A Study of Solar Cooking: Exploring Climate-Resilient Food Preparation and Opportunities for HCI

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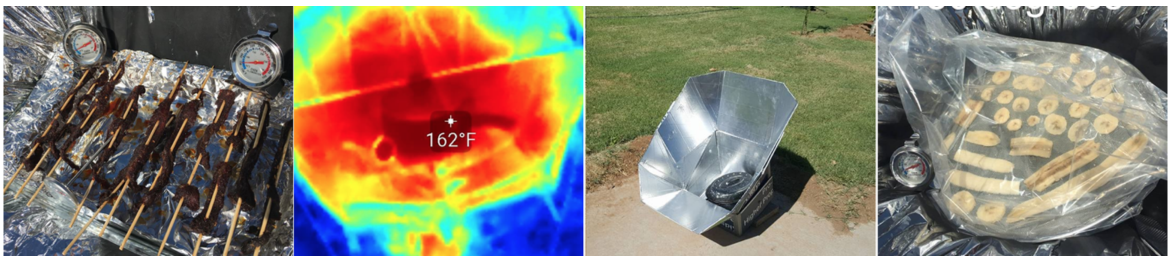

Figure 1: Participants' solar cooking projects: beef jerky, carnitas (pulled pork) being captured by a thermal camera, noodles in a closed pot, and banana chips.

ABSTRACT

As parts of our planet continue to experience extreme heat waves, it is more urgent than ever for human-food interaction research to examine climate-resilient and sustainable food practices. Our work, conducted in the hottest city in the USA, focuses on solar cooking as a set of creative DIY activities that use extreme heat and mitigate human impact on the environment. We report on a summer-long study whereby 7 enthusiasts built solar ovens from scratch and experimented with solar recipes ranging from slow-cooked pork and chicken to bread, kale chips, brownies, jerky, and fruit rollups. Our findings depict solar cooking as a form of iterative DIY, which, through its challenges and creative workarounds, serves as a point of engagement with both food and extreme heat. We reflect on solar cooking as a climate-resilient food practice and conclude with design considerations for HCI to support solar cooking as a habitual community practice.

CCS CONCEPTS

• **Human-centered computing**; • **Interaction design**; • **Interaction design process and methods**;

KEYWORDS

Solar cooking, DIY, food science, sustainable HCI

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1 INTRODUCTION

The world is projected to heat up and experience more extreme heat waves over the next few decades, presenting urgent challenges for human health and economy [25]. Food systems play a critical role in these trends as mainstream modes of food production, distribution, and preparation both contribute to and are impacted by climate change. Within HCI, human-food interaction research is increasingly focusing on climate resiliency by shifting consumer value systems [23], and incorporating both situated human and non-human stakeholders [35] and playful and speculative methods to envision alternative food futures [16][17], among many other approaches. In this paper, we explore solar cooking as an alternative area of research on climate-resilient food systems and a point of reflection for food preparation and climate change. We frame solar cooking as a set of creative DIY activities that embody both adaptation to and mitigation of extreme heat. As an adaptation strategy, solar cooking helps retain cooler indoor temperatures and reduces economic impacts of energy/AC bills, unlike indoor ovens which heat up indoor spaces. At the same time, solar cooking also mitigates environmental footprints by lowering electricity/gas energy consumption, reusing/upcycling materials, and reducing food waste (e.g., through solar dehydration and other food preservation methods).

Yet, while solar cooking is more affordable and less resource-intensive than indoor cooking, it has not been widely adopted in the USA, even in heat and sun intensive Phoenix, AZ, where we conducted this research. In our city, temperatures regularly exceed 110°F, making it a particularly useful location to study both solar cooking and heat mitigation strategies.

1.1 Research questions and contributions

Our research studies the motivations and experiences of food enthusiasts as they learn to harness the sun to cook. In doing so, we explore two central questions: 1) what are the capabilities and limitations of solar cooking as a means if sustainable food preparation? and 2) based on the challenges unearthed by our study, how can HCI lower the barrier to entry and support solar cooking amongst individuals and communities?

To examine these questions, we conducted a study with a community of 7 enthusiasts who designed their own solar cookers from low-cost materials and prepared foods ranging from slow-cooked pork and chicken to bread, kale chips, brownies, beef jerky, and fruit rollups. Participants shared their recipes, tips, and failures through a Facebook (FB) group, during our collective solar potluck at the end of the summer, and in follow-up semi-structured interviews. Our analysis of this data, which includes community Facebook posts and recordings of individual and group conversations, shows that solar cooking was creative, experimental, and fun for participants. At the same time, certain challenges such as gaps in information resources and the logistics of planning and monitoring the longer solar cooking process led participants to iterate on their recipe and oven designs and to approach solar cooking differently than their habitual food preparation. Reflecting on our findings, we discuss solar cooking as a step towards an alternative food future that both adapts to and mitigates extreme heat. Our research contributions include the following: 1) insights into the requirements and limitations of solar cooking as a systematic activity that enables heat mitigation in the home; 2) an understanding of community practices and motivations behind solar cooking; and 3) practical design considerations to support solar cooking as a habitual community practice through HCI.

2 SOLAR COOKING AND SUSTAINABLE HCI

Solar energy has been used to prepare food for thousands of years. Some of the earliest known practices include warming wafers and dehydrating ingredients for preservation [33]. People have been experimenting with solar ovens for centuries, and today DIY designs range from free or ultra-cheap set-ups (e.g., a car sunshade shaped as a funnel around a pot) to more intricate and pricey hobby projects such as sensor-enabled 'smart' solar ovens [42]. There are also commercially-available products and kits, including box and parabolic designs [1][12][21], costing anywhere from $50 to $400 or more. Many solar cooking recipes, ranging from simple (e.g., sun-dried tomatoes, granola) to elaborate (e.g., stews, baked goods), are widely available across solar cooking wikis, groups and forums (e.g., [38][41]), books (e.g., [2]) and solar oven product websites, where recipes are tailored to specific solar ovens (e.g., recipes for the All American Sun Oven [37]).

In our research, we focus specifically on how people make solar ovens from scratch to explore designs that could be replicated at low cost and without specialized fabrication skills. We then investigate community-based solar cooking practices, which are often slower and more iterative, and directly engage participants with extreme heat and climate change mitigation. We thus position solar cooking as an alternative to the world's increasing reliance on mass-produced foods, as well as a strategy for adaptation to and mitigation of extreme heat. As such, solar cooking parallels other areas within sustainable HCI, including research on DIY and maker practices [32][45]), sustainable food systems [28][49][50], and systemic shifts in habitual practice, contexts, and values [15], among others.

As a DIY practice, solar cooking is aligned with the longstanding sustainable HCI research on maker practices, such as studies of online communities and how-to websites (e.g., [32][45]), explorations of relationships between makers and product developers [44], and work at the intersection of maker practices and professional design [20]. In our study, participants' use of everyday materials to create solar ovens can be seen as a form of "everyday design" and "design-in-use" [5][51][52]. Wakkary and Maestri discuss these concepts in the context of people artfully modifying available resources to fulfill everyday needs [51]. Others have studied ad-hoc tool making in hackerspaces [4], personalization of IKEA products [39], digital collections of modifications [27], "domestic artifacts" in Indian households [48], and creative reuse in the context of design fiction [43]. Similarly, our work examines how participants approached available materials to design, iterate on, and troubleshoot their solar ovens through reuse and upcycling.

More broadly, as sustainability research within and outside of HCI continues exploring hybrid strategies for adaptation to and mitigation of climate change [28][49][50], we frame solar cooking as a climate-resilient food practice that both adapts to and mitigates extreme heat. Over the past decade, numerous human-food interaction workshops have been reflecting on and envisioning sustainable food systems [8][13][24][36]. Such systems present alternatives to mainstream forms of food production and distribution (as studied by [14][24] and others), or operate within existing neoliberal systems and yet simultaneously challenge them [34]. Moreover, trends in sustainable HCI have been decentralizing humans in the design process, such as Prost et al.'s study of relations and complexities of food systems [35], and work on alternative value exchange and resource management among human and non-human actors [23]. We contribute to this body of work by focusing on an alternative means of food preparation—solar cooking—which has not been previously explored in HCI. Similar to technologies in [34], solar cooking relies on aspects of neoliberal systems (e.g., upcycling commercial materials for solar oven construction or sourcing food ingredients from grocery stores), but at the same time bypasses or reduces reliance on the electric power grid during meal preparation. Moreover, solar cooking relies on complex relationships among environmental actors (e.g., sun, heat) and materials comprising the oven and the food ingredients, therefore decentralizing humans in the process ideas, as explored by [23]. Lastly, given the playful aspects of DIY solar cooking, we draw particular inspiration from workshops by Dolejšová et al. [17] and Wilde, et al. [54], which explored creative and imaginative strategies for supporting climate resilient food practices [17]. Similar to the experimental design strategies in these workshops, in our study, cooking proved to be a playful prompt for critical reflection on (un)sustainable modes of food preparation and our relationship with extreme heat.

To summarize, solar cooking has a long history and spans a variety of information resources, DIY practices, and commercial products. Against this backdrop, we situate our inquiry within related sustainable HCI work on DIY and maker communities, as well as research on sustainable human-food interaction. We continue by presenting our study methods and limitations.

3 METHODS

To explore the challenges and opportunities of solar cooking, we conducted a summer-long study with local food enthusiasts. We recruited 7 participants, none of whom knew each other before the study (3 male, 4 female; ages mid 20's to late 60's) through various local food groups. At the beginning of the summer, participants were invited to attend an introductory workshop where they ideated solar cooker designs and brainstormed the types of meals they would cook. Participants were provided with a range of common materials to prototype solar ovens during the workshop (e.g., reflective tape, foil, wood, cardboard, bricks) and were also offered a ~75$ budget to spend on additional construction materials over the summer. Participants were also provided with safety resources, including the FDA guidelines for minimum cooking temperatures of various foods, an oven thermometer, an internal food thermometer, safety gloves, a food/recipe journal to keep track of their experiments, and several thermal cameras to be shared amongst the group.

Over the summer, participants experimented with solar cooking recipes, iterated on their oven designs, and shared their experiences on the group's Facebook page. The study did not require a minimum number of meals, and to encourage open experimentation among the group, we offered $15 to cover the costs of ingredients of each failed or successful cooking attempt that was shared on FB. At the end of the summer, the group re-united at a solar cooking potluck, hosted at the home of one of the participants, to which everyone brought or prepared a solar-cooked dish to share.

At the end of the summer, we also followed up with participants through semi-structured interviews. During these interviews, we first discussed participants' general cooking practices (e.g., whether they tended to cook alone or with other people, how often their meals involved indoor oven use, and what types of meals they prepared on a daily basis). We then asked participants to walk us through their solar oven design, why they chose that particular design and what information sources they used, and any iterations they made to their ovens over the course of the summer. Then, using content from participants' FB posts as prompts, we asked them to describe each of their solar cooking projects in more detail. In regards to each solar cooking project, we asked participants how they came up with the idea/recipe and what resources they used to research/troubleshoot what it would involve; whether it turned out as they expected and how the experience compared to other cooking projects they've worked on; as well as what they learned from the project and what (if anything) they would do differently next time. Lastly, we asked participants about general benefits and drawbacks of solar cooking and ideas for making it more accessible.

Each interview was tailored to and guided by participants' summer-long FB posts as prompts. Our discussions during workshops and interviews were both grounded and wide ranging, eliciting diverse insights into solar cooking motivations, practices, and challenges. Audio from all events and interviews was recorded and transcribed, and the researchers repeatedly read and revisited the transcripts alongside our field notes and photographs to draw out underlying themes using open coding. We also cross-checked the emergent themes with participants' Facebook posts. The themes were then clustered using affinity diagramming, with similar concepts merged and relationships between themes drawn out. Our findings broadly fall into four major thematic categories: motivations for solar cooking; approaches to solar oven design; types of solar cooking experiments (low temperature cooking and hybrid oven use); and solar cooking challenges (gathering knowledge, planning, and monitoring).

3.1 Research limitations

We did not explicitly define what constitutes a "failed" or "successful" solar cooking attempt for participants. Instead, these judgements were made by participants' themselves in their Facebook posts (e.g., with comments such as "failed attempt", or "mushy", "terrible", etc.). In general, failed projects seemed to be meals that were exceptionally under or overcooked, while all other projects were deemed as having variable degrees of success based on the taste and texture of the food.

We chose to reimburse participants for both failed and successful cooking projects to encourage more attempts, iteration, and "risk-free" experimentation. However, this could have potentially put less 'stake' on each attempt, and sunk costs have been shown to sometimes encourage more radical design changes [47]. Nevertheless, we chose to fund our study this way because we wanted to ethically redistribute the material cost of experimentation, and we did not want participants to incur financial costs for any failed attempts. As our findings show, this supported very creative ideas and new oven and recipe approaches. It is also worth noting that all of our participants were already interested in solar cooking, so there is a self-selection bias in our study.

We continue by presenting participants' motivations for solar cooking, their DIY oven designs and cooking experiments, and how the challenges they encountered shaped their practice.

4 FINDINGS

4.1 Motivations for solar cooking

From the onset, all participants considered themselves proficient cooks, whether through decades of at-home food projects such as brewing (e.g., P2), fermenting and pickling (P1, P7), cooking daily for their family (e.g., P4, P5, P6), or by training as a professional chef (e.g., P3). Participants' motivations for solar cooking spanned 3 areas: 1) sustainability, 2) experimenting with food, and 3) fun. In regards to the first, participants wanted to use a natural energy source:

"Anything we can do to lessen the resources is the better, we're not using as much gas or electricity and that it's all right here—the sun's out, the oven's on. It's all here." P4

"You're saving efficiently in two ways: inside from unwanted heat, and then outside utilizing the sun for the cooking." P7

These quotes are indicative of the larger fact that all participants were drawn to solar cooking as an energy-efficient process. In addition, participants saw solar cooking as a form of "intentional

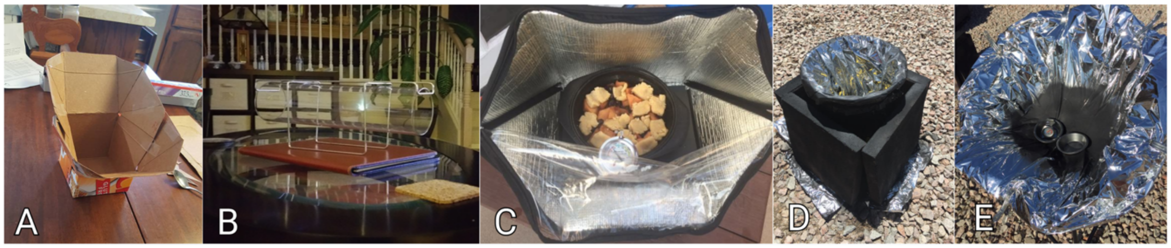

Figure 2: Participants' solar oven designs constructed with materials they had on hand: A and B emulate commercial solar ovens [1][21] using cardboard and an acrylic tube; while C, D, and E emulate DIY tutorials [42] using a car sunshade, camp chair, bricks, an emergency heat blanket, and black spray-paint, which was purchased for the study.

cooking" (P6) and an opportunity to practice and experiment with different cooking methods, recipes, and flavors. Moreover, participants were interested in solar cooking to experiment with recipes that were not feasible in the summer due to excess heat produced by indoor ovens (e.g., solar dehydrating: "*you just throw it out in the sun, it's easy*", P5; or braising: "*anything that you can braise will work pretty well in the solar*", P3). Finally, upon reflecting on their experiences at the end of the summer, all participants emphasized that they enjoyed being part of the solar cooking community and described the group as "fun" and "supportive". Most participants also described the process of solar cooking itself as interesting and fun (e.g., "*it's fun, it's been real fun*", P5; "*a fun challenge*", P6).

4.2 DIY solar ovens

All participants wanted to design their ovens using primarily the materials they already had on hand, despite the study budget we provided. In this way, the available materials in each household seemed to guide the design process, and the 'device design goal' shared by all participants was to reach a consistent, high temperature using whatever they had on hand. To design their DIY solar ovens, participants looked at commercial products [1][21], online tutorials (on Instructables [42] and the Solar Cooking Wiki [40]), the designs shared on their Facebook group, and their own trial and error (e.g., "*I looked at a few [designs] online. I also looked at some of the successes and failures of the rest of the people in our group*", P1). Participants selected and adopted ideas they saw online to incorporate the materials they already had on hand, sometimes purchasing a few additional, low-cost parts (Figure 3). Starting points included the following items: a chair lined with reflective foil, a car sunshade staked to the ground in a curved shape, a trash can lined with a reflective wilderness rescue blanket, discarded election signs assembled into a box and covered with reflective tape, a wooden box lined with mirror acrylic, and a black spray-painted box.

Participants reported baseline temperatures of 130-165F.

"If you wanna control it, you have to understand it. It's not just about aiming at the sun and hoping things'll happen. You have to devise how it's gonna happen." P6.

The above quote reflects participants' desire to understand and improve on their designs. Everyone iterated on their ovens, usually by modifying one particular aspect and measuring the effect on the cooking temperature. For instance, three of the participants (P1, P2, and P5) found that they could raise the air temperatures by 15-20 degrees by adding a black surface to the bottom of their cookers (either spray-painted directly or by adding a black platform). Others (P2, P3, and P7) achieved additional gains by sealing their cookers with clear acrylic or plastic. Meanwhile, P6 further improved performance by moving his solar cooker onto the roof of his house, which increased the temperature by 10-15 degrees. Participants also discovered that the containers they used to cook in were important in achieving higher temperatures (e.g., slower heat-up time for cast iron, faster heat loss with aluminum). In fact, P3 went as far as to test his cookware with a thermal camera to learn how "*different blacks reflect infrared and absorb infrared.*" While P3 was perhaps the most thorough, all participants added tweaks and iterations, using temperature monitoring and the quality of prepared foods to gauge their oven performance. Moreover, P1, P3, and P6 reported plans to expand their projects to include energy-efficient solutions in other contexts (camping, low-income residents on a Native American reservation, and aquaponics).

4.3 Solar cooking experiments

All participants were able to cook at least one food item that they considered successful, with the majority having 4-5 successes, and one person (P2) creating 10 successful solar dishes. Most participants began by experimenting with simple recipes they had previously tried with regular ovens—a strategy that led to varying degrees of success. Although some were able to cook corn (P4) or oatmeal cookies (P2) on their first attempt, others experienced initial failures ranging from a watery omelet (P6) or rubbery pizza (P5), to mushy sweet potato chips (P5), bread that didn't fully rise (P2), or a BLT where "nothing happened" to the bacon after 2 hours in the solar oven (P7). Failures led participants to iterate on their oven designs (as outlined above) and to experiment with different cooking methods.

4.3.1 Low temperature recipes. Many participants tried slow cooking recipes to utilize the relatively constant but lower temperatures in their ovens.

"I knew that I could get my oven to 150 pretty regularly, I was like, well, what cooks at 150? I started Googling that and I was like, literally what cooks at 150 degree Fahrenheit? Through that trail I found that most of those recipes were dehydration recipes." P5.

Above, P5 describes how she arrived at dehydration as a cooking method for her solar oven, which led to many successful attempts, ranging from banana chips, sun-dried tomatoes, and kale chips to fruit roll-ups and beef jerky. P6 used a similar method to create

Figure 3: Solar-cooked kale chips and fruit rollups.

dehydrated blueberries, apple chips, and carrot chips. Other low-temperature recipes included toasted bruschetta (P7) and yogurt (P2).

Participants also adopted highly acidic recipes to ensure food safety during slow, low-temperature cooking. For instance, while making coq au vin, a French braised chicken dish, P1 described feeling "*little afraid, because this is my first with the new oven, but the wine is acidic enough to make it relatively safe*". Similarly, P3 used a combination of lime juice and beer in his slow-cooked pork recipe, stating: "*If you have no temperature at all, and you just can it in that broth, it's the acidity that takes care of it.*"

4.3.2 The hybrid method. In addition to using specialized recipes, all participants described instances when they tried a combination of regular cooking appliances and their solar ovens to prepare complex items such as meats. For instance, P3 first seared pork shoulder on a grill, then put it in marinade, left it in the solar cooker for "pretty much all day", and in our interview described the result as his "most tasty" dish. Others prepared meat dishes such as beef bourguignonne, rib eye, beef jerky, and roasted chicken by implementing what they called a "two-step" method:

"I tended to use a two-step method where I brought the main ingredients, especially in a chicken, to food-safe temperatures before I finished it in the [solar] oven." P1.

"It [beef jerky] hit 140 within two hours. It was at 150 within four. After four hours I put it in the oven to cook it up to the 165 that it needed to be at to be at to heat. It didn't make us sick at all. We both ate it. It was great." P5.

In the above, P1 and P5 describe how they deliberately used hybrid cooking (regular and solar ovens) to prepare successful slow-cooked dishes. The "two-step" method was also used to "fix" solar cooking "failures" (e.g., microwaving a pot of beans that did not fully cook outside, P4).

4.4 How challenges influenced practice

The unique challenges for solar cooking—specialized knowledge, particular weather conditions, and monitoring food while cooking—led participants to further iterate on their projects and cooking practice.

4.4.1 Gathering hybrid knowledge. All participants noted that they had trouble finding information sources for beginners, or information on how to adapt recipes to their particular ovens:

"A challenge is just not knowing what the result would be... When I did the beef jerky I was like, is this safe? There was some nervousness there." P4.

"I haven't found a website that specifically says at 160 degrees, cook all this stuff. At 170 cook all this. . . I couldn't really find a good resource for that." P5.

Here, participants reference the fact that many solar cooking recipes require a specific cooking temperature (see recipes on [38]), which are not always reached by the solar ovens they constructed. Lack of information on how to adapt recipes or check for food safety was a challenge, and sometimes led participants to doubt their projects. To address this, participants drew on a variety of sources, integrating knowledge from solar and regular recipe websites, food safety guidelines, information shared on their FB group, and their own prior cooking experiences.

4.4.2 Pre-planning for weather conditions. Many participants encountered wind and shade as challenges: P5's apple chips flew away; a tree cast a shadow over P3's solar oven during a rice cooking attempt; clouds ruined P7's zucchini pizza attempt. In addition, since the time of day was important for attaining highest cooking temperatures, all participants noticed a temperature drop of 10-15 degrees after 5pm. These experiences led participants to actively pre-plan for their solar cooking day ahead of time based on weather forecasts and their routines that day. Participants checked the forecasted hourly sun conditions and organized their daily schedules to begin solar cooking around noon.

4.4.3 Frequent monitoring during cooking process. Most participants checked their solar ovens every 15-20 minutes to track the temperature or to reposition their cookers towards the sun. For some, there was a degree of curiosity (e.g., "*I was kind of anxious to see what it was gonna do*", P7); while for others, it was a matter of food safety:

"It took a lot more attention to detail because of food safety. I would have to go out every 20 minutes to change the angle of the oven and do periodic temperature checks." P1.

P1's comment reflects the experiences of most participants who frequently monitored their cooking projects and repositioned their ovens throughout the day.

5 DISCUSSION AND IMPLICATIONS

This paper outlined participants' motivations for solar cooking, which spanned sustainability, food science, and fun. We then detailed how participants creatively designed their solar ovens from everyday materials and experimented with solar-cooked meals. Participants designed their solar ovens based on the materials they had on hand, and the low-fi nature of their designs raises interesting questions around the immediacy, discard-ability, and thus transience of the ovens designed. Indeed, consistent with prior research on DIY and everyday design [52], participants did not view their solar ovens or cooking projects as final "products". Rather, both the solar ovens and the recipes were seen as works in progress to be iterated upon throughout the course of the summer, whether to optimize cooking temperature, food flavor, or the safety and efficiency of the cooking process itself. These iterations led participants (and researchers) to discover the pros and cons of solar cooking, and we continue by discussing the capabilities and limitations of solar cooking, as well as its implications for sustainability. We then conclude with practical design considerations and actionable guidelines for supporting solar cooking as a community practice within our current food and information systems.

5.1 Capabilities and limitations of solar cooking

Our participants were able to cook dishes they deemed successful either when their ovens kept consistent, high temperatures; or when their recipes were adapted for lower temperatures. Accordingly, the study suggests two main practical take-aways. First, regular cooking methods (boiling, frying, etc.) are harder to achieve in solar ovens, but can be possible when high temperatures are consistently maintained. High temperatures, in turn, are best achieved by ovens that use highly reflective materials and are repositioned throughout the cooking period to direct sunlight onto the cooking container (every 15-20 minutes). Second, in cases when the ovens operate at lower temperatures, low-heat cooking methods can still be successful through techniques such as curing, solar dehydrating, or sous vide, to name a few. Moreover, low temperatures can be used in a two-step method where foods are prepared in solar ovens and then finished in short cooking sessions on a regular oven.

Furthermore, whether solar cooking is being used for high-heat or low-heat recipes, our findings reveal that a degree of planning is necessary to prepare the meals. Before cooking, participants researched recipes and ways to adapt them to their solar oven or low-temperature cooking, gathered the ingredients, and consulted the weather forecast to ensure sunny conditions on the day of cooking. In addition, participants tried to cook during the hottest, sunniest part of the day (usually 11am-3pm), and had to plan to be home for several hours to monitor and adjust their ovens during this time. In our study, participants did not view this as a limitation and reported this process to be interesting and fun, however, the planning requirements could potentially deter people with less free time or availability to be home. To mitigate this constraint, HCI could provide planning tools (e.g., recommending recipes based on weather forecast) and support solar cooking as a community practice to share the planning responsibilities amongst groups of people (see section 5.3).

Our research also revealed several environmental and practical limitations of solar cooking. Many of the "failed" attempts were due to inconsistent or low temperatures in the solar ovens, either from changes in weather conditions (e.g., clouds); the orientation of the oven (not directly facing the sun); or, in some cases, the designs of the ovens themselves (not using enough reflective material, not angling the material to direct sunlight to the booking container). While our study was conducted in Phoenix, AZ over the summer, it is likely the oven design and cooking methods would be different in other locations with less direct sunlight, lower ambient temperatures, or higher humidity. Although speculating on how solar cooking would work in different climates and geographical locations is beyond the scope of this paper, it's important to note that solar cooking practices would vary depending on those factors. As more knowledge is developed in different regions, HCI can intervene to support information sharing and community-building around solar cooking (see section 5.3).

5.2 Implications for sustainability

We have framed solar cooking as a creative and iterative DIY process and a form of climate-resilient food practice. Indeed, in our study, we saw how participants were drawn to solar cooking both because it supported adaptation to extreme heat, as it helped lower indoor temperatures (by not running an oven indoors), and mitigated their impact on the environment through reduced electric energy consumption. Throughout the summer, we also saw how solar cooking led participants to engage with heat more deeply, as they tracked local weather and planned their solar meals and schedules around sunny conditions.

At the same time, while participants enjoyed the experimental aspects of solar cooking, the failed attempts sometimes resulted in food waste, which is a major environmental and social issue. In our own critical reflection on this issue, we believe that while some failed recipes may be inevitable during early experimental stages of solar cooking, it is imperative to develop tools, infrastructures, and information resources that reduce food waste, especially if solar cooking is adopted at scale. HCI is well-positioned to intervene in this area by supporting successful, non-wasteful solar cooking projects through systems such as smart ovens and community resources (see next section), as well as by better managing waste (e.g., composting infrastructure). Moreover, as noted in prior research, sustainable cooking involves a complex combination of ingredient choices and preparation methods, since cooking energy alone does not capture the full environmental footprint of a meal [10]. Our study focused primarily on meal preparation, and future research can further situate solar cooking within systems of ingredient production and distribution. Moreover, we see solar cooking as a way to explore potential alternative food futures where our cooking practices and meal choices are more aligned with environmental conditions. For instance, we can imagine solar cooking as operating within broader climate-resilient food systems that value equity, environment, and more-than-human approaches in production, sourcing, and distribution of ingredients. Future work can draw on speculative human-food interaction methods such as [17] to incorporate solar cooking into the envisioning of and critical reflection on such systems to deepen our understanding of climate resilience and transform our relationships with extreme heat.

5.3 Supporting solar cooking through HCI

Our study revealed how the various challenges of solar cooking led participants to approach food preparation with more intention, from iterating on their ovens to "*devise how it's gonna happen*" (P6), to pre-planning for weather conditions, monitoring the cooking process, experimenting with flavors, and iterating on recipes. These unique practical challenges and creative workarounds suggest several touchpoints for HCI.

First, there are many opportunities to innovate how solar cooking knowledge is captured, analyzed, and shared. On one hand, while there are thousands of solar cooking recipes and tutorials across different media (e.g., [1][26]), our study revealed how participants often struggled to find information that was relevant for their ovens, weather conditions, and cooking goals. Similar to other food science practices [30], participants drew upon hybrid knowledge sources to inform their practice, ranging from online tutorials to personal trial and error and the experiences shared by other community members on Facebook. Here, new tools for aggregating and visualizing solar cooking recipes could help users compare cooking methods and find recipes that best match the weather conditions of a particular day. Drawing on systems such as RecipeScape [7], which enables people to analyze different approaches to cooking a dish, future aggregator and analysis tools could visualize solar cooking recipes by parameters such as the method (e.g., dehydration, "two-step" cooking, slow cooking, sous vide), maximum required temperature, duration, ideal time of day, and food safety tips (e.g., raising the pH). Moreover, the tools involved in the solar cooking process could be re-imagined to capture and share tacit knowledge. Recent research has emphasized the importance of embodied knowledge during cooking [3], and likewise in our study we saw how participants drew on highly specialized and diverse knowledge, which was validated through trial and error. Similar to concepts for networked kitchen objects (sensor-enabled utensils, etc.) (e.g., [3][46]), future solar oven technologies could capture user interactions during cooking and generate online recipes based on temperature, time, and care during the food preparation process. New interactive platforms could also allow users to collect and share their first-hand expertise of building and using solar ovens.

Finally, our study focused on solar cooking as a community practice, through both the online Facebook group interactions with other participants, and with the shared community potluck at the end of the summer. Participants underscored the value of this social support, and we see future opportunities to design for solar cooking as a community practice. Indeed, prior research has highlighted the importance of community in sustainable food preparation and suggested approaches to facilitate communal meal preparation through coordination apps and meal sharing schemes [10]. Similarly, in the domain of solar cooking, HCI could explore community support tools that enable people to connect with solar cooking enthusiasts in their area, pre-plan their meals, solar cook together, or take turns cooking for each other—especially in cases where not everyone is able to plan or commit time to solar cooking. Moreover, HCI could also explore systems that enable real-time live sharing and troubleshooting during solar cooking in different locations. These rich interactions between members could support solar cooking as a community practice and scaffold larger-scale food science learning and collective dialogues around extreme heat.

6 CONCLUSION

This paper examined solar cooking as set of creative DIY practices that utilize natural energy in extremely hot climates. We presented a summer-long solar cooking study, whereby a community of food enthusiasts experimented with preparing meals ranging from meats and vegetables to chips and desserts. We framed the participants' iterations on their solar oven designs as examples of iterative design-in-use, and their solar cooking projects as forms of climate-resilient food preparation. Our findings suggest several opportunities for HCI to support solar cooking through systems that capture, aggregate, and visualize solar cooking knowledge, as well as tools that scaffold community-based practices. More broadly, there is an urgency to envision creative mitigation and adaptation strategies in response to accelerating climate change, and we have presented solar cooking as an alternative touchpoint for HCI to engage with climate-resilient food systems and extreme heat.

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