Behaviour & Information Technology

ISSN: 0144-929X (Print) 1362-3001 (Online) Journal homepage: www.tandfonline.com/journals/tbit20

Mapping future eating: insights from structured design fiction workshops

Sibo Pan , Xipei Ren , Yiying Wu , Steven Vos , Aarnout Brombacher & Yunye Yu

To cite this article: Sibo Pan , Xipei Ren , Yiying Wu , Steven Vos , Aarnout Brombacher & Yunye Yu (14 Jan 2026): Mapping future eating: insights from structured design fiction workshops, Behaviour & Information Technology, DOI: 10.1080/0144929X.2026.2614038

To link to this article: https://doi.org/10.1080/0144929X.2026.2614038

BEHAVIOUR & INFORMATION TECHNOLOGY
https://doi.org/10.1080/0144929X.2026.2614038

Taylor & Francis
Taylor & Francis Group

Mapping future eating: insights from structured design fiction workshops

Sibo Pan[a], Xipei Ren[b]*, Yiying Wu[c], Steven Vos[a], Aarnout Brombacher[a] and Yunye Yu[d]**

[a]Department of Industrial Design, Eindhoven University of Technology, Eindhoven, The Netherlands; [b]Beijing Institute of Technology, Beijing, People's Republic of China; [c]School of Architecture, Design and Planning, The University of Sydney, Sydney, Australia; [d]Southeast University, Nanjing, People's Republic of China

ABSTRACT

This paper presents two design fiction workshops exploring future eating scenarios in 2040. A narrative workshop with 116 participants and an ideation workshop with 68 participants utilised a pre-researched matrix framework as the core design fiction material. In total, 97 narratives and 60 design outcomes were collected and analysed around three key themes: *Efficiency*, *Entertainment*, and *Ecology*. A more-than-human lens is applied to interpret the speculative outcomes, with particular attention to tech-driven food alternatives, sensory-enhanced eating experiences, and ecologically resilient food innovations. Follow-up feedback suggests that participants from diverse backgrounds were able to generate coherent and consistent visions of the future when supported by the structured framework and workshop process. We conclude by discussing key tensions and design opportunities for future food technologies, and reflect on the integration of design fiction with more-than-human perspectives.

ARTICLE HISTORY
Received 20 May 2025
Accepted 29 December 2025

KEYWORDS
Human-food interaction; future eating; design fiction; more-than-human

1. Introduction

Eating is a fundamental aspect of human life, and the integration of digital technologies–such as robotics (Berezina, Ciftci, and Cobanoglu 2019; Moley Robotics 2025; Zhu and Chang 2020), 3D food printing (Ashok Khot et al. 2017; Sun et al. 2015), virtual reality (Arnold, Ashok Khot, and Mueller 2018), capacitance sensing (Y. Wang et al. 2020), and genetic mold-arrangement algorithms (Y. Wang et al. 2018) – has opened up new possibilities in the Human-Food Interaction (HFI) field. These innovations offer promising approaches to transforming how people grow, prepare, cook, eat, dispose of, and interact with food (Ashok Khot et al. 2017). Furthermore, the exploration of future HFI from an envisioning perspective is an important emerging topic. It appears to be shifting toward an increasing emphasis on factors such as accessibility and imaginability (Grimes and Harper 2008). Notable examples include Niijima and Ogawa's (2016) method for simulating virtual food textures using electrical muscle stimulation, Wang et al.'s (2017) 2D edible sheets that morph into 3D shapes when hydrated, and Vi et al.'s (2017) TastyFloats, an acoustic levitation-based system that delivers food directly to the user's tongue. These innovations reflect a deepening exploration of the relationship among humans, food, and technology, which lies at the heart of HFI research (Altarriba Bertran et al. 2019). The growing body of experimental future studies within the HFI field is essential for uncovering and articulating the values, desires, and imaginative possibilities that shape food-tech futures and future eating practices (Dolejšová et al. 2020).

Regarding the conceptualisation of future eating scenarios and alternative practices, Design Fiction (DF) (Dunne and Raby 2013) has been used as a common approach (Grand and Wiedmer 2010; Linehan et al. 2014). DF creates a discursive space (Dunne and Raby 2013; Lindley and Coulton 2015) that lies not only in envisioning future possibilities or proposing technological solutions but also in serving as a dual-purpose method for design and research (He, Wu, and Qin 2024). Recently, DF has been applied to speculate on sustainable futures (Hauser, Desjardins, and Wakkary 2014; Tanenbaum, Pufal, and Tanenbaum 2016), investigate food futures (Hebrok and Mainsah 2022; Oogjes, Bruns, and Wakkary 2016; Tarik Celik et al. 2024), and imagine technological futures (Baumann et al. 2018; Johnson 2011). While the number of studies adopting DF workshops in the context of future food technologies has been growing, there remains a lack of critical reflection on how these workshops are prepared and implemented structurally (Amer, Daim, and Jetter

CONTACT Sibo Pan sibe9292@gmail.com Department of Industrial Design, Eindhoven University of Technology, Den Dolech 2, 5612 AZ Eindhoven, The Netherlands
*Present address: Faculty of Arts and Humanities, University of Macau, Macau, People's Republic of China
**Center for General Education, Westlake University, Hangzhou, Zhejiang, People's Republic of China

2013; Dahlström 2019; Gruen et al. 2002; Välk, Thabsuwan, and Mougenot 2023), i.e. how research is incorporated into the design/development of DF materials. Furthermore, existing DF studies have often overlooked non-designers (e.g. engineers) compared to designers (Ng, Lee, and Wu 2021; Tsekleves et al. 2017). From a broader perspective, previous studies point to a gap that non-designers themselves should be empowered to actively imagine futures for themselves, rather than merely responding to designer-led visions (He, Wu, and Qin 2024). Building on this, we also see an opportunity to engage both non-design participants and designers in exploring their perspectives on future eating through DF workshops.

Recently, noting the tension of DF in tackling future food technologies and eating practices, some scholars have introduced a More-than-Human (MTH) lens to incorporate nonhuman perspectives and deepen the understanding of speculative outcomes (Eriksson et al. 2024; Yanlıç and Coşkun 2024). While DF often centres on human needs and technological innovation, this focus risks reducing nonhuman entities (such as microbes or ecosystems) to mere functional elements, overlooking their intrinsic roles (Biggs, Bardzell, and Bardzell 2021; S.-Y. Liu 2019). In contrast, HFI researchers have argued that humans should extend their understanding of nonhuman life and exceed these binaries (Clarke et al. 2019; Heitlinger, Bryan-Kinns, and Comber 2019; J. Liu, Byrne, and Devendorf 2018; S.-Y. Liu 2019; Smith, Bardzell, and Bardzell 2017), promoting a more inclusive approach to design that acknowledges the interconnectedness of all life forms. However, integrating MTH perspectives directly into the DF process poses challenges, as participants may find it difficult to empathise with or design for nonhumans. Instead, scholars have seen value in applying the MTH lens as a post-hoc analytical approach represented or marginalised in participants' visions of the future (Eriksson et al. 2024; Poikolainen Rosén, Normark, and Wiberg 2022; Rodgers et al. 2023). Rather than embedding nonhuman concerns within the design process, this approach enables critical reflection on speculative outcomes, offering a pathway to enrich DF outcomes with greater reflective depth and relational awareness (Coulton and Lindley 2019; Giaccardi 2020; J. Liu, Byrne, and Devendorf 2018; Smith, Bardzell, and Bardzell 2017).

We address these gaps and opportunities through a case study. Our aim is to demonstrate how DF can be employed to explore future food-tech scenarios while applying an MTH lens to gain a deeper understanding of the outcomes. Specifically, we seek to investigate how a structured DF framework enables participants from diverse backgrounds to articulate and develop future eating scenarios, and how the MTH lens enriches understanding of the ecological, technological, and societal interconnections within the future eating context. First, we conducted research to develop workshop materials and structure the workshop process. Second, two workshops were held: one with 116 participants and another with 68 participants, where the pre-researched matrix framework was utilised as DF material. Moreover, we contribute to demonstrating how DF, guided by a structured framework, generates consistent and diverse future eating scenarios across participants within two workshops. We also reflect on how the MTH lens provides new insights into future food technologies, focussing on food alternatives, sensory experiences, and ecological sustainability. We hope the findings from this case study can further guide researchers interested in applying DF and the MTH lens in future eating studies.

2. Related work

2.1. Future eating in human-food interaction

The increasing interest in food within the Human-Food Interaction (HFI) discipline underscores the importance of merging interactive technology with food to envision future eating experiences (Altarriba Bertran et al. 2019). Numerous workshops have been conducted to explore how technological innovations can transform everyday food practices. For example, Designing Recipes for Digital Food Futures (Dolejšová et al. 2018) explored the creation of future recipes using digital tools, while Handmaking Food Ideals: Crafting the Design of Future Food-Related Technologies (Dolejšová et al. 2019) investigated human-food automation through AI-based food technologies. Similarly, Future of Food in the Digital Realm (Ashok Khot et al. 2017) examined the potential of food printing technologies, and Fantastic(e)ating Food Futures: Reimagining HFI (Davis et al. 2020) contributed novel ideas for how technology can support future food practices. These workshops have successfully brought together designers, researchers, and artists to explore creative food-tech possibilities. However, there is a growing need to broaden this interdisciplinary space by involving participants from diverse fields beyond design, fostering a more inclusive discussion on the future of HFI in food (Deng et al. 2021).

2.2. Design fiction workshop

Design Fiction (DF) is a speculative method that facilitates the exploration of near-future possibilities,

allowing for the imagination and speculation of future technologies in flexible and subjective worlds (Dunne and Raby 2013). DF serves as an anti-solutionist approach, focussing on inspiration, context, and speculative thought for future design rather than solving hypothetical problems that may not arise (Wakkary et al. 2013). It emphasises imaginative world-building, using diverse media like narratives, artifacts, and videos to craft alternate futures that challenge norms, explore emerging technologies, and provoke reflection (Coulton et al. 2017; Markussen, Knutz, and Lenskjold 2020). The artifacts and narratives produced not only embody the questions and concerns of the creators but also generate new insights and open up novel design possibilities (Blythe 2014). The performative and narrative nature of DF engages audiences viscerally, bridging fiction and reality to envision how future relationships with technology and society might unfold. Besides, a well-structured DF process and carefully prepared materials are critical to achieving the intended outcomes (Dunne and Raby 2013). Since diverse drivers shape the future and lead to varying DF outcomes (Amer, Daim, and Jetter 2013), prior research (Benton 2019; Ringland and Schwartz 1998) emphasises identifying at least two significant drivers and incorporating them into a cohesive framework before creating future scenarios. Moreover, DF workshops were also suggested to broaden participation beyond designers to include diverse stakeholders such as customers, technologists, and engineers, fostering multidisciplinary collaboration and leveraging creative storytelling to generate innovative insights and actionable ideas (Dahlström 2019; Gruen et al. 2002; Välk, Thabsuwan, and Mougenot 2023). Thanks to the prior studies, we see an opportunity to refine DF workshops with thoughtfully designed processes and inclusive participation, particularly in specific future-oriented topics such as future eating and food technologies.

In the realm of HFI domain, DF allows for the creation of food futures, focussing on how emerging technologies might reshape our relationship with eating practices (Cho, Devendorf, and Voida 2021; Heitlinger, Bryan-Kinns, and Comber 2019; Heitlinger et al. 2019; Lyle, Choi, and Foth 2014; Raturi et al. 2017; Rodgers et al. 2023). A few past works have leveraged DF to explore topics related to future eating and food. For example, Rutzerveld's project on edible growth (Rutzerveld 2025) showcases speculative design as a means to imagine sustainable food cultivation systems. Some studies (Gomez-Corona, Wathelet, and Minvielle 2024; Wathelet and Minvielle 2023) explored how DF can be employed as a methodological tool to engage stakeholders in imagining and critically reflecting on sustainable futures in food systems. While these studies demonstrate the utility of DF in imagining future food practices and engaging stakeholders, there remains a noticeable emphasis on human-centred approaches. Emerging research in HCI and DF increasingly advocates for integrating MTH perspectives, which include nonhuman species such as plants, animals, and fungi, to address sustainability challenges (Clarke et al. 2019; Heitlinger, Bryan-Kinns, and Comber 2019; J. Liu, Byrne, and Devendorf 2018; S.-Y. Liu 2019). Building on this direction, further exploration is needed to understand how DF can incorporate these perspectives to envision food futures that account for broader ecological and systemic interdependencies.

2.3. More-than-human lens

Over the past few decades, HCI scholars have increasingly embraced MTH lens in both design and research (Clarke et al. 2018; Coskun et al. 2022; Dew and Rosner 2018; Fritsch et al. 2023; Kuijer and Giaccardi 2018). These perspectives highlight the inclusion of nonhuman entities–such as robotics, artificial intelligence, smart products, and digital platforms–as stakeholders in the technologies being designed, acknowledging their integral role in shaping and being shaped by technological futures (Cheatle et al. 2019; Clarke et al. 2019; van Beek et al. 2025; Wilkie and Michael 2025). Central to this line of research is the idea of relationality between humans and nonhumans, which emphasises fostering ethical, intimate connections with the natural world to promote sustainable action (Poikolainen Rosén, Normark, and Wiberg 2022; Rodgers et al. 2023). For example, the concept of 'noticing' encourages design that heightens awareness of the complexities of nonhuman life, fostering recognition of the interdependencies and temporalities within ecosystems (Biggs, Bardzell, and Bardzell 2021; J. Liu, Byrne, and Devendorf 2018; S.-Y. Liu 2019).

According to a previous review (Eriksson et al. 2024), HFI is a key domain within the MTH research field (Heitlinger et al. 2021; Prost et al. 2021), with DF in speculative design being widely used to engage both human and nonhuman stakeholders in imagining sustainable futures (Eriksson et al. 2024). Research on DIY tools for urban interventions illustrates how speculative fabulation can inform citizens about urban issues involving nonhuman entities, such as plants and animals (Nijs et al. 2020). Similarly, Rodgers et al. integrate co-design fictions with MTH perspectives in workshops that foster relational thinking and speculation on sustainable futures (Rodgers et al. 2023). These examples demonstrate how DF can address ecological and sustainability challenges by emphasising the

interdependencies between humans and nonhumans. Furthermore, incorporating DF creates a discursive space for questioning anthropocentric assumptions, fostering relational thinking, and exploring ethical futures for all life forms (Coulton et al. 2017; Rodgers et al. 2023). This approach has influenced the exploration of future food practices, where DF is used not only to speculate on future technologies but also to engage with the broader ecological systems that are shaped by these technologies (Coulton and Lindley 2019; Giaccardi 2020).

3. Method and process

This case study aims to construct speculative scenarios of future eating in the year 2040 with DF workshops (Pan 2024). The study consisted of two main phases. In the first phase, we developed DF materials guided by scenario planning principles (Amer, Daim, and Jetter 2013; Ringland and Schwartz 1998) to support a deeper exploration of the future eating topic. This preparation included the development of a matrix-based framework structured around two key drivers: *eating objectives* and the *relationship between humans and technology*. The framework served as a conceptual foundation for the subsequent DF workshops, ensuring the relevance and depth of the insights generated. In the second phase, drawing on a process similar to that outlined in Wu, Pan, and Yu (2024), we conducted two DF workshops and analysed the results through thematic analysis. Notably, the findings revealed themes resonant with a MTH perspective. The detailed research process is illustrated in Figure 1.

3.1. Exploring design fiction materials

To ensure methodological rigour, the framework used in this study was grounded in established scenario planning approaches and design futures research. Scenario planning provides a structured way of identifying critical drivers and visualising alternative futures (Amer, Daim, and Jetter 2013; Benton 2019; Ringland and Schwartz 1998), while design futures and science and technology studies (STS) emphasise discursive and participatory engagement with emerging technologies (Dunne and Raby 2013; Wu, Pan, and Yu 2024). Building on these traditions, and aligning with recent work on food futures (Wu, Pan, and Yu 2024), we developed a two-axis matrix to guide the workshops. Rather than a stand-alone construction, the matrix was derived from a systematic review of food-tech drivers and validated through iterative team discussions. This grounding ensured that the framework was theoretically supported and provided participants–especially those without prior design training–with a structured yet open design space to envision food futures.

Given that the future is shaped by a range of factors that could lead to divergent outcomes, it is essential to carefully understand and select the appropriate drivers before constructing DF scenarios (Amer, Daim, and Jetter 2013; Benton 2019). The DF materials were developed by identifying key drivers, based on an initial review conducted by two researchers (the first and third authors) in a three-step process: *(1) Literature and Design Platform Review:* The initial step focussed on extensive research of existing designs and technologies associated with future eating. This research encompassed academic platforms (i.e. ACM digital library and Scopus) and design-oriented platforms (e.g. Pinterest, Dezeen, and Future Food Design Awards). The search employed targeted keywords: ('human-food interaction' OR 'dietary technology' OR 'food technology') AND ('future eating' OR 'future food'), enabling the collection of a comprehensive dataset. *(2) Screening and Identification of Key Drivers:* After gathering a broad range of materials, the same two members meticulously screened the gathered results to identify drivers central to the research topic. *(3) Visualisation of Selected Drivers:* Through iterative deliberation and discussions with other coauthors, a consensus was reached on the two most significant drivers: *Eating objective* (spanning from entertainment-centred to health-centred) and *Relationship between human and technology* (ranging from people relying on technology to technology empowering people). These two drivers were subsequently visualised within a two-axis matrix (Figure 2), offering a clear and structured framework for capturing diverse potential directions for future eating.

The visualised two-axis matrix served as a foundational material for the subsequent DF workshop, providing a clear framework to guide scenario building. Also, tangible examples were provided in the matrix to illustrate the potential implications of the key drivers, enabling a more focussed and insightful exploration during the DF workshop.

3.2. Design fiction workshops

3.2.1. Narrative workshop

Participant. Given that different outcomes may be produced across various demographics and cultural contexts (Itenge-Wheeler et al. 2016; Taylor, Soro, and Brereton 2018), the participants' similar age and cultural backgrounds were expected to ensure a focus primarily on the results themselves. We engaged 116 young individuals, all aged in their early 20s, from non-design

Figure 1. A visual outline of DF workshops, including three steps, participants, and main outcomes.

backgrounds and second-year students at a Tier-A engineering university in China. Despite not being trained in design, participants demonstrated the ability to imagine innovative food technology functions and critically consider a wide range of societal, environmental, and ethical consequences.

Procedure. Guided by the DF method (Dunne and Raby 2013), a 90-minute workshop was conducted onsite at a Tier-A university in China, aimed at envisioning future scenarios around emerging eating technologies through a narrative approach.

We began by briefly explaining the DF method to participants and introduced two key prompts: (1) The first prompt presented a framework with two drivers, outlined by the scenario planning method (Figure 2), which served as a backdrop for participants to explore possible plots, settings, and themes for future eating. (2) The second prompt included a range of exemplary scenarios and food-technology innovations to help participants familiarise themselves with the framework (Figure 2) and inspire their creative narratives.

After the introduction, participants started random pair discussions of the two prompts, during which they developed potential scenarios, technologies, and themes. Considering participants' limited experience in storytelling and imaginative thinking, we provided a suggested story structure based on previous research (Börjeson et al. 2006; Van Notten et al. 2003), which included three key components: *Why* (background settings in 2040), *How* (future plots and persona development), and *What* (design concept or future eating scenario). Moreover, in alignment with the provocative nature of the DF, participants were encouraged to draw inspiration from their own daily experiences while considering both the positive and negative insights of the proposed future scenarios. Once completion, the narratives, along with participants' feedback (including open-ended questions such as '*What do you think of the idea of creating scenarios with Design Fiction method?*', '*What do you like or dislike about the workshop?*', and '*What are your main reasons for like/dislike?*'), were submitted as PDF files to the research team and compiled as raw data for further analysis.

Data Analysis. A total of 116 narratives were collected after the workshop. Two team members (the first and third authors) screened the 116 narratives, selecting 97 (identified as P1 through P97) that provided sufficiently detailed visions of future eating scenarios, including both specific technologies and reflective insights. The analysis followed a two-stage process. (1) The narratives were transformed into quote statements and organised in Microsoft Excel for systematic coding and content analysis (Stemler 2000). An inductive thematic coding approach (Braun and Clarke 2012; Thomas 2006), supported by word frequency analysis (Silge and Robinson 2017), was applied to identify salient patterns and emerging scenario codes. Initial codes were independently generated and iteratively refined through team discussions, ensuring both consistency and analytical depth (Birt et al. 2016). (2) The refined codes were clustered into broader conceptual categories that captured the underlying design intentions. Through further team deliberation, these categories were consolidated into three overarching themes: *Efficiency*, *Entertainment*, and *Ecology*. While some narratives contained elements spanning multiple themes (e.g. an edible poster combining entertaining visualisation with efficient information delivery), each case was assigned to the theme that best represented its primary intention. This approach provided analytic clarity while acknowledging overlaps, ensuring that the diversity and creativity of participants' ideas were preserved in the analysis. Additionally, a MTH perspective was applied as an analytic lens throughout the analysis. Moreover, the feedback data were analysed by the first author using thematic analysis with MAXQDA software, following an inductive analytic approach.

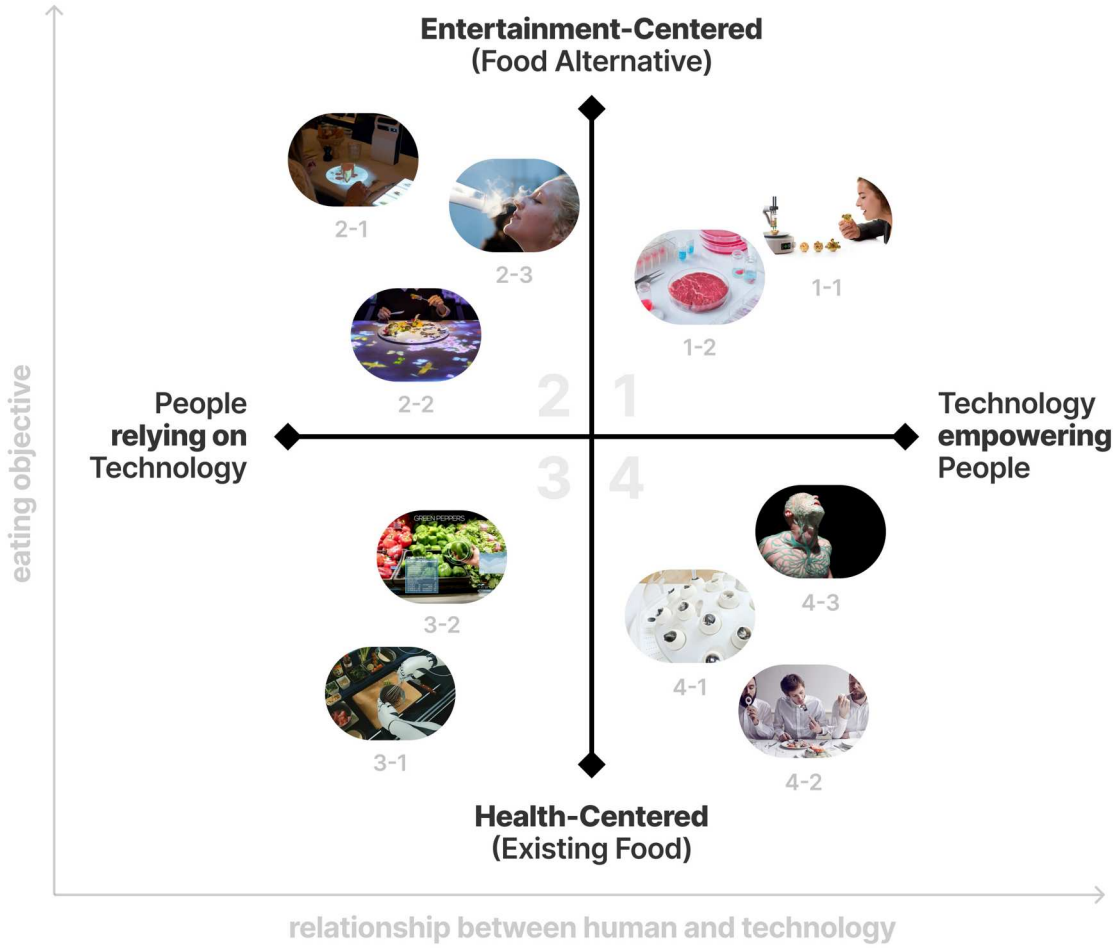

Figure 2. The matrix based on two drivers with future scenario exemplars: (1) Quadrant 1: 1-1 Edible Growth (Rutzerveld 2025), 1-2 In Vitro Meat (van Mensvoort and Grievink 2014); (2) Quadrant 2: 2-1 The restaurant of the future (Future Rroof 2020), 2-2 Immersive interactive restaurant (teamLab 2025), 2-3 Phora (Katharina Unger 2025b); (3) Quadrant 3: 3-1 Moley Robotics (Moley Robotics 2025), 3-2 Visualising the Future of Shopping (Patio Interactive 2016); (4) Quadrant 4: 4-1 Fungi Mutarium (Katharina Unger 2025a), 4-2 Human Hyena (Gong 2025), 4-3 Algaculture (Burton Nitta 2010).

3.2.2. Ideation workshop

Participant. In total, 68 volunteer designers (41 females, 27 males; Age: M = 24.72, SD = 3.11) were recruited from two Tier-A universities in China through convenience sampling. Inclusion criteria required participants to have (1) at least one year of design experience and (2) proficiency in both digital tools (e.g. Rhino, Photoshop, and Generative AI) and tangible design tools (e.g. 3D modelling/mockups and sketching). The recruited designers, identified as D1 to D68, had design experience ranging from 1 to 10 years (M = 3.60, SD = 2.20). Due to the geographical locations of the two universities, the 68 designers were divided into two groups, each participating in separate venues. In the workshop, both groups followed an identical process, generating future eating scenarios through the DF method.

Process. The one-day DF workshop, following the same process as the narrative workshop described in Section 3.2.1, was held separately at two Tier-A universities in China. Participants were introduced to two prompts: a framework with two drivers (Figure 2) and reviewed future eating examples. A structure–*Why* (2040 background), *How* (future plots and personas), and *What* (design concepts or scenarios)–was also provided to help participants generate future eating scenarios. Since all participants had a design background, they were asked to present these scenarios as design reports using digital or tangible tools. After the workshop, participants submitted their design outcomes and feedback (addressing the same questions as in the narrative workshop) as PDF files to the research team for analysis.

Data Analysis. A total of 68 submitted design reports were collected and first screened for completeness, resulting in 60 outcomes (D1–D60) that provided sufficiently detailed concepts and reflective insights for analysis. We applied a parallel analytic procedure to that of the narrative workshop, combining inductive

thematic analysis (Braun and Clarke 2012; Thomas 2006) with iterative team discussions (Birt et al. 2016) to derive higher-level themes from the raw data. This ensured consistency across both datasets. As with the narratives, several outcomes exhibited cross-theme qualities. For consistency of reporting, each outcome was positioned within the theme most strongly reflected in its description, and the results were consolidated into three overarching themes: *Efficiency*, *Entertainment*, and *Ecology*. The MTH was used as an analytic lens, reflected in our findings, while the feedback data were analysed using thematic analysis with MAXQDA software and a grounded theory approach, following an inductive coding process (Thomas 2006).

3.2.3. Data collection and exemplars

The study generated a diverse corpus of raw data across the two workshops, encompassing textual, visual, and hybrid formats (Figure 3). In the *Narrative Workshop*, 97 speculative stories were produced, averaging 535 words each. Written individually, these narratives articulated future eating scenarios through short stories, dialogues, and metaphorical descriptions. They often displayed imaginative extremes–for example, *Sadize Bread and Happilize Milk*, which induced emotional states through edible media, or *Edible Chess*, where nutrition was embedded in a gamified setting. In the *Ideation Workshop*, 60 design reports were created, combining written descriptions with sketches, diagrams, and, in some cases, AI-generated visuals. These outcomes typically described future artefacts, services, or systems in more structured terms, such as a *VR-assisted dining table simulator* for immersive eating or a *Smart Jellyfish* system that repurposed marine micro-organisms into edible matter. All outputs were digitally collected–narratives submitted as text files and design reports documented through scanned sketches and photographs–and systematically catalogued into a dataset that informed the subsequent coding and thematic analysis, ensuring transparency and enabling traceability from raw outputs to thematic abstraction.

4. Findings

We conducted two DF workshops: the Narrative Workshop and the Ideation Workshop. Prior to the workshops, we developed a matrix using a scenario planning approach to guide participants in creating future eating scenarios. In the Narrative Workshop, 116 participants developed narratives, resulting in 97 selected narratives for further analysis. In the Ideation Workshop, 68 participants were invited to explore potential design outcomes using the same matrix framework and process as the Narrative Workshop and 60 design reports were selected. The findings from both workshops were consistently aligned and grouped into three key themes: *Efficiency*, *Entertainment*, and *Ecology*. In the context of MTH insights, key findings highlighted the significance of *tech-driven food alternatives*, *sensory-enhanced eating experiences*, and *ecologically resilient food innovations*. We present the detailed findings of both workshops below.

4.1. Narrative workshops – narrative analysis

A total of 116 narratives were collected after the workshop, with a combined word count of 60,849 (mean = 524.56; max = 1014; min = 199). Among these, 97 narratives providing detailed explanations of future scenarios were selected for further analysis, comprising 51,872 words (mean = 534.76; range: 199–1014 words). Specifically, content analysis focussing on word frequency revealed that participants frequently referenced words related to eating experience (e.g. '*Entertainment Industry*' and '*Multi-sensory*'), environment (e.g. '*Global Environmental Deterioration*'), and eating quality (e.g. '*Efficiency*' and '*Balanced Nutrition*') when describing future eating scenarios in 2040.

As shown in Figure 4, each theme includes a summary of the 20 most frequently mentioned words, presented as a word cloud. The size of the words represents the relative frequency, with larger words appearing more frequently than smaller ones. Additionally, column diagrams illustrate the top ten frequent words in each theme. Specifically, in the *Efficiency* theme (Figure 4(a)), participants frequently mentioned words often in the context of future eating, such as '*Balanced Nutrition*', '*Robot*', '*Artificial Intelligence*', and '*Save Time*'. For the *Entertainment* theme (Figure 4(b)), terms like '*Multi-sensory*' and '*Virtual Technology*' were prominent, reflecting a focus on immersive and engaging eating experiences. Besides, the *Ecology* theme (Figure 4(c)) highlighted words such as '*Pollution*', '*Dearth of Food*', and '*Food Alternative*', emphasising environmental concerns and sustainable practices in future eating scenarios.

Efficiency theme. There were 49 narratives envisioning 2040 where societal and technological shifts influence eating practices. The narratives depicted a 2040 where: (1) individuals adapt to working over 15 hours daily to sustain social development, reflecting trends in overworking scenarios commonly observed in Chinese work culture; (2) eating processes are simplified through the use of concentrated foods, streamlining meal preparation and consumption; (3) advanced

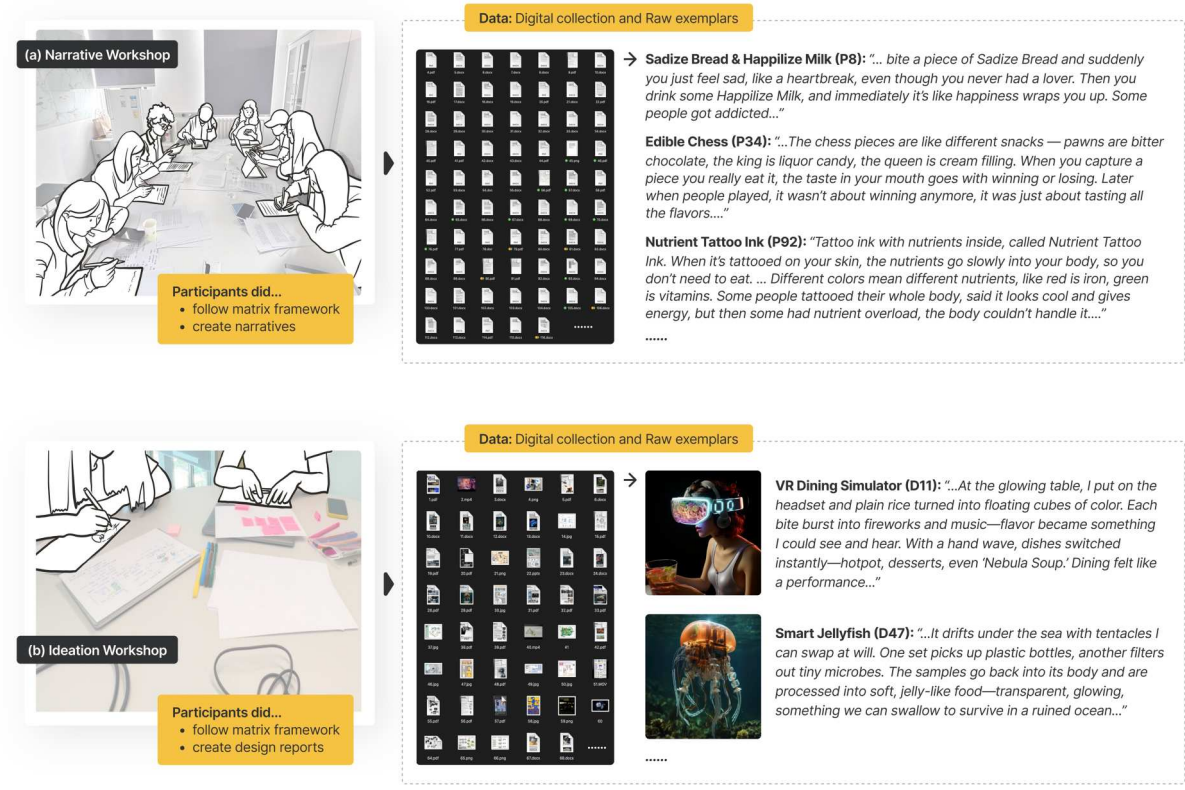

Figure 3. Workshop data collection and examples of raw outputs: Narrative (top) and Ideation (bottom).

technologies play a crucial role in ensuring accurate dietary management and balanced nutrient intake; and (4) personal health and eating patterns take precedence over traditional societal customs, marking a significant shift in priorities. Under the *Efficiency* theme, future food technologies in 2040 were categorised into five clusters based on the analysis: *Nutrient Concentration*, *Artificial Intelligence Robots*, *Redesign of Existing Products*, *Virtual Intake*, and *New Modes of Transportation*. As shown in Figure 4, ***Nutrient Concentration*** ($n = 19$) includes technologies like capsules and injections for efficient nutrient delivery. ***Artificial Intelligence Robots*** ($n = 15$) involve AI and 4D-printing robots that create personalised, nutrition-rich meals. ***Redesign of Existing***

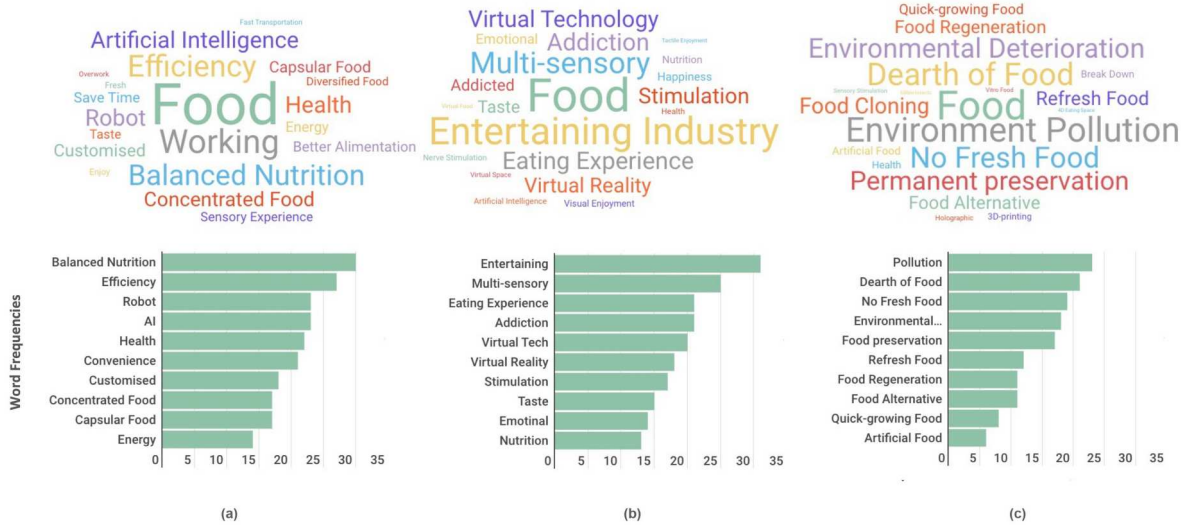

Figure 4. Word cloud (top panel) representing the most frequently mentioned words and corresponding 10 most frequent words (bottom panel) for (a) *Efficiency*, (b) *Entertainment*, and (c) *Ecology*.

Products ($n = 8$) focuses on innovations that optimise tools, such as multipurpose ovens, for rapid meal preparation. ***Virtual Intake*** ($n = 4$) introduces concepts like energy charging or virtual food consumption as alternatives to traditional eating. And ***New Modes of Transportation*** ($n = 3$) enable instant global food delivery through internet-connected 3D printers.

Entertainment Theme. Twenty-seven narratives envisioned 2040 where technological advancements and the desire for enhanced eating experiences shape the food industry. These narratives highlighted a future where: (1) higher expectations for enjoyable eating experiences emerge, driven by rapidly advancing science and technology, including sensory simulation, holographic images, and artificial food technologies; (2) the eating entertainment industry intensifies, evolving into a trend that encourages people to seek diverse sensory stimulation–taste, vision, and smell–as well as playful eating experiences. In response to this, the future food technologies in 2040 were categorised into three clusters: *Neural Technologies for Sense Augmenting*, *Technology-Enabled Food Modification*, and *Services for Immersive Eating*. As shown in Figure 5, ***Neural Technologies for Sense Augmenting*** ($n = 13$) provide multi-sensory eating experiences through wearable technology that links consciousness to the virtual world, allowing imagined food consumption. ***Technology-Enabled Food Modification*** ($n = 8$) includes products that alter flavours, textures, or shapes in real-time, offering interactive and personalised eating experiences. And ***Services for Immersive Eating*** ($n = 6$) use virtual reality and other immersive technologies to create unique dining experiences, where chefs experiment with emotional connections to food.

Ecology Theme. In the *Ecology* theme, 21 narratives envisioned 2040 shaped by severe environmental pollution and ecological destruction, where: (1) fresh food is scarce and expensive, accessible only to the wealthy; (2) the general population struggles with hunger, and technology plays a crucial role in addressing food shortages. The future food technologies in 2040 were categorised into four clusters: *Self-Growing Food*, *Recycled Food*, *Programmable Food*, and *Black-box Food*. As shown in Figure 4, ***Self-Growing Food*** ($n = 3$) includes technologies like '*Magic Refrigerators*' that can grow food in minutes and preserve it indefinitely. ***Recycled Food*** ($n = 10$) focuses on technologies that regenerate food, such as reviving ruined food or cloning plant and animal cells. ***Programmable Food*** ($n = 6$) enables people to design and print food with customised shapes, flavours, and smells through virtual programming, helping to alleviate ecological pressures. And ***Black-box Food*** ($n = 2$) represents government-regulated food distribution, where the wealthy enjoy fresh food while others survive on government-issued nutrient bars.

4.2. Ideation workshops – design outcomes analysis

A total of 60 design reports were collected following the workshop. Then, 60 design reports, which illustrated detailed explanations of future scenarios, were selected for further analysis. Content analysis revealed that many reports went beyond surface-level descriptions by identifying specific target groups, defining clear design purposes, and developing functional systems and products. This demonstrated an extension of food-tech possibilities in envisioning future eating scenarios for 2040. Coincidentally, consistent with the findings from the narrative workshop, the results from the ideation workshop were also categorised into three main themes: *Efficiency* ($n = 20$), *Entertainment* ($n = 20$), and *Ecology* ($n = 20$). Exemplar design outcomes among the three themes can be found in Figure 6.

Efficiency Theme. In the *Efficiency* theme, 20 design outcomes were generated. The most popular target group identified by the participants included '*working individuals*', '*the young generation*', and '*common people*'. These groups were considered across various contexts, such as '*workplace*', '*home kitchen*', '*supermarket*', '*car*', '*growing farm*', and even '*outer space*'. Additionally, one participant (D18) identified patients as target group with eating-related diseases in their daily routines. Furthermore, the design purposes across the outcomes were generally similar, focussing on the accurate intake of nutritional components, providing easy-to-eat solutions such as '*virtual food*', '*nutrient capsules*', and '*edible smoke*', as well as '*building individual ecosystems to promote healthier food and lifestyles*'. To support these goals, the participants mentioned technologies like '*3D printing*', '*food compression techniques*', '*robotic assistants*', '*space shuttle transportation technology*', and '*data recognition and auto-collection technology*' to facilitate customised eating practices.

Entertainment Theme. In the *Entertainment* theme, 20 design concepts were generated. Many designers identified '*children*' and '*young adults*' as key target groups due to their potential to improve picky eating habits, alleviate negative emotions, and promote healthy eating knowledge through playful eating practices. '*Patients*' (D34) were also explored as an important target group, with food technologies offering potential treatments for diseases such as anorexia nervosa through creative future approaches, such as '*edible*

Figure 5. Illustrated narrative analysis results for (a) *Efficiency*, (b) *Entertainment*, and (c) *Ecology*.

chess', where eating the lost pieces provides necessary neutrinos. Family dynamics were another motivating factor for enjoyable eating, including '*using the singing of family members to create food* (D1)', '*emulating the taste of home-cooked meals for remotely living family members* (D56)', and '*previewing the taste and appearance of new recipes before cooking* (D19)'. Additionally, other designers (D6, D7, D11, and D37) proposed that common people in the future could stimulate sensory experiences during eating through visual, auditory, gustatory, olfactory, and *tactile perception* using AR, VR, and other augmented technologies.

Ecology Theme. In the *Ecology* theme, all 20 developed ideations identified '*human beings*' as the target

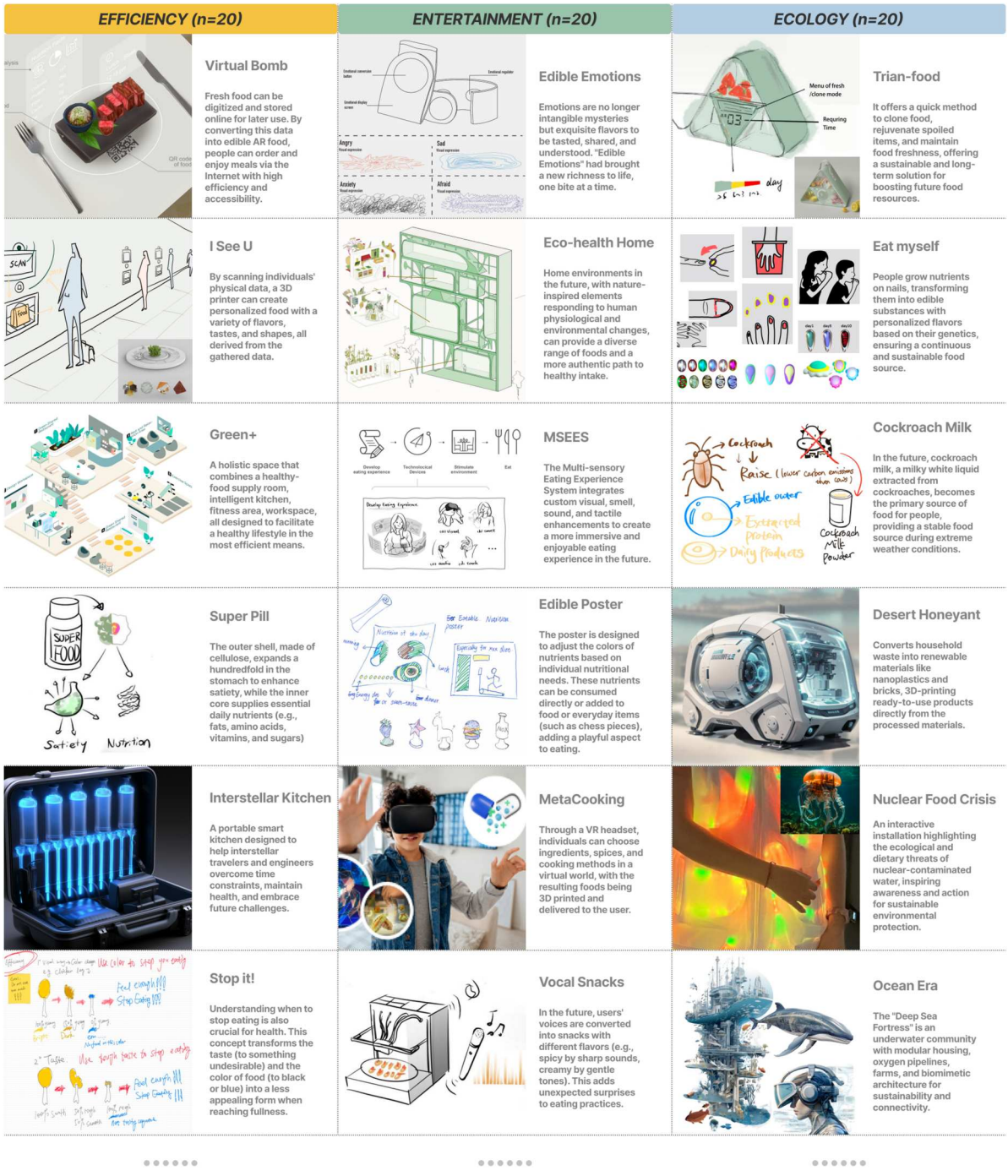

Figure 6. Exemplar design outcomes of future eating and technologies for (a) *Efficiency*, (b) *Entertainment*, and (c) *Ecology*.

group, leading to two main design objectives: '*ensuring an adequate supply of fresh food*' and '*exploring nutrient-rich food alternatives in response to future environmental pollution*'. Regarding '*adequate supply of fresh food*', almost half designers devised future-oriented solutions, including '*the extraction and conversion of waste into nutritious food* (D4, D37, and D60)', '*purification of nuclear wastewater into potable water* (D29)', '*food cloning* (D10 and D41)', '*food compression technology aimed at reducing volume and extending shelf life* (D15 and D28)', and '*the cultivation of plants either through hydroponics* (D43) *or within in-home greenhouses* (D16)'. Regarding '*nutrient-rich food alternatives*', other designers envisioned '*edible insects and processed foods* (D1 and D12)', '*growing food from the human body, such as nails* (D2) *and skin* (D31)', '*transforming everyday items into food, e.g. hair/fur* (D5, D20, and D52) *and tableware* (D14)', '*lab-grown seafood* (D3)',

and '*artificial meat protein* (D6 and D18)' as potential future choices.

4.3. Thematic findings of both workshops with more-than-human lens

In the following sections, we further analyze the findings through a MTH lens, reorganising the insights around the interconnectedness of humans, technology, and nonhuman entities. By adopting this perspective, we aim to highlight the complex relational dynamics embedded in the narratives and design outcomes developed during our two workshops. The three themes identified not only reflect the participants' hopes and concerns about future technological challenges but also underscore the importance of considering nonhuman insights in the process of shaping future eating practices. More details are presented below.

4.3.1. Efficiency – *tech-driven food alternatives*

Keywords. As shown in Figure 7(a), the MTH keywords derived from the *Efficiency* theme across the Narrative and Ideation workshops include Synthetic Nutrients, Human-Technology Symbiosis, Personalised Food, AI Food Creation, and Technological Customisation, which together reflect the role of advanced technologies in reshaping food systems, creating individualised food experiences, and transforming the relationship between humans, technology, and ecosystems.

Narrative Workshop. Regarding the findings of the Narrative workshop, the *Efficiency* theme highlights five technological groups that incorporate advanced technologies and MTH elements, showcasing evolving interactions between humans, technology, and ecosystems: *Nutrient Concentration* involves tailored synthetic nutrients optimised for individual needs, which detaches from traditional food practices and raises concerns about human physiology and culture. *Artificial Intelligence Robots* use AI and 4D-printing to create personalised meals, shifting food expertise from humans to machines, with potential ecological impacts due to resource-intensive processes. *Redesign of Existing Products* focuses on advanced food appliances that optimise resources but risk further detaching humans from ecological food practices. *Virtual Intake* proposes wearable devices or energy technologies that replace digestion, challenging the relationship between humans and natural ecosystems. *New Mode of Transportation* introduces rapid and automated food delivery systems that offer convenience but reduce communal eating and cultural connections. Taken together, these five groups illuminate the multifaceted MTH dynamics within the *Efficiency Theme* theme. Key elements include the integration of human-technology symbiosis, the disruption of cultural and traditional practices, the transformation of biological processes, the redistribution of resources, and the detachment from emotional and interpersonal connections. These findings underscore the need for a balanced approach to future food design that not only prioritises efficiency but also considers ecological and cultural sustainability.

Ideation Workshop. The Ideation workshop findings within the *Efficiency* theme reveal a deep integration of MTH elements, where technological advancements reshape food systems and human-environment relationships. Innovations like virtual food, nutrient capsules, and edible smoke detach food from traditional biological and cultural processes, while technologies such as 3D printing, robotic assistants, and data recognition create personalised, efficient eating experiences. These developments shift food consumption to a bio-digital exchange, raising concerns about the loss of cultural connections and ecological ties to food. The vision of building individual ecosystems for healthier lifestyles further challenges traditional notions of nourishment, suggesting a redefined human-technology relationship. Overall, these findings highlight the need for a balanced approach to future food design, prioritising both efficiency and ecological, cultural, and emotional sustainability.

Conclusion. The findings from both the Narrative and Ideation workshops under the *Efficiency* theme demonstrate the transformative potential of advanced technologies in future food alternatives. These innovations integrate MTH elements and reshape the relationship between humans, technology, and ecosystems. From personalised synthetic nutrients to AI-powered meal creation and rapid automated delivery, these advancements promise efficiency as well as raise concerns about detachment from traditional food practices, cultural connections, and ecological sustainability. As food consumption becomes more bio-digital and individualised, it is crucial to consider the broader implications of these changes, ensuring that technological progress is balanced with respect for ecological, cultural, and emotional values. Future food design must embrace not only efficiency but also sustainability and human connection to maintain a harmonious balance between technological innovation and the natural world.

4.3.2. Entertainment – *sensory-enhanced eating experiences*

Keywords. As shown in Figure 7(b), the MTH keywords derived from the *Entertainment* theme across

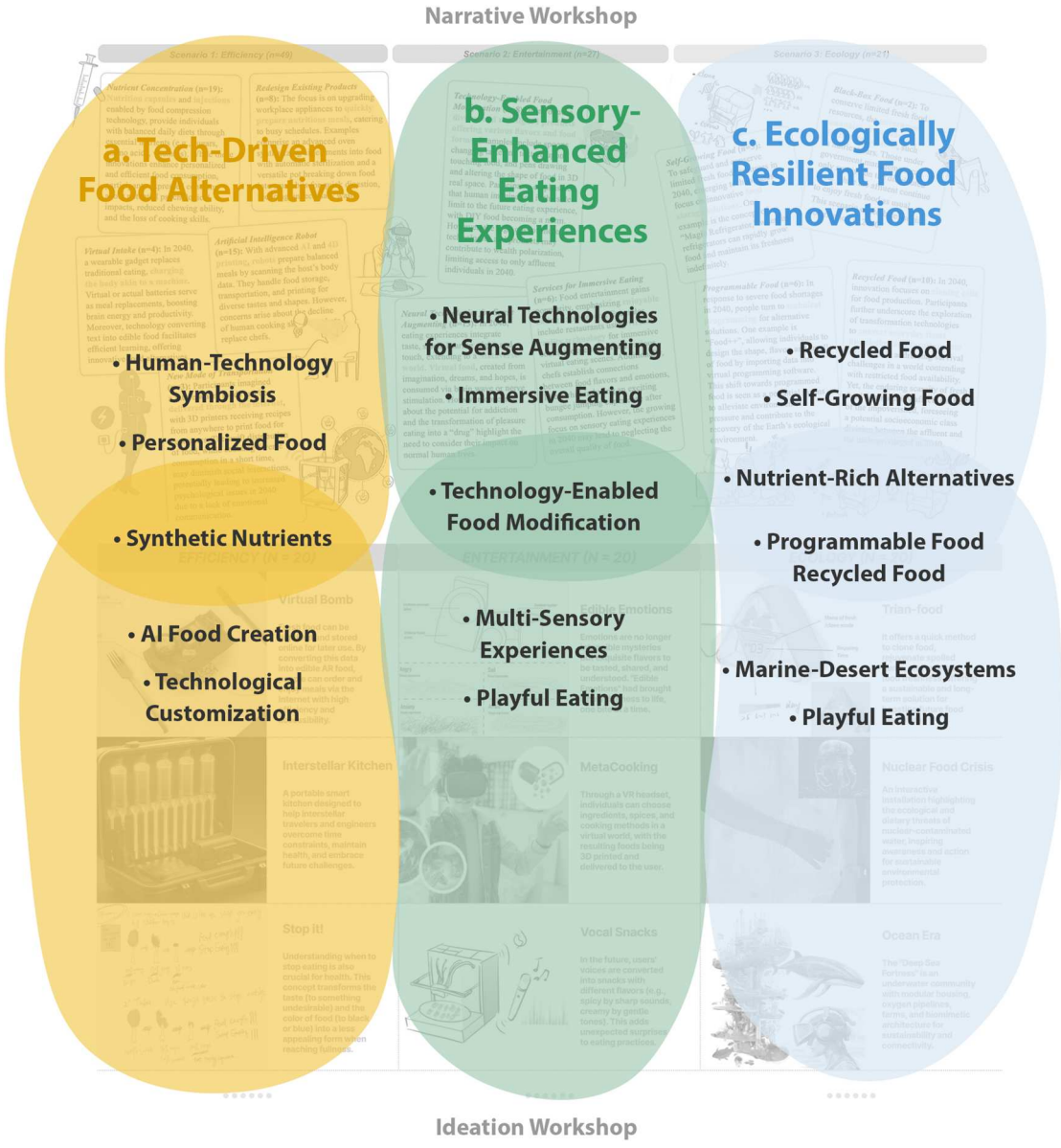

Figure 7. Thematic mapping of keywords from both workshops, analysed through an MTH lens across three themes.

the Narrative and Ideation workshops include Neural Technologies for Sense Augmenting, Technology-Enabled Food Modification, Immersive Eating, Multi-Sensory Experiences, and Playful Eating, which together reflect the integration of advanced sensory technologies into food systems, creating immersive and interactive eating experiences, and transforming the relationship between humans, technology, and food consumption.

Narrative Workshop. The *Entertainment* theme identifies three technological groups that integrate MTH elements into future eating experiences. Neural Technologies for *Sense Augmenting* ($n = 13$) offer immersive multi-sensory experiences through wearable devices that simulate food consumption, separating it from traditional practices. *Technology-Enabled Food Modification* ($n = 8$) enables real-time alteration of food properties, fostering playful personalisation but distancing food from cultural and ecological roots. *Services for Immersive Eating* ($n = 6$) leverage virtual reality to create emotional connections via virtual eating, which challenges conventional eating practices. Together, these three groups demonstrate the blending of human and technological elements, enriching eating experiences while raising concerns about emotional, cultural, and ecological detachment. Future food designs must balance innovation with sustainability to ensure meaningful and connected experiences.

Ideation Workshop. The Ideation workshop findings within the *Entertainment* theme reveal a deep integration of MTH elements, where technologies reshape

food systems and enhance sensory and emotional eating experiences. Playful food concepts target groups such as children, young adults, and patients to improve habits, ease emotional distress, and foster healthier relationships with food. Examples like 'edible chess' combine interactive play with nutrition, creating both entertainment and emotional connections. Technologies like AR and VR further enrich sensory experiences, making food consumption an immersive activity. These findings highlight a future where food extends beyond sustenance to become a multifaceted experience, addressing psychological and health needs while intertwining human biology, emotions, and technology.

Conclusion. The findings from both the Narrative and Ideation workshops underscore the transformative role of advanced technologies in reimagining future eating experiences. By integrating MTH elements, these innovations reshape the interactions between humans, food, and technology, from neural technologies simulating food consumption to real-time modifications and immersive eating. While these advancements enrich sensory and emotional engagement, they also raise concerns about detachment from natural food processes, cultural traditions, and emotional connections. To ensure a harmonious integration of innovation and tradition, future food design must balance entertainment and sensory enhancement with sustainability and the preservation of meaningful human connections.

4.3.3. Ecology – *ecologically resilient food innovations*

Keywords. As shown in Figure 7(c), the MTH keywords derived from the *Ecology* theme across the Narrative and Ideation workshops include Self-Growing Food, Recycled Food, Programmable Food, Marine-Desert Ecosystems, Food Cloning, and Nutrient-Rich Alternatives. These concepts illustrate the role of advanced technologies in reshaping food systems, addressing environmental challenges, and exploring new ways to produce and consume food in a drastically altered ecological landscape.

Narrative Workshop. The *Ecology* theme in the Narrative workshop highlights four technological groups that reshape food systems in response to ecological challenges: *Self-Growing Food* ($n = 3$) features technologies like 'Magic Refrigerators' that rapidly grow and preserve food, detaching from traditional agriculture. *Recycled Food* ($n = 10$) includes technologies that regenerate food, such as food revival and cell cloning, utilising waste and reducing dependence on conventional production. *Programmable Food* ($n = 6$) allows for customisable, eco-friendly food production through digital controls. *Black-box Food* ($n = 2$) envisions a dystopian future with government-issued nutrient bars, where fresh food is reserved for the wealthy. These groups highlight the tension between innovation and ecological, cultural, and biological ties to food, suggesting the need for future systems that balance technological progress with sustainability and equitable access.

Ideation Workshop. The Ideation workshop findings within the *Ecology* theme emphasise ensuring an adequate supply of fresh food and exploring nutrient-rich alternatives. Pariticipants proposed solutions like waste-to-nutrition conversion, food cloning, nuclear wastewater purification, and hydroponics to secure fresh food. Nutrient-rich alternatives included edible insects, lab-grown seafood, artificial meat proteins, and unconventional ideas like growing food from human-derived materials and repurposing everyday items. These innovations challenge traditional food production, addressing ecological challenges and food scarcity, but raise concerns about cultural acceptance, ethical issues, and long-term ecological effects. The focus on alternative food sources underscores the need for sustainable solutions that respect cultural traditions and biological diversity.

Conclusion. The findings from both the Narrative and Ideation workshops under the *Ecology* theme emphasise the role of advanced technologies in reshaping food systems amidst environmental degradation. From self-growing food and recycled nutrients to programmable and alternative foods, these innovations promise solutions to food scarcity and ecological destruction. However, they also raise significant concerns about cultural detachment, ecological impacts, and ethical considerations. To ensure a sustainable and inclusive food future, future food designs must integrate technological advancements with ecological and cultural sensitivity, fostering systems that promote both sustainability and meaningful human connections to food.

4.4. Follow-up feedback

According to the follow-up feedback after the Narrative and Ideation workshops, most participants expressed a positive attitude toward the participant process using the DF method and our pre-researched materials. More detailed findings from the feedback are presented below.

Prepared DF Material. The introduction of the matrix, with its two key drivers, was strongly emphasised by participants in both the Narrative and Ideation workshops. They highlighted the importance and

necessity of incorporating this framework (illustrated in Figure 2) at the beginning of each workshop session to guide the development of future eating scenarios. The reasons provided by participants were as follows: (1) *A clarified structure*: The matrix, which includes two central drivers–*Eating objective* and *Relationship between humans and technologies*–as outlined in Section 3.1, facilitated '*a rapid and comprehensive mapping of the food-tech future*' and provided participants with '*a clear sense and a well-defined envisioning direction*'. The development of the matrix as a DF workshop material was regarded by most participants as '*trustworthy*', '*scientific*', and '*supportive*'. (2) *Enhanced workshop efficiency*: Many participants noted that the introduction of the two drivers as a framework with accompanying examples '*provided various background knowledge without requiring additional time and effort from participants*' and '*helped to quickly locate imaginative directions for future eating.*' This efficiency was praised for streamlining the envisioning process and enabling participants to focus on creativity without the need for extensive preparatory work. (3) *Rapid Scenario Development and Reflection*: Numerous participants highlighted that the structure–*Why* (2040 background), *How* (future plots and personas), and *What* (design concepts or future scenarios)–enabled them to quickly establish a narrative or design draft, offering the opportunity to explore various perspectives within a short workshop timeframe and to deeply reflect on how their envisioned outcomes might influence the future. For instance, P114 mentioned, '*Having this structure gave me the confidence to think more holistically about the scenarios, pushing me to not only develop new ideas but also critically reflect on how my concepts would play out in the future.*' Similarly, D19 stated, '*The structure provided me with a clear raw storyline that helped me quickly focus my thinking and efficiently generate diverse design concepts in a short amount of time, something I wouldn't have achieved otherwise.*'

Extra Findings. Participants from both workshops described their experiences as '*exciting*', '*interesting*', '*impressive*,' and '*creative*'. They also offered three key suggestions for improving future workshop experiences: (1) Some participants recommended extending the duration of the workshop process, noting that '*a longer timeslot would afford additional opportunities to refine narratives with deeper and more speculative insights* (P92)' and '*exploring how these concepts could be effectively translated into practical applications and products within the industry* (D39)'. (2) There was a shared *aspiration for the implementation of advanced generative tools*, such as '*Artificial Intelligence content generation tools*', to expedite the ideation process and assist in developing future eating fictions. (3) While the workshop offered participants an opportunity to communicate, the potential formation of smaller groups was viewed favourably, as it could facilitate more in-depth discussions and the development of more detailed concepts compared to working individually.

5. Discussion

5.1. Reflection on participation and future-eating outputs in design fiction workshops

Reflecting on the DF workshops, the preparation of materials appears to have been instrumental in facilitating effective participation and outputs (Bleecker 2022; Dunne and Raby 2013). By providing a structured matrix and clear instructions, participants were equipped with a flexible framework that allowed them to engage with the workshops using approaches aligned with their individual strengths (Amer, Daim, and Jetter 2013). This structure supported diverse participation, enabling individuals from various backgrounds–whether or not they had prior design expertise–to contribute meaningfully. Participants could express their ideas through narrative storytelling or design reports, fostering critical thinking and creativity. While this method appeared effective in engaging a range of participants, further studies could explore how variations in preparation materials might impact the inclusivity and quality of outputs in similar workshops, especially those addressing future-eating-oriented topics.

While our findings were reported under three overarching themes–*Efficiency*, *Entertainment*, and *Ecology*–many narratives and design outcomes displayed qualities that cut across these themes. For example, playful edible posters could be interpreted as both *Efficiency* (communicating health information effectively) and *Entertainment* (engaging users through visual playfulness), while concepts addressing eating disorders intersect issues of efficiency, wellbeing, and affective experience. These overlaps underscore the richness of participants' imaginaries and the entangled nature of technological, social, and ecological concerns in future food scenarios. By presenting the findings through three overarching themes, we provide a structured analytic lens while recognising that the boundaries between these themes remain fluid and interdependent.

As previously noted, DF workshops often rely heavily on designers, which limits the inclusion of non-designer perspectives (Dunne and Raby 2013; Ng, Lee, and Wu 2021; Tsekleves et al. 2017). In our case, by organising

two distinct participant groups (non-designers and designers) and employing a structured process with carefully prepared materials, we observed limited differences in the quality of outputs between groups. This suggests that a structured DF approach can effectively support meaningful participation from diverse backgrounds, bridging the gap between designers and non-designers (Amer, Daim, and Jetter 2013; Dunne and Raby 2013; He, Wu, and Qin 2024). Our workshops thus demonstrate the viability of this approach, offering valuable guidance for future studies on future eating that seek to engage broader participant demographics.

An additional observation from the workshops was the notable use of AI tools (e.g. MidJourney, Stable Diffusion, ChatGPT) by participants to assist in generating outputs. Data from the submitted PDFs suggests that AI-supported outputs often exhibited greater detail and cohesiveness, particularly in design reports. Moreover, participants who incorporated AI tools frequently used AI-generated videos to supplement their concept presentations, which appeared to enhance their ability to communicate ideas effectively. This observation points to the possibility of AI tools enriching the outcomes of DF workshops by enabling participants to explore and present their ideas more comprehensively (Rezwana and Maher 2023). However, it also raises questions about the implications of AI use on the originality and depth of participant engagement. Further examination of this phenomenon could provide a more nuanced understanding of the role AI might play in shaping creative and collaborative processes within DF.

Taken together, these reflections suggest that our study contributes by showing how structured preparation materials, the inclusion of both designers and non-designers, and systematic archiving of raw data with an MTH lens can enhance creative future food scenarios in DF workshops. By framing the findings through three overarching themes, we aimed to balance analytic clarity with respect for the diversity of participants' ideas. We hope this approach can serve as a useful reference that future studies on food futures and related domains may further adapt and refine.

5.2. Tension of more-than-human insights

The integration of MTH perspectives into DF highlights both opportunities and challenges in envisioning future eating (Heitlinger et al. 2021; J. Liu, Byrne, and Devendorf 2018; Prost et al. 2021). The tension between DF and the MTH perspective arises from their differing focal points in addressing future food systems. DF often prioritises human needs and technological innovation, emphasising how novel technologies like programmable food systems or waste-to-nutrition technologies can address ecological and societal challenges. However, these approaches frequently reduce nonhuman entities–such as ecosystems or microorganisms–to functional tools, overlooking their intrinsic value and complex roles within ecological systems. This reductionist approach risks oversimplifying ecological challenges and undermining sustainability efforts (Biggs, Bardzell, and Bardzell 2021; S.-Y. Liu 2019).

Additionally, DF typically emphasises scalability and universality, proposing solutions that aim for broad applicability. In contrast, the MTH perspective stresses the importance of contextual sensitivity, highlighting the need to account for local ecosystems, cultural traditions, and the interdependencies between humans and nonhuman entities (Clarke et al. 2019; Poikolainen Rosén, Normark, and Wiberg 2022). For example, proposals in our findings, such as food cloning or insect protein production, demonstrate technological promise but also raise concerns about cultural acceptance and ecological balance. This tension challenges participants to balance global solutions with localised needs and relational complexities.

Moreover, the narrative frameworks in DF are often anthropocentric, positioning nonhuman entities as tools or background elements rather than active participants. The MTH perspective, however, advocates for recognising nonhuman entities as influential agents in shaping design outcomes. For instance, designs for ecological restoration or circular food systems must consider the agency of nonhuman actors, rather than solely focussing on human-driven control (Clarke et al. 2018; Eriksson et al. 2024). Shifting to this narrative approach not only challenges conventional notions of agency but also fosters richer, more inclusive discussions about the ethical and ecological implications of future food-tech innovations.

In summary, DF must navigate the dynamic balance between technology-driven innovation and ecological sensitivity. Incorporating the MTH perspective allows to better understand the complexities of food systems, fostering solutions that are not only speculative and innovative but also inclusive and sustainable.

5.3. Possible future eating technologies

Contemporary HFI research increasingly focuses on leveraging innovative approaches to enhance eating experiences through the integration of emerging technologies (Velasco et al. 2018). In both narrative and ideation workshops employing the DF method, participants generated 97 future narratives and 60 design

outcomes. These outputs informed the conceptualisation of future food-tech ideas, which were categorised into three overarching themes: *Efficiency*, *Entertainment*, and *Ecology*. The analysis of these narratives and design outcomes offers valuable MTH perspectives on the potential of envisioned food-tech futures. This potential aligns with recent advancements in HFI research, which have highlighted several promising food-tech implementations, including:

- ***Robotics.*** Recent HFI studies propose integrating robotics into future eating innovations to create nutrient-balanced meals tailored to individual needs. Advancements such as 'personal service robotics', expected to grow significantly (Thrun 2004), and food printing technology for customised meal production (Yang, Zhang, and Bhandari 2017), provide a strong foundation for enhancing personalised eating experiences. These technologies also invite consideration of the ecological impact of ingredient sourcing and the sustainability of production processes, fostering a more interconnected and ethical approach to food-tech futures.
- ***Virtual Food.*** Emerging studies highlight the potential of augmented reality (AR) and digital food technologies to transform eating experiences by altering food's visual qualities, such as texture and colour (Nishizawa, Jiang, and Okajima 2016), displaying full-size 3D representations of food in restaurants (HoloLamp 2020), and utilising a 2D-3D hydration process to accelerate delivery times (W. Wang et al. 2017). However, developing edible AR and digital food on a scalable and evidence-based foundation requires significant time and an interdisciplinary approach. Encouragingly, recent efforts have focussed on turning speculative concepts into practical innovations, with 'Digital Gastronomy' (Zoran and Coelho 2011) standing out as a notable example.
- ***Multisensory Eating Experience.*** Augmentation technologies have the potential to transform the future of eating by enhancing various sensory aspects, including the visual characteristics of food (e.g. texture Okajima and Spence 2011, colour modifications via AR Narumi 2016; Nishizawa, Jiang, and Okajima 2016 and VR Bruijnes, Huisman, and Heylen 2016), auditory experiences (e.g. chewing sounds Zampini and Spence 2004, environmental noise Woods et al. 2011; Yan and Dando 2015, music Crisinel et al. 2012, eating sound intervals Kadomura et al. 2011, and interactive sounds with food Kadomura, Tsukada, and Siio 2013), and tactile interfaces (e.g. for the lips Tsutsui et al. 2016, biting Iwata et al. 2004, cutlery and tableware Hirose et al. 2015; Spence 2017). HFI researchers, who seek to replicate real-life eating experiences, emphasise that the development of dietary technologies enhanced by these sensory augmentations is expected to grow rapidly, providing a strong foundation for more immersive eating experiences in the future (Kita and Rekimoto 2013).
- ***3D-Printing Technology.*** Advanced food-tech innovations, such as 3D and 4D printing, have emerged as promising tools for creating novel flavours and food structures, offering high-quality and customisable eating experiences. One key advantage of 3D printing is its ability to tailor ingredients, tastes, forms, and textures to meet individual health conditions, lifestyles, and preferences (Yang, Zhang, and Bhandari 2017). However, the slow pace of technological development means that such techniques are still limited, with some applications, like 3D printing for oral medication (Pandey et al. 2020; Vithani et al. 2019), only being intermittently used in the medical field. Despite this, these technologies present a promising design space for future HFI research.
- ***Food Alternatives.*** Ecological changes are expected to reduce global agricultural yields (Nelson et al. 2010; Rosenzweig et al. 2014), while altering dietary composition and impacting population health (Springmann et al. 2016). Furthermore, deforestation contributes to meat production accounting for 15% to 24% of global greenhouse gas emissions. As agricultural resources are optimised, meeting future meat demand becomes increasingly challenging (Steinfeld et al. 2006). Recently, the development of meat alternatives, such as in-vitro meat and myocyte culturing, has gained momentum and shows potential in alleviating the ecological burden while meeting meat demand more sustainably (Datar and Betti 2010; Hocquette 2016). The design concepts proposed in this study aim to offer potential solutions to the agricultural challenges posed by environmental changes.

5.4. Limitation and future work

The research findings should be interpreted with the following limitations in mind. First, the DF method prioritised open-mindedness, amplifying social and environmental issues without being constrained by current technological advancements. As such, the resulting narratives and design outcomes for food-tech futures are not intended as practical solutions but rather as speculative references and potential pathways for future eating. Second, the workshops did not consider detailed

demographic variations within participant groups, such as the sex ratio. Additionally, the findings, rooted in a Chinese urban context, may have limited applicability to other cultural or geographical settings. Third, the study did not delve into specific topics for future eating; instead, the scenario planning matrix (Figure 2) served as the foundation for both the narrative and ideation workshops. Finally, although for analytic clarity each case was reported under a single dominant theme, this involved some simplification of their multidimensional qualities. Future research could further explore methods that explicitly capture such overlaps, providing richer accounts of the interconnections between efficiency, entertainment, and ecological concerns in food futures.

For future research, it may be beneficial to explore topic-specific and/or MTH-based workshops to expand the scope of inquiry and refine design orientations. Additionally, incorporating tools like AI-generated content into the workshop process could enhance the efficiency and quality of outcomes. Moreover, sharing the findings and proposed future scenarios with HFI researchers and experts could also provide valuable insights, enabling refinement and further development of narratives and design outcomes for food-tech futures.

6. Conclusion

This paper explored potential future eating scenarios for 2040 through two design fiction workshops, guided by a structured matrix framework. A narrative workshop with 116 participants and an ideation workshop with 68 participants generated 97 narratives and 60 design reports, which were analysed into the themes of *Efficiency*, *Entertainment*, and *Ecology*. These outputs highlighted innovative concepts such as programmable foods, sensory-enhanced eating experiences, and ecologically adaptive food systems, showcasing the potential of advanced technologies to address societal and ecological challenges. The workshops also demonstrated the effectiveness of the matrix framework in engaging participants from diverse backgrounds, allowing them to generate creative and critical visions of reimagining future eating.

Adopting a more-than-human lens revealed tensions, including the balance between scalability and contextual sensitivity and the challenge of incorporating nonhuman perspectives into traditionally human-centric design fiction. The use of AI tools by some participants further enhanced the quality and completeness of their outcomes, suggesting opportunities for integrating generative technologies into future workshop processes. This study underscores the value of embedding more-than-human insights into design fiction outcomes, advocating for more inclusive and reflective approaches to envisioning sustainable and equitable food futures.

Author contributions

CRediT: **Sibo Pan:** Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing - original draft, Writing - review & editing; **Xipei Ren:** Conceptualization, Methodology, Resources, Supervision; **Yiying Wu:** Conceptualization, Formal analysis, Methodology, Resources; **Steven Vos:** Conceptualization, Methodology, Supervision; **Aarnout Brombacher:** Conceptualization, Methodology, Supervision; **Yunye Yu:** Conceptualization, Methodology, Resources.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Altarriba Bertran, Ferran, Samvid Jhaveri, Rosa Lutz, Katherine Isbister, and Danielle Wilde. 2019. "Making Sense of Human-Food Interaction." In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, 1–13. New York, NY: ACM.

Amer, Muhammad, Tugrul U. Daim, and Antonie Jetter. 2013. "A Review of Scenario Planning." *Futures* 46:23–40. https://doi.org/10.1016/j.futures.2012.10.003.

Arnold, Peter, Rohit Ashok Khot, and Florian Mueller. 2018. ""You Better Eat to Survive": Exploring Cooperative Eating in Virtual Reality Games." In *TEI 2018 – Proceedings of the 12th International Conference on Tangible, Embedded, and Embodied Interaction*, 398–408. Vol. 2018-Janua. 9781450355681. New York, NY: ACM. https://doi.org/10.1145/3173225.3173238.

Ashok Khot, Rohit, Deborah Lupton, Markéta Dolejšová, and Florian'Floyd' Mueller. 2017. "Future of Food in the Digital Realm." In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, 1342–1345. New York, NY: ACM.

Baumann, Karl, Ben Caldwell, François Bar, and Benjamin Stokes. 2018. "Participatory Design Fiction: Community Storytelling for Speculative Urban Technologies." In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*, 1. New York, NY: ACM.

Benton, Tim G. 2019. "Using Scenario Analyses to Address the Future of Food." *EFSA Journal* 17:e170703. https://doi.org/10.2903/j.efsa.2019.e170703.

Berezina, Katerina, Olena Ciftci, and Cihan Cobanoglu. 2019. "Robots, Artificial Intelligence, and Service Automation in Restaurants." In *Robots, Artificial Intelligence, and Service Automation in Travel, Tourism and Hospitality*. Bingley: Emerald Publishing Limited.

Biggs, Heidi R., Jeffrey Bardzell, and Shaowen Bardzell. 2021. "Watching Myself Watching Birds: Abjection, Ecological

Thinking, and Posthuman Design." In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, 1–16. New York, NY: ACM.

Birt, Linda, Suzanne Scott, Debbie Cavers, Christine Campbell, and Fiona Walter. 2016. "Member Checking: A Tool to Enhance Trustworthiness or Merely a Nod to Validation?" *Qualitative Health Research* 26 (13): 1802–1811. https://doi.org/10.1177/1049732316654870.

Bleecker, Julian. 2022. "Design Fiction: A short Essay on Design, Science, Fact, and Fiction." In *Machine Learning and the City: Applications in Architecture and Urban Design*, edited by Silvio Carta, 561–578. Hoboken, NJ: Wiley.

Blythe, Mark. 2014. "Research through Design Fiction: Narrative in Real and Imaginary Abstracts." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 703–712. New York, NY: ACM.

Börjeson, Lena, Mattias Höjer, Karl-Henrik Dreborg, Tomas Ekvall, and Göran Finnveden. 2006. "Scenario Types and Techniques: Towards a User's Guide." *Futures* 38 (7): 723–739. https://doi.org/10.1016/j.futures.2005.12.002.

Braun, Virginia, and Victoria Clarke. 2012. *Thematic Analysis*. Washington, DC: American Psychological Association.

Bruijnes, Merijn, Gijs Huisman, and Dirk Heylen. 2016. "Tasty Tech: Human-Food Interaction and Multimodal Interfaces." In *Proceedings of the 1st Workshop on Multi-sensorial Approaches to Human-Food Interaction*, 1–6. New York, NY: ACM.

Burton Nitta. 2010. *Algaculture*. https://www.burtonnitta.co.uk/Algaculture.html.

Cheatle, Amy, Hannah Pelikan, Malte Jung, and Steven Jackson. 2019. "Sensing (co) Operations: Articulation and Compensation in the Robotic Operating Room." *Proceedings of the ACM on Human-Computer Interaction* 3 (CSCW): 1–26. https://doi.org/10.1145/3359327.

Cho, Janghee, Laura Devendorf, and Stephen Voida. 2021. "From the Art of Reflection to the Art of Noticing: A Shifting View of Self-Tracking Technologies' Role in Supporting Sustainable Food Practices." In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, 1–7. New York, NY: ACM.

Clarke, Rachel, Sara Heitlinger, Marcus Foth, Carl DiSalvo, Ann Light, and Laura Forlano. 2018. "More-than-Human Urban Futures: Speculative Participatory Design to Avoid Ecocidal Smart Cities." In *Proceedings of the 15th Participatory Design Conference: Short Papers, Situated Actions, Workshops and Tutorial-Volume 2*, 1–4. New York, NY: ACM.

Clarke, Rachel, Sara Heitlinger, Ann Light, Laura Forlano, Marcus Foth, and Carl DiSalvo. 2019. "More-than-Human Participation: Design for Sustainable Smart City Futures." *Interactions* 26 (3): 60–63. https://doi.org/10.1145/3319075.

Coskun, Aykut, Nazli Cila, Iohanna Nicenboim, Christopher Frauenberger, Ron Wakkary, Marc Hassenzahl, Clara Mancini, Elisa Giaccardi, and Laura Forlano. 2022. "More-than-Human Concepts, Methodologies, and Practices in HCI." In *CHI Conference on Human Factors in Computing Systems Extended Abstracts*, 1–5. New York, NY: ACM.

Coulton, Paul, Joseph Lindley, Miriam Sturdee, and Michael Stead. 2017. "Design Fiction as World Building." In *Proceedings of the 3nd Biennial Research Through Design Conference*, 1–16. Edinburgh: Figshare.

Coulton, Paul, and Joseph Galen Lindley. 2019. "More-than Human Centred Design: Considering Other Things." *The Design Journal* 22 (4): 463–481. https://doi.org/10.1080/14606925.2019.1614320.

Crisinel, Anne-Sylvie, Stefan Cosser, Scott King, Russ Jones, James Petrie, and Charles Spence. 2012. "A Bittersweet Symphony: Systematically Modulating the Taste of Food by Changing the Sonic Properties of the Soundtrack Playing in the Background." *Food Quality and Preference* 24 (1): 201–204. https://doi.org/10.1016/j.foodqual.2011.08.009.

Dahlström, Anna. 2019. *Storytelling in Design: Defining, Designing, and Selling Multidevice Products*. Sebastopol, CA: O'Reilly Media.

Datar, Isha, and Mirko Betti. 2010. "Possibilities for an in Vitro Meat Production System." *Innovative Food Science & Emerging Technologies* 11 (1): 13–22. https://doi.org/10.1016/j.ifset.2009.10.007.

Davis, Hilary, Danielle Wilde, Ferran Altarriba Bertran, and Markéta Dolejšová. 2020. "Fantastic (e) Ating Food Futures: Reimagining Human Food Interaction." In *Companion Publication of the 2020 ACM Designing Interactive Systems Conference*, 377–380. New York, NY: ACM.

Deng, Jialin, Yan Wang, Carlos Velasco, Ferran Altarriba Altarriba Bertran, Rob Comber, Marianna Obrist, Katherine Isbister, Charles Spence, and Florian'Floyd' Mueller. 2021. "The Future of Human-Food Interaction." In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, 1–6. New York, NY: ACM.

Dew, Kristin N., and Daniela K. Rosner. 2018. "Lessons from the Woodshop: Cultivating Design with Living Materials." In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–12. New York, NY: ACM.

Dolejšová, Markéta, Ferran Altarriba Bertran, Danielle Wilde, and Hilary Davis. 2019. "Crafting and Tasting Issues in Everyday Human-Food Interactions." In *Companion Publication of the 2019 on Designing Interactive Systems Conference 2019 Companion*, 361–364. New York, NY: ACM.

Dolejšová, Markéta, Rohit Ashok Khot, Hilary Davis, Hasan Shahid Ferdous, and Andrew Quitmeyer. 2018. "Designing Recipes for Digital Food Futures. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–8. New York, NY: ACM.

Dolejšová, Markéta, Danielle Wilde, Ferran Altarriba Bertran, and Hilary Davis. 2020. "Disrupting (More-than-) Human-Food Interaction: Experimental Design, Tangibles and Food-Tech Futures." In *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, 993–1004. New York, NY: ACM.

Dunne, Anthony, and Fiona Raby. 2013. *Speculative Everything: Design, Fiction, and Social Dreaming*. Cambridge, MA: MIT Press.

Eriksson, Eva, Daisy Yoo, Tilde Bekker, and Elisabet M. Nilsson. 2024. "More-than-Human Perspectives in Human-Computer Interaction Research: A Scoping Review." In *Proceedings of the 13th Nordic Conference on Human-Computer Interaction*, 1–18. New York, NY: ACM.

Fritsch, Jonas, Vasiliki Tsaknaki, Karin Ryding, and Stina Hasse Jørgensen. 2023. "'Breathing-with': a Design Tactic for the

More-than-Human." *Human–Computer Interaction* 40 (1-4): 89–103.

Future Rroof. January 2020. *The Restaurant of the Future*. Youtube. https://www.youtube.com/watch?v=TRHqxQK3CX8.

Giaccardi, Elisa. 2020. "Casting Things as Partners in Design: Towards a More-than-Human Design Practice." In *Relating to Things: Design, Technology and the Artificial. Bloomsbury, London*, edited by Heather Wiltse, 99–132. London: Bloomsbury Academic.

Gomez-Corona, Carlos, Olivier Wathelet, and Nicolas Minvielle. 2024. "How to Think about the Future of Food? Speculative Design and Design Fiction Applied to Consumer Research." *Current Opinion in Food Science* 60: 101226. https://doi.org/10.1016/j.cofs.2024.101226.

Gong, Paul. 2025. *Human Hyena*. Accessed January 2025. https://www.paulgong.co.uk/human-hyena.

Grand, Simon, and Martin Wiedmer. 2010. "Design Fiction: A Method Toolbox for Design Research in a Complex World".

Grimes, Andrea, 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. New York, NY: ACM.

Gruen, Dan, Thyra Rauch, Sarah Redpath, and Stefan Ruettinger. 2002. "The Use of Stories in User Experience Design." *International Journal of Human-Computer Interaction* 14 (3–4): 503–534. https://doi.org/10.1080/10447318.2002.9669132.

Hauser, Sabrina, Audrey Desjardins, and Ron Wakkary. 2014. "Sfuture: Envisioning a Sustainable University Campus in 2065." In *Proceedings of the 2014 Companion Publication on Designing Interactive Systems*, 29–32. New York, NY: ACM.

He, Siqian, Jiajie Wu, and Jingyan Qin. 2024. "Exploring Post-Human Futures with Design Fiction among Undergraduate Students: Implications for Future-Oriented Design Education." *The Design Journal* 28 (1): 82–105.

Hebrok, Marie, and Henry Mainsah. 2022. "Skinny as a Bird: Design Fiction as a Vehicle for Reflecting on Food Futures." *Futures* 141:102983. https://doi.org/10.1016/j.futures.2022.102983.

Heitlinger, Sara, Nick Bryan-Kinns, and Rob Comber. 2019. "The Right to the Sustainable Smart City." In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, 1–13. New York, NY: ACM.

Heitlinger, Sara, Rachel Clarke, Adrian K. Clear, Simran Chopra, and Özge Dilaver. 2019. "Co-Creating Smart Sustainable Food Futures with Urban Food Growers." In *Proceedings of the 9th International Conference on Communities & Technologies-Transforming Communities*, 114–120. New York, NY: ACM.

Heitlinger, Sara, Lara Houston, Alex Taylor, and Ruth Catlow. 2021. "Algorithmic Food Justice: Co-Designing More-Than-Human Blockchain Futures for the Food Commons." In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, 1–17. New York, NY: ACM.

Hirose, Masaharu, Karin Iwazaki, Kozue Nojiri, Minato Takeda, Yuta Sugiura, and Masahiko Inami. 2015. "Gravitamine Spice: A System That Changes the Perception of Eating through Virtual Weight Sensation." In *Proceedings of the 6th Augmented Human International Conference*, 33–40. New York, NY: ACM.

Hocquette, Jean-François. 2016. "Is in Vitro Meat the Solution for the Future?" *Meat Science* 120:167–176. https://doi.org/10.1016/j.meatsci.2016.04.036.

HoloLamp. January 2020. *HoloLamp AR Menu*. Youtube. https://www.youtube.com/watch?v=VoCcK6EzA80.

Itenge-Wheeler, Helvi, Essi Kuure, Margot Brereton, and Heike Winschiers-Theophilus. 2016. "Co-Creating an Enabling Reading Environment for and with Namibian Children." In *Proceedings of the 14th Participatory Design Conference: Full Papers-Volume 1*, 131–140. New York, NY: ACM.

Iwata, Hiroo, Hiroaki Yano, Takahiro Uemura, and Tetsuro Moriya. 2004. "Food Simulator: A Haptic Interface for Biting." In *IEEE Virtual Reality 2004*, 51–57. Chicago, IL: IEEE.

Johnson, Brian David. 2011. "Science Fiction Prototyping: Designing the Future with Science Fiction." *Synthesis Lectures on Computer Science* 3 (1): 1–190. https://doi.org/10.1007/978-3-031-01796-4.

Kadomura, Azusa, Reina Nakamori, Koji Tsukada, and Itiro Siio. 2011. "EaTheremin." In *SIGGRAPH Asia 2011 Emerging Technologies*, 1. New York, NY: ACM.

Kadomura, Azusa, Koji Tsukada, and Itiro Siio. 2013. "EducaTableware: Computer-Augmented Tableware to Enhance the Eating Experiences." In *CHI'13 Extended Abstracts on Human Factors in Computing Systems*, 3071–3074. New York, NY: ACM.

Katharina Unger. 2025a. *Fungi Mutarium*. Accessed January 2025. https://katharinaunger.com/fungi-mutarium.

Katharina Unger. 2025b. *Phora*. Accessed January 2025. https://katharinaunger.com/phora.

Kita, Yui, and Jun Rekimoto. 2013. "Spot-Light: Multimodal Projection Mapping on Food." In *International Conference on Human-Computer Interaction*, 652–655. Heidelberg: Springer.

Kuijer, Lenneke, and Elisa Giaccardi. 2018. "Co-Performance: Conceptualizing the Role of Artificial Agency in the Design of Everyday Life." In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–13. New York, NY: ACM.

Lindley, Joseph, and Paul Coulton. 2015. "Back to the Future: 10 Years of Design Fiction." In *Proceedings of the 2015 British HCI Conference*, 210–211. New York, NY: ACM.

Linehan, Conor, Ben J. Kirman, Stuart Reeves, Mark A. Blythe, Theresa Jean Tanenbaum, Audrey Desjardins, and Ron Wakkary. 2014. "Alternate Endings: Using Fiction to Explore Design Futures." In *CHI'14 Extended Abstracts on Human Factors in Computing Systems*, 45–48. New York, NY: ACM.

Liu, Jen, 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. New York, NY: ACM.

Liu, Szu-Yu. 2019. "Designing with, through, and for Human-Nature Interaction." In *Companion Publication of the 2019 on Designing Interactive Systems Conference 2019 Companion*, 101–104. New York, NY: ACM.

Lyle, P., J. H.-J. Choi, and M. Foth. 2014. "Designing for Grassroots Food Production: An Event-Based Urban Agriculture Community." In *Proceedings of the 26th Australian Computer-Human Interaction Conference, OzCHI 2014*. 362–365. New York, NY: ACM. https://doi.org/10.1145/2686612.2686666.

Markussen, Thomas, Eva Knutz, and Tau Lenskjold. 2020. "Design Fiction as a Practice for Researching the Social." *Temes De Disseny* 36:16–39. https://doi.org/10.46467/TdD36.2020.16-39.

Moley Robotics. 2025. *Moley Robotics – A Game-Changing Step into the Future of Cooking at Home and in Restaurants*. Accessed January 2025. https://www.moley.com/b-air-kitchen/.

Narumi, Takuji. 2016. "Multi-Sensorial Virtual Reality and Augmented Human Food Interaction." In *Proceedings of the 1st Workshop on Multi-sensorial Approaches to Human-Food Interaction*, 1–6. New York, NY: ACM.

Nelson, Gerald C., Mark W. Rosegrant, Amanda Palazzo, Ian Gray, Christina Ingersoll, Richard Robertson, Simla Tokgoz, Tingju Zhu, Timothy B. Sulser, and Claudia Ringler. 2010. *Food Security, Farming, and Climate Change to 2050: Scenarios, Results, Policy Options*. Vol. 172. Washington, DC: Intl Food Policy Res Inst.

Ng, Tse Pei, Jung-Joo Lee, and Yiying Wu. 2021. "Unpacking Cultural Perceptions of Future Elder Care through Design Fiction." In *Congress of the International Association of Societies of Design Research*, 1632–1652. Singapore: Springer.

Niijima, Arinobu, and Takefumi Ogawa. 2016. "A Proposal of Virtual Food Texture by Electric Muscle Stimulation." In *2016 IEEE International Conference on Multimedia & Expo Workshops (ICMEW)*, 1–6. Seattle, WA: IEEE.

Nijs, Greg, Giulietta Laki, Rafaella Houlstan, Guillaume Slizewicz, and Thomas Laureyssens. 2020. "Fostering More-than-Human Imaginaries: Introducing DIY Speculative Fabulation in Civic HCI." In *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society*, 1–12. New York, NY: ACM.

Nishizawa, Masahiro, Wanting Jiang, and Katsunori Okajima. 2016. "Projective-AR System for Customizing the Appearance and Taste of Food." In *Proceedings of the 2016 Workshop on Multimodal Virtual and Augmented Reality*, 1–6. New York, NY: ACM.

Okajima, Katsunori, and Charles Spence. 2011. "Effects of Visual Food Texture on Taste Perception." *i-Perception* 2 (8): 966–966. https://doi.org/10.1068/ic966.

Oogjes, Doenja, Miguel Bruns, and Ron Wakkary. 2016. "Lyssna: A Design Fiction to Reframe Food Waste." In *Proceedings of the 2016 ACM Conference Companion Publication on Designing Interactive Systems*, 109–112. New York, NY: ACM.

Pan, Sibo. 2024. "Exploring Design Opportunities for Promoting Healthy Eating at Work".

Pandey, Manisha, Hira Choudhury, Joyce Lau Chui Fern, Alice Teo Kee Kee, Janice Kou, Jane Lee Jia Jing, How Chiu Her, Hong Sin Yong, Hon Chian Ming, and Subrat Kumar Bhattamisra. 2020. "3D Printing for Oral Drug Delivery: A New Tool to Customize Drug Delivery." *Drug Delivery and Translational Research* 10 (4): 986–1001. https://doi.org/10.1007/s13346-020-00737-0.

Patio Interactive. April 2016. *Visualizing the Future of Shopping*. Vimeo. https://vimeo.com/151910417.

Poikolainen Rosén, Anton, Maria Normark, and Mikael Wiberg. 2022. "Towards More-than-Human-Centred Design: Learning from Gardening." *International Journal of Design* 16 (3): 21–36.

Prost, Sebastian, Irina Pavlovskaya, Kahina Meziant, Vasilis Vlachokyriakos, and Clara Crivellaro. 2021. "Contact Zones: Designing for More-than-Human Food Relations." *Proceedings of the ACM on Human-Computer Interaction* 5 (CSCW1): 1–24. https://doi.org/10.1145/3449121.

Raturi, Ankita, Juliet Norton, Bill Tomlinson, Eli Blevis, and Lynn Dombrowski. 2017. "Designing Sustainable Food Systems." In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, 609–616. New York, NY: ACM.

Rezwana, Jeba, and Mary Lou Maher. 2023. "User Perspectives on Ethical Challenges in Human-AI Co-creativity: A Design Fiction Study." In *Proceedings of the 15th Conference on Creativity and Cognition*, 62–74. New York, NY: ACM.

Ringland, Gill, and Peter Préfacier Schwartz. 1998. *Scenario Planning: Managing for the Future*. Chichester: John Wiley & Sons.

Rodgers, Shannon, Kellie Vella, Bernd Ploderer, and Margot Brereton. 2023. "Nature Fictions: Designing for a Sustainable Future through Nature Relations." In *Proceedings of the 2023 ACM Designing Interactive Systems Conference*, 1566–1580. New York, NY: ACM.

Rosenzweig, Cynthia, Joshua Elliott, Delphine Deryng, Alex C. Ruane, Christoph Müller, Almut Arneth, Kenneth J. Boote, Christian Folberth, Michael Glotter, and Nikolay Khabarov. 2014. "Assessing Agricultural Risks of Climate Change in the 21st Century in a Global Gridded Crop Model Intercomparison." *Proceedings of the National Academy of Sciences* 111 (9): 3268–3273. https://doi.org/10.1073/pnas.1222463110.

Rutzerveld, Chloé. 2025. *Edible Growth*. Accessed January 2025. https://www.chloerutzerveld.com/edible-growth.

Silge, Julia, and David Robinson. 2017. *Text Mining with R: A Tidy Approach*. Sebastopol, CA: "O'Reilly Media, Inc".

Smith, Nancy, Shaowen Bardzell, and Jeffrey Bardzell. 2017. "Designing for Cohabitation: Naturecultures, Hybrids, and Decentering the Human in Design." In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 1714–1725. New York, NY: ACM.

Spence, Charles. 2017. *Gastrophysics: The New Science of Eating*. London: Penguin UK.

Springmann, Marco, Daniel Mason-D'Croz, Sherman Robinson, Tara Garnett, H. Charles J. Godfray, Douglas Gollin, Mike Rayner, Paola Ballon, and Peter Scarborough. 2016. "Global and Regional Health Effects of Future Food Production under Climate Change: A Modelling Study." *The Lancet* 387 (10031): 1937–1946. https://doi.org/10.1016/S0140-6736(15)01156-3.

Steinfeld, Henning, Pierre Gerber, Tom D. Wassenaar, Vincent Castel, Mauricio Rosales, Mauricio Rosales, and Cees de Haan. 2006. *Livestock's Long Shadow: Environmental Issues and Options*. Rome: Food & Agriculture Org.

Stemler, Steve. 2000. "An Overview of Content Analysis." *Practical Assessment, Research, and Evaluation* 7 (1).

Sun, Jie, Zhuo Peng, Weibiao Zhou, Jerry Y. H. Fuh, Geok Soon Hong, and Annette Chiu. 2015. "A Review on 3D Printing for Customized Food Fabrication." *Procedia Manufacturing* 1:308–319. https://doi.org/10.1016/j.promfg.2015.09.057.

Tanenbaum, Theresa Jean, Marcel Pufal, and Karen Tanenbaum. 2016. "The Limits of Our Imagination: Design Fiction as a Strategy for Engaging with Dystopian Futures." In *Proceedings of the Second Workshop on Computing within Limits*, 1–9. New York, NY: ACM.

Tarik Celik, Abdullah, Ali Cankat Alan, Gizem Çelebi, and Cigdem Kaya. 2024. "Design (ing) Fiction in the Studio." *International Journal of Technology and Design Education* 34 (4): 1491–1511. https://doi.org/10.1007/s10798-023-09865-3.

Taylor, Jennyfer Lawrence, Alessandro Soro, and Margot Brereton. 2018. "New Literacy Theories for Participatory Design: Lessons from Three Design Cases with Australian Aboriginal Communities." In *Proceedings of the 15th Participatory Design Conference: Full Papers-Volume 1*, 1–13. New York, NY: ACM.

teamLab. 2025. *Immersive Interactive Restaurant*. Accessed January 2025. https://www.teamlab.art/.

Thomas, David R. 2006. "A General Inductive Approach for Analyzing Qualitative Evaluation Data." *American Journal of Evaluation* 27 (2): 237–246. https://doi.org/10.1177/1098214005283748.

Thrun, Sebastian. 2004. "Toward a Framework for Human-Robot Interaction." *Human–Computer Interaction* 19 (1–2): 9–24. https://doi.org/10.1207/s15327051hci1901&2_2.

Tsekleves, Emmanouil, Andy Darby, Anna Whicher, and Piotr Swiatek. 2017. "Co-Designing Design Fictions: A New Approach for Debating and Priming Future Healthcare Technologies and Services." *Archives of Design Research* 30 (2): 5–21. https://doi.org/10.15187/adr.2017.05.30.2.5.

Tsutsui, Yuhei, Koichi Hirota, Takuya Nojima, and Yasushi Ikei. 2016. "High-Resolution Tactile Display for Lips." In *International Conference on Human Interface and the Management of Information*, 357–366. Cham: Springer.

Välk, Sander, Chitipat Thabsuwan, and Céline Mougenot. 2023. "The Ideation Compass: Supporting Interdisciplinary Creative Dialogues with Real Time Visualization." *International Journal of Design Creativity and Innovation* 11 (2): 99–116. https://doi.org/10.1080/21650349.2022.2142674.

van Beek, Evert, Elisa Giaccardi, Stella Boess, and Alessandro Bozzon. 2025. "The Everyday Enactment of Interfaces: A Study of Crises and Conflicts in the More-than-Human Home." *Human–Computer Interaction* 40 (1-4): 221–248.

van Mensvoort, K. M., and Hendrik-Jan Grievink. 2014. *The in Vitro Meat Cookbook*. Amsterdam: Bis Publishers.

Van Notten, Philip W. F., Jan Rotmans, Marjolein B. A. Van Asselt, and Dale S. Rothman. 2003. "An Updated Scenario Typology." *Futures* 35 (5): 423–443. https://doi.org/10.1016/S0016-3287(02)00090-3.

Velasco, Carlos, Marianna Obrist, Olivia Petit, and Charles Spence. 2018. "Multisensory Technology for Flavor Augmentation: A Mini Review." *Frontiers in Psychology* 9: 26–26. https://doi.org/10.3389/fpsyg.2018.00026.

Vi, Chi Thanh, Asier Marzo, Damien Ablart, Gianluca Memoli, Sriram Subramanian, Bruce Drinkwater, and Marianna Obrist. 2017. "Tastyfloats: A Contactless Food Delivery System." In *Proceedings of the 2017 ACM International Conference on Interactive Surfaces and Spaces*, 161–170. New York, NY: ACM.

Vithani, Kapilkumar, Alvaro Goyanes, Vincent Jannin, Abdul W. Basit, Simon Gaisford, and Ben J. Boyd. 2019. "An Overview of 3D Printing Technologies for Soft Materials and Potential Opportunities for Lipid-Based Drug Delivery Systems." *Pharmaceutical Research* 36 (1): 1–20. https://doi.org/10.1007/s11095-018-2531-1.

Wakkary, Ron, Audrey Desjardins, Sabrina Hauser, and Leah Maestri. 2013. "A Sustainable Design Fiction: Green Practices." *ACM Transactions on Computer-Human Interaction (TOCHI)* 20 (4): 1–34. https://doi.org/10.1145/2494265.

Wang, Wen, 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. New York, NY: ACM.

Wang, Yan, Zhuying Li, Robert Jarvis, Rohit Ashok Khot, and Florian'Floyd' Mueller. 2018. "The Singing Carrot: Designing Playful Experiences with Food Sounds." In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*, 669–676. New York, NY: ACM.

Wang, Yan, Zhuying Li, Robert S. Jarvis, Joseph La Delfa, Rohit Ashok Khot, and Florian Floyd Mueller. 2020. "WeScream! Toward Understanding the Design of Playful Social Gustosonic Experiences with Ice Cream." In *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, 951–963. New York, NY: ACM.

Wathelet, Olivier, and Nicolas Minvielle. 2023. "Studying Future Food Scenarios with Design Fiction." In *Consumer Research Methods in Food Science*, 449–466. Humana, New York, NY: Springer.

Wilkie, Alex, and Mike Michael. 2025. "The Aesthetics of More-than-Human Design: Speculative Energy Briefs for the Chthulucene." *Human–Computer Interaction* 40 (1-4): 104–116.

Woods, Andrew T., E. Poliakoff, D. M. Lloyd, J. Kuenzel, R. Hodson, H. Gonda, J. Batchelor, Garmt B. Dijksterhuis, and A. Thomas. 2011. "Effect of Background Noise on Food Perception." *Food Quality and Preference* 22 (1): 42–47. https://doi.org/10.1016/j.foodqual.2010.07.003.

Wu, Yiying, Sibo Pan, and Yunye Yu. 2024. "The Metaphorical Capacity of Future-Food: Enhancing Design's Role in Public Engagement with Emerging Technologies." *The Design Journal* 28 (1): 146–164.

Yan, Kimberly S., and Robin Dando. 2015. "A Crossmodal Role for Audition in Taste Perception." *Journal of Experimental Psychology: Human Perception and Performance* 41 (3): 590–590.

Yang, Fan, Min Zhang, and Bhesh Bhandari. 2017. "Recent Development in 3D Food Printing." *Critical Reviews in Food Science and Nutrition* 57 (14): 3145–3153. https://doi.org/10.1080/10408398.2015.1094732.

Yanlıç, Berre Su, and Aykut Coşkun. 2024. "Designing Harvesting Tools for Olive Trees: Methodological Reflections on Exploring and Incorporating Plant

Perspectives in the Early Stages of Design Process." *The Design Journal* 27 (6): 1165–1187. https://doi.org/10.1080/14606925.2024.2397207.

Zampini, Massimiliano, and Charles Spence. 2004. "The Role of Auditory Cues in Modulating the Perceived Crispness and Staleness of Potato Chips." *Journal of Sensory Studies* 19 (5): 347–363. https://doi.org/10.1111/jss.2004.19.issue-5.

Zhu, Dong Hong, and Ya Ping Chang. 2020. "Robot with Humanoid Hands Cooks Food Better? Effect of Robotic Chef Anthropomorphism on Food Quality Prediction." *International Journal of Contemporary Hospitality Management* 32 (3): 1367–1383.

Zoran, Amit, and Marcelo Coelho. 2011. "Cornucopia: The Concept of Digital Gastronomy." *Leonardo* 44 (5): 425–431. https://doi.org/10.1162/LEON_a_00243.