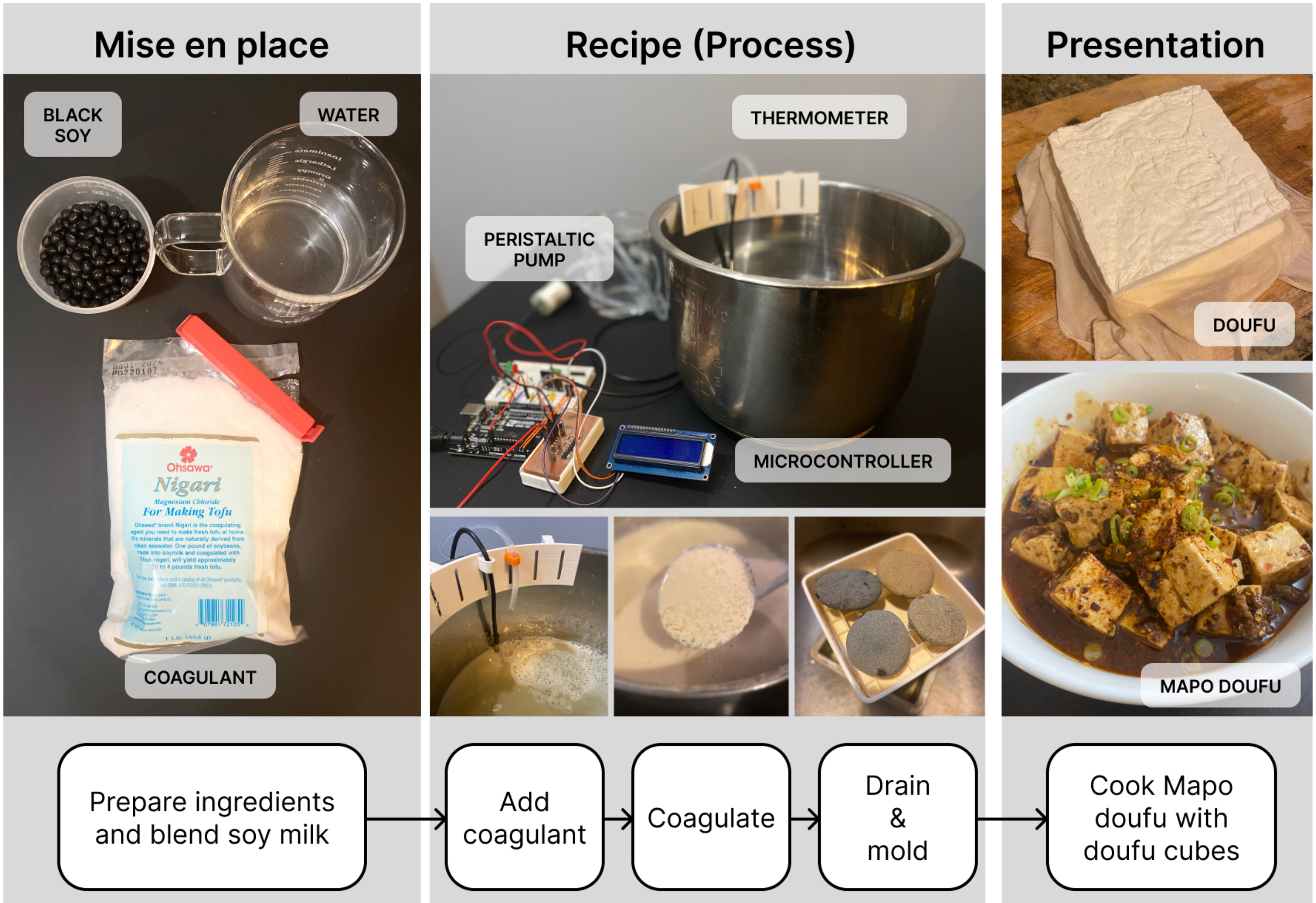

Figure 4: Workflow of making doufu. Making doufu requires the soy to be juiced and boiled. The cookware is equipped with a temperature probe and a peristaltic pump to transfer the coagulant at the right temperature. Once coagulated, the liquid soy milk turns into white chunks and is then transferred to a mold. Some weights are placed on top of the mold lid to extract excessive liquid and control the firmness of the doufu.

process differed in the role that automation plays or might play. Even with the help of the toolkit, for example, she had to monitor the doufu texture by testing the graininess on her tongue. While the rice wine benefited from measurement precision, she had to largely ignore computational tools for the flour skin and learn to create the skin by cultivating a particular embodied sensitivity for the light quality of the dough. Despite the goal-directed nature of each of these tasks, she noticed how her interactions with the ingredients could bring great joy—the moment flour skin peeled off the pan, the gentle effervescence of the rice wine, and the doufu curdling. Danli needed instrumentation to guide her in terms of an acceptable range of precision, but within that tolerance she took pleasure in exploration and invention. For Danli, the three recipes presented a progression of precision control while creating opportunities to analyze and blend forms of scientific knowledge and cultural, traditional, and ritualistic practices. Through the investigation, she lifted the required attention to precision control to make space for reflecting on culturally significant knowledge.

5 DISCUSSION

Through our experiments, we have begun exploring the confluence of culturally-meaningful food practices and precision control. While HCI scholars have attended to traditional culinary practices, the field has only scratched the surface of the entanglement of traditional and engineering practices. Our toolkit development extends HCI food and tradition studies with an analysis of Danli's own cooking experience. An engagement with the particular knowledge-forms that come from personal and cultural relationships to food—and reading of measurement tools as meaningfully relational—troubles a narrow focus on instrumentation. As designers of digital tools, many of us struggle to make sense of what it means for mediated practices to depend on generations of passed-down embodied routines and inherited habits that tend to resist technical codification or enumeration. As a primary mode of sustenance and cultural production, food preparation offers one such example.

Our toolkit design may seem removed from industrialized food production. Industrialized cooking tends to turn the embodied experience of people who cook into data, relying on a sometimes subtle process of extraction. It then uses that data to set ingredient amounts, cooking temperatures, and cooking times, abstracting away the experience of the people who have long cooked the food. In this transformation, it can seem like precision itself is erasing cultural cache and identity. However, we see from Danli's experiments that there is space to use precision methods without erasing the nuances of embodied experience. Through sensors, feedback loops, and timers, precision control may give people like Danli the ability to have the precision of an expert when handling their ingredients while allowing them to draw from and grow embodied sensitivities. The toolkit allows us to iteratively explore cultural connections to food with precision control. In this iterative approach, it emphasizes the need to treat precision as a situated condition, and not something to strive for as a universal solution to home cooking-related challenges. Using the toolkit, we learned the importance of assessing the role of smart automatic cookware in situ, including a recognition of how any precision tool may complement or supplant cultural knowledge. This recognition resonates with Horn et al.'s concept of "computational modesty", which emphasizes the intentional degree of computational design and digital fabrication added to existing forms of labor [29]. We argue that this concept is applicable in our context of culturally meaningful food preparation because we strive to support personal agency and access to cultural knowledge during creative food preparation. Specifically, our approach, using a lightweight toolkit to probe cultural connections in cooking, embodies this concept by offering just enough technical instrumentality in precision control, allowing space for creative exploration and reflection on the process of cultural food experience.

In closing, we look closer at what these insights bring to studies of food preparation in HCI, and how attention to ritual as precision (and precision as ritual) opens new avenues for HCI research. We organize this reflection around two main thrusts: supporting the circulation of cultural knowledge and approaching toolkit design as building cultural knowledge.

5.1 Supporting the Circulation of Cultural Knowledge

As a first theme, we see the importance of supporting access to cultural knowledge for Danli. Even before she began experimenting, she recognized how difficult it could be to recreate dishes from her memories. To be sure, this observation motivated our initial study (as noted earlier). She didn't know anyone in her immediate environment sufficiently familiar with the three dishes, and she didn't find recipes or videos that work as complete and comprehensive guides. Failures of thickened pancakes and acidic wine pervaded her process. How could she glean the skills to recreate recipes from her childhood? Attempts to recover this traditional practice presented her with merely dead ends.

In prior works, HCI studies of craft and food preparation have established the importance of shared content such as how-to videos and dedicated step-by-step instruction websites that scaffold embodied learning around shared techniques [20, 34, 58]. But with the introduction of the toolkit, we see how the physical environment shapes what techniques are possible to learn. Skills become distributed not only across the tools used to increase the precision of process and measurement but also across tacit memories used to check and iterate on the result. Using smart cookware for streamlining the process of cooking takes the burden off of precise measurement and timing, yet current automation only makes the redundant part of cooking, such as measuring ingredients and monitoring times, seamless and automated but it dismisses the intrinsic human connection and capacity in the practice of cooking. Acknowledging critiques of automation, we nonetheless wish to highlight the positive role we believe precision can play in emphasizing embodied experience in cooking. This toolkit prioritizes the intention to probe traditional knowledge compared to emphasizing convenience and efficiency. Through the toolkit, Danli is building new capacities: becoming able to sear flour skin or adjust the temperature of rice wine and potentially (one day) demonstrate this to others. In her rehearsal of technical practices from her past, she exhibits a knitting together of cultural and material expertise. This blending exposes how traditional practices are not the same as materials science, but they are also not completely separate. Using the toolkit takes off attention to redundant details in cooking and redirects attention to the ritual of cooking and materiality. Materials science or precision control does not rely on or disapprove of traditional practices; they negotiate the ground of embodiment in the experience and sensitivity to such practices. What we learn from following the toolkit is that supporting the circulation of cultural knowledge requires a certain interweaving of both cultural and material forms of knowledge.

5.2 Approaching Toolkit Design as Building Cultural Knowledge

While building each kit, we find that the relationships Danli held to the underlying recipes and practices often shaped her process, and sometimes took precedence. As we noted earlier, this valuing of personal memories and cultural practices tends to fall into the background within technical HCI research, which often emphasizes the value of precision and adherence to recipes instead. Across the toolkit development, we see how precision enables the Danli to develop particular forms of understanding and capacity for which she would otherwise require a heightened sensitivity. This heightened sensitivity highlights a cultural connection to the process that forms of digital codification often dismiss, a situation we see beyond these recipes. Consider making a cup of tea. In some contexts, people take great care to measure the temperature of the water (e.g. 85°C versus 82 °C) and the time a tea bag sits in water (e.g. two minutes versus six). People adjust these variables to change the resulting flavor. But what result people consider desirable is based on cultural context and tradition. The work of monitoring time and temperature relies on precision but also a sense of cultural awareness, one that Danli experienced first-hand. Our study suggests that in the combination of the two (precision and cultural knowledge), researchers may bring new and important insights into digital tools for analysis.

This combination of precision and cultural knowledge can take varied forms. To understand this variety, let's take the example of "doneness"—the state when a particular food preparation process is complete. With something like rice wine, Danli could measure its alcohol or sugar content as an indicator of doneness but this process requires lab-grade equipment. Instead, it involved visual cues and tasting, two practices embedded in cultural knowledge and familial memories. In the case of flour skin, her assessment of whether the skin is sufficiently cooked to the desired degree felt difficult or impossible to achieve with instrumentation alone. She found that a fully cooked flour skin should be lightly scorched on both sides without discernible yellow spots, something she learned through repeated practice and continual assessments based on cultural memories. Similarly, she judged a rice wine as ready and successful by tasting it and doufu chunks as ready to be transferred to the mold based on the amount of clear water being squeezed out of coagulated soy proteins. It is only learned in the embodied experience as part of the ritual.

Attending to ritual knowledge in toolkit design involves a concern for both the moral and technical character of any work to sustain connections, what Sareeta Amrute [2] might call technoaffects (in relation to technoethics). In contexts of food preparation, this care work invites more than an instrumental knowledge of particular tools and ingredients (although both are necessary). It also compels a sensitivity to the kinds of memories, cultural resonances, and sensory reorientations they evoke and sustain for that cooking. Participating in these cooking practices prompt HCI scholars to shift food preparation support from a focus on tools of production/efficiency toward tools of measurement/noticing. It is through the negotiation between cultural knowledge and precision control that we might meaningfully connect forms of precision control with cultural memories and practices.

6 CONCLUSION

This work has explored the intersection between precision tooling and traditionally and culturally meaningful culinary practices in a home kitchen that explores the long-standing dismissal of ritual food knowledge alongside automation. We used a custom precision-control toolkit to guide three traditional recipes in Chinese cuisine each with a specific flavor note. In addition to offering simple utility, we saw how this toolkit helped probe the attachment to ritual knowledge with the involvement of modern technology in cooking. Weaving the materials science of food and the tacit knowledge of cooking techniques, our investigation shaped a negotiation of precision control with ritual knowing.

As a final reflection, we want to consider a seemingly unrelated context: a moment from the late 19th century, when American microbiologist Fanny (Lina) Hesse worked as an unpaid assistant in her husband's microbiology laboratory. At one point in her lab work, she observed her husband struggle to use gelatin as a solid media for microbial culturing. Gelatin's low melting temperature and susceptibility to enzymes produced by microbes limited its utility, especially in hot summer months. Recalling recipes from one of her friends had previously lived in Indonesia, she came up with an idea. The Indonesia recipes used agar-agar in fruit jellies because it did not melt in the summer heat. Hesse swapped the gelatin in the solid media for agar-agar, thereby creating vital growth surfaces used across microbiology and setting a standard employed to this day [47, 65].

While this story may seem disconnected from our inquiry into ritual and precision cooking, it offers an important connection. Recent HCI research has also used agar-agar and gelatin to create bioplastics and shape-shifting materials [6, 7, 68, 74, 75]. As for Fanny Hesse, this work makes important inroads for scientific thinking (offering materials that bolster sustainability). But it also begins to appropriate local cultural knowledge in the name of scientific explanations and techniques. Responding to this observation, our work adds to a growing body of HCI scholarship on narrative silence [9, 12, 55, 61] to emphasize the importance of situating HCI food development in cultural practices and histories. This extractive work echoes conversations beyond HCI where food media is currently reckoning with a history of discrimination and exploitation, grappling with ownership and representation and questions of who owns recipes and who gets to cook, publish, and present them [11, 17, 77]. We are sensitive to contexts in which instrumentation and automation are deployed to replace and surveil people, in the context of food and otherwise [53]. Our work contrasts with a science-only framing and using automation only for efficiency and optimization, by rather showing what it might look like to historically situate "novel" or "innovative" technological contributions and place them in a particular personal and cultural context. While our inquiry remains preliminary, we argue that our explorations demonstrate a valuable direction for HCI food interaction and toolkit research that celebrates cultural context while taking advantage of the precision of instrumentation.

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REFERENCES

[1] Sareeta Amrute. 2016. *Encoding race, encoding class: Indian IT workers in Berlin.* Duke University Press.
[2] Sareeta Amrute. 2019. Of techno-ethics and techno-affects. *Feminist Review* 123, 1 (2019), 56–73.
[3] Elisa AG Arfini. 2019. The making of authentic tortellini: Aestheticization of artisanal labor and elite univorism in the case of local food. *European Journal of Cultural Studies* 22, 4 (2019), 433–451.
[4] Jeffrey Bardzell and Shaowen Bardzell. 2015. Humanistic hci. *Synthesis Lectures on Human-Centered Informatics* 8, 4 (2015), 1–185.
[5] Shaowen Bardzell and Jeffrey Bardzell. 2011. Towards a feminist HCI methodology: social science, feminism, and HCI. In *Proceedings of the SIGCHI conference on human factors in computing systems.* 675–684.
[6] Fiona Bell, Latifa Al Naimi, Ella McQuaid, and Mirela Alistar. 2022. Designing with Alganyl. In *Sixteenth International Conference on Tangible, Embedded, and Embodied Interaction* (Daejeon, Republic of Korea) *(TEI '22).* Association for Computing Machinery, New York, NY, USA, Article 2, 14 pages. https://doi.org/10.1145/3490149.3501308
[7] Fiona Bell, Netta Ofer, Ethan Frier, Ella McQuaid, Hyelin Choi, and Mirela Alistar. 2022. Biomaterial Playground: Engaging with Bio-Based Materiality. In *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) *(CHI EA '22).* Association for Computing Machinery, New York, NY, USA, Article 171, 5 pages. https://doi.org/10.1145/3491101.3519875
[8] Genevieve Bell and Joseph Kaye. 2002. Designing technology for domestic spaces: A Kitchen Manifesto. *Gastronomica* 2, 2 (2002), 46–62.
[9] Cynthia L Bennett, Burren Peil, and Daniela K Rosner. 2019. Biographical prototypes: Reimagining recognition and disability in design. In *Proceedings of the 2019 on Designing Interactive Systems Conference.* 35–47.
[10] William Bolton. 2021. *Instrumentation and control systems.* Newnes.
[11] Sarah Bond. 2017. Who Owns A Recipe? Race, Food And The Debate Over Cultural Appropriation. Retrieved from https://www.forbes.com/sites/

drsarahbond/2017/05/30/who-owns-a-recipe-race-food-and-the-debate-over-cultural-appropriation/?sh=5fab4514e686, accessed July 2022.
[12] Kirsten Bray and Christina Harrington. 2021. Speculative blackness: considering Afrofuturism in the creation of inclusive speculative design probes. In *Designing Interactive Systems Conference 2021*. 1793–1806.
[13] Leah Buechley and Hannah Perner-Wilson. 2012. Crafting technology: Reimagining the processes, materials, and cultures of electronics. *ACM Transactions on Computer-Human Interaction (TOCHI)* 19, 3 (2012), 1–21.
[14] Leah Buechley, Daniela K Rosner, Eric Paulos, and Amanda Williams. 2009. DIY for CHI: methods, communities, and values of reuse and customization. In *CHI'09 Extended Abstracts on Human Factors in Computing Systems*. 4823–4826.
[15] Ying-Yu Chen, Jason Yip, Daniela Rosner, and Alexis Hiniker. 2019. Lights, music, stamps! Evaluating mealtime tangibles for preschoolers. In *Proceedings of the thirteenth international conference on tangible, embedded, and embodied interaction*. 127–134.
[16] Sally Jo Cunningham and Matt Jones. 2005. Autoethnography: a tool for practice and education. In *Proceedings of the 6th ACM SIGCHI New Zealand chapter's international conference on Computer-human interaction: making CHI natural*. 1–8.
[17] Dan Q. Dao. 2020. During Food Media's Time Of Reckoning, Let's Not Forget The Recipes. Retrieved from https://www.delish.com/food/a34945169/recipes-misrepresentation-food-media/, accessed July 2022.
[18] Hilary Davis, Bjorn Nansen, Frank Vetere, Toni Robertson, Margot Brereton, Jeannette Durick, and Kate Vaisutis. 2014. Homemade cookbooks: a recipe for sharing. In *Proceedings of the 2014 conference on Designing interactive systems*. 73–82.
[19] Jialin Deng, Patrick Olivier, Josh Andres, Kirsten Ellis, Ryan Wee, and Florian Floyd Mueller. 2022. Logic Bonbon: Exploring Food as Computational Artifact. In *CHI Conference on Human Factors in Computing Systems*. 1–21.
[20] Laura Devendorf, Katya Arquilla, Sandra Wirtanen, Allison Anderson, and Steven Frost. 2020. Craftspeople as Technical Collaborators: Lessons Learned through an Experimental Weaving Residency. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–13.
[21] Laura Devendorf and Kimiko Ryokai. 2014. Being the machine: Exploring new modes of making. In *Proceedings of the 2014 companion publication on Designing interactive systems*. 33–36.
[22] Thomas David DuBois. 2021. There's a Body in the Kitchen! A Cook's-Eye View of Sichuan Cuisine. *KNOW: A Journal on the Formation of Knowledge* 5, 1 (2021), 1–26.
[23] Sheena Erete, Yolanda A Rankin, and Jakita O Thomas. 2021. I can't breathe: Reflections from Black women in CSCW and HCI. *Proceedings of the ACM on Human-Computer Interaction* 4, CSCW3 (2021), 1–23.
[24] Ylva Fernaeus, Martin Jonsson, and Jakob Tholander. 2012. Revisiting the jacquard loom: threads of history and current patterns in HCI. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 1593–1602.
[25] Kathrin Gerling and Katta Spiel. 2021. A critical examination of virtual reality technology in the context of the minority body. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. 1–14.
[26] Andrea Grimes and Richard Harper. 2008. Celebratory technology: new directions for food research in HCI. In *Proceedings of the SIGCHI conference on human factors in computing systems*. 467–476.
[27] J Guo and X-Q Yang. 2015. Texture modification of soy-based products. In *Modifying Food Texture*. Elsevier, 237–255.
[28] Evan Hertafeld, Connie Zhang, Zeyuan Jin, Abigail Jakub, Katherine Russell, Yadir Lakehal, Kristina Andreyeva, Sneha Nagaraj Bangalore, Jerson Mezquita, Jonathan Blutinger, et al. 2019. Multi-material three-dimensional food printing with simultaneous infrared cooking. *3D Printing and Additive Manufacturing* 6, 1 (2019), 13–19.
[29] Melody Horn, Amy Traylor, and Leah Buechley. 2022. Slabforge: Design Software for Slab-Based Ceramics. In *CHI Conference on Human Factors in Computing Systems*. 1–12.
[30] Noura Howell, Audrey Desjardins, and Sarah Fox. 2021. Cracks in the success narrative: Rethinking failure in design research through a retrospective trioethnography. *ACM Transactions on Computer-Human Interaction (TOCHI)* 28, 6 (2021), 1–31.
[31] Zhitang Hu and Xiaoqing Chen. 2022. Flavor Origins: Guiyang. Retrieved from https://youtu.be/a4qWbYJZdbA, accessed September 2022.
[32] Sherrie A Inness. 2001. *Kitchen culture in America: Popular representations of food, gender, and race*. University of Pennsylvania Press.
[33] Lilly Irani. 2019. Chasing Innovation. In *Chasing Innovation*. Princeton University Press.
[34] Kristiina Janhonen, Kaisa Torkkeli, and Johanna Mäkelä. 2018. Informal learning and food sense in home cooking. *Appetite* 130 (2018), 190–198.
[35] Judy. 2020. Sweet Fermented Rice (Jiu Niang). Retrieved from https://thewoksoflife.com/sweet-fermented-rice-jiu-niang/, accessed February 2022.
[36] Flavius Kehr, Marc Hassenzahl, Matthias Laschke, and Sarah Diefenbach. 2012. A transformational product to improve self-control strength: the chocolate machine. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 689–694.
[37] Rohit Ashok Khot, Deepti Aggarwal, Ryan Pennings, Larissa Hjorth, and Florian'Floyd' Mueller. 2017. Edipulse: investigating a playful approach to self-monitoring through 3D printed chocolate treats. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. 6593–6607.
[38] Aya Hirata Kimura. 2013. *Hidden hunger: Gender and the politics of smarter foods*. Cornell University Press.
[39] Brian Kinnee, Daniela K Rosner, and Audrey Desjardins. 2022. Sonic Technologies of a Queer Breakup. In *Designing Interactive Systems Conference*. 1377–1393.
[40] Jakob A Klein and James L Watson. 2016. *The handbook of food and anthropology*. Bloomsbury Publishing.
[41] Meiwei Koay, Hui Yin Fan, and Clemente Michael Vui Ling Wong. 2022. An overview of fermentation in rice winemaking. *Canrea Journal: Food Technology, Nutritions, and Culinary Journal* (2022), 12–37.
[42] Ying-Ju Lin, Parinya Punpongsanon, Xin Wen, Daisuke Iwai, Kosuke Sato, Marianna Obrist, and Stefanie Mueller. 2020. *FoodFab: Creating Food Perception Illusions Using Food 3D Printing*. Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3313831.3376421
[43] Jen Liu, Daragh Byrne, and Laura Devendorf. 2018. Design for collaborative survival: An inquiry into human-fungi relationships. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–13.
[44] Andrés Lucero, Audrey Desjardins, Carman Neustaedter, Kristina Höök, Marc Hassenzahl, and Marta E Cecchinato. 2019. A sample of one: First-person research methods in HCI. In *Companion Publication of the 2019 on Designing Interactive Systems Conference 2019 Companion*. 385–388.
[45] Anita Mannur. 2007. Culinary nostalgia: Authenticity, nationalism, and diaspora. *Melus* 32, 4 (2007), 11–31.
[46] David Marshall. 2005. Food as ritual, routine or convention. *Consumption Markets & Culture* 8, 1 (2005), 69–85.
[47] H. McGee. 2007. *On Food and Cooking: The Science and Lore of the Kitchen*. Scribner.
[48] Mako Miyatake, Koya Narumi, Yuji Sekiya, and Yoshihiro Kawahara. 2021. Flower Jelly Printer: Slit Injection Printing for Parametrically Designed Flower Jelly. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. 1–10.
[49] Moran Mizrahi, Amos Golan, Ariel Bezaleli Mizrahi, Rotem Gruber, Alexander Zoonder Lachnise, and Amit Zoran. 2016. Digital gastronomy: Methods & recipes for hybrid cooking. In *Proceedings of the 29th Annual Symposium on User Interface Software and Technology*. 541–552.
[50] Carman Neustaedter and Phoebe Sengers. 2012. Autobiographical design in HCI research: designing and learning through use-it-yourself. In *Proceedings of the Designing Interactive Systems Conference*. 514–523.
[51] Charlotte Nordmoen and Andrew P McPherson. 2022. Making space for material entanglements: A diffractive analysis of woodwork and the practice of making an interactive system. In *Designing Interactive Systems Conference*. 415–423.
[52] Jeni Paay, Jesper Kjeldskov, and Mikael B Skov. 2015. Connecting in the kitchen: an empirical study of physical interactions while cooking together at home. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. 276–287.
[53] Srishti Palani, David Ledo, George Fitzmaurice, and Fraser Anderson. 2022. "I Don't Want to Feel like I'm Working in a 1960s Factory": The Practitioner Perspective on Creativity Support Tool Adoption. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) *(CHI '22)*. Association for Computing Machinery, New York, NY, USA, Article 379, 18 pages. https://doi.org/10.1145/3491102.3501933
[54] Yolanda A Rankin and Jakita O Thomas. 2019. Straighten up and fly right: Rethinking intersectionality in HCI research. *Interactions* 26, 6 (2019), 64–68.
[55] Kristen Reynolds. 2021. Black literary technoculture and afrofuturist rupture. *Interactions* 28, 6 (2021), 8–9.
[56] Marco Roccetti, Angelo Semeraro, and Gustavo Marfia. 2011. On the design and player satisfaction evaluation of an immersive gestural game: the case of tortellino x-perience at the Shanghai world expo. In *Proceedings of the 29th ACM international conference on Design of communication*. 45–50.
[57] Sophia Roosth. 2013. Of foams and formalisms: Scientific expertise and craft practice in molecular gastronomy. *American Anthropologist* 115, 1 (2013), 4–16.
[58] Daniela Rosner and Jonathan Bean. 2009. Learning from IKEA hacking: i'm not one to decoupage a tabletop and call it a day.. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 419–422.
[59] Daniela Rosner, Marco Roccetti, and Gustavo Marfia. 2014. The digitization of cultural practices. *Commun. ACM* 57, 6 (2014), 82–87.
[60] Daniela K Rosner, Miwa Ikemiya, and Tim Regan. 2015. Resisting alignment: Code and clay. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction*. 181–188.
[61] Daniela K Rosner, Samantha Shorey, Brock R Craft, and Helen Remick. 2018. Making core memory: Design inquiry into gendered legacies of engineering and craftwork. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–13.

[62] Daniela K Rosner and Alex S Taylor. 2011. Antiquarian answers: book restoration as a resource for design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 2665–2668.

[63] Kimiko Ryokai, Elena Duran, Dina Bseiso, Noura Howell, and Ji Won Jun. 2017. Celebrating laughter: Capturing and sharing tangible representations of laughter. In *Proceedings of the 2017 ACM Conference Companion Publication on Designing Interactive Systems*. 202–206.

[64] Kimiko Ryokai, Elena Durán López, Noura Howell, Jon Gillick, and David Bamman. 2018. Capturing, representing, and interacting with laughter. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–12.

[65] A. Smith. [n.d.]. History of the Agar Plate. Retrieved from https://web.archive.org/web/20121014060019/http://www.labnews.co.uk/features/history-of-the-agar-plate/, Aug 2022.

[66] Robert Soden, David Ribes, Maggie Jack, Will Sutherland, Vera Khovanskaya, Seyram Avle, Phoebe Sengers, and Susanne Bødker. 2019. Fostering historical research in CSCW & HCI. In *Conference Companion Publication of the 2019 on Computer Supported Cooperative Work and Social Computing*. 517–522.

[67] André Souto, Jian Zhang, Alejandro M Aragón, Krassimir P Velikov, and Corentin Coulais. 2022. Edible mechanical metamaterials with designed fracture for mouthfeel control. *Soft Matter* 18, 15 (2022), 2910–2919.

[68] Wenhuan Sun, Saul Schaffer, Kevin Dai, Lining Yao, Adam Feinberg, and Victoria Webster-Wood. 2021. 3D printing hydrogel-based soft and biohybrid actuators: a mini-review on fabrication techniques, applications, and challenges. *Frontiers in Robotics and AI* 8 (2021), 673533.

[69] Herve This. 2005. Modelling dishes and exploring culinary 'precisions': the two issues of molecular gastronomy. *British Journal of Nutrition* 93, S1 (2005), S139–S146.

[70] Amy L Tigner and Allison Carruth. 2017. *Literature and Food Studies*. Routledge.

[71] Cristen Torrey, Elizabeth F Churchill, and David W McDonald. 2009. Learning how: the search for craft knowledge on the internet. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 1371–1380.

[72] Jasper Tran O'Leary, Sara Zewde, Jennifer Mankoff, and Daniela K Rosner. 2019. Who gets to future? Race, representation, and design methods in Africatown. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–13.

[73] Gang Wang. 2020. Chef Wang teaches you 'Fushun Douhua' with melt-in-your-mouth texture. Let's keep the tradition alive! Retrieved from https://youtu.be/NRbcgVyb15Q, accessed September 2022.

[74] Wen Wang, Lining Yao, Chin-Yi Cheng, Teng Zhang, Hiroshi Atsumi, Luda Wang, Guanyun Wang, Oksana Anilionyte, Helene Steiner, Jifei Ou, Kang Zhou, Chris Wawrousek, Katherine Petrecca, Angela M. Belcher, Rohit Karnik, Xuanhe Zhao, Daniel I. C. Wang, and Hiroshi Ishii. 2017. Harnessing the hygroscopic and biofluorescent behaviors of genetically tractable microbial cells to design biohybrid wearables. *Science Advances* 3, 5 (2017), e1601984. https://doi.org/10.1126/sciadv.1601984 arXiv:https://www.science.org/doi/pdf/10.1126/sciadv.1601984

[75] Wen Wang, Lining Yao, Teng Zhang, Chin-Yi Cheng, Daniel Levine, and Hiroshi Ishii. 2017. Transformative appetite: shape-changing food transforms from 2D to 3D by water interaction through cooking. In *Proceedings of the 2017 CHI conference on human factors in computing systems*. 6123–6132.

[76] Humphrey Yang, Danli Luo, Kuanren Qian, and Lining Yao. 2021. Freeform Fabrication of Fluidic Edible Materials. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 620, 10 pages. https://doi.org/10.1145/3411764.3445097

[77] Jenny G. Zhang. 2020. New Report Details Pervasive Culture of Racism at Bon Appétit: 'Nowhere Have I Ever Felt More Isolated'. Retrieved from https://www.eater.com/2020/6/10/21286688/bon-appetit-toxic-work-culture-of-racism, accessed July 2022.

[78] Amit Zoran and Marcelo Coelho. 2011. Cornucopia: the concept of digital gastronomy. *Leonardo* 44, 5 (2011), 425–431.

[79] Amit Zoran and Dror Cohen. 2018. Digital konditorei: programmable taste structures using a modular mold. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–9.

[80] S Zorzetto. 2014. Ancestral Cuisine and Cooking Rituals. (2014).

A ORIGINAL RECIPES

The original recipes used in Section 4 are attached below. Note that these recipes reflect how the food is made without using the toolkit. The recipes are adapted and translated from [31], [35], and [73].

A.1 Flour skin (面饼)

(1) Add 90 g of water to 100 g of wheat flour. Stir to combine.
(2) Let the dough sit for at least one hour so that the gluten network forms without kneading.
(3) Heat a flat-bottomed pan on medium to high heat. Avoid using non-stick pans.
(4) Hold the wet gooey dough with one hand and flap the dough onto the hot pan to leave a round, thin layer of dough. Quickly retract the dough.
(5) Sear the dough for 1 minute until it peels off the pan.

A.2 Rice wine (酒酿)

(1) Soak 500 g of glutinous rice in water overnight.
(2) Layer fully soaked glutinous rice over cheesecloth and steam until cooked. Let the glutinous rice cool to room temperature.
(3) Stir 15 g of rice wine yeast in 450 mL of water.
(4) Put room-temperature glutinous rice in a container. Pour the yeast water into the container until it levels with the glutinous rice.
(5) Cover the container with plastic wrap and place it near a warm place. On cold days, somewhere near a radiator would be fine.
(6) The rice wine will be ready in 48 hours.

A.3 Doufu (豆腐)

(1) Soak 500 g of soy in 3 L of water overnight.
(2) Blend the soy in water as fine as possible. Filter the soy milk with cheesecloth. Wrap the cheesecloth around the remaining solid and squeeze out all the liquid. Discard the leftover solid chunks.
(3) Dissolve 6 g of nigari in 30 g of water.
(4) Bring the soy milk to a boil. Let it cool to 80°C.
(5) Gradually add the nigari solution to the soy milk while gently stirring the surface of the soymilk with a ladle.
(6) The soy milk will start to coagulate. Let it sit until doufu curds start to separate from the water. This process takes roughly 10 minutes.
(7) Line a doufu mold with cheesecloth. Scoop the curds into the mold and let the water drain.
(8) Cover the doufu with cheesecloth and the lid. Put extra weight on the lid to squeeze out excess water.
(9) Leave for 1 hour to set, and then remove the doufu from the mold.