



Recipes for Sustainability

Understanding Social and Material Impacts of
Public and Private Food Practices

Dissertation

zur Erlangung des Doktorgrades
an der Fakultät für Geowissenschaften
der Ludwig-Maximilians-Universität München

Vorgelegt von

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München, den 12. November 2020

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Tag der mündlichen Prüfung: 31. Mai 2021

Acknowledgments

I would like to express my sincere gratitude to Prof. Dr. Henrike Rau for her generous support, open-mindedness, lightheartedness, and for always challenging the status quo. I have never met a supervisor who so effortlessly combines academic guidance with personal warmth. Thank you also to my second reviewer Prof. Dr. Matthias Garschagen for taking the time to review this dissertation.

I would like to thank my collaborator Yuki Asano, not only for his brilliance in research but also for having become one of my most trusted allies over our years of friendship.

Thank you to Prof. Dr. Coye Cheshire for hosting me during my research stay at the University of California, Berkeley and to Prof. Dr. William Orsi and the LMU Mentoring Program of the Faculty of Geoscience for making my stay abroad possible.

To my colleagues at the Center for Digital Technology and Management (CDTM) – thank you for four years full of late-night discussions, challenging and supporting each other at table football and beyond, and for making the CDTM a home for everyone’s ideas. Special thanks to my office roommates for laughing together way more than what could technically fit into a productive workday. Thank you also to the CDTM board of directors for believing in the institution and supporting it for over 20 years.

To my good friends, most thorough proof-readers, and general lifelines: Felix Krauth, Florian Fincke, Pauline Heusterberg, Tim Hermes, and Ronja Wolf. Your words of encouragement and critical questions helped me revise more than one way too long sentence. Being able to count on you all in any situation is such a gift. For this, I am very grateful.

I would also like to thank Thomas Schreiber for dragging me out of the city and showing me the nature we are trying to protect. Without you, I never would have climbed so many mountaintops or learned so much about strange insects.

I am eternally grateful to my family for their manifold support throughout my studies, allowing me to write this dissertation in the first place. Special thanks go to my brother Linus Biermann for putting up with and technically prototyping my constantly changing ideas of how to best track food consumption.

Finally, I want to reflect on the impact my dissertation has had on the environment. While the larger influence my writing may have is unknown to me at this point, I wanted to offset the emissions directly related to the creation of this dissertation. The largest part is travel related: 5 train rides and 3 flights within the EU and 1 flight to the US – a total of 6.7 tons of CO₂ or more than twice the annual per capita budget of about 2.7 tons to stay within 2°C of warming (Messner et al., 2010). I offset the emissions by supporting a project in India that replaces fossil fuels with power generated from mustard crop residues and a project that restores peatland in the north of Germany. While the emissions reduction of the first project is already complete, it will take 45 more years until the CO₂ I offset is fully sequestered in the peatland. I will be 75 years old by then – a good point in time to check in again on the impact of this research.

Abstract

Dietary practices play a key role in the transition towards a more sustainable food system. Livestock in particular drives environmental impacts such as greenhouse gas emissions, deforestation, and water use. While it is clear that curbing meat demand is vital for life within planetary boundaries, pathways to change remain contested. Contemporary food policy often focuses on guiding individual food choices through education and information, without much success at a societal scale. The sociology of consumption offers an alternative lens that focuses on socially and materially embedded *practices* beyond the individual. However, recent research lacks an analysis of large-scale changes over time as well as a comparison of the footprint of food practices in different social settings. A feminist view can further address neglected links between gender equality, sustainable diets, and domestic foodwork.

Based in human geography, this dissertation uses a mixed-methods research design to address these gaps and expand beyond traditional qualitative methods of praxeographic research. Large-scale dietary transitions were studied through secondary analysis of a popular online recipe platform, including over 243,000 recipes with 2.5 million user ratings. An online survey with 420 participants contrasted food consumption at home and out of home, while qualitative interviews helped interpret quantitative results and shed light on underlying meanings.

An extensive trend analysis showed a growing interest in and transition to meat-free diets over the past decade. However, extrapolating these trends revealed that the rate of change would not suffice for diets to arrive within planetary boundaries by 2030. Further, sustainable diets do not translate across all sites and social occasions. Eating at a restaurant is more meat-focused than eating at home. Even flexitarians increased their meat consumption when eating out. Eating out and eating meat are both perceived as ‘special’ and ‘treating oneself.’ These related meanings may link eating out to a higher environmental footprint. Even though less meat was eaten at home than at a restaurant, the effect of social eating also permeated the domestic sphere: cooking for guests or even the own household involved more meat than cooking for oneself. A gender perspective further revealed stark differences between omnivorous men and women. Women were largely responsible for foodwork, more skilled at cooking, and consumed fewer animal products. These gender differences were not found for people who adopt a meat-less diet. This part of the analysis thus revealed the significance of meat-less diets as a connector between environmental sustainability and gender equality.

The most significant contribution of this dissertation is to emphasize the importance of taking intersecting issues of sustainability – human health, environmental sustainability, and gender equality – into account when studying food practices. Internalizing ecosystem services and social reproduction in current policy is essential for a future beyond an ecological crisis and gender injustice. Socially shared and gendered meanings of appropriate diets can be a significant barrier for sustainable food practices. Therefore, a key challenge will be to frame plant-focused dishes as reflections of ‘the good life,’ appropriate for both eating in and out. Delinking the meat-masculinity as well as the foodwork-femininity nexus may help to promote a bundle of just and environmentally safe food practices for all. A practice-theoretical lens helps bring this interlinkage of sustainable diets, foodwork, and gender to light.

Zusammenfassung

Menschliche Ernährungsgewohnheiten spielen eine zentrale Rolle für die Transformation hin zu einem nachhaltigen Ernährungssystem. Besonders die Nutztierhaltung belastet dabei die Umwelt in hohem Maße, unter anderem durch den Ausstoß von Treibhausgasen, Waldrodungen und einen hohen Wasserverbrauch. Daher scheint ein Rückgang der Nachfrage nach Fleisch für ein Leben innerhalb der ökologischen Grenzen der Erde unerlässlich. Wie dies erreicht werden kann ist jedoch umstritten. Politische Maßnahmen zielen aktuell häufig darauf ab, durch Bildung und Informationsbereitstellung individuelle Ernährungsentscheidungen zu beeinflussen. Die so erhofften Verhaltensänderungen auf gesellschaftlicher Ebene sind jedoch bisher weitestgehend ausgelassen. Eine alternative Perspektive auf die Mechanismen, die Konsumententscheidungen zugrunde liegen, bietet die sozialwissenschaftliche Konsumforschung. Statt individueller Handlungen untersucht sie sozial und materiell situierte *Praktiken* wie beispielsweise auswärts essen oder Gäste bewirten. Bisher wenig Beachtung in praxistheoretischer Forschung fanden allerdings Langzeitstudien zu Veränderungen von Ernährungspraktiken. Zudem fehlen direkte Vergleiche der Ernährungspraktiken in verschiedenen sozialen Situationen, z.B. zu Hause oder auswärts essen, sowie der jeweils zugehörige ökologische Fußabdruck. Durch die Einbeziehung einer feministischen Forschungsperspektive können außerdem Verknüpfungen zwischen Geschlechterrollen, nachhaltiger Ernährung und häuslicher Arbeitsteilung deutlich gemacht werden, die in der bisherigen Forschung vernachlässigt wurden.

Zur Untersuchung der genannten Forschungslücken nutzt die vorliegende Dissertation einen ‚mixed-methods‘ Ansatz und geht damit über die traditionell qualitativen Methoden der praxistheoretischen Forschung hinaus. Mithilfe einer Sekundäranalyse der Nutzungsdaten einer populären Online-Rezeptplattform wurden Trends bezogen auf Ernährungspraktiken untersucht. Dafür wurden über 243.000 Rezepte mit 2,5 Millionen Bewertungen von Nutzer*innen ausgewertet. Um Ernährungspraktiken zu Hause und außer Haus zu kontrastieren, wurde eine Online-Umfrage mit 420 Teilnehmer*innen durchgeführt. Zur Vertiefung und kontextuellen Einbettung der quantitativen Ergebnisse wurden außerdem qualitative Interviews geführt.

Die Analyse der Nutzungsdaten der Rezeptplattform zeigt ein wachsendes kollektives Interesse an und eine steigende Zahl von individuellen Übergängen zu einer fleischlosen Ernährung während des letzten Jahrzehnts. Überträgt man diese Trends auf die Gesamtbevölkerung der Bundesrepublik Deutschland zeigt sich jedoch, dass die aktuelle Veränderungsrate nicht ausreicht, damit Deutschland bis 2030 seinen ökologischen Fußabdruck so reduziert, dass die Ernährungsgewohnheiten der Bevölkerung innerhalb der ökologischen Grenzen bleiben. Außerdem wird deutlich, dass sich nachhaltige Ernährungspraktiken nicht ohne weiteres auf verschiedene sozio-materielle Arrangements und soziale Anlässe übertragen lassen. So wird laut Umfrageergebnissen beispielsweise bei einem Restaurantbesuch eher Fleisch gegessen als zu Hause. Selbst Flexitarier*innen erhöhen ihren Fleischkonsum wenn sie auswärts essen. Dabei wird sowohl ‚Essen gehen‘ als auch ‚Fleisch essen‘ als etwas Besonderes empfunden. Die Assoziation von Fleischkonsum mit ‚sich etwas gönnen‘ verbindet dadurch das Auswärtsessen

mit einem erhöhten Ressourcenverbrauch. Dies beschränkt sich jedoch nicht auf Restaurantbesuche. Die Verknüpfung zwischen sozialem Anlass und Fleisch dringt auch in den häuslichen Bereich vor: Beim Kochen für Haushaltsmitglieder oder Gäste wird mehr Fleisch zubereitet als wenn für sich selbst gekocht wird. Betrachtet man außerdem die Arbeitsteilung zwischen den Geschlechtern, treten deutliche Unterschiede zwischen omnivoren Männern und Frauen zutage: Frauen die Fleisch essen sind häufiger für die Ernährung zu Hause zuständig, weisen höhere Kochfertigkeiten auf und konsumieren weniger tierische Produkte als männliche Fleischesser. Bei Männern und Frauen die sich fleischlos ernähren konnte keiner dieser skizzierten geschlechtsspezifischen Unterschiede festgestellt werden. Diese Ergebnisse unterstreichen die Bedeutung fleischloser Ernährungspraktiken als eine mögliche Brücke zwischen ökologischer Nachhaltigkeit und Gleichstellung der Geschlechter.

Der wichtigste Beitrag dieser humangeographischen Forschungsarbeit besteht darin, die enge Verzahnung unterschiedlicher Nachhaltigkeitsziele – menschliche Gesundheit, ökologische Nachhaltigkeit und Geschlechtergleichstellung – in Bezug auf Ernährungspraktiken aufzuzeigen. Die Berücksichtigung von Ökosystemleistungen und unbezahlter Reproduktionsarbeit in politischen Zielsetzungen ist unerlässlich für eine Zukunft jenseits einer ökologischen Krise und Geschlechterungleichheiten. Gesellschaftlich verankerte und geschlechtsspezifische Bedeutungen können ein signifikantes Hindernis für eine nachhaltige Ernährung darstellen. Eine zentrale Herausforderung besteht darin, eine vorwiegend pflanzliche Ernährung in Einklang mit der sozial verankerten Vorstellung eines ‚guten Lebens‘ zu bringen, so dass diese für verschiedene Anlässe gleichermaßen geeignet scheint. Die Entkoppelung von Fleisch und Männlichkeit sowie von Kochen und Weiblichkeit kann dabei den Zugang zu gerechteren und umweltfreundlicheren Ernährungspraktiken ermöglichen. Eine praxistheoretische Sichtweise macht den Zusammenhang zwischen nachhaltiger Ernährung, Essenszubereitung und Geschlechterrollen dabei explizit.

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List of abbreviations

BMEL	German Federal Ministry of Food and Agriculture
CO ₂	Carbon dioxide
DGE	German Nutrition Society
EIGE	European Institute for Gender Equality
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse gas
GTAI	Germany Trade and Invest
LCA	Life Cycle Assessment
OECD	Organisation for Economic Co-operation and Development
ppm	Parts-per-million
SDG	Sustainable Development Goal

List of publications

Asano*, Y. M., & Biermann*, G. (2019). Rising adoption and retention of meat-free diets in online recipe data. *Nature Sustainability*, 2(7), 621–627. <https://doi.org/10.1038/s41893-019-0316-0> *authors contributed equally, listed alphabetically

Biermann, G., & Rau, H. (2020). The meaning of meat: (Un)sustainable eating practices at home and out of home. *Appetite*, 153. <https://doi.org/10.1016/j.appet.2020.104730>

Biermann, G. (2020). Gender differences in household food practices: The role of sustainable diets. *Manuscript submitted for publication*.

1 INTRODUCTION

“Human activities have become so pervasive and profound that they rival the great forces of Nature and are pushing the Earth into planetary terra incognita.”

– Steffen et al. (2007) p. 614

1.1 Human nutrition: Current and future sustainability challenges

Human activity is the primary driver of environmental change in our current era, termed the *Anthropocene* (Crutzen, 2002; Lewis and Maslin, 2015). Moving outside of the stable environmental state of the past 11,700 years – the *Holocene* – could have detrimental consequences for humanity’s survival on this planet (Steffen et al., 2015). The concept of ‘planetary boundaries’ aims to quantify biophysical thresholds for a ‘safe operating space,’ within which humanity can live without significant disturbance to the Earth system (Rockström et al., 2009). Of the nine planetary boundaries, four have already surpassed the safe zone. Genetic diversity, nitrogen and phosphorus cycles, atmospheric CO₂ concentration¹, and forest cover are at increasing or even high risk of regime shifts (Steffen et al., 2015). The food system heavily impacts all of these boundary indicators. Agriculture and food production

¹ At the time of writing an atmospheric CO₂ concentration of 411 parts-per-million (ppm) was recorded for September 2020 (<https://co2.earth>). The ‘zone of uncertainty’ (beyond the safe zone) is defined as 350-450 ppm CO₂, beyond which a much higher probability of significant changes to Earth’s processes is expected (Steffen et al., 2015).

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contribute over 25% of global greenhouse gas emissions (GHGs) (Clark and Tilman, 2017; Tilman and Clark, 2014; Vermeulen et al., 2012). Livestock, in particular, is a key issue. Animal husbandry makes up an estimated 15% of anthropogenic GHG emissions globally and 44% of total methane emissions (Gerber et al., 2013). Land-use changes required for animal feed and pasture land make livestock responsible for 70% of global deforestation and 30% of biodiversity loss (Stoll-Kleemann and Schmidt, 2017; Westhoek et al., 2011). Nemecek et al. (2016) further point out the efficiency losses of animals raised for human consumption: “Raising and feeding animals introduces an additional trophic level in the food chain, and each trophic level leads to losses of energy and nutrients, thus reducing the efficiency of the production” (p. 610). The central role of ruminant meat cannot be emphasized enough: for all examined environmental indicators², a meta-analysis of over 700 Life Cycle Assessment (LCA) studies found ruminant meats to be between 3-10 times more impactful than other animal products and even 20-100 times more impactful than plant-based foods (Clark and Tilman, 2017).

Livestock is not only an environmental issue. High red and processed meat consumption are associated with increased risks of colorectal cancer, heart disease, and type 2 diabetes (Godfray et al., 2018; Stubbs et al., 2018). This makes meat consumption a central factor in what Tilman and Clark (2014) termed the ‘diet-environment-health trilemma.’ Population growth and trends towards ‘Western diets’ (high in calories and animal protein), driven by rising incomes, increasing urbanization, and cultural changes, are further likely to escalate this nexus of issues (Popkin, 2006; Sans and Combris, 2015; Tilman and Clark, 2014). Economic interests in the agricultural sector more generally, and the meat industry in particular, further contribute to the growing popularity of meat- and CO₂-intensive diets (Wellesley et al., 2015). Daily meat consumption has increased sharply, from 61 g per capita in 1961 to 80 g in 2011 (Sans and Combris, 2015). Current levels of per capita meat consumption in the EU (65 kg p.a.) are nearly twice as high as the world average (35 kg p.a.; OECD and FAO, 2020). While meat consumption may have plateaued in developed countries, it is projected to increase further, especially due to shifts in consumption among members of the growing middle class of emerging economies (Stubbs et al., 2018; Vermeulen et al., 2020). Demand for animal-based products is expected to rise by close to 80% between 2006 and 2050, with demand for beef likely to increase even more dramatically, by 95% (Ranganathan et al., 2016). These developments amplify the impending ‘food gap,’ between the crop calories available in 2006 and the demand expected for 2050, estimated at 70% (Ranganathan et al., 2016). Not only the anticipated environmental pressures of livestock are highly problematic, current levels already present an urgent need for large-scale changes to the food system. The rapidly changing biophysical conditions of the planet due to human-induced climate change further add recursive uncertainty to future food security (Myers et al., 2017; Wheeler and von Braun, 2013).

² The study took into account GHG emissions, land use, energy use, acidification potential, and eutrophication potential.

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Much research tackles issues of food system sustainability from a production perspective. Measures, such as adapting breeding and feeding to reduce methane emissions from enteric fermentation, improving animal and crop productivity, or optimizing fertilizer application can reduce GHG emissions (Xue et al., 2019). However, efficiency gains in agricultural production will likely be insufficient to keep a rise in global temperatures below 2°C compared to pre-industrial levels (Bajželj et al., 2014). Significant changes to demand-side food consumption will likely be necessary to reach climate targets. According to Bryngelsson et al. (2016), “Large reductions, by 50% or more, in ruminant meat (beef and mutton) consumption are, most likely, unavoidable if the EU targets are to be met” (p. 152). While the need for change in food consumption habits becomes clear, the quest for *sustainable* diets and their implications for everyday food practices remains a work in progress.

1.1.1 Healthy food within planetary boundaries: Defining sustainable diets

Hans Carl von Carlowitz is credited with the first formulation of the concept of ‘sustainability,’ as it is understood today. In his work *Sylvicultura Oeconomica*, published in 1713, he devises a ‘sustainable’ yield to allow for long-term harvesting of wood without depletion of the forest (von Carlowitz, 2013). Since von Carlowitz’ times, the concept of sustainability – or rather, sustainable development – has gained extensive public awareness through its definition in the report “Our Common Future” (also known as the Brundtland report) of the UN World Commission on Environment and Development (Brundtland, 1987). Within the report, sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” Sustainability is often also defined as a three dimensional concept consisting of environmental, social, and economic aspects (the “triple bottom line,” see Elkington, 1997). While the three dimensions are often visualized using an overlapping Venn diagram, where the center suggests win-win-win strategies, other authors have been critical of the effortless compatibility of the three dimensions. Campbell (1996), for example, argues against a vague and ‘romanticized’ view of sustainability in the context of urban planning (p. 297). Rather than overlapping, he draws up the three dimensions of sustainability as corners of a triangle, pointing to potential friction that can arise between the goals, such as a resource conflict between environmental protection and economic growth.

To date, what constitutes a sustainable food system remains a lively debate in the scientific community. Rather than a uniform definition, different narratives prioritize singular dimensions of sustainability (Béné et al., 2019). The word ‘sustainability’ may be defined to include the ‘triple pillars’ of environment, economy, and society, be more narrowly understood in terms of environmental impact or, more narrowly still, focus on a particular environmental goal, such as GHG emissions (Garnett, 2014). The FAO (2012), in their definition of sustainable diets, expands beyond the three pillars of sustainability, but remains vague, without any specific metrics or nutritional guidelines:

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Sustainable Diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources. (p. 7)

While it is hard to disagree with this broad definition, it leaves much to be more expressly defined. LCA studies help to quantify at least the environmental dimension of sustainability. Studies generally agree that foods of animal origin, in particular meat, have higher environmental impacts than foods of plant origin (e.g., Nemecek et al., 2016), resulting in lower impacts for vegan and vegetarian than omnivorous diets. However, their effectiveness depends on the environmental performance of the substitute for meat (Hallström et al., 2015; see Box 1 for a discussion of meat substitutes). For example, Rosi et al. (2017) found considerable inter-individual variability within diets and high footprints for fruitarian vegans. Béné et al. (2019) advocate for the consideration of trade-offs between sustainability dimensions, challenging the notion of ‘win-win-win’ solutions. Such trade-offs may occur between nutrition and environmental indicators; as Perignon et al. (2017) found: “[...] in contradiction with the widely accepted view that healthy diets are also good for the environment, when nutritional quality was assessed, it was not necessarily convergent with the environmental dimension” (p. 14). Further conflicts may arise due to restrictions in disposable income or cultural considerations. The difficulty of dealing with trade-offs and problem shifting is also reflected in siloed public policy, where agricultural subsidies are often separate from nutritional and environmental considerations (Vermeulen et al., 2020). National nutritional guidelines, in some instances, do take both environmental and health impacts into account. However, recent studies have shown that while adhering to these guidelines is an improvement for most populations (Scherer et al., 2019), they are not ambitious enough to reach climate targets (Ritchie et al., 2018; Springmann et al., 2020).

Box 1. The role of meat substitutes

Ranganathan et al. (2016) see ‘minimizing disruption’ (p. 53) of existing food habits as a promising route to effect change. According to this strategy, instead of eliminating meat and changing to a potentially starkly different plant-based diet, meat replacement products could take the place of meat, but with lower environmental impacts. Meat replacement can occur in two ways: “[...] either the ‘meat’ is constructed from manipulating plant or fungal material, or it is grown in the lab from animal stem cells” (Ranganathan et al., 2016, p. 54). Lab-grown meat, where stem cells are extracted from animals and grown in lab conditions, is also known as in-vitro, cell-based, clean, or cultured meat. In order to be a viable pathway towards a more sustainable food system, meat replacement products have to be advantageous in different dimensions of sustainability – environmental, health, economic as well as social impacts – and be culturally acceptable.

An LCA study compared the environmental sustainability of chicken, lab-grown meat, dairy-, gluten- (e.g., seitan), insect-, mycoprotein- (e.g., *Quorn*), and soy meal-based (e.g., tofu, tempeh) products (Smetana et al., 2015). The authors concluded that soy meal and insect substitutes had

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the lowest impacts. Lab-grown meat and mycoprotein-based substitutes had the highest impacts. These results show the importance of differentiating between types of meat replacement products in their effectiveness to reduce the environmental impact of food. Insect-based food, while potentially viable from an environmental perspective, has been found to lack consumer acceptance, especially in Western cultural contexts (Hartmann and Siegrist, 2017).

Replicating the experience of eating meat includes taste, texture, look, packaging, in-store positioning, and messaging. The brand *The Vegetarian Butcher*, for example, explicitly focuses on replicating the ‘meat experience’ with mostly soy-based products. The founder, Jaap Korteweg, explicitly identifies as a ‘meat lover’ and is currently applying for admission to the German Butchers’ Association^a. Regarding its nutritional profile, soy contains high amounts of protein (Parodi et al., 2018) and is recommended at levels of 25 g per day in the EAT-Lancet reference diet (Willett et al., 2019). Emphasizing the *replacement* of products of animal origin with plant-based sources is vital to avoid introducing *additional* consumption next to animal products. Soy-based meat replacement products could pose an interesting pathway to more sustainable eating practices, especially for heavy meat-eaters.

Notes:

^a <https://vegconomist.com/companies-and-portraits/the-vegetarian-butcher-applies-to-german-meat-associations-to-help-shape-future-of-meat-industry/> (accessed 10 Sept 2020)

The report of the EAT-Lancet commission can be seen as one of the most prominent recent attempts to define a sustainable diet more specifically. Their ‘planetary-health’ diet is a flexitarian diet low in animal-based foods and high in plant-based foods. It “[...] largely consists of vegetables, fruits, whole grains, legumes, nuts, and unsaturated oils, includes a low to moderate amount of seafood and poultry, and includes no or a low quantity of red meat, processed meat, added sugar, refined grains, and starchy vegetables” (Willett et al., 2019, p. 447). The authors have further specified sustainable levels of meat consumption as no more than 98 g of pork, beef, or lamb, 203 g of poultry, and 196 g of fish per week. While the diet is proposed as: “[...] universal for all food cultures and production systems in the world,” (p. 447) the authors see a large potential for local adaptation, acknowledging that “[...] local and regional realities need to be carefully considered” (p. 456).

The EAT-Lancet diet outperforms many national nutritional guidelines in terms of health and environmental performance (Springmann et al., 2020). However, the *universal* applicability of such a diet has been questioned. Previous research revealed healthy diets to be more expensive than unhealthy diets (Perignon et al., 2017). Even the most inexpensive version of the EAT-Lancet diet is not affordable for the world’s poor, surpassing household incomes for approximately 1.6 billion people (Hirvonen et al., 2020). Accordingly, Béné et al. (2019) challenge the notion and usefulness of a *global* food system, arguing for “[...] a need to acknowledge more explicitly the local-specific nature of food systems” (p. 127) due to differences in culture and identities formed around food. Country-specific analyses may therefore be better suited to account for the importance of trade, income levels, and culture in diets.

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Germany poses a relevant case, as current dietary patterns are far from meeting sustainability targets. At 1.2 kg per week, meat consumption in Germany is currently twice as high as recommendations by the German Nutrition Society (BMEL, 2017; DGE, 2018). In order to be in line with the EAT-Lancet reference diet, the current level of German meat consumption (excluding fish) would have to be reduced by 74%. In a study modeling diets for 140 countries, vegan diets resulted in the lowest per capita GHG footprint in Germany, closely followed by low food chain diets³ (Kim et al., 2020). Two-thirds vegan⁴, no red meat, vegetarian, and low red meat diets also performed better than current dietary patterns. Eating meat is further deeply embedded in German culture, especially as a part of social events, such as barbecuing (Weinrich, 2018). Germany is also one of the largest producers of meat in the EU; meat products make up the largest ratio (24%) of the food industry's total production value in Germany (GTAI, 2018). Béné et al. (2019) stress the lack of a systematic relationship between 'cultural acceptability' and sustainability, noting that "[...] a food system that provides culturally acceptable food may not be sustainable" (p. 128). This appears to also be the case in Germany. As the previous statistics illustrate, the high cultural and economic relevance of meat in Germany is in conflict with human health and environmental targets. As the largest of the EU-27 countries by population (Eurostat, 2020), however, Germany plays a key role in large-scale dietary change.

The dietary practices of households are inextricably linked not only with health, environmental, economic, and cultural dimensions. Social equality, especially in relation to gender, is also central to food system sustainability (Esterik, 1999). Essentially, food consumption requires work, such as planning meals, shopping for ingredients, and cooking. If demand-side changes are essential, the question of *who* puts in the time needed for meal planning, food shopping, and cooking is far from trivial. Will sustainable diets reduce or exacerbate existing domestic gender discrepancies?

1.1.2 Socially sustainable food consumption: Gender equitable foodwork

Germany shows distinct gender patterns in sustainable eating: While overall the number of people following plant-focused diets is slowly increasing, in July 2020, 71% of vegetarians in Germany were women, while only 29% were men (IfD Allensbach, 2020). A study by Meier and Christen (2013) further found the reduction potential in GHG and ammonia emissions as well as land, phosphorus, and primary energy use to be twice as high for German men as for women based on average diets in 2006. Next to these diverging environmental pressures, food consumption links to gender inequalities in labor market participation. Even though women's

³ For the low food chain diet, insect-based protein replaced 10% of protein from terrestrial animals, while protein from aquatic animals was replaced with 70% forage fish and 30% bivalve mollusks.

⁴ The two-thirds vegan diet assumes a vegan diet for two out of three meals per day and uses an average consumption scenario without restrictions for the third meal.

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labor market participation has increased sharply, they are still more often responsible for domestic care work. This has led to women taking on a ‘second shift’ (Hochschild, 1989) of childcare, housework, and food provisioning after returning home from paid work. In Germany, women continue to be responsible for the bulk of unpaid care work, with 72% of women cooking or doing housework daily, and only 29% of men doing the same (EIGE, 2019). The current coronavirus pandemic exacerbates this gap: “While women were already doing most of the world’s unpaid care work prior to the onset of the COVID-19 pandemic, emerging research suggests that the crisis and its subsequent shutdown response have resulted in a dramatic increase in this burden. It is likely that the negative impacts for women and families will last for years without proactive interventions” (Power, 2020, p. 67). In particular, the ‘fourth shift’⁵ of homeschooling while working could disadvantage women far into the future, affecting their lifetime income and pension payments (Power, 2020).

The planetary boundaries framework was expanded by Kate Raworth (2012) to also include social boundaries (see Figure 1). Within this framework, the environmental ceiling is complemented by a ‘social foundation’ to create an ecologically safe *and* socially just space for humanity (Dearing et al., 2014). The framework “[...] visualizes sustainability in terms of a doughnut-shaped space where resource use is high enough to meet people’s basic needs (the inner boundary), but not so high as to transgress planetary boundaries (the outer boundary)” (D. W. O’Neill et al., 2018, p. 88). O’Neill et al. (2018) quantified this relationship for 150 countries, mapping the resources required for basic human needs against planetary boundaries. They found that “[...] no country meets basic needs for its citizens at a globally sustainable level of resource use” (p. 88). While basic physical needs (sanitation, nutrition, electricity⁶) could be met, a ‘high life satisfaction’ for all would require between 2-6 times the resources considered sustainable. They conclude: “If all people are to lead a good life within planetary boundaries, then our results suggest that provisioning systems must be fundamentally restructured to enable basic needs to be met at a much lower level of resource use” (p. 92). While Germany meets all 11 social thresholds, it surpasses all but two planetary boundaries: land-use change and blue water use⁷. Boundaries for CO₂, nitrogen, and phosphorus are transgressed most heavily, by 5-8 times the threshold value. While gender equality is not quantified as an indicator by O’Neill et al. (2018), Raworth (2012), in her original publication, stresses the importance of

⁵ Next to the ‘first shift’ of paid labor and the ‘second shift’ of care work on top of paid work, a ‘third shift’ has been proposed that refers to the (unpaid) emotional labor of women in family, work, and sexual relationships (Fahs and Swank, 2016).

⁶ See also the work of Steinberger and Roberts (2009) on energy demand and human wellbeing. They found a significant global decrease of the energy required to meet human development needs (Human Development Index \geq 0.8), despite population growth. While this progress is mostly due to technological efficiency gains, they argue that further advancements need to also be driven by politics and the economy. They point out that highly developed countries could reduce their energy consumption significantly, without measurable losses in human wellbeing (see also Lamb et al., 2014).

⁷ <https://goodlife.leeds.ac.uk/countries/#Germany> (accessed 10 Sept 2020)

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the issue: “Gender biases are embedded in markets, politics, and institutions, and can be reinforced by poorly designed economic policies and development strategies. Tackling the source of these disparities is critical for achieving the social foundation for all, to the benefit of women, their families, and society” (p. 9). Therefore, targets for a sustainable food system must include social, and in particular, gender equality, next to health and environmental considerations.

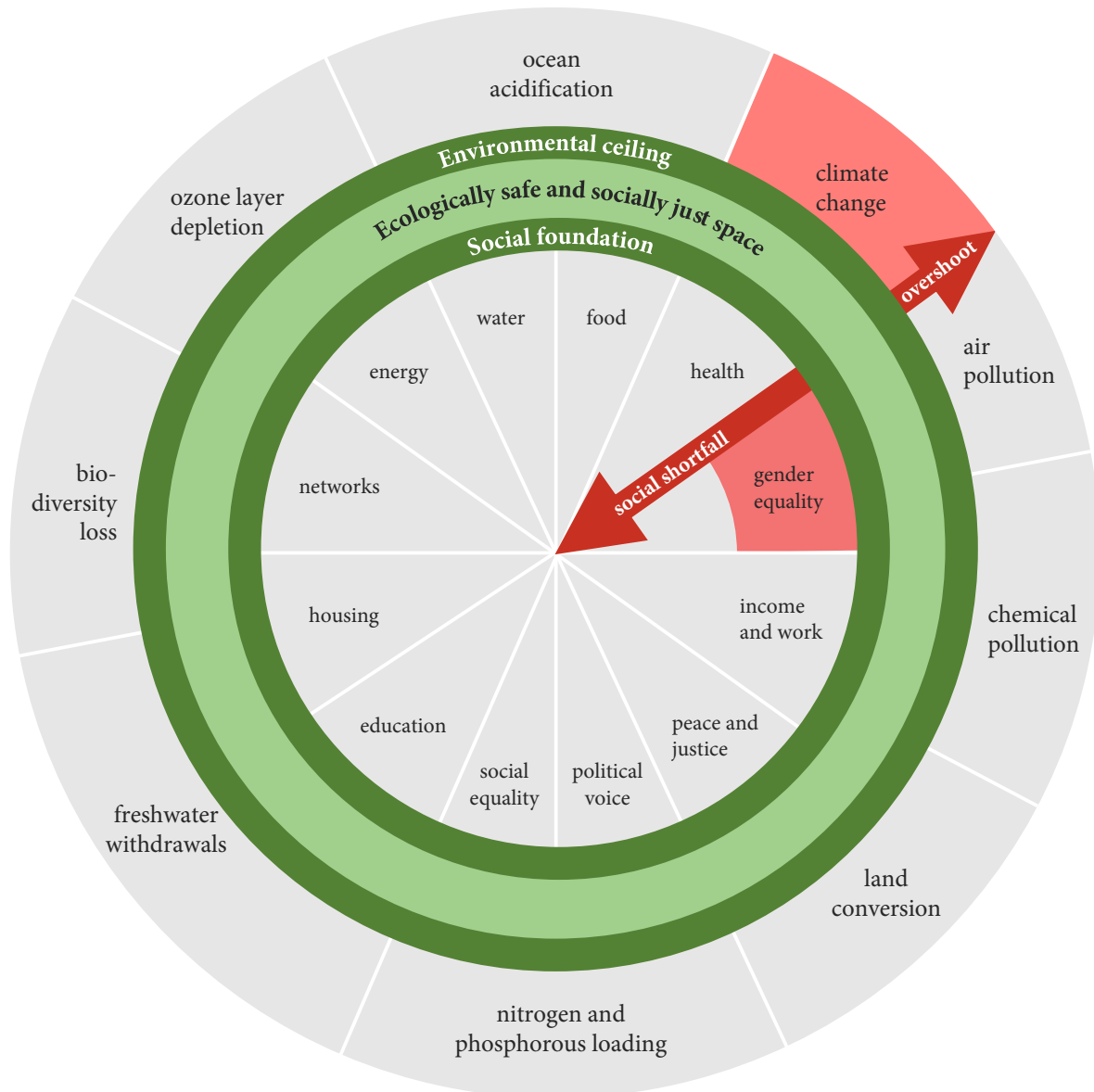


Figure 1. A safe and just space for humanity

Note. Adapted from Dearing et al. (2014) and Raworth (2012)

A feminist ecological economic perspective draws a parallel between the externalization of environmental resources and gendered care work in current economic policy and its central indicator, gross domestic product (GDP) (Perkins, 2007; Raworth, 2012). “What we commonly refer to as ‘the economy’ would not function without the (often unrecognized) foundation of work provided by the ‘care economy’: the reproduction of everyday life through cooking,

raising children, and so forth” (Power, 2020, p. 67). It is, therefore, imperative to not only take multiple dimensions of sustainability into account but to deconstruct gender stereotypes that are obstructive to environmental, health, and equality targets. Food consumption practices in Germany exert extensive pressure on the environment. However, relying on households to ‘do the work’ of sustainable food provisioning may exert additional pressure on women. Therefore, finding ways to shift unsustainable food consumption has to take into account gendered ways of doing, next to environmental and health impacts.

1.1.3 Research gap

The previous considerations have shown that current food consumption patterns are in dire need of transformation to stay – or rather, arrive – within ecologically safe and socially just boundaries. However, the question remains of how to turn the needed changes into reality. The next section will briefly introduce important issues of current research on sustainable food consumption. An in-depth review of relevant literature will be presented in Chapter 2.

While sustainable consumption has received increasing attention in the scientific community, much research still places the individual at the center of inquiry. Economic or social psychological perspectives emphasize the role of personal beliefs, attitudes, and knowledge as well as the agency of the individual to effect social change. Policy approaches consequently also primarily focus on individuals’ choices and education as a vehicle to bring about change (Spaargaren, 2011). However, “[...] information provision as a means to encourage more sustainable food choices is a broadly ineffective strategy” (Vermeulen et al., 2020, p. 4). A lack of effectiveness of current policy in bringing about change at the needed scale has led to the proposal of alternative approaches (Hargreaves, 2011). Anchored in the sociology of consumption, one such alternative lens emphasizes ‘practices’ instead of individual action (Warde, 2016). Practices are understood as habitual ‘doings,’ situated at the meso-level between individual agency and systemic structure (Spaargaren, 2011). Instead of an individual’s choices, practices – such as ‘dining out,’ ‘hosting guests,’ or ‘barbecuing’ – and their associated environmental impacts become the objects of interest.

In the study of human-environment relations, it is central to connect findings of both social and natural sciences to identify unsustainable practices based on their environmental impact. While it is difficult to draw a clear line between sustainable and *unsustainable* practices, it is possible to identify practices that make up a relatively large share of global environmental burdens. Practice-theoretical studies do not always base what is considered a particularly ‘sustainable’ consumption practice on results of studies quantifying their environmental impact (but see Burger Chakraborty et al., 2016 for a counterexample). As laid out in Chapter

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1.1.1, food consumption is of key importance to human life within planetary boundaries. Therefore, this research seeks to uncover patterns of unsustainability within food practices⁸.

Among practice-theoretical studies of food consumption, the study of household practices has received considerable attention. However, venturing beyond the home is rare, with few studies analyzing public food consumption practices (Goggins and Rau, 2016). This gap is surprising, given the already significant and increasing relevance of eating out in people's daily food routines. In Germany, 28% of the population reported eating out at least once per week (BMEL, 2018). More specifically, a direct comparison of the sustainability of food consumption at home and out of home is lacking. Studies in related fields have stressed the importance of not generalizing findings across different settings (Barr et al., 2010, 2011). For example, in a study on environmental commitments at home and while on holiday, Barr et al. (2011) noted: "Significant differences emerged in reported environmental commitments according to their consumption setting. Those with higher levels of commitment in and around the home also tended to be those who flew furthest and most frequently" (p. 1234). Therefore, findings for food practices at home should not simply be transferred beyond the home. The significant environmental impact of eating behavior in general and the increasing frequency of eating out as well as the current research gap make it a valid and relevant focus of this dissertation.

Just as eating practices in the home have environmental impacts beyond the home, gendered food practices within a domestic context are linked to larger structures of inequality and power. A key phrase of second-wave feminism 'the personal is political' (Hanisch, 1970) also applies to domestic food provisioning. Practices closely interlinked with cooking, such as paid labor and mobility, demonstrate that the gendered performance of food practices within the home is not an individual issue (personal), but of systemic nature, embedded in our social structures (political). While food studies more generally engage in questions of inequality and power, this has not been central to practice-theoretical works on food (Neuman, 2019). Notable exceptions include the work of Dubuisson-Quellier and Lamine (2008) as well as Dubuisson-Quellier et al. (2011) on consumer-producer relationships in the context of alternative food systems. The meso-level of practice theory is well suited to take into account the interrelatedness of practices of food provisioning – planning meals, shopping for food, and cooking – and actual eating. Thereby the *work* involved in consumption can be made explicit. Exploring the question of who is 'doing' sustainable food consumption at home can therefore shed light on heretofore obscured links between gender equality, sustainable diets, and domestic labor.

Furthermore, quantitative approaches are not traditionally used for practice-theoretical inquiries. However, given the centrality of studying changes in practices over time, mixed-methods approaches that incorporate a significant quantitative element present a considerable

⁸ The terms 'food practices' and 'food consumption' will be used throughout this work to describe food preparation (planning meals, shopping for ingredients, cooking) and consumption at home as well as food choice and consumption practices out of home.

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opportunity. Therefore, this dissertation combines qualitative and quantitative methods in an innovative way to answer the central question of how sites of consumption and practitioner demographics link to (un)sustainable food consumption practices.

This introduction has shown that diets heavy in animal-protein are a central concern for an ecologically safe and socially just life for all. Eating meat is deeply embedded in social, cultural, economic, and political systems. Changing meat consumption patterns is, therefore, a ‘wicked problem’ (Rittel and Webber, 1973) and will require the involvement of multiple actors and multi-dimensional, context-specific measures to effect change (Rust et al., 2020; Vermeulen et al., 2020). This research aims to identify food consumption practices that entail high meat consumption and understand how to replace these unsustainable patterns with new notions of a plant-focused ‘good life.’ The next chapter will detail the research approach chosen to fulfill this aim.

1.2 Research framework

The research approach of this dissertation paid particular attention to avoid drawbacks regularly criticized in sustainable consumption research. These include viewing consumers as rational agents, not understanding action as socially and materially situated, not taking rebound effects into account, not focusing on behaviors that are key in terms of environmental impact, and using a siloed concept of ‘sustainability’ (Davies et al., 2014; Sahakian and Wilhite, 2014; Spurling et al., 2013).

To avoid focusing on individual action, the unit of analysis to study the phenomenon of eating is ‘practices’ occurring in and shaped by different sites of consumption. The different sites of public and private consumption are used as the unit of analysis to carry out a comparative study between the two spheres. *Private* food practices are understood as the preparation and consumption of food within the household. *Public* eating can entail various scenarios, such as eating at a restaurant, at a work or school canteen, or ‘on the go.’ Within this research, eating at a restaurant serves as a case study for public food consumption.

As discussed in Chapter 1.1.1, the debate of what exactly constitutes a ‘sustainable diet’ is still ongoing (see Sahakian et al., 2019 for examples from Switzerland). To avoid focusing on practices that do not significantly contribute to environmental impacts, this dissertation relies on the results of LCA studies and focuses on diets instead of production mode (e.g., organic,

local, seasonal) or food waste⁹. Particularly, reduced meat and dairy consumption, replaced by increased consumption of plant-based foods, serve as a proxy for diets optimal for human and planetary health.

Sustainability – in the context of human nutrition – encompasses further issues apart from environmental and human health impacts. Global food supply chains are riddled with class, race, and gender inequalities (e.g., Alkon and Agyeman, 2011; Heynen et al., 2012; Pelling and Garschagen, 2019), a fact that spills over into domestic food consumption. Higher priced organic and locally produced food, for example, remains inaccessible to most and the promotion of ‘cooking from scratch’ an ineffective strategy for healthy eating of socio-economically disadvantaged groups (e.g., Bowen et al., 2019; McIntyre and Rondeau, 2011; Parsons, 2016; van Kesteren and Evans, 2020). Moreover, gendered divisions of labor play a particularly central role in food practices. The persisting gendered presumption that women will care for others leaves them responsible for the majority of foodwork, even today (e.g., Cairns et al., 2010; Szabo, 2011). Therefore, the link between gender and domestic foodwork is important to consider as part of a holistic sustainability framework. This dissertation explicitly includes gender relations in the study of sustainable food practices at home, thereby positioning itself in critical social theory (Anantharaman, 2018).

1.2.1 Aim and research questions

This dissertation aims to substantially contribute to the knowledge on sustainable dietary practices. It links heretofore separate strands of public and private consumption to effectively understand how their specificities and similarities can contribute to large-scale social change. Specifically, this dissertation aims to:

- Contribute to the understanding of sustainable food consumption from a practice-theoretical perspective
- Identify specific practices and their according elements that are key for transitions to sustainable food consumption
- Advance methods to study large-scale changes in food consumption practices

⁹ This is not to say that food waste is not a significant environmental issue. Every year, about one-third of food produced for human consumption is lost or wasted, amounting to approximately 1.3 billion tons of food, with an estimated 35% taking place during the consumption stage of the value chain (FAO, 2011; Lipinski et al., 2013). However, research shows that reducing food waste only plays a minor role in meeting EU climate targets through changes to the food system. If current avoidable food waste is halved, emissions are lowered by only 1-3% (Bryngelsson et al., 2016).

These overarching aims to contribute to theory and methods are pursued by answering the following central research question:

How can food practices at home and out of home become more environmentally and socially sustainable?

This overarching question can be further detailed out into the following sub-questions:

RQ 1 *How are (un)sustainable food practices evolving over time at a large scale?*

RQ 2 *How do public and private food practices differ in their materiality, necessary skills, and social meanings?*

RQ 3 *How do (un)sustainable household food practices differ between women and men?*

In answering these questions, this dissertation aims to make a substantial contribution to the understanding of public and private sustainable food provisioning and consumption from a practice-theoretical perspective. By identifying potential barriers to sustainability and suggesting ways to overcome them, this research further aims to generate scientific knowledge relevant to policy.

The dissemination of generated knowledge has been important throughout the research process. Insights have been shared with a wide variety of actors by presenting preliminary results at scientific conferences and co-organizing such an event (see Table 3), writing a blog post¹⁰ and press release¹¹, engaging in scientific discussion on social media¹², giving an interview for one of the leading national newspapers in Germany (*Süddeutsche Zeitung*)¹³, and ultimately publishing the empirical findings as peer-reviewed journal articles (see Table 2). The following section will detail the methodological approach to answer the research questions posed above.

1.2.2 Research design

Within this dissertation, practices of public and private food consumption were investigated using an innovative mixed-methods research design. Combining qualitative and quantitative methods made it possible to triangulate research outcomes and advance the empirical study of

¹⁰ <https://sustainabilitycommunity.springernature.com/posts/50548-rising-adoption-and-retention-of-meat-free-diets-in-online-recipe-data>

¹¹ https://uni-muenchen.de/forschung/news/2020/biermann_fleisch.html

¹² <https://twitter.com/GesaBiermann>

¹³ <https://sueddeutsche.de/wissen/ernaehrung-fleisch-restaurant-1.5014054>

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practices. The data collected focused on Germany as a geographic and cultural context. The research design followed a circular research process (Flick, 2009), alternating between data collection and data interpretation (see Figure 2). The approach, albeit its focus on quantitative methods, comprises elements of both deductive and inductive research. The online survey, for example, was constructed deductively based on a thorough study of existing literature. However, the evaluation of the survey data regarding food practices at home and out of home yielded interesting additional insights on the gender dimension of food practices, inductively. This specific lens – and the literature on feminist ecological economics – was subsequently used for data analysis and theory formulation in the third publication.

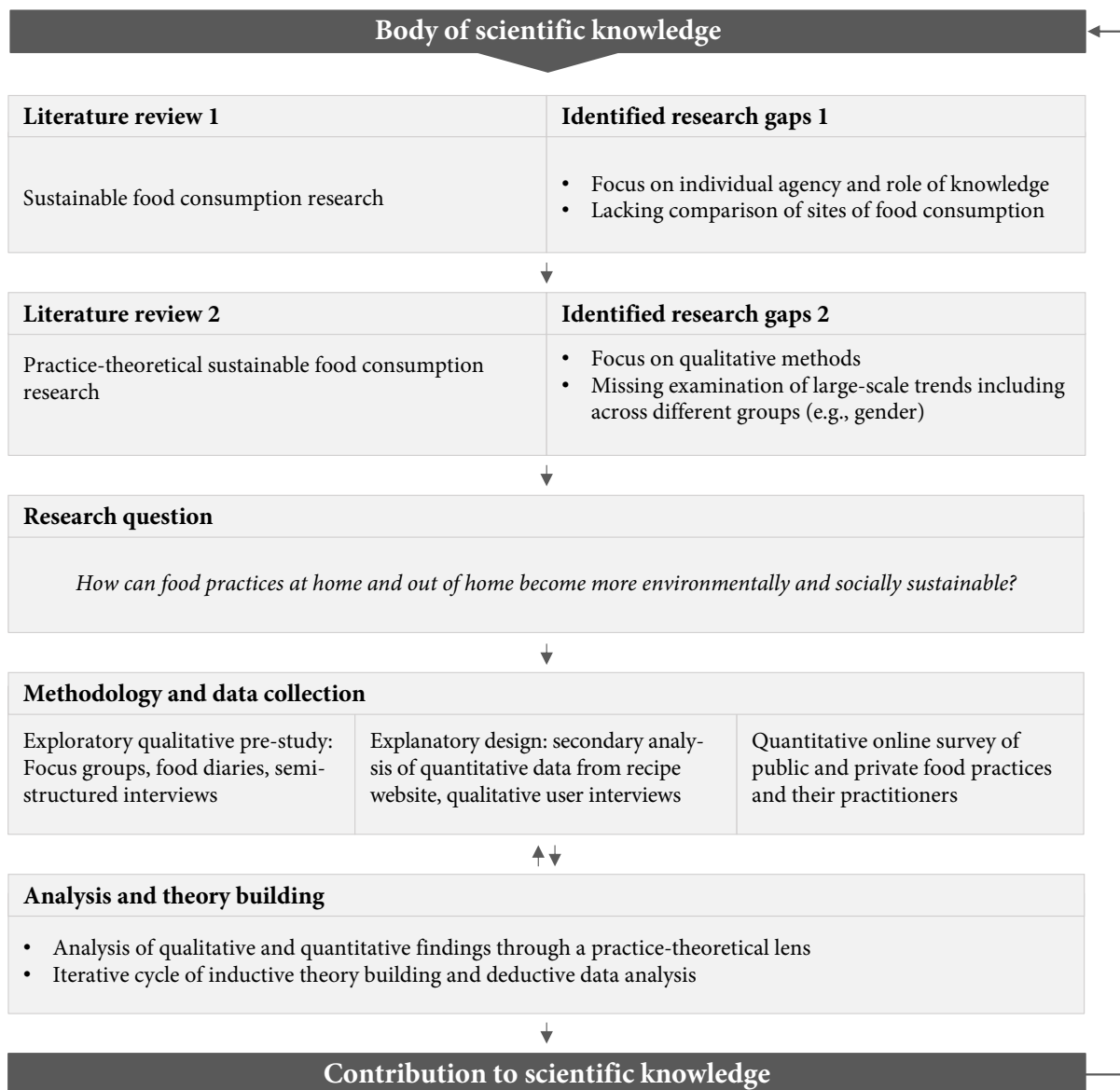


Figure 2. Overview of research process and framework

1.2.3 Research methods

This research employed an innovative mixed-methods approach to bridge the gap between mostly qualitative praxiographic research and quantitative methods (see Figure 2). Within this approach, an initial phase of qualitative exploration was followed by a mixed-methods study of explanatory sequential design (Creswell and Plano Clark, 2011). This second phase of studying practices over time was complemented by qualitative interviews with practitioners to juxtapose quantitative findings. The third and final phase of data collection was entirely quantitative, with a survey questionnaire designed specifically for this study. The survey captured food practices both at home and out of home. It included a descriptive section (e.g., regarding the frequency of eating meat) and associational components to draw out associated meanings. Aside from combining quantitative and qualitative empirical data, this research additionally made use of primary and secondary analysis.

In the first exploratory phase of the research process, different qualitative methods were combined:

- **Focus groups:** A world café format was used to facilitate dialog in a large group of people and uncover patterns of meanings, skills, and materials of an ideal sustainable food system. The groups rotated tables, which represented different sites of food consumption, such as home, restaurant, and work in each round. The collected artifacts (drawings, statements) were translated into ‘summary sketches’ by the author (see Figure 3 for an example).
- **Food diaries:** In the absence of observational data, food diaries helped to recall the role of meat in interviewees’ diets and discover potential differences between the public and private sphere. Eating practices were recorded for approximately ten days and used during the in-depth interviews for recall.
- **In-depth narrative interviews:** Interviews were used to uncover underlying situational and semantic knowledge in addition to multiple meanings of food, with a view to revealing potential similarities or differences between sites of public and private food consumption.

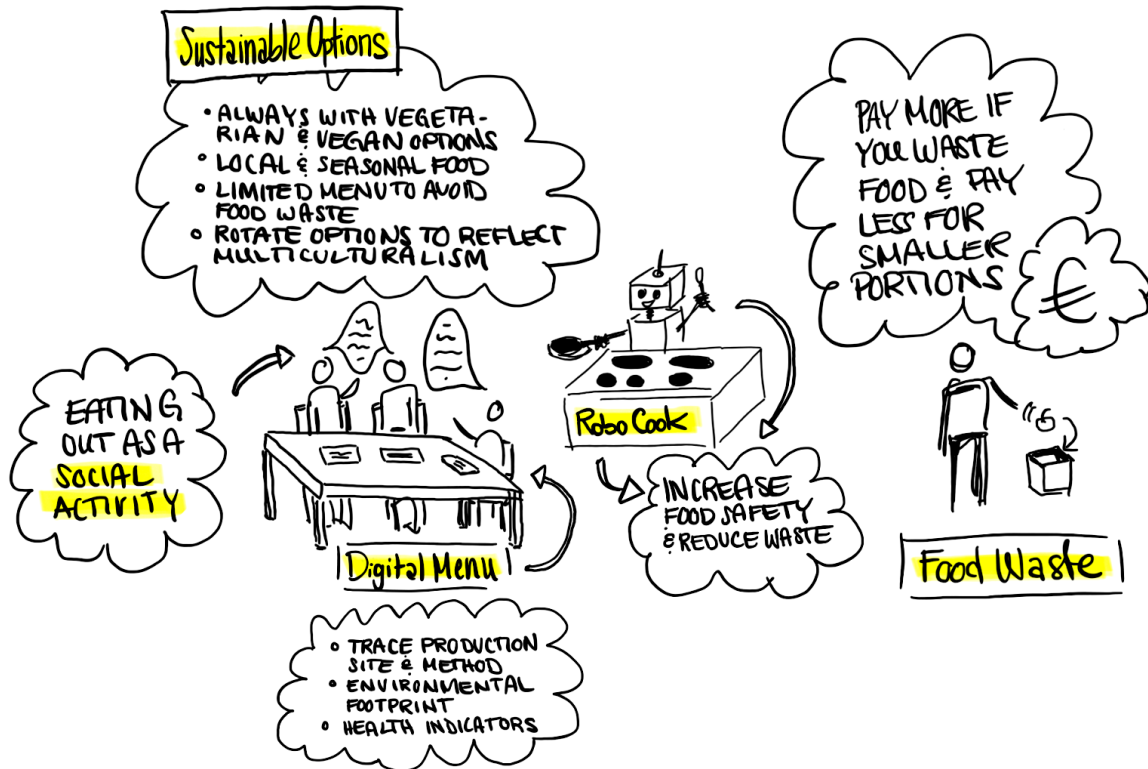


Figure 3. Sketch depicting a scenario for future sustainable restaurant eating proposed by a focus group

The results of this qualitative exploratory study were used to better understand differences between sites of consumption and how to appropriately capture food practices in the subsequent quantitative phases of research. The emerging themes were ultimately translated into questionnaire items for the third phase of research.

The second phase of data collection encompassed both qualitative and quantitative data (see Appendix: Publication 1 for a detailed description):

- **Secondary data analysis:** User data from an online cooking platform were analyzed to address RQ1. The platform – chefkoch.de – was chosen due to its popularity, reflecting many common food practices in Germany, and due to its long existence, with the first recipes dating back to 2000.
- **Semi-structured interviews:** To validate and supplement quantitative findings, users of the platform, previously quantitatively identified as having undergone a transition in their dietary practices, were contacted and interviewed via telephone or email. The interviews focused on the meanings of dietary transitions and the role of the online platform in this transition.

Following this investigation of large-scale changes in food practices over time, an online survey was conducted to compare and contrast practices of cooking and eating at home with eating at a restaurant (for a detailed description of the survey design, see Appendix: Publication 2):

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- Online survey:** A quantitative survey was used to measure the reported eating habits of a self-selected sample of German residents. This data was used to assess differences in food practices for plant-/meat-based diets and understand the role of practitioner socio-demographics, particularly gender, at the intersection of sustainability and gender equality. The survey comprised a descriptive section (e.g., reporting the frequency of eating out) and an associational component to elicit the meanings associated with food consumption. The use of a ‘semantic differential’ to draw out meanings of eating practices proved particularly useful in the survey study (see Figure 4 for an example). A semantic differential consists of multiple pairs of antonyms used to measure the ‘subjective realities’ or connotations of a word or concept (Eck, 1982; Osgood, 1952). As such, it is well suited to measure ‘meanings’ quantitatively.

What do you associate with cooking and eating at home?

Please select an option close to the word you associate spontaneously.

positive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	negative
everyday	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	special occasion
together	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	alone
meat-heavy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	meat-free
pleasure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	duty

Figure 4. Excerpt of a semantic differential used in the survey

An overview of data samples and methods of analysis used in the publications of this dissertation can be found in Table 1.

Table 1. Methodological approach

Research question	Research method	Sample	Time of data collection	Data analysis	Chapter
RQ1	Mixed-methods: recipe website data and qualitative interviews	243,333 recipes with 2,499,547 user ratings 10 semi-structured interviews with platform users	March-Sept 2018	Quantitative analysis (e.g., linear time trend analysis, ordinary least-squares regression) Qualitative content analysis	3.1
RQ2 + RQ3	Quantitative online survey	420 responses from German residents	Jan-April 2019	Quantitative statistical analysis: • by site of consumption (home vs. restaurant) • by gender of practitioner	3.2 + 3.3

1.3 Thesis structure

The empirical findings of this dissertation have been presented at international academic conferences and published as peer-reviewed journal articles (see Table 2 and Table 3). This thesis summarizes the individual publications and serves to highlight their main contributions to scientific knowledge on food consumption. Throughout the manuscript, the publications will be referenced as [P1-3]. The original articles can be found in the Appendix.

The further structure of this thesis is organized as follows: building on this chapter – **Chapter 1** – which discussed sustainability challenges in the food sector, defined sustainable diets, and explained the research approach, **Chapter 2** lays the theoretical foundation for this thesis. It introduces fundamental concepts of practice theory and reviews a wide range of practice-theoretical studies of sustainable food consumption. **Chapter 3** presents and discusses the original empirical findings. **Chapter 4** concludes this dissertation by highlighting key contributions, limitations, and suggestions for future research.

Table 2. Peer-reviewed publications of this dissertation

	Year	Author	Title	Journal	Chapter
[P1]	2019	Asano ¹ , Y.M., Biermann ¹ , G.	Rising adoption and retention of meat-free diets in online recipe data	<i>Nature Sustainability</i>	3.1
[P2]	2020	Biermann, G., Rau, H.,	The meaning of meat: (Un)sustainable eating practices at home and out of home	<i>Appetite</i>	3.2
[P3]	2020	Biermann, G.	Gender differences in household food practices: The role of sustainable diets	[Manuscript submitted for publication]	3.3

Note. ¹Authors contributed equally, listed alphabetically

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Table 3. Conference presentations of research included in this dissertation

Date	Presenter	Title	Conference	Venue
May 7-8, 2020	Biermann, G.	(Conference co-organizer)	5 th Network of Early Career Researchers in Sustainability Transitions (NEST) Conference	virtual / ETH Zürich, Switzerland
Aug 27-30, 2019	Biermann, G.	The sustainability of digitally mediated food choices: Case study of a German recipe website	Royal Geographical Society (RGS) Annual Conference	Imperial College London, UK
July 17-20, 2019	Biermann, G., Asano, Y.M.	Patterns in online recipe data reveal rising adoption and retention of meat-free diets	5 th International Conference on Computational Social Science (IC2S2)	University of Amsterdam, The Netherlands
May 15-18, 2019	Biermann, G., Rau, H.	Investigating the sustainability of public and private food preparation and consumption practices	7 th Congress of the Association of Geographical Societies in Europe (EUGEO) in conjunction with the 51 st Conference of Irish Geographers	National University Ireland, Galway, Ireland
Nov 7, 2018	Biermann, G., Asano, Y.M.	Vegan sticks: patterns in online recipe data reveal food consumption behaviors and trends	Livestock, Environment and People (LEAP) Conference	Oxford University, UK
Oct 11-12, 2018	Biermann, G.	Navigating patterns of sustainability in creation and consumption from online recipe data	15 th Meeting of the Junior Research Group in Environmental Sociology	Goethe University, Frankfurt/Main, Germany
Sept 19-22, 2018	Biermann, G.	Which way is vegan? Navigating patterns of content creation from online recipe data	Digital Cultures: Knowledge / Culture / Technology Conference	Leuphana University, Lüneburg, Germany
Aug 29-31, 2018	Biermann, G.	Which way is vegan? Navigating patterns of content creation and consumption in online recipe data	1 st Life Cycle Innovation Conference (LCIC)	Berlin, Germany
July 9-13, 2018	Biermann, G.	Presentation of the project proposal and research design	9 th LERU Doctoral Summer School	KU Leuven, Belgium

2 THEORETICAL BACKGROUND AND RELATED WORK

2.1 Theorizing sustainable consumption

Theory and policy approaches to create a food system that stays within planetary boundaries have focused mostly on production-side innovation. However, studies show that technological advancement alone will not suffice (Bajželj et al., 2014). For the food system, “yield-gap closures achieved with sustainable intensification would not meet projected future demands without an increase in agricultural area and in GHG emissions. Sustainable intensification is crucial; however, it is unlikely to be sufficient” (Bajželj et al., 2014, p. 3). More sustainable food consumption research is thus urgently needed that explores ongoing and future demand-side changes and identifies underlying social and cultural reasons for observable shifts in food practices. For example, the global rise of meat consumption clearly represents a major societal challenge. This shift can only be adequately understood through social-scientific food research that addresses issues of demand and dynamics of everyday food practices in a systematic way.

Neoclassical economic theory views human behavior as the result of a linear decision-making process performed by a rational agent or *homo economicus* (Doyle, 1999; Scott, 2000). Behavioral economics – drawing on research in the fields of psychology and neuroscience – has advanced beyond simplistic models of rational choice to include factors specific to their target audience (e.g., financial resources, attitudes, social network) and the context of the target behavior (e.g., laws, cultural setting, incentives) (Hampton and Adams, 2018; Nielsen et al.,

2020). The field uses ‘behavioral interventions,’ including appeals to values, attitudes, and personal beliefs, information provision or nudges¹⁴, to change individual action (Stern, 2020). Prominent theoretical models that focus on motivational factors to influence individual choices include the Theory of Planned Behavior, the Norm-Activation Model, and the Value-Belief-Norm Theory (Steg and Vlek, 2009). Even though these theories evolved to consider contextual factors – or at least individual’s perceptions of them (Steg and Vlek, 2009) – the inquiry still largely centers on the individual. Within this predominant individualist paradigm (Spaargaren, 2011), consumption is viewed as the summation of individual decisions, “[...] leading to the notion that ‘silver bullet solutions’ are readily available and that it is people who either act as barriers or as catalysts to change” (Sahakian and Wilhite, 2014, p. 26).

Literature from social psychology and behavioral economics has indicated that the proposed behavioral interventions are most effective, when used in combination with market-based or other regulatory instruments (Nielsen et al., 2020; Reisch et al., 2013; Stern, 2020). However, in the translation into policy measures, strategies to shift consumption have primarily focused on information-based, educational instruments, with limited effect (e.g., Hargreaves, 2011; Ranganathan et al., 2016). Even though these policy initiatives may have increased environmental knowledge among the population, they largely fail in their mission to change behavior as “[...] awareness turns out to be only a weak predictor for actually performed environmental behaviours” (Spaargaren, 2011, p. 814). The acknowledgment that individuals do not exist in a ‘social vacuum’ and that consumption in general, and environmentally significant consumption specifically, is determined by multiple, contextual factors, has led to the inclusion of ever more variables into behavioral models (Hargreaves, 2011, p. 81). However, seeing these ‘driving factors’ as external influences on behavior does not capture how the ‘process of doing’ itself shapes and reinforces practices (Shove et al., 2012, p. 143). Alternative attempts try to include the many variables viewed as *external* drivers and barriers of behavior into theories of social change. Within these alternative approaches, “[...] institutions, infrastructures, and daily life interact [...] needs and desire are located as outcomes of sociotechnical change, not as external drivers of it” (Shove, 2010, p. 1278). These approaches do not see drivers and barriers as abstract variables universally applicable to explain a broad range of pro-environmental behaviors (Barr et al., 2011; Shove et al., 2012). Instead, social convention is viewed as emerging within a specific cultural, historical, and geographical setting through the inconspicuous ‘doings’ of everyday life.

¹⁴ Influencing behavior through ‘nudging’ refers to changes in the environment decisions are made in, by e.g., changing the positioning of goods offered in a supermarket or the default size of a plate of food in a restaurant (Thaler and Sunstein, 2008). This ‘choice architecture’ does not rely on influencing attitudes, providing economic incentives, or restricting choices through policy. Rather, it relies on automatic, unconscious mechanisms of human behavior that will respond to changes in default options (see Lehner et al., 2016 for a detailed discussion of nudging in the context of sustainable consumption behavior).

A theoretical approach that allows for a shift away from a view of consumption as an individualistic act are theories of practice. Built on the work of Bourdieu, Giddens, and Schatzki in the mid to late 20th century, theories of practice have evolved and received renewed interest since the millennium by Reckwitz (2002) and Warde (2005), among others. Within this approach, ‘practices’ themselves, instead of individuals, become the unit of analysis. In Reckwitz (2002) words, a ‘practice’ is “a routinized way in which bodies are moved, objects are handled, subjects are treated, things are described and the world is understood” (p. 250). Next to the actual ‘doings,’ practices incorporate locations, time frames, infrastructures, emotions, mental and physical activities, and the discourses that bestow social meaning upon a practice (Plessz et al., 2016). As such, theories of practice bridge the agency-structure dualism, the separation of micro and macro levels, by acknowledging that human ‘doings’ and the structures shaping them are ‘recursively related’ (Shove et al., 2012). Consumption is, in this way, understood not as an individual decision about a particular behavior, but as the engagement in a practice; changes in behavior are implied to stem from changes in the practices themselves (Warde, 2005). This ‘radically nonindividualist paradigm of thought’ (Neuman, 2019, p. 90), therefore calls for a social-ecological transformation through changes at the level of practices, rather than focusing on the individual. As a result, theories of practice raise a very distinct set of questions:

The focus is no longer on individuals’ attitudes, behaviours and choices, but instead on how practices form, how they are reproduced, maintained, stabilized, challenged and ultimately killed-off; on how practices recruit practitioners to maintain and strengthen them through continued performance, and on how such practitioners may be encouraged to defect to more sustainable practices. (Hargreaves, 2011, p. 84)

From this point of view, environmentally significant behavior changes imply the need to transform practices to less resource-intensive ones (Hargreaves, 2011). When focusing on anthropogenic environmental impact, a practice perspective asks about the footprint of a *practice* instead of the footprint of an *individual* (Spaargaren, 2011). In the case of dietary practices, a key area of inquiry is, therefore, how more or less environmentally friendly food becomes customary within and through everyday social life. This research work asks, more specifically, which (un)sustainable dietary conventions exist in society that shape food practices at home and out of home, how these practices evolve, and what might be encouraging practitioners to reproduce unsustainable practices of cooking and eating. The next section will clarify fundamental concepts of practice theory, such as the elements a practice is made of and how changes are conceptualized within practice-theoretical work.

2.2 Practice theory: Key concepts

“The analytic focus shifts from the insatiable wants of the human animal to the instituted conventions of collective culture, from personal expression to social competence, from mildly constrained choice to disciplined participation.”

– Warde (2005) p. 146

This dissertation is based on a definition of practices as consisting of materials, skills, and meanings (Shove and Pantzar, 2005). ‘Skills’ are understood as competences necessary to carry out a practice, ‘materials’ refer to the technologies, objects, and physical infrastructure involved in a practice, and ‘meanings’ relate to the social and symbolic connotation, emotions, and motivations accompanying a practice. Spurling et al. (2013) give an illustrative example of the elements of practice in the context of food:

What elements, for example, compose the practice of hosting a dinner party? Firstly, the material components are required: food and drink, obviously, and cutlery, crockery, tables and chairs. As well as these objects and tools we require the domestic infrastructure of the home, most evidently the kitchen, which is shared with many other practices, and the wider infrastructures of energy and water supply on which this in turn depends. What competences are required? Clearly competence in cooking is required, but also, to successfully perform the practice, knowledge of dinner party etiquette. We might achieve distinction in our performance of the practice through specialised knowledge of wine, or perhaps of music. [...] The relative informality of many contemporary dinner parties in the UK, for example, is no less a cultural convention than the complex formality of dinner party etiquette amongst certain social groups and settings. (p. 9)

Through this example, it becomes clear that a practice is constructed through nonrandom activity and identifiable as such by practitioners (Neuman, 2019). Repeated performance – the ‘doing’ – by practitioners links these elements to form a more or less stabilized practice. Therefore, “performance presupposes a practice” (Warde, 2005, p. 134), and practices are recursive in nature, themselves an entity upheld only by repeated enactment. From a practice-theoretical perspective, behavior is not understood as the visible result of an individual’s attitude, but as “the observable expression of social phenomenon (socially shared tastes and meanings, knowledge and skills, and materials and infrastructure)” (Spurling et al., 2013, p. 8). Practices can further be divided into ‘practice-as-performance’ (observable acts situated in time and space) and ‘practice-as-entity’ (stabilized links between elements of a practice as the result of repeated performance) (Shove, 2010, p. 1279). The discernible part of practices, the tip of the ‘iceberg’ (see Figure 5), are the former, where practices are enacted, thereby stabilizing the nexus of materials, skills, and meanings. As entities, practices are intelligible and can be described by practitioners (Southerton et al., 2012). As a practice consists of both ‘doings and sayings,’ it is necessary to include both physical acts and their representations in the study of practices (Schatzki, 1996).

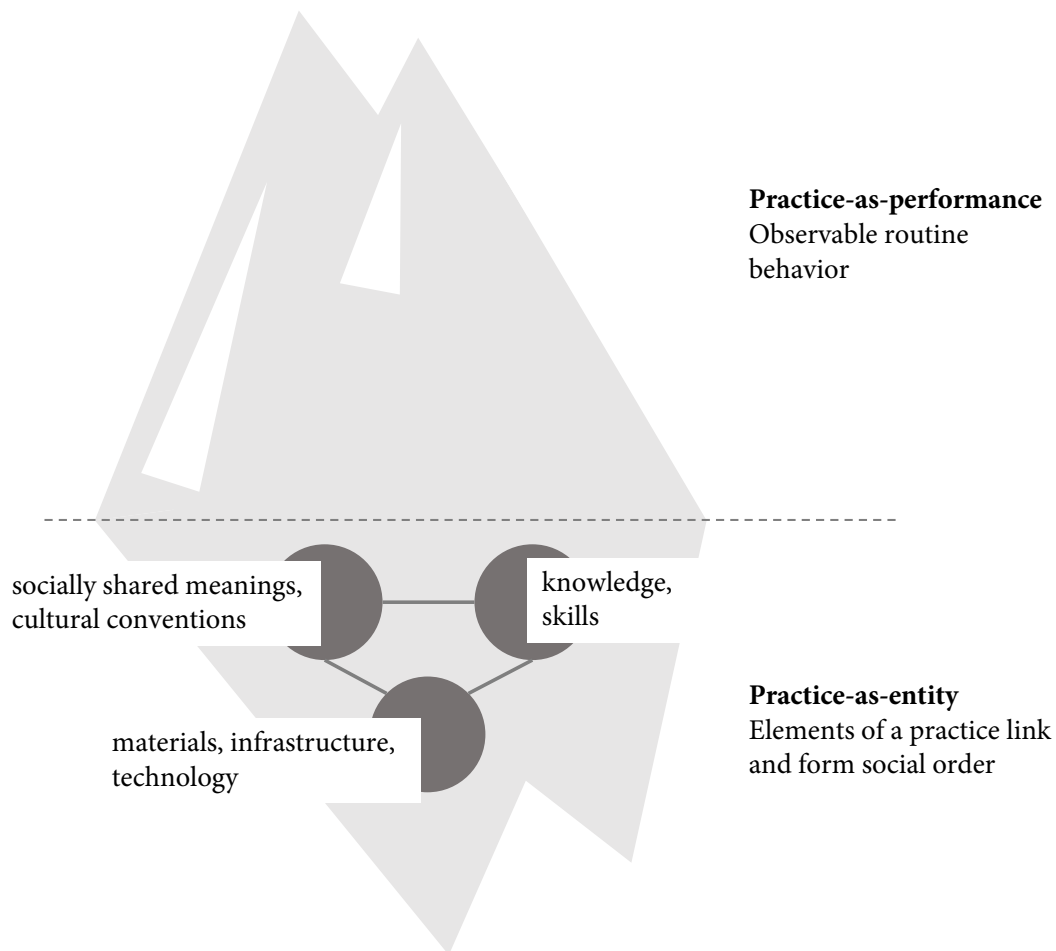


Figure 5. The iceberg of observable behavior and underlying elements of practice

Note. Adapted from Jaeger-Erben and Offenberger (2014) and Spurling et al. (2013)

Practice theory has been criticized for its focus on routines, thereby seemingly unsuited to explain change (Liedtke et al., 2013). While practices do exhibit considerable inertia, they are not in and of themselves static (Sahakian, Rau, et al., 2020; Sahakian and Wilhite, 2014; Warde, 2005). Specifically, three pathways to change in practices have been identified: (1) changes to the elements a practice is made of, (2) a change in practitioner population through recruiting or defection, and (3) changes in the way practices are interlinked (Shove et al., 2012; Watson, 2012). Concerning the first pathway to change, Sahakian and Wilhite (2014) argue for the importance of viewing the elements of a practice as exhibiting ‘distributed agency.’ To effect change, addressing one element (e.g., ‘skills’ through informational campaigns) may not be sufficient. They maintain that multiple elements must be addressed in unison. However, the example of the introduction of freezers shows that sometimes changing one element – in this case the material – may be sufficient to effect large scale change in food practices (see Shove and Southerton, 2000 for a detailed discussion of the normalization of the freezer in Britain and coinciding changes in the food industry and domestic labor). An example of a ‘multi-factorial policy’ (Hampton and Adams, 2018) addressing multiple elements to instigate change

in the realm of nutritional practices is the ‘London on Tap’ initiative (Sahakian and Wilhite, 2014). The initiative made use of multiple instruments to target the specific practice of ordering tap water in a sophisticated dining setting: Discussing the ‘taboo’ of ordering tap water in a restaurant publicly, holding a competition for the design of a special carafe made of recycled glass, and adding charity donations to WaterAid as part of every restaurant participating in the initiative. In this way, routine meanings (the unspoken ‘social rule’ of drinking bottled water in restaurants) were challenged and a new material object (the designer carafe) was introduced. In the words of Sahakian and Wilhite (2014): “The use of the carafe is relevant here, as it offered a new means for communicating environmentally sound – and stylish – consumption preferences” (p. 33). The material itself thereby linked to meanings of the restaurant setting. Therefore, how elements of a practice are linked has to be carefully considered for change initiatives to be effective. Moreover, thinking about different elements of a practice and their propensity towards change helps to understand unintended or forced changes (e.g., in the context of the COVID-19 lockdown).

A second key mechanism of change is practitioners taking up or abandoning a practice (Watson, 2012). This raises the issue of individual agency within changing practices. Most practice-theoretical research focuses on the life of the practice, but as Greene and Rau (2018) discuss: “how exactly the agency of subjects themselves is linked to practices is an important question that requires theoretically and empirically rigorous answers” (p. 77). They argue for a greater focus on practitioners’ biographies “to shed light on the complex and dynamic linkages between individuals’ lives and the developmental trajectory of practices” (p. 68). Using a life-course perspective can therefore help explain when changes in practice happen (e.g., Jaeger-Erben and Offenberger, 2014; K. J. O’Neill et al., 2019; Plessz et al., 2016). Life events or ‘turning points,’ such as changes in household composition, changing jobs, or health events “can serve as windows of opportunities for the adoption of new practices” (Plessz et al., 2016, p. 105; see also Rau and Manton, 2016; Schäfer et al., 2012 for examples regarding food, mobility, and energy practices). Next to life-course, Southerton (2006) also names gender, age, and education as relevant factors in how people allocate practices within their daily schedules. Social practices further rely centrally on the concept of ‘convention’ and “[...] established understandings of what courses of action are not inappropriate” (Warde, 2005, p. 140). Existing social ties, membership in communities, or networks can, therefore, facilitate the introduction to such a ‘convention.’ According to Liedtke et al. (2013): “[...] networks are one of the most central concepts to understand the diffusion and acceptance for new practices” (p. 17). They argue that rising ‘social costs’ due to unmet expectations of others in a personal network can lead to changes in practice. Actors who represent central nodes within social networks – ‘change agents’ – can therefore play a central role in the diffusion of practices to reach a critical mass.

Thirdly, viewing individual practices as spatially and temporally bound to other practices can help explain ripple effects of change. Going back to the example of life-courses, Shove et al. (2012) argue that “[...] not all practices are equal. Instead, lives revolve around a handful of ‘dominant projects’, these being inter-linked practices” (p. 78). They continue by describing ‘bundles’ and ‘complexes’ of practice. The first is a looser connection through the co-location of practices, while the second refers to more tightly integrated, co-dependent practices. Blue

and Spurling (2017) name these temporally, materially, or spatially linked configurations “bundles, complexes, constellations and systems in order to capture issues of scale, fixity, flexibility and structuration in connection” (p. 25). Shared materials (e.g., in the kitchen) and meanings (e.g., in relation to gender) can increase the likelihood of practices being enacted in the same space and time, thereby allowing for mutual influence (Shove et al., 2012). Changes in one practice can, therefore, affect further linked practices. For example, “the shifting character of grocery shopping is inseparable from shifting patterns of personal mobility, with out of town supermarkets co-evolving with patterns of personal car mobility” (Watson, 2012, p. 491). Acknowledging the links between practices that together form systems of practice illustrates that “theories of practice have the (so far under-explored) potential to illuminate processes across what can be understood as systemic scales, whilst always keeping a grip on how those systems are constituted, reproduced and have presence only through the continued performance of mostly profoundly mundane practices” (Watson, 2012, p. 491).

Spurling et al. (2013) have adapted these pathways to change in practices for the sustainability challenge that is also the focus of this dissertation. Specifically, they contrast the way this challenge is framed in contemporary sustainability policy with a perspective based in theories of practice. While the first three problem framings refer to approaches commonly found in contemporary sustainability policy – (1) technological innovation, (2) shifting consumer choice, and (3) behavior change – framings 4 through 6 are practice-specific:

- (4) *Re-crafting practices*: changing the elements a practice is made of
- (5) *Substituting practices*: replacing existing with more sustainable practices
- (6) *Changing how practices interlock*: leveraging linked practices to scale change

In the context of sustainable food consumption, *re-crafting practices* may take the form of substituting material elements on a smaller scale, such as exchanging meat for tofu, or a larger scale, such as introducing a mostly vegetarian menu at school cafeterias. An example of *substituting practices* can be found in many contemporary domestic kitchens, where cooking from scratch may be replaced with convenient pre-prepared meals or ‘to go’ options. The COVID-19 pandemic draws attention to an example of unexpectedly *interlocked practices* in the context of food: In a recent study by Süßbauer et al. (2020), an interviewee from Berlin explained how she took up the practice of drying vegetables at home (an activity that takes between 8 to 15 hours of baking) for trekking tours she is planning to undertake in the future, when travel becomes possible again. This food preservation practice, initiated by the lockdown, shows how travel and food practices can additionally interlock with an activity quite the opposite of traveling: spending time at home.

The publications of this dissertation provide further empirical backing for Spurling’s three practice-centered problem framings. In particular, the findings of links between meanings and unsustainable material elements of socially situated food consumption practices highlight the usefulness of these problem framings for research design. The next section will review empirical findings of research on sustainable food consumption that employ the introduced practice-theoretical lens.

2.3 Practice-theoretical food consumption research: Empirical findings

“Food is an important part of the special as well as the mundane [...] but the little things are, after all, what enables us to answer the big questions; it is through the ordinary that we understand the spectacular.”

– Neuman (2019) p. 91

Food studies is a rapidly growing academic field and becoming more engaged with practice theories (Neuman, 2019). An increasing orientation towards practice theories in food consumption research reflects a reaction to the ‘cultural turn,’ where communicative functions and symbolic meaning of food took center stage, while materiality and production took a backseat (Warde, 2016, p. 27 ff.). Practice-theoretical empirical food research has covered a wide range of topics, such as dietary prescriptions (Godin and Sahakian, 2018; Plessz et al., 2016; Sahakian, Godin, et al., 2020), food discourse in the media (Halkier, 2010), and changes in food practices (Spaargaren et al., 2012; Spurling et al., 2013). This includes groundbreaking sociological work on eating as a social practice by Warde (1997, 2016). These studies use a variety of methods, from more traditional qualitative ethnographic interviews and observations to mixed-methods research. Burger Chakraborty et al. (2016), in their study of the capital region of the Philippines, for example, used an innovative combination of in-depth qualitative household interviews and quantitative data on food purchases. They further used LCA to quantify the environmental impact of household food practices. One of their key findings included that eating out has become a central practice – one that is often not part of consumption surveys, leading to an underestimation of total household consumption.

Practice-theoretical research of food consumption has “[...] tended so far to focus on two particular societal challenges: health and environmental sustainability. Whether explicitly stated or not, the research contains a normative element: long-term ambitions to influence public policy through a critique of orthodox understandings of behavioral change and consumption” (Neuman, 2019, p. 86). This dissertation continues in this tradition, focusing on sustainable food consumption, understood as environmentally friendly and healthy food practices, with an additional social dimension of sustainability: gender equality. Therefore, the following sections will review empirical findings of practice-theoretical work that focuses on questions of sustainable and gendered food practices at home and out of home.

2.3.1 Sustainable food consumption

The link between environmental impact and food consumption can be understood from two distinct perspectives within practice theory: Environmental food consumption as a practice itself and environmental food consumption as a part of broader food practices (Halkier, 2009). The practice of ‘organic food consumption’ is an example of the former, while the latter can be exemplified by environmental issues of packaging and transportation *within* diverse food consumption practices. This dissertation took a broader set of food practices as a starting point and focused on the material composition of meals, due to their large environmental impact

(e.g., Poore and Nemecek, 2018). Following this logic, vegan, vegetarian, pescatarian, and flexitarian diets are understood as recognizable entities of (more) environmentally friendly food practices within this dissertation.

The topic of environmental sustainability has received increasing attention in recent practice-theoretical food research (e.g., Brons and Oosterveer, 2017; Evans et al., 2020; Godin and Sahakian, 2018; Halkier, 2009; Lawo et al., 2020; K. J. O’Neill et al., 2019; Paddock, 2017; Plessz et al., 2016; Sahakian, Godin, et al., 2020; Twine, 2018). Many studies anchor their questions on dietary practices. For example, Niederle and Schubert (2020) studied vegan restaurants and their customers in Brazil. House (2018), in contrast, took a different approach. In his study, he focused on a novel ingredient to replace animal protein – insects – and why this may or may not fit within existing Western food consumption practices. Many of these practice-theoretical studies conclude that a lack of cognitive know-how, misaligned personal values, or motivations is not the issue that is preventing sustainable eating; rather, conventions, time, taste preferences of household members, and divisions of domestic and paid labor contribute to a more multifaceted understanding of unsustainable practices (Neuman, 2019).

2.3.2 Cooking and eating at home

A study that situates sustainable food within the domestic context, specifically, is the work of Devaney and Davies (2017). In their *HomeLabs* study, they set up experimental sites at the household level to uncover ways to increase sustainable eating. The authors stress the importance of taking multiple elements and interconnected practices into account to effect change. One of the interventions aiming to reduce meat consumption, for example, used “the simultaneous provision of affordable and appropriate products (vegetarian proteins were provided free to households for 1 week) and materials highlighting the carbon impacts of food (carbon graph), alongside provocative ideas about how to alter eating practices (vegetarian recipe ideas)” (p. 833) to effect changes in practice. The authors also point to the importance of face-to-face interaction with the research team as a sounding board and guide through the five-week intervention. This, however, raises questions of scalability, as “[i]t is not feasible, neither economically or temporally, to provide such concentrated attention to individual households nationwide” (p. 840). While they see their results transferable onto community movements, product development, and government initiatives, this remains to be tested in follow-up studies.

Further practice-theoretical research of domestic food practices has focused on topics of temporal rhythms and routines (Dyen et al., 2018; Liu, 2020), household appliances (Sahakian, 2019; Truninger, 2011), meal box schemes (Fuentes and Samsioe, 2020; Hertz and Halkier, 2017), and what constitutes a ‘proper dinner’ (Bugge and Almås, 2006). Recent work by van Kesteren and Evans (2020) also ventured into the less explored subject of inequality and power relations in practice. In their mixed-methods study of mothers in the UK, they stress the impact of social deprivation on materials, meanings, and skills, limiting the ability to cook healthy meals. Something as seemingly mundane as a dining table significantly impacted the access to healthy meals: “[...] having only a tiny pack-away children’s table increased the relative appeal

of convenience meals [...] the less suitable their table was for eating on and the more effort they found eating at the table the more they were likely to enjoy eating ultra-processed foods” (p. 6). This recent work introduces important aspects of socioeconomic inequality due to education, income, and occupation into practice-theoretical studies of food consumption.

2.3.3 Gendered food practices

Next to socioeconomic status, gender plays a central role in shaping household practices. Women still shoulder much of the responsibility in modern households, especially concerning food provisioning (e.g., Szabo, 2011). In contrast, men’s cooking is performed more as a leisure activity than a domestic duty (DeVault, 1991; Roos et al., 2001). This gendered division is also reflected in research on households adopting more sustainable practices. Through a ‘feminist analysis of household temporalities,’ Organo et al. (2013) found that women “shouldered expectations of sustainability as part of their roles as mothers and household managers” (p. 559). In comparison, for the men in their study, “sustainability was commonly understood as a leisure practice, a downtime after work” (p. 572). Similarly, in the *HomeLabs* study discussed above, Devaney and Davies (2017) note:

[...] the two familial households (Households FA and FY) both possessed one member (who tended to be both the predominant food shopper and cook) who was willing to take responsibility to establish more sustainable eating routines on behalf of the entire family. [...] it was these participants who assumed principal responsibility for implementing the HomeLabs interventions. For example, the mother in Household FA began purchasing more organic and low carbon foods as part of the weekly shopping routine and also organised the family refrigerator around the specifications and tools provided by the HomeLabs team. Such practices reduced the need for other household members (principally the champion’s partner and children) to exert much effort in, or attention to, transforming their eating practices; they were passive rather than pro-active in the process. (p. 838)

While Devaney and Davies acknowledge that the ‘maternal dominance’ they found in enactments of sustainable household practices aligns with findings on traditional labor divisions, they do not discuss this as problematic. Sustainable consumption research often ignores these gendered inequalities, especially when promoting more time-intensive practices, such as ‘cooking from scratch.’ As Szabo (2011) argues, “The demands of paid work, especially given contemporary household arrangements and ideologies, often leave little time or energy for cooking. This is especially the case when food work in a household is one person’s responsibility rather than being shared” (p. 561). Women’s central role in the household entails the opportunity of turning them into change agents but also bears the danger of imposing yet another domestic responsibility on them.

While numerous studies link masculinity and meat (e.g., Rosenfeld, 2018) as well as femininity and household foodwork (e.g., Kerr and Charles, 1986; Szabo, 2011), studies that combine these two strands of research and explore gender relations in sustainable eating are rare. An explicit focus on gender in practice-theoretical studies of food and eating can be found in the work of

Halkier (2007) on Danish women's cooking, Meah's (2017) study of fathers' food practices in the UK, the study of men's cooking in Belgium by Daniels and Glorieux (2017), and the research by van Kesteren and Evans (2020) of UK mothers described above. However, a thorough search of the relevant literature yielded no practice-theoretical empirical works that study the intersection of domestic foodwork, planetary-health diets, and gender explicitly.

2.3.4 Eating out of home

Eating out has become increasingly common in the Global North and beyond (e.g., Burger Chakraborty et al., 2016; Edwards, 2013; Paddock et al., 2016). Warde (2016) places much emphasis on restaurants as “[...] responsible for some of the most radical changes to eating patterns” (p. 159). Based on extensive empirical research in the UK in the 1990s, the influential work of Warde and Martens (2000) describes ‘eating out’ as “[...] a concept with which people are familiar and which they use in their everyday talk [...] People recognise a set of shared elements which allows them to participate satisfactorily, and to identify which particular activities or events fall into the relevant category, but without any overarching model of how such an occasion should be managed or played out” (pp. 61-62). They thereby acknowledge ‘eating out’ as an intelligible entity, while at the same time making room for variations in performance.

Albeit being an important site for practice-theoretical inquiry into everyday consumption, the research on eating out is limited (Paddock et al., 2016). Even more limited are inquiries into *sustainable* food consumption practices outside the home. While Horgan et al. (2019) compared different sites in terms of the quantity of meat consumed, little is known about the associated meanings of (un)sustainable food consumption out of home. Warde and Martens (2000) qualify meanings of eating out as “[...] doing or experiencing something different from the everyday, getting a break from cooking and serving, relaxing, having a treat, socialising, celebrating, a liking for food, and preventing hunger” (p. 47). They further underscore the “emphasis on ‘special’ in understandings of eating out” (p. 47). While these empirical findings indicate the importance of meanings for practices of eating out, it remains unclear how they tie into related materials and their ecological footprints.

Overall, food consumption is increasingly studied, also in practice-theoretical work. These studies have been able to expand the understanding of food beyond informational or motivational aspects. The empirical works of this dissertation extend previous research by tracing historical changes of food practices, comparing home and out of home practices, and analyzing interwoven gender-relations. The next section will give details on these empirical findings.

3 EMPIRICAL FINDINGS

This chapter outlines the main empirical contributions of this dissertation, which have been published in the form of peer-reviewed journal articles. The overarching aim of the following studies was to shed light on the (un)sustainability and (in)equality of food consumption practices at home and out of home. The first study assessed changes in food consumption practices in Germany through the secondary analysis of website data spanning more than a decade. The second study focused on comparing food practices at home and contrasting them with restaurant visits, while the third study zoomed in further on the household to analyze the link between gender, foodwork, and sustainable diets. The upcoming section will use the scientific *we*, as most of the works present collaborations with other academic partners. The full articles can be found in the Appendix.

3.1 Trends and transitions towards plant-focused diets

Citation

Asano*, Y. M., & Biermann*, G. (2019). Rising adoption and retention of meat-free diets in online recipe data. *Nature Sustainability*, 2(7), 621–627. <https://doi.org/10.1038/s41893-019-0316-0> *authors contributed equally, listed alphabetically

Summary

The main motivation of the first empirical work was to extend the methodological toolbox for the study of food consumption practices. Traditional methods to study food consumption encompass several shortcomings: survey studies may lack accuracy and contain biases of self-reports, while observational studies are usually only feasible at a small scale. The increasing use of online resources for cooking presents an opportunity to overcome these hurdles. The

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interaction with online platforms leaves ‘digital traces’ that can help deduce offline patterns of practice. This publication focused on answering the following research question:

[RQ1] How are (un)sustainable food practices evolving over time at a large scale?

To understand changing patterns of cooking and eating at a large scale, we used data from the online recipe platform *chefkoch.de*. In addition to being the most popular cooking platform in Germany, its long existence of over a decade and comprehensive data about recipe ingredients, categories (i.e., tags such as ‘vegan,’ ‘vegetarian’), and user ratings allowed for a detailed analysis of practices over time. The dataset used for this study reflects the content of the platform as of March 2018.

Our quantitative study analyzed 243k recipes and 2.5M user ratings to understand how large-scale sustainability trends are evolving on the platform, which dietary practices are adopted or abandoned by practitioners, and how the material composition of recipes may ease the transition towards meat-free diets. For the qualitative part of the study, we interviewed ten practitioners who had engaged with the platform over an extended period of time and had undergone a transition in their dietary practices from meat- to plant-focused. The interviews served to, on the one hand, confirm that we had correctly identified changes in practice through our quantitative analysis and, on the other hand, to gain further insights on meanings, as well as the role of materials (the online platform, recipe ingredients) and food skills in dietary transitions.

We noted a positive trend in terms of the sustainability of recipes submitted on the platform: between 2005 and 2018 the share of vegan recipe submissions increased from 1% to 14% and the share of vegetarian recipe submissions from 17% to 30%. These increasing submissions also led to increasing total shares of plant-focused recipes on the platform. This change in recipe composition on the platform is initiated by practitioners engaging in recipe creation; we next focused on users of the platform, who do not shape the platform by producing recipes, but rather through the digital traces they leave of their engagement, such as rating recipes.

We found that vegetarian recipes are increasingly ‘tested,’ while vegan recipes are increasingly adhered to. In contrast, we discovered low and declining dietary adherence for meat-related recipes (tags such as ‘pork,’ ‘poultry,’ and ‘roast’). We additionally identified the highest rates of change for recipes tagged ‘vegan’ and ‘vegetarian’: more users adopt these diets than abandon them than for any other recipe tag. The proportions of users who, according to our model, are practitioners of vegan or vegetarian diets correspond well with the numbers found in national surveys of Germany. While the trends we found are promising, extrapolating this rate of dietary transition until 2030 showed that the eating practices of Germany’s population would still fall short of the changes necessary to stay within the range of planetary boundaries.

In order to understand the transition period between rating recipes of meat-related tags and recipes tagged ‘vegetarian’ in more detail, we next quantified the similarity of recipes in terms of the number of ingredients they share. We find vegetarian recipes used in the transition phase

from meat- to plant-focused to be closer to meat recipes than the average vegetarian recipe. For example, a recipe for ‘zucchini-patty’ was used during the transition, whose close meat-containing neighbor recipes include ‘burger patty.’ This similarity of vegetarian recipes and traditional meat recipes is not found after the transition period. Substituting meat in familiar recipes may therefore help transition to a vegetarian diet but is not as relevant for dietary adherence after an initial period of transition.

The qualitative interviews confirmed that the identified users had in fact undergone dietary transitions, with seven of ten interviewees now practicing a vegan diet and the remaining three following a flexitarian or vegetarian diet. Next to using already familiar recipes – but leaving out meat or fish – when transitioning to vegetarian diets, interviewees further explained the centrality of increasing their knowledge of replacement products when transitioning to a vegan diet. This indicates a stronger link of skills and materials in vegan, than in vegetarian diets.

This was the first study to investigate (un)sustainable food practices using data from an online recipe platform. Specifically, the study contributes to knowledge on transitions to sustainable diets on a theoretical level and to the study of large-scale changes in practices on a methodological level. The applicability of the methods developed as part of this research will likely expand further, as the use of online sources of information grows.

3.2 Meanings of meat at home and out of home

Citation

Biermann, G., & Rau, H. (2020). The meaning of meat: (Un)sustainable eating practices at home and out of home. *Appetite*, 153. <https://doi.org/10.1016/j.appet.2020.104730>

Summary

The first empirical element of this dissertation found encouraging trends towards more sustainable dietary practices. However, using a practice-theoretical problem framing makes it necessary to delve deeper into specific food practices to understand the links between materials, skills, and meanings. While food consumption at home and out of home have been studied separately in practice-theoretical empirical works, a direct, quantitative comparison is lacking. Therefore, the second publication focused on answering the following research question:

[RQ2] How do public and private food practices differ in their materiality, necessary skills, and social meanings?

Continuing the quantitative approach of the first publication, this study made use of an online survey developed specifically for this research. The construction of the survey was informed by an extensive review of relevant literature as well as qualitative focus groups, semi-structured interviews, and food diaries. The themes that emerged from the qualitative pre-study were subsequently translated into questionnaire items. The survey was conducted in German and a total of 420 responses were collected using a convenience sample in the months of January to

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April 2019. The resulting data were evaluated with a focus on meanings and material (environmental) impacts of eating practices using univariate and bivariate statistical analyses.

The data analysis revealed that sustainable diets do not fluently translate across all sites and social occasions. We found eating at a restaurant to be associated with more meat consumption than eating at home. Interestingly, even respondents adhering to a form of reduced-meat, flexitarian diet reported eating meat more frequently, when eating out. Within the home, cooking for others – the household or, especially, guests – was also associated with higher meat consumption. Social eating within the home, like eating out, was therefore found to be linked to increased meat consumption. The meanings element of eating practices lends interesting insights into why this may be the case. It seems as soon as the food practice serves a distinct social function, prioritizing taste and celebrating the ‘specialness’ of the occasion, meat is deemed a core material component. The material element follows the meanings associated with the eating practice. The ‘specialness’ of hosting guests and eating out is, in this way, satisfied by ‘treating oneself’ to more meat. This leads to the question of how plant-focused dishes can be framed as a ‘special treat,’ qualifying them for occasions that reflect socially shared notions of ‘the good life.’

The case of the meaning of meat is particular, in part due to its long history. Prevailing notions of meat as ‘special,’ associated with a high social status and hospitality, are strengthened by religious and political institutions. The European Statistical Office, for example, uses eating meat regularly as an indicator for an ‘adequate lifestyle’ in their measure of economic strain. Organizations, therefore, play a key role in changing the meanings of plant-focused eating. However, given the more frequent meat consumption during restaurant visits, other public actors, such as restaurant owners and (celebrity) chefs, are also well-positioned as advocates for sustainable eating. As the first publication of this dissertation indicated, online media, especially social media, is increasingly used as a source of information about food. Actors in this space can thereby further shape meanings of desirability in (un)sustainable food practices.

Aside from changing meanings, our study revealed two further potential pathways to more plant-focused eating. Firstly, increasing the vegetarian offering at restaurants may be helpful, especially for flexitarians. Secondly, increasing vegetarian cooking skills could provide omnivorous practitioners with access to more plant-focused practices. However, competences and offering alone cannot override the meanings element, and further, level out systematic inequalities, such as economic disadvantages.

This was the first study to directly compare at home and out of home consumption, not only in terms of what is eaten but also regarding underlying social meanings. The study contributed to the theoretical knowledge on public and private eating practices, highlighting the importance of considering their differences in advocacy for sustainable eating. Eating at home without company seems to give practitioners more leeway to live out their own lifestyle, independent of social ideals, norms, and conventions. Social occasions, such as hosting guests, going out to eat, or dinners for special occasions, on the other hand, link strongly to meanings that are best satisfied with meat. It is these already established social practices sustainability campaigns need to focus on.

3.3 Linking sustainable diets and gender in household food practices

Citation

Biermann, G. (2020). Gender differences in household food practices: The role of sustainable diets. *Manuscript submitted for publication.*

Summary

‘Consumption’ is often not directly associated with work. This missing link is particularly glaring in the case of ‘food consumption.’ Even at the end of the supply chain, food still requires foodwork: planning meals, shopping for ingredients, and cooking. Historically, and until the present day, domestic work – especially concerning food – has been the responsibility of women. The call for households to engage in more sustainable practices may thereby inadvertently exert additional pressure on women. The literature on sustainable consumption does not explicitly address this invisible injustice in most cases. In contrast, this research acknowledges the intersectionality of multiple issues of sustainable food consumption at the household level: environmental impact, human health, and gender inequality. In particular, the third empirical element of this dissertation answers the following question:

[RQ3] How do (un)sustainable household food practices differ between women and men?

To answer this research question, the survey dataset used in the second empirical study was analyzed further. Responses were partitioned by gender and additionally split by type of dietary practice. Statistical tests were used to compare food practices between men and women and test for differences between practices within gender groupings.

The results yielded significant differences between men and women in household food practices. Overall, men in the sample were less likely to follow sustainable diets than women, confirming previous empirical findings on the link between meat and masculinity. Additionally, men were less likely to be responsible for food provisioning tasks and had lower cooking abilities. This finding, in turn, is in line with literature on the foodwork-femininity nexus. Zooming in on these differences between men and women and partitioning by dietary practice adds the connective tissue of the intersecting issues of sustainability and gender equality. Omnivorous and flexitarian men took less responsibility in foodwork than women adhering to the same diets. Omnivorous men additionally cooked more animal products when cooking for themselves than omnivorous women. However, for practitioners of pescatarian, vegetarian, and vegan diets these gender differences were not found. Men and women following meat-less diets shared in the responsibility of food provisioning equally. Practicing gender non-conforming sustainable diets appears to be linked to also participating in gender non-conforming foodwork for men in the sample.

While men and women following meat-less diets did not differ significantly in their use of animal-products overall, women did differentiate between cooking for themselves and others more than men did. Women prepared animal-products more frequently when cooking for

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guests than when cooking for themselves, independent of their own diet. The link between femininity and care, as well as care and meat, may, in this way, prove an additional obstacle for women's sustainable cooking. As the results of the first analysis of the survey data [P2] showed, unlinking meat-focused dishes from special occasions, such as hosting guests, is challenging. This work adds to that, highlighting that this link may be particularly relevant when women are participating in these practices.

These findings again place 'meanings' at the center of sustainability considerations. Meanings of traditional masculinity, linked to meat, power, and strength, clash with equally traditional meanings of femininity in food provisioning and meat-free diets. These meanings may discourage men from following sustainable diets and sharing in the responsibility for foodwork. Drawing on previous findings of the link between gender identity, meat consumption, and domestic food labor, I argue that plant-focused diets, responsibility for foodwork, and new ways of 'doing gender' carry a shared meaning of 'care': for others and the environment. This shared meaning allows foodwork and meat-free eating to form a complex of interlinked practices.

Reframing gendered meanings of food practices may, in the short run, rely on strategies aiming to showcase traditionally masculine personas engaging in meat-free diets and foodwork. Long-term strategies may, however, rather aim to deconstruct traditional gender stereotypes obstructive to gender and climate justice altogether. Practices of caring for others and the planet through food could be framed as desirable for any person, irrespective of gender.

This study is among the first to connect previously separate strands of research on gender and diet as well as gender and domestic food labor. An additional distinction is its quantitative approach, as previous studies – especially with a practice-theoretical lens – have used mostly qualitative data. The most significant contribution of this work is to emphasize the importance of taking intersecting sustainability issues – human health, environmental sustainability, and gender equality – into account when studying food practices. This intersectionality is especially relevant to uncover who is doing 'the work of consumption' and prevent unthinkingly adding another layer of imbalance on women through sustainability targets. Internalizing previously externalized systems of survival, such as ecosystem services and social reproduction, is essential for a future beyond an ecological crisis and gender injustice. A practice-theoretical perspective helps to uncover the links between issues of sustainable diets, foodwork, and gender.

4 DISCUSSION AND CONCLUSIONS

4.1 Key findings, contributions, and implications

This dissertation contributes directly to scientific knowledge on how the links between skills, materials, and meanings may prevent or encourage more environmentally and socially sustainable food practices at home and out of home. A practice-theoretical approach to the study of sustainable food consumption facilitates a shift away from a sole focus on the thoughts, motivations, and agency of individual consumers and towards the collective performance of everyday food practices and their social and material dimensions. By placing socially, culturally, and materially situated *practices* of cooking and eating at the center of inquiry, this study offers a fresh perspective of the sustainability challenge of rising meat consumption. By combining primary and secondary analysis of different sets of quantitative data, this dissertation developed methods to ‘scale-up’ practice-theoretical research, expanding on and complementing more interpretative qualitative work. In sum, three key themes emerged from the empirical works of this dissertation: the centrality of meanings, the interlinked issues of sustainability in food practices, and the specificity of different eating occasions. Figure 6 summarizes the central findings of the three empirical projects.

While the first publication found encouraging sustainability trends, with an increased availability and use of meat-free recipes on chefkoch.de, this speed of dietary transition would still fall short of change necessary for Germany to stay within the range of planetary boundaries. Misaligned meanings can play a central role in the speed of this transition. Rationally, people may be aware that too much meat is unhealthy and has a relatively large impact on the environment, but it may still prove to be the most (socially) ‘suitable’ ingredient in the meal they are preparing or eating. The second publication uncovered that practices of eating at a

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restaurant or cooking for others at home – especially when hosting guests – carry meanings of ‘specialness.’ With meat also associated with a high status, treating oneself, and living ‘the good life,’ social eating practices are more prone to a higher environmental impact due to their reliance on meat as a core ingredient to satisfy linked meanings.

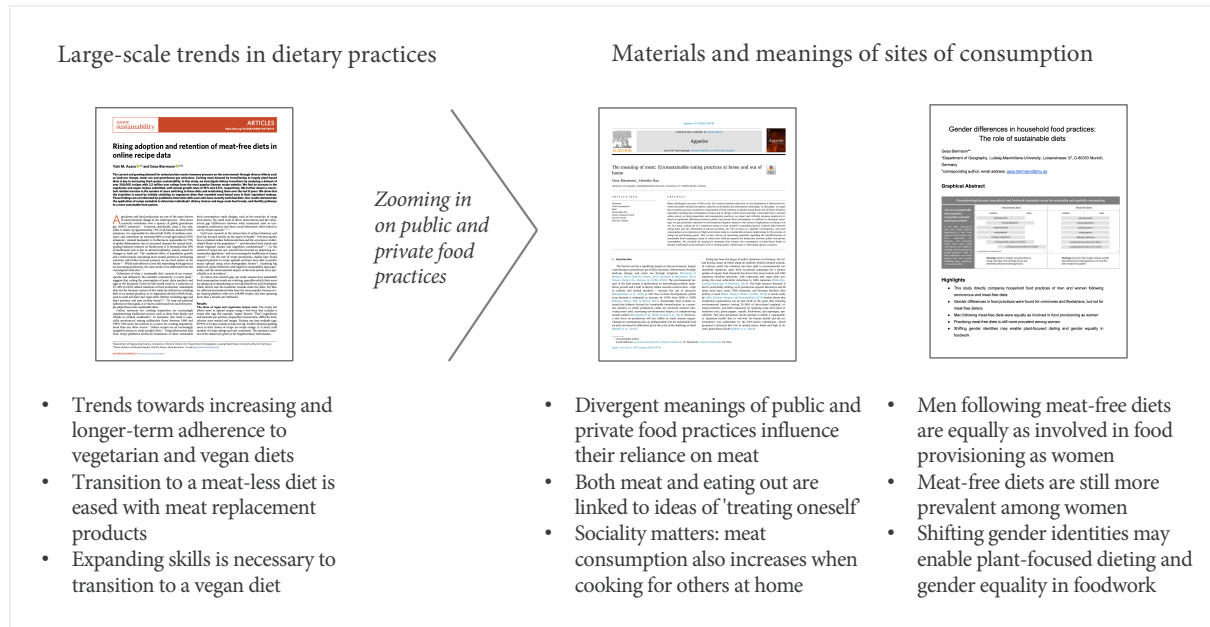


Figure 6. Central findings of empirical works

Gender adds another important layer to meanings of sustainable food consumption. This research found that men follow meat-free diets less often than women and cook more meat for themselves. However, when cooking for others (especially guests), women may ignore their own dietary practice and fall back on unsustainable food choices more often than men. The link between femininity and caring for others plays a central role in women taking on much of the responsibility in household cooking. The high status of meat may take on a meaning of caring *especially well* for others and be an additional obstacle for women’s sustainable cooking. The third publication thereby extended the findings of the sustainability challenges of public/private eating. A gender perspective highlights the need to address women’s cooking specifically.

Meanings also play an important role in linking gender with unjust distributions of foodwork in domestic food practices. The link between meat and masculinity as well as foodwork and femininity exerts double pressure on environment and society. Meat-less dietary practices present an opportunity to alleviate this problem in two distinct ways: Meat-less practices, while decoupling masculinity and meat, also appear to link to foodwork. Men who followed meat-less diets participated in food provisioning just as much as women, while their meat-eating counterparts did not. The link between food provisioning and sustainable diets is theorized to relate to meanings of ‘care:’ care for others, and the environment, through food.

Aside from meanings, materials and skills can also serve as obstacles or opportunities for more sustainable food practices. Substituting or leaving out meat in already familiar recipes was

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found to help transition to a vegetarian diet but was not as relevant for dietary adherence after the period of transition. Meat replacement products can, therefore, play an important role in transitions to meat-free dietary practices because they mimic the existing materials and meanings, thereby making adoption easier. Increasing the vegetarian offering was further found to be helpful in a restaurant setting, especially for flexitarians. While vegetarian cooking allows practitioners to often simply leave out unwanted ingredients, the empirical findings of this dissertation showed that for vegan diets, an increase in cooking knowledge is necessary. Increasing plant-focused cooking skills may further be particularly relevant for omnivores, but less so for flexitarians. In this way, these findings add nuance to information deficit and knowledge provision narratives that put all bets on an informed consumer who acts rationally and adjusts his or her food practices accordingly. Increasing skills may be less relevant for ‘easy to access’ vegetarian cooking, but necessary for more stark dietary transitions – such as taking up a vegan diet – and practitioners of meat-heavy diets.

Methodologically, this dissertation contributes to ‘scaling-up’ practice-theoretical research. The first empirical work drew on website usage data to study cooking and eating practices at home. In this way, the study advanced quantitative approaches to studying everyday consumption, avoiding limitations such as the small scale of direct observations and issues of reactivity linked to food diaries. The second and third publication drew on the results of a survey comparing the sustainability of food consumption practices at home and out of home, conceptualized specifically for this dissertation. While Neuman (2019) argues for the suitability of quantitative time-use surveys in studying occurrence and time spent on practices, I argue that ‘understandings’ of a practice can also be elicited with quantitative survey methods. Particular elements of survey design, such as a ‘semantic differential’ to elicit meanings, were found to be an effective way to capture practices quantitatively.

This dissertation empirically corroborates the practice-centered problem framings put forward by Spurling et al. (2013) discussed in Chapter 2.2. Regarding ‘re-crafting practices,’ replacing meat with less impactful options (e.g., meat-replacement products or simply leaving meat out in vegetarian meals, which do not require other recipe adjustments) was found to be an effective measure. ‘Substituting practices,’ in the form of replacing an omnivorous with a meat-free diet, will only be successful if the practice adequately satisfies the eating event’s social meanings. While overall, this dissertation found an encouraging trajectory towards more sustainable practices, some practices may be more difficult to substitute than others. In the case of restaurant visits or hosting guests, the meanings element of the eating practices and its association with meat will likely prevent such a direct substitution. The third empirical work further advances problem framing 6 (‘changing how practices interlock’): not only the synchronization and sequence of practices in time and space play a role, but practices may interlock through shared meanings. In this empirical work, eating practices were found to be so strongly linked to ways of ‘doing gender’ that these meanings may hamper sustainability transitions. Traditional gender stereotypes can be obstructive to gender and climate justice by tying men to meat and women to foodwork. I argue that to effect change which “ripples through interconnected practices,” (Spurling et al., 2013, p. 5), *gendered* meanings of cooking and eating have to be explicitly considered.

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Concluding, the findings show that some elements of dietary practices can pose obstacles to the widespread adoption of planetary-health diets, especially when eating practices serve a distinct social function. This type of ‘wicked’ policy problem (Rittel and Webber, 1973) demands “[...] multi-stakeholder, multi-issue approaches to intervention which aim, for example, to disrupt one or more practices or to substitute one element of a practice with another” (Warde et al., 2017, p. 32). Suggested practical implications of this research for sustainability action, targeting multiple elements of food consumption practices and necessarily involving multiple actors for implementation, are summarized in Table 4.

Table 4. Implications for elements of practice to shift to more sustainable eating

Meanings	Materials	Skills
<ul style="list-style-type: none"> • Link plant-focused dishes with notions of ‘specialness,’ in particular for social eating (hosting guests, eating out) • Deconstruct traditional gender stereotypes, obstructive to gender and climate justice, for omnivores and flexitarians 	<ul style="list-style-type: none"> • Offer attractive plant-focused dishes at restaurants, especially for flexitarians • Emphasize familiar meat-free meals for dietary transition • Expand access to affordable meat-replacement products 	<ul style="list-style-type: none"> • Expand plant-focused cooking skills for meat-heavy dieters • Transitions to more restrictive vegan diets require learning specific food skills

The meanings element of practices has proven to be of central importance to dietary sustainability transitions. As meanings shift with social occasion and site of consumption, a nuanced inclusion of the meanings of eating practices is necessary for effective sustainability strategies. A central challenge will be to break the problematic link of ‘social as special’ and ‘meat as special.’ Preparing food for oneself at home seems to give practitioners more freedom to live out their own lifestyle, independent of meanings attributed by others. Social occasions – hosting guests, eating out – link strongly to meanings best satisfied with meat. It is these established social practices sustainability campaigns need to focus on. Therefore, a central question for future research is: How can the meaning of meat be transferred to plant-focused dishes, especially in situations of social eating?

Further, the intersectionality of sustainability issues – human health, environmental sustainability, and gender equality – needs to be more explicitly considered, when studying food practices. Therefore, I argue for a more prominent role of gender in sustainable consumption research, integrating an ecofeminist perspective with practice-theoretical considerations. This can be achieved by considering which ‘meanings’ or stereotypically gendered components a practice includes and how making these practices more sustainable may affect gendered elements. This consideration is central in two regards: firstly, to prevent unthinkingly adding yet another burden on women through sustainability targets and secondly, to identify traditional gender stereotypes in practices that are obstructive to gender and climate justice.

Spurling et al. (2013) fittingly wrote: “Social change is about the *new* becoming *normal*—smoke-free pubs, wearing seatbelts, putting out the recycling. A practice perspective encourages us to imagine what the ‘new normal’ of everyday sustainability might look like—and suggests possible trajectories towards it” (p. 14). Regarding food practices, this *new normal* must include not only a shift away from the overconsumption of animal protein to stay within planetary boundaries, but also a transition towards equally shared responsibility for the *foodwork* necessary for consumption. Central institutions in a position to effect this change are restaurant owners and (celebrity) chefs, social media influencers in the food sphere, and governmental organizations. The latter shape not only who is responsible for food at home through the labor market, but also what is perceived to be an adequate reflection of ‘a good life’ through public food procurement and country-level statistics.

4.2 Limitations

Despite the importance of the theoretical contributions and practical implications of this dissertation, certain limitations need to be made explicit. A central aim of this work was to adequately capture and describe practices of eating quantitatively. While the studies were preceded by qualitative elements and included mixed-methods, in-depth qualitative exploration was not the central focus of this dissertation. As an important component of the ethnographic research toolkit, field-based observations (e.g., at restaurants) would have added even more depth and detail to the underlying themes found in this research.

Given the quantitative nature of this work, the reported behavior is, in all cases, a proxy of actual behavior. The survey study may further be affected by a social desirability bias, especially as the normativity of following a plant-based diet increases through advocacy in (social) media. In the context of researching pro-environmental behavior at the household level, Barr and Prillwitz (2013) qualify the risk of using behavioral proxies in survey research as follows: “while reported behaviour is not a strictly accurate measure of actual commitment, the differences between individuals are proportionate and so assumptions can be made with a degree of certainty concerning the relative commitments of different respondents” (p. 37). Since the central questions of this work focused on relative differences between food consumption practices at home and out of home, rather than absolute quantities, the results are likely less affected by the risks associated with using proxies.

In the study using data from an online recipe platform, groups with an affinity for technology may be overrepresented. Further, online behavior may not be reflective of ‘real world’ behavior. These risks are somewhat mitigated by the popularity of the platform used as a case study, with over half of the users rating more than one recipe each week. Triangulating results from multiple platforms could make these results more robust. Similarly, the survey data was gathered through a convenience sample, leading to an overrepresentation of certain groups, such as practitioners of sustainable diets. While this was useful in statistical analysis, as we were able to partition into large enough groups for each type of diet, the results are not representative for the German population.

Eating practices – as the results of this dissertation also demonstrate – are so multifaceted that an even more detailed distinction may be of value. Differentiating between types of dining (e.g., fast food versus fine dining), as well as paying tribute to the distinction between eating as part of work or private life, may add additional insights. A more nuanced examination may also be warranted for intersecting sustainability issues, such as race and class. While this research took gendered meanings of cooking and eating into account, an expansion beyond the gender dimension and the home setting represent important future extensions of this work.

4.3 Recommendations for future research

The findings and limitations of this dissertation lead to several recommendations for future research. Firstly, the following research question should be addressed: How can the meaning of meat be transferred to plant-based dishes, especially in situations of social eating? Secondly, practice-theoretical research may benefit from integrating quantitative methods into its toolkit, ultimately combining qualitative and quantitative strands into mixed-methods research.

The increasing use of digital technologies as part of our everyday practices poses a chance for practice-theoretical research to ‘scale-up’ using behavioral trace data (e.g., Ilieva and McPhearson, 2018; Trattner and Elsweiler, 2019). Digital traces make it possible not only to study the status quo but also to look into the past using historical data. This, in turn, fosters a much deeper understanding of the nature and pace of changes in practices and what drives them. Digital technology and, especially, online social media are an interesting medium to study food practices for another reason. Digitalization is transforming many of our daily practices. In the case of cultural goods, such as music consumption, digital technologies are de- and rematerializing core elements of the practice (Magaudda, 2011). While digital technologies cannot strip eating practices of their materiality, the involved skills, procurement of materials, and associated meanings can be affected.

Regarding the role of socially shared meanings in practice transitions, Liedtke et al. (2013) fittingly state: “routine practices are not likely to change as long as social costs of routines are low or even beneficial [...] Moral and social costs will rise when images and meanings in a social practice, associated with a product used in a practice, change to negative” (pp. 16-17). Platforms such as Facebook, Twitter, Instagram, or TikTok implicitly transport messages of these social costs. The currency of the social media world – ‘likes’ – may serve as an indicator of which practices are deemed socially desirable (Ballew et al., 2015). Given the importance of meanings and social norms in linking meat with certain eating occasions, social media may be an impactful force driving changes in practices. A first practice-theoretical study exploring the role of digital technologies in vegan eating practices emphasizes the role of communities to

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allow practices to be shared (Lawo et al., 2020). Food ‘influencers,’ such as Jamie Oliver¹⁵, may play a central role in shaping our shared understanding of practices. Social media, in general, and influencer personalities, in particular, may therefore be an interesting avenue of research to shed light on the question of how the meaning of meat can be transferred to plant-based dishes. Unlike a technocentric view often found to dominate much conventional consumption research and policy, this lens focuses on technology’s role in *transforming* practices rather than making *existing* behavior ecologically viable through technological efficiency gains.

The impacts of household practices can vary widely depending on the scope set for the study. The contribution of household practices to national GHG footprints can only become clear, if system boundaries acknowledge the intricate links of local and global markets. In their research on the environmental pressures of household consumption, Ivanova et al. (2016) note that a “significant fraction of household footprints in the developed world depends on impacts embodied in imports from poorer countries” (p. 534). Accounting for domestic and foreign impacts at the place of final consumption ensures that the responsibility for the impact of household practices is not shifted to the world’s poorest countries. This link between LCA studies and environmental social science is crucial in setting a scope that correctly identifies key leverage points to effect change.

On a theoretical level, practice-theoretical studies should take multiple systems of oppression into account as they may hinder trajectories towards sustainable consumption for all. Race, class, and gender can shape not only access to material infrastructure and skills but also – less visibly – the meanings of practices. In their book *Pressure Cooker: Why Home Cooking Won’t Solve Our Problems and What We Can Do About It*, Bowen et al. (2019), for example, question the narrative of the home-cooked meal as the solution to obesity, unhealthy diets, and environmental pressures. They point out that our romantic view of the family meal leaves many inequalities unconsidered. In interviews about the research, Bowen states, “Romantic depictions of cooking assume that everyone has a home, that family members are home eating at the same time, and that kitchens and dining spaces are equipped and safe. This is not necessarily the case for the families we met” (Kliff, 2015). Aside from socio-economic disadvantages, she further elaborates on issues of gender: “[...] we need to uncouple the ‘package deal’ that links good mothering with preparing wholesome family dinners from scratch” (Elliot, 2014). This is not only problematic in everyday life but also an issue related to the focus of sustainable consumption research. The focus, as in this dissertation, is mostly on households and their (un)sustainable practices. The pressure to solve the imminent climate crisis is thereby also put on ordinary people and their everyday lives. In the case of food consumption at the household level, the people responsible are mostly women. Theories of practice alleviate this pressure in that they include the broader institutional context that shapes

¹⁵ At the time of writing, Jamie Oliver had 7.2 million followers on Facebook and 8.3 million followers on Instagram (<https://facebook.com/jamieoliver/>; <https://instagram.com/jamieoliver/>, accessed 30 Sept 2020)

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skills, materials, and meanings. However, I suggest future research on sustainable food consumption to shift its lens to a higher level: from household to institutional practices. The role of firms and industry has so far received little attention in studies of agro-food transitions (El Bilali, 2019). An explicit focus on institutional practices – for example, asking how companies and governmental organizations might shift their internal food-related practices – is significant in that implemented changes can scale to many practitioners at once and meanings are often shaped by institutional contexts.

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Rising adoption and retention of meat-free diets in online recipe data

Yuki M. Asano ^{1,3} and Gesa Biermann ^{2,3*}

The current and growing demand for animal protein exerts immense pressure on the environment through diverse effects such as land-use change, water use and greenhouse gas emissions. Curbing meat demand by transitioning to largely plant-based diets is key to increasing food system sustainability. In this study, we investigate dietary transitions by analysing a dataset of over 240,000 recipes with 2.5 million user ratings from the most popular German recipe website. We find an increase in the vegetarian and vegan recipes submitted, with annual growth rates of 16% and 3.5%, respectively. We further detect a consistent relative increase in the number of users switching to these diets and maintaining them over the last 8 years. We show that the transition is eased by initially switching to vegetarian diets that resemble meat-based ones in their ingredient makeup. These findings are corroborated by qualitative interviews with users who have recently switched diets. Our results demonstrate the application of recipe metadata to determine individuals' dietary choices and large-scale food trends, and identify pathways to a more sustainable food system.

Agriculture and food production are one of the main drivers of environmental change in the Anthropocene¹. This sector currently contributes over a quarter of global greenhouse gas (GHG) emissions^{2–4}. Livestock, specifically, plays a key role: while it makes up approximately 15% of all human-induced GHG emissions, it is responsible for almost half (44%) of methane emissions⁵ and contributes an estimated 80% to total agricultural GHG emissions⁶. Animal husbandry is furthermore responsible for 70% of global deforestation due to increased demand for animal feed⁷, putting immense pressure on biodiversity. It is estimated that 30% of biodiversity loss is due to animal husbandry, mainly caused by changes in land-use⁸. The combined effect of population growth and a shift towards consuming more animal protein in developing countries will further increase pressure on our food system in the future^{3,9}. While most efforts to close this impending food gap focus on increasing production, the issue needs to be addressed from the consumption side also^{10–12}.

Definitions of what a 'sustainable diet' consists of are context-specific and debated in the scientific community. A recent study¹³ suggests that cutting the consumption of meat, dairy products and eggs in the European Union by half would result in a reduction of 25–40% in GHG-related emissions of food production. Sustainable diets for the German context of this study are defined as including little or no animal products, as in vegetarian (devoid of flesh foods, such as meat and fish) and vegan diets (further excluding eggs and dairy products and may exclude honey)^{14,15}. To map out potential pathways to these goals, it is vital to understand how and when people adopt these more sustainable diets.

Online resources for cooking inspiration are increasingly supplementing traditional sources, such as ideas from family and friends or printed cookbooks¹⁶. In Germany, this trend is especially pronounced among millennials (born between 1980 and 1995): 76% name the internet as a source for cooking inspiration, more than any other source¹⁷. Online recipes are an increasingly insightful avenue to study people's diets¹⁸. Using behavioural data from recipe platforms avoids the limitations of other sustainable

food consumption study designs, such as the reactivity of using food diaries, the small scale of direct observations and the value-action gap (differences between what consumers state as consumption preferences and their actual behaviour) often found in survey-based research^{14,19–21}.

Until now, research at the intersection of online behaviour and food has focused mostly on the aspect of health²². Previous studies have correlated online behavioural data and the occurrence of diet-related illness in the population^{23–27} and described food trends and meals (regional cuisine and ingredient combinations)^{28–32}. In the context of recipe site use, research has focused on improving recommender algorithms³³ and on increasing the healthiness of recipes chosen^{34–38}. On the side of recipe production, studies have found temporal patterns in recipe uploads and have been able to predict recipe uploads using socio-demographic factors³⁹. Analysing big data from online behaviour with regard to sustainability topics generally, and the environmental impact of the food system more specifically, is in its infancy²¹.

To reduce this research gap, our study assesses how sustainable food consumption trends are evolving, quantifies which diets users are taking up or abandoning on an individual level, and investigates which factors ease the transition towards meat-free diets. For this, we collected and analysed data from the most popular German recipe sharing platform with over 240,000 recipes and data spanning more than a decade (see Methods).

Results

The share of vegan and vegetarian recipes rises. The recipe site allows users to upload recipes using a web form that includes a recipe title, tags (for example, 'vegan', 'dessert', 'Thai'), ingredients and amounts per portion, preparation instructions, difficulty level, calories, time needed and images. Recipes can have multiple tags; 99.97% of recipes contain at least one tag. Further elements guiding users in their choice of recipe are recipe ratings (1–5 stars), total number of recipe ratings and user comments. The summary statistics of the dataset are given in the Supplementary Information.

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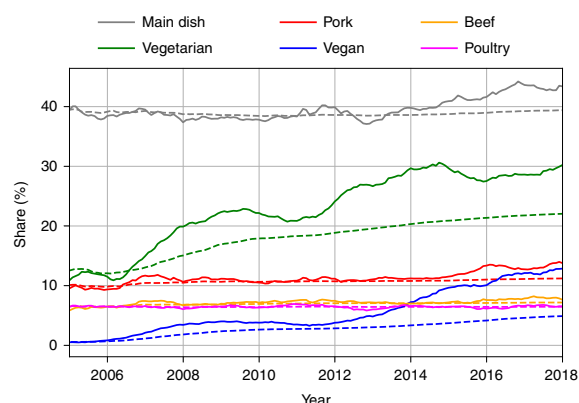


Fig. 1 | Share of submitted recipes containing different tags from 2005 to 2018 as a time series. Dashed lines present total shares of tags on the platform, solid lines show submission shares per tag. Curves are smoothed using a 12-month moving average. Percentages do not add up to 100% as recipes can have multiple tags.

First, we analyse the temporal patterns of newly published recipes for five different recipe tags. The tags were selected to reflect plant- or meat-centric diets and thereby serve as proxies for higher or lower levels of sustainability: ‘pork’, ‘beef’, ‘poultry’, ‘vegetarian’ and ‘vegan’ (translated from German). The tag ‘main dish’ serves as a baseline, as it is the most popular tag over the time period. In Fig. 1, we show the monthly evolution of the share of submitted recipes per tag and the share of recipes present on the platform against time. From Fig. 1, we find the recipe submission shares to be highly dynamic: the share of vegan recipe submissions rose from 1.2% to 13.5% and the vegetarian one from 17% to 30%, amounting to compound annual growth rates of 16% and 3.5% respectively. Compared to their current total shares on the site, submission shares are almost three times as high for vegan (14% versus 5%) and just short of a third higher for vegetarian recipes (30% versus 22%). Evidently, the current platform offering and the submission trends for these sustainable diets are in disequilibrium. The gap between submission share and platform share shows by how much the different tags need to ‘catch-up’ to meet the present perceived interest driven by recipe authors.

While these findings shed light on production trends, as reflected in recipe submission data, they do not inform about individual consumption choices. For this, we increase the granularity and consider the changes in diets of individual users.

Users increasingly adopt and maintain sustainable diets. This section is on the basis of data of users engaging in rating recipes (1–5 stars) of certain tags. We restrict the data used for this analysis to users that have rated more than ten recipes to exclude extremely short histories without much informational depth (see Methods). To analyse changes in individual behaviour, we define two rates for any given tag: the infection rate, defined as the probability of an individual switching to consuming a high proportion of a certain tag τ , and the retention rate, as the probability of a user ‘sticking’ with their dietary choice, as defined by consistently rating recipes with tag τ . We further correct these rates using a null model that accounts for the different number of recipes in the different tags (see Methods).

Firstly, we find that tags have a higher retention and infection rate than random (that is, the corrected rates are higher than 0). This is in line with the results of previous studies that found recipe choices to be non-random for an Austrian recipe website⁴⁰. Secondly, the infection and retention rates do not correspond one-to-one with

the share of submitted recipes in Fig. 1: For example, the share of submitted recipes for the tag ‘roast’ is constant but the retention rate is declining. Finally, both rates are dynamic: most notably, the infection rate of ‘vegetarian’ and the retention rate of ‘vegan’ rise remarkably, while for meats (tags: ‘pork’, ‘poultry’ and ‘roast’) retention is low and declining (see Fig. 2). Given our definitions of the two rates, we can calculate the equilibrium proportion of users who eat vegetarian or vegan at a given point in time (see Methods). For the vegetarian diet, the equilibrium proportions are 6.9% for 2015 and 8.4% for 2018 and for vegan 1.5% in 2018, which correspond well with the numbers from population-wide surveys conducted in Germany for the given years of 6.5%, 7.6% and 1.2%, respectively⁴¹.

To analyse whether these changes in the infection and retention rate are caused by changes in user behaviour or are only driven by the specifics of the recipes, we corrected for variables (such as the number of recipes and average rating) to see if a significant time trend exists (see Methods). The regression results are given in Table 1 (full results in the Supplementary Information).

Regressing for the corrected retention rate, we find linear models including fixed effects for tags to perform much better (adjusted $R^2=0.77$) than when only including control variables (adjusted $R^2=0.41$). This means that retention rates cannot be explained simply by the control variables, such as the number of recipes or the average recipe preparation time but, instead, tag-specific characteristics exist. Furthermore, from model (1) in Table 1, the coefficients for both the ‘vegan’ and ‘vegetarian’ tags are positive and significant. These values are also higher than that of the tag ‘main dish’ (see Supplementary Information), showing that significantly more users uphold sustainable diets compared to other tags. Finally, including a linear, tag-specific time trend further improves the model: we find a significant positive linear trend in the corrected retention rate for vegan recipes. This trend is robust and even increases when including the control variables. Indeed, we find a yearly increase in the retention rate of around 3 percentage points explained by outside variables, such as food trends and changing attitudes (see Supplementary Information).

For the regressed infection rates we find that the basic model (0) using only the control variables is already precise. This means that the infection rate is well explained by the control variables such as the number of tags available in a specific tag. This is unsurprising, as the infection rate (first try of a recipe of a certain tag) is more dependent on the website’s layout than is the retention rate. Including tags and a time trend again improves the model: we find a significant positive trend for vegan and vegetarian dishes, indicating a rise in the uptake of these diets.

To gauge the scale of dietary behaviour changes, we identified the number of users that have completed dietary behaviour transitions, given different thresholds (Fig. 3a,b). Here, ‘adopt’ refers to the number of users starting below a given threshold share θ of recipes of a certain tag and ending at above $1-\theta$. Similarly, ‘discontinue’ refers to the number of users starting above $1-\theta$ and ending below θ . Compared to the rates defined earlier, this presents a more extreme transition, as we further limited the starting range.

Many users completely changed their diet, even at $\theta=10\%$ (that is, a switch from $<10\%$ to $>90\%$). Ratios exceeding 1.0 (that is, the dark grey bar is taller than the light grey one) indicate that people are more likely to adopt a certain type of diet rather than move away from it. The transition ratios are highest among all recipe tags for ‘vegan’ and ‘vegetarian’ (see Supplementary Information). In contrast, the use of recipes tagged ‘pork’ or ‘main dish’ is discontinued or kept constant. We note that our analysis is not biased by a phase of ‘initial exploration’ of users trying different recipes, as we excluded the first ten recipes rated. This further corroborates the findings from the longitudinal analysis: that even for a more restrictive definition of behavioural change, we find vegan and vegetarian diets gaining in popularity and retention.

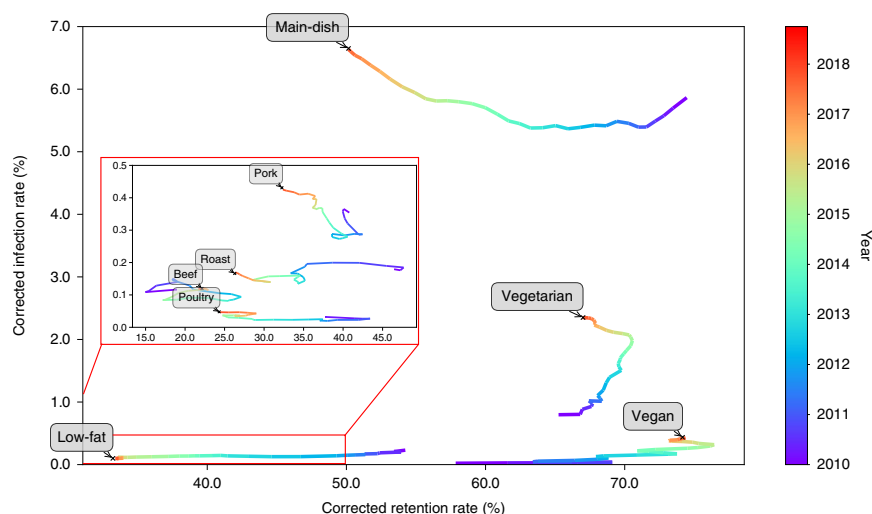


Fig. 2 | Infection and retention rate trajectories for selected tags. Colours indicate the change over time. The inlay shows a close-up of meat-related tags.

Table 1 | Ordinary least-squares regression results

	tag		tag × time		adj. R^2
	vgn	vgt	vgn × t	vgt × t	
Retention					
(0)					0.41
(1)	0.70***	0.68***			0.77
(2)	0.63***	0.68***	0.15***	0.016	0.86
(3)	2.3	1.5	0.24***	0.056	0.86
Infection					
(0)					0.86
(1)	0.022***	0.016***			0.99
(2)	0.00	0.01***	0.005***	0.02***	0.99
(3)	-0.01**	-0.02**	0.004***	0.02***	0.99

'vgn', vegan; 'vgt', vegetarian. The models considered are: (0), only control variables; (1), only fixed effects of tags (the tag 'main dish' is the baseline); (2), model (1) and also including linear time trend; (3), model (2) and also including controls. Statistical significance is indicated by stars (*): ** $P < 0.05$; *** $P < 0.01$. Adjusted (adj.) R^2 is given by penalizing the goodness-of-fit value R^2 by the number of parameters included³⁹. Only regression coefficients and P values for the 'vegan' and 'vegetarian' tags are shown.

Lastly, we explore in more detail example journeys of users who have started such a dietary transition. One user started out with recipes such as 'horse pot roast' or 'fried mushrooms with bacon and onion' and ended with 'low-carb mushroom pan' and 'vegan remoulade'. Another user started with several chicken breast-based recipes and ended with recipes such as 'vegan soy-cheese', 'marinated tofu' and 'falafels from fresh chickpeas'. To better understand what might be enabling these dietary changes, we analyse the recipes most often rated during dietary transitions.

Meat-substitution facilitates dietary change. To better understand initial shifts towards more restrictive diets, we focus on users who have transitioned from an omnivorous to a vegetarian diet, as indicated by their rating behaviour. We expect the 'transition recipes' to be more like recipes containing meat than the average vegetarian

recipe, as they may use a similar ingredient makeup but include replacement products for meat-based items. The distance measure used is the number of differing ingredients between two recipes, referred to as 'hamming' distance (see Methods).

Transition recipes have more meat-containing neighbour recipes (recipes that differ only by a few ingredients), than the average vegetarian recipe (see Fig. 4). One such example is the 'zucchini-patty', whose closest meat-based neighbours include recipes such as 'burger patty' and 'fresh patty with minced pork'. This substitution effect is only present for recipes during the transition phase, as afterwards the recipes are as close to meat-based ones as regular vegetarian recipes (further details in the Supplementary Information). This finding suggests that substituting meat helps to successfully initiate a vegetarian diet but is less relevant for maintaining it.

Nutritional knowledge facilitates dietary transition. To gain in-depth insights into the mechanisms of these extreme dietary changes, we identified users of the platform who underwent a transition and invited them to an interview. The interview questions focused on reasons for dietary change (initial and current) and the (potential) use of the recipe platform during dietary transition (see Methods). The participants are referred to as P1–P10.

Initial reasons for changing to a vegetarian diet most often focused on animal welfare ($n=7$). Only two participants named health aspects (weight loss and food intolerances) as their main motivation. However, when asked about current reasons for keeping up their new diet, participants named more factors that they had become aware of in the meantime, such as environmental effects of meat consumption ($n=5$), monetary savings ($n=3$), distaste for meat after not having eaten it for a while ($n=3$), and the relation of meat to inequality and world hunger ($n=2$).

Most (7 of 10) named gaining knowledge about how to replace animal-based ingredients as a central skill when transitioning towards a vegetarian or vegan diet. During the transition, especially from omnivorous to vegetarian, many users stated that they were cooking recipes that were similar to the ones they were already familiar with. One interviewee stated: 'At the beginning of my vegetarian diet, the dishes were almost one-to-one what I had already eaten as an omnivore, only without meat. But then you become more experimental in the course of time' (P1). Six users also explicitly

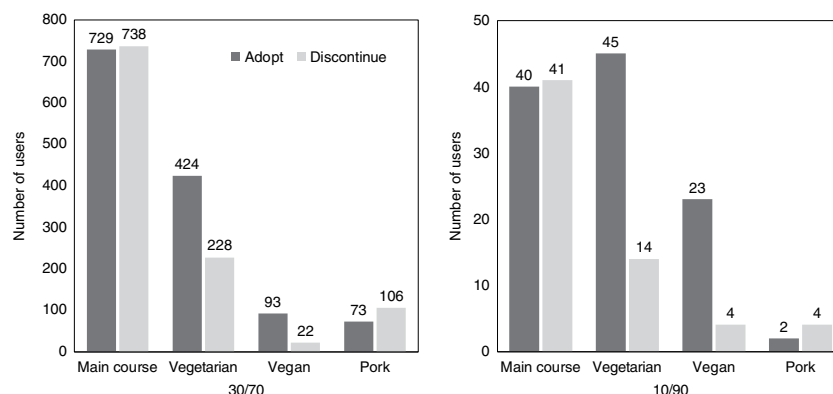


Fig. 3 | Occurrences of extreme user behaviour transitions. Axis labels 30/70 and 10/90 refer to transitions from rating, for example, 30% or less recipes of a given tag and ending with a share of 70% or more. The values for 'adopt' and 'discontinue' are the number of users who take up or abandon diets described by a given tag. A full table with the most popular 50 tags is given in the Supplementary Information.

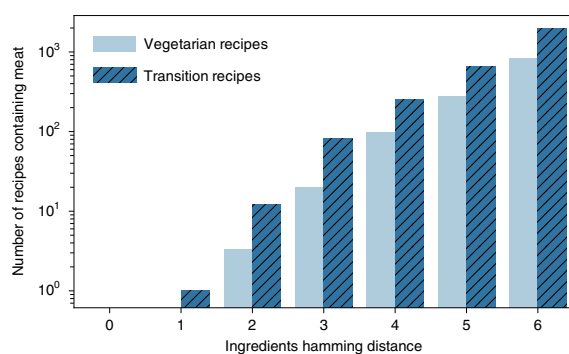


Fig. 4 | Closeness to meat-containing recipes in the ingredient space. The number of neighbouring meat-containing recipes as a function of hamming distance is shown. For the transition recipes, the top 200 recipes by occurrence during the transition period (five recipes before and three after crossing the 50% midline) are shown. For the vegetarian recipes, a Monte-Carlo estimate of 20 samples with the same number of random vegetarian recipes, excluding the selected transition recipes, is used.

mentioned that offering already familiar recipes, but in a vegetarian or vegan version, would ease the transition to these diets. While leaving out or replacing meat or fish components of recipes is a simple adjustment, users in transition to a more restrictive vegan diet stated that more knowledge was necessary. One interviewee termed this 'veganizing' recipes (P2), that is, replacing traditional animal-based products with alternatives (for example, exchanging eggs for flaxseed). Once these skills are acquired, more options become available again, as one vegan interviewee put it: 'I'll search specifically for meatless recipes, but not vegan ones, because I've learned how to replace dairy and don't need to restrict the recipe search anymore' (P3).

Discussion

Transitions to more sustainable diets are a central component of environmental protection. The dynamics of this transition, however, need to be better understood, to support behavioural change effectively. To the best of our knowledge, this work is the first to investigate online recipe production and use from the viewpoint

of sustainable (healthy and environmentally friendly) diets. Recipe platforms play an increasingly important role, not only in guiding choices⁴² but also as a source of behavioural data. In this study, we analysed a dataset of over 240,000 recipes and 2.5 million user ratings from the most frequently used German recipe site. The results show that vegetarian and vegan recipes have grown, both in terms of offering and use. Recipe authors are rapidly increasing the number of vegetarian and vegan recipes on the platform, with current submission rates of 14% vegan and 30% vegetarian recipes. Current market dynamics in Germany reflect this finding but show a stronger trend for vegan products: in 2016, 13% of newly introduced products were vegan and 7% vegetarian; rising from 1% and 3% in 2012, respectively⁴¹. We find a significant increase in users starting vegetarian and maintaining vegan diets, which cannot be explained solely by the increased offering on the website. Comparing this to the current dietary habits of the German population, both vegetarianism and veganism are growing. The number of vegetarians grew from 6.5% in 2015 to 7.6% in 2018⁴¹, while veganism increased from 0.01% in 2008 to 1.6% in 2016⁴³. Therefore, both recipe offerings on the platform analysed in this study and product offerings on the German market are changing more than consumer habits. Due to the increase on the supply side, especially for vegan products, we expect the trend of an increasing uptake rate of sustainable diets to continue.

A recent study proposed a scenario of ambitious dietary change to limit projected environmental pressures by the food system to the planetary-boundary range⁴⁴, including a flexitarian diet with a maximum of 300 g of meat per week⁴⁵. The current average meat consumption of Germans is much higher at 1.5 kg per week, which is also twice as high as the recommendation of the German Nutrition Society^{46,47}. If a part of society was to keep this habit, a proportion of 75% non-meat-eaters would be necessary to reach the goal of 300 g per week for the total population. However, even if we extrapolate the trends we found, we would reach at most 32% non-meat-eaters by 2030 (see Methods, equations (6) and (7)), falling short by about 35 million people. This shows that the current speed of change will not suffice to reach this goal.

Our findings support the hypothesis of earlier research that replicating an already familiar experience in terms of taste, texture or look makes a shift in diets easier¹⁰. Previous studies have used recipe recommender systems to 'nudge' users towards healthier options³⁴. Similarly, we propose to use recommender algorithms to suggest familiar, yet environmentally friendlier, options to users. Our

findings show that suggested options need to closely resemble already known recipes in their ingredient makeup to qualify as replacement options. However, previous research finds that meat-substitutes face a number of challenges (for example, product unfamiliarity and lower perceived quality) and may not be equally well received by all customer groups^{48,49}. The authors of these studies suggest targeting the segment of ‘meat reducers’, specifically, and using the attributes ‘health’ and ‘convenience’ as central arguments for meat-replacement products. Further, the willingness of key people, such as recipe site managers, to put recommender systems for sustainable recipes into practice remains an open question.

The findings of our qualitative analysis suggest that knowledge about replacement products can help users transition to a vegetarian or vegan diet. However, providing knowledge to induce behaviour change follows a rational choice paradigm and has shown mixed results in terms of effectiveness in inducing pro-environmental food choices in previous studies⁵⁰. Dual-process models expand this approach by targeting deliberate, rational choices as well as automatic decisions to effectively change behaviour⁵¹. Applying this to the recipe platform, a recipe search could, as a first step, recommend vegetarian options similar to meat-containing neighbours and, if a meat-containing recipe is chosen nonetheless, suggest replacement ingredients. Suggesting replacement ingredients for animal-based ingredients would, at the same time, expand the offering of recipes available to vegetarian and vegan users.

Despite the importance of these findings, our approach is limited by the use of proxies for sustainable diets (the user-generated tags ‘vegetarian’ and ‘vegan’). Furthermore, behavioural data from online platforms may be affected by a sampling bias, over-representing wealthy and young groups, with a stronger affinity for technology⁵². This effect is especially important as we only consider a single platform and might be exacerbated in the small sample for our qualitative study. Online behaviour may also only represent the behaviour of a specific ‘active’ user group. In our data, the number of ratings received is highly correlated with the number of prints and number of views of a recipe (Pearson correlation coefficient 0.85 and 0.82 with $P < 0.01$). We believe our findings are likely to be transferable to a broader set of users of the platform who do not have an account and therefore can only view or print recipes but not rate them. Finally, online behaviour may not be reflective of offline behaviour. For our transition analysis (Fig. 2), we find that more than 50% of users have rated more than one recipe per week. Therefore, while our data do not give details on daily food choices, the sampling frequency is high enough to detect changes in routine behaviour accurately.

Future research at the intersection of online behaviour and sustainable diets should explore the environmental and health aspects of recipe contents in more detail by, for example, linking ingredient lists with carbon footprint and nutritional data (such as, calories, fat and salt). Analysis of large-scale online behavioural data has proved useful in understanding dietary trends and individual choices. Our findings show that bottom-up innovation (both from recipe authors and users) is driving the trend towards less animal-product-centric diets. However, our results also suggest that top-down policy approaches are nonetheless essential for the environmental effects of the food system to stay within planetary boundaries.

Methods

Data. The online platform analysed (chefkoch.de) is the tenth most visited website in Germany and seventh among the most popular mobile offerings by net reach, with 17.7 million unique users in July 2018 (around 21% of the German population)^{53–55}, thereby providing unique access to eating patterns in Germany.

The recipe data were extracted using the website’s application programming interface (API) in March 2018, after email communication with the company about using the data for research. The usage data were extracted using a web crawler. We made sure to respect robots.txt and to only impose a minimal load on the platform during our crawl. The platform comprises over 240,000 recipes since

the year 2000 and more than 2,499,547 unique ratings since November 2005. The dataset provides detailed information on recipes, such as a list of ingredients and serving sizes and preparation instructions, and tags such as ‘main dish’, ‘dessert’ or ‘vegan’. Furthermore, metadata on recipe popularity—the number of votes, prints, views and saves, as well as average rating scores from 1 (worst) to 5 (best)—are available. In a mixed-methods approach⁵⁵, we complemented this dataset with qualitative interviews of selected users, to gain insights into underlying reasons for behavioural shifts, which we identified on the platform.

Microdynamic rates. To analyse the ‘infection’ (uptake) and ‘retention’ (continuation) of vegetarian and vegan diets, we denoted the moving average proportion of recipes rated as m and the threshold proportion as θ . A ‘high’ proportion is given when $m > 1 - \theta$. The infection rate i_t of tag τ is specified as

$$i_t(\theta) = \frac{n(m_\tau^{t-\text{start}} < \theta | m_\tau^{t-\text{end}} > 1 - \theta)}{n(m_\tau^{t-\text{start}} < \theta)} \quad (1)$$

where t is the time and n is the number of users satisfying this criterion. Similarly, the retention rate is defined as

$$r_t(\theta) = \frac{n(m_\tau^{t-\text{start}} > 1 - \theta | m_\tau^{t-\text{end}} > 1 - \theta)}{n(m_\tau^{t-\text{start}} > 1 - \theta)} \quad (2)$$

which describes the probability of a user ‘sticking’ with his or her dietary choice, defined as consistently rating recipes of a certain tag. The different rates are shown in a schematic in Fig. 5 in the Supplementary Information. We achieved a longitudinal study design by varying t_{end} , allowing us to trace the evolution of these rates with time. Both rates were corrected by subtracting the rates we obtained from a null model, in which each user chooses a recipe randomly. This allowed us to remove the effect of users choosing recipes only due to their relative occurrence. Given this model and the binomial cumulative distribution function, both the infection and retention were corrected as

$$i_t^{\text{corr}}(\theta) = i_t(\theta) - \left(1 - \sum_{i=0}^k \binom{n}{i} (1-p_\tau)^i p_\tau^{n-i} \right) \quad (3)$$

$$r_t^{\text{corr}}(\theta) = r_t(\theta) - \left(1 - \sum_{i=0}^k \binom{n}{i} p_\tau^i (1-p_\tau)^{n-i} \right) \quad (4)$$

with p_τ representing the proportion of recipes of tag τ . Note that $k = \lceil \theta n \rceil$ and with $\lceil \cdot \rceil$ being the next largest integer, defines the number of necessary ‘hits’ given a moving average of n . For the analysis presented in the main text, we set $n = 5$ and $\theta = 0.25$. We restrict the data used for this analysis to users who had rated more than ten recipes to exclude extremely short histories without much informational depth. We are left with $N = 46,524$ users that constitute 65% of the total ratings.

Equilibrium numbers. We write the number of users that consume tag τ as u_t , and the overall user base size to be u . We assume u stays constant. The difference equation is

$$u_t(t+1) = ru_t(t) + i(u(t) - u_t(t)) \quad (5)$$

To find the equilibrium, we require $u_t(t+1) = u_t(t)$, and we find

$$u_t^* = \frac{i}{1-r+i} u \quad (6)$$

Linear time-trend analysis. The changes in the infection and retention rates were further analysed to understand whether they are caused by changes in user behaviour or are driven by the recipe characteristics. For this analysis, we conducted an ordinary least-squares (OLS) regression, with

$$q \sim (\text{controls} + \text{tag}_{\text{dummy}} + \text{tag}_{\text{dummy}} \times \text{time}) \quad (7)$$

where q is the corrected infection or retention rate. For the OLS fit we used separate models to regress the rates on a quarterly basis for the top 50 tags since 2010 (to ensure the existence of tags). The control variables for each tag are: the number of recipes, the average rating of recipes, the share of recipes of that tag that are in the top 90th percentile of all recipes by number of ratings and the average preparation time. The full regression coefficients for all models are given in the Supplementary Information.

Qualitative study. We identified users who underwent extreme transitions in behaviour, from rating a maximum of 10% vegan or vegetarian recipes to more than 90%, and contacted 42 of 104, who had filled out their profile, through the

platform. We explained the goal of our study in a personal message and asked them to reply if they were interested in an interview. The subjects then gave extra informed oral consent to participate at the beginning of the interview. The study protocol follows the International Sociological Association (ISA) code of ethics. In total, ten semi-structured interviews were conducted, six by telephone (average duration 16 min) and four by email. The respondents included nine females and one male. Of the interviewees, one was semi-vegetarian/flexitarian (occasional consumption of meat), one vegetarian, one in transition from vegetarian to vegan and seven had already transitioned to an at-least 90% vegan diet. All interviewed users had been using the recipe platform for many years and in each case our method correctly identified the change in diet. The interview script focused on initial and current reasons for dietary changes ('What was your motivation to change your eating habits? Has this motivation changed over time?'), the use of the online recipe platform during the transition phase ('Did the platform play a role in your transition? If yes, how?') and ideas for easing this transition ('How could users of the platform be better supported in their transition?'). The interviews were analysed using qualitative content analysis⁴⁶.

Substitution analysis. To analyse the relative 'closeness' of recipes rated during the transition phase to meat-containing recipes, we compared their ingredient composition. For this we created a BallTree structure⁵⁷ using the 3,569-dimensional binary ingredients vectors for the meat-containing recipes. This allowed us to quickly identify meat-containing recipes that are 'similar'; that is, have only a few ingredients added or removed from any given input recipe. We quantify the distance of two recipes A and B using the hamming distance⁵⁸; the number of changes in ingredients necessary to get from A to B. It is defined as the sum of removing and adding ingredients; thus, exchanging one ingredient for another is expressed as a hamming distance of 2. This measure on the ingredients space has the advantage of being easy to interpret, whereas the cosine similarity and the equivalent Jaccard Index measure lack this ease. As the last metrics divide by the lengths of the vectors, they automatically yield higher similarities for recipes that contain more ingredients, which can be unintuitive. For the transition recipes, the top 200 recipes by occurrence in the transition period (five recipes before and three after crossing the 50% midline) were part of the analysis. For the vegetarian recipes, a Monte-Carlo estimate of 20 samples with the same number of random vegetarian recipes, excluding the selected transition recipes, was used. We further removed recipes containing fewer ingredients than the maximum hamming distance they were plotted against.

Data availability

Recipe data developed for the analyses and visualizations in this manuscript are available from the authors upon reasonable request.

Code availability

The Python notebooks developed for the analyses and visualizations in this manuscript are available from the authors upon reasonable request.

Received: 8 February 2019; Accepted: 21 May 2019;

Published online: 01 July 2019

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Acknowledgements

The authors thank L. Biermann for his support. Y.M.A. is funded by the EPSRC Centre for Doctoral Training in Autonomous Intelligent Machines & Systems (EP/L015897/1).

Author contributions

Y.M.A. and G.B. jointly conceived the study and analysed the data. Y.M.A. and G.B. both interpreted the results, wrote the paper and approved the submitted version.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information is available for this paper at <https://doi.org/10.1038/s41893-019-0316-0>.

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Supplementary Information:

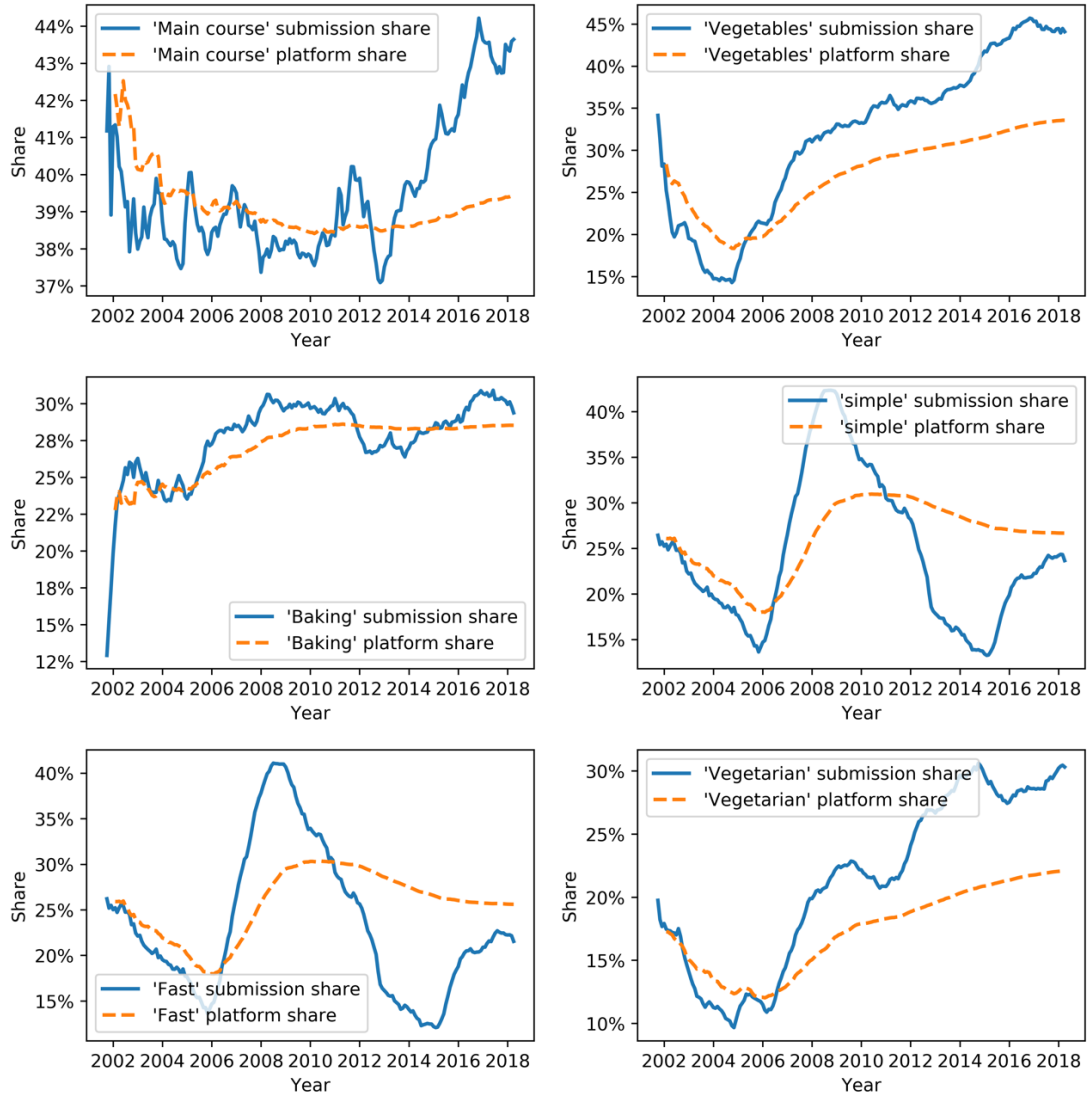
Rising Adoption and Retention of Meat-Free Diets in
Online Recipe Data

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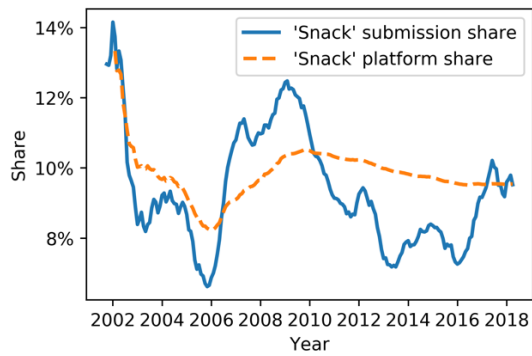
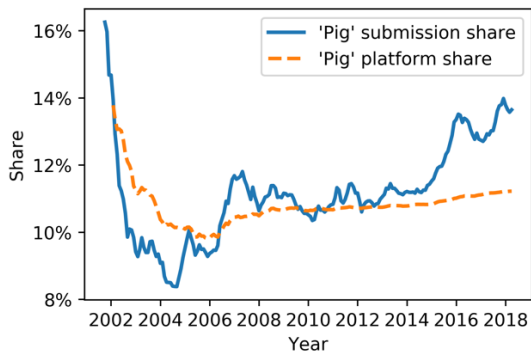
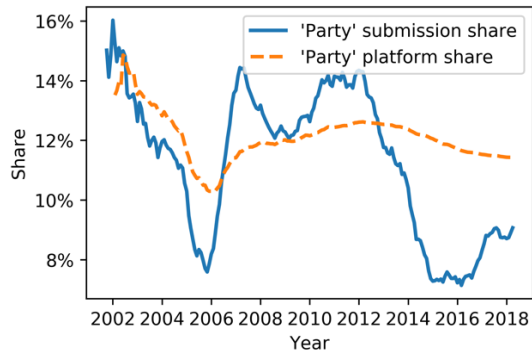
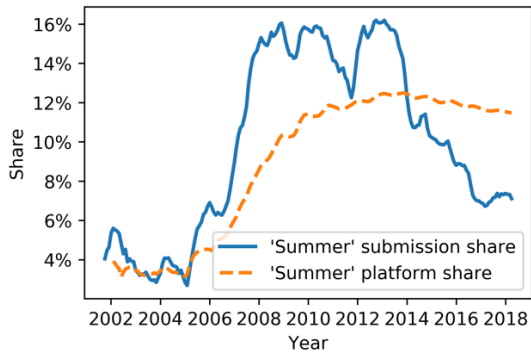
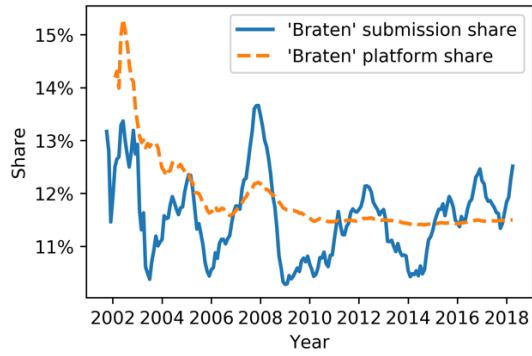
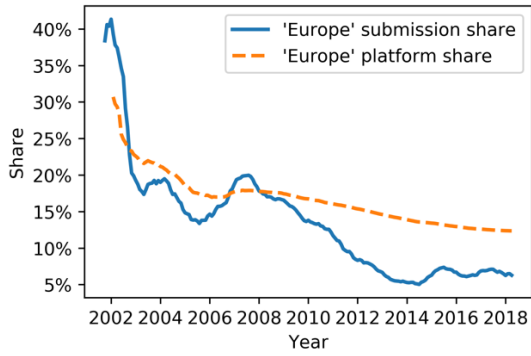
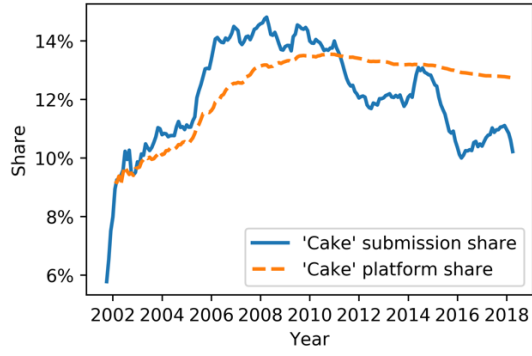
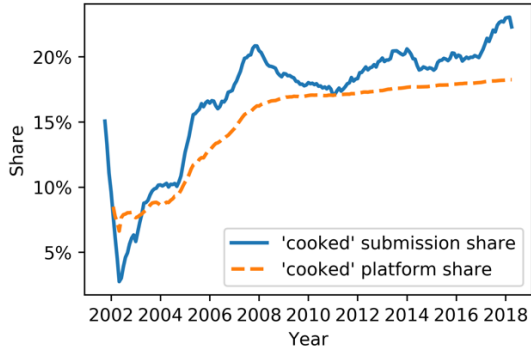
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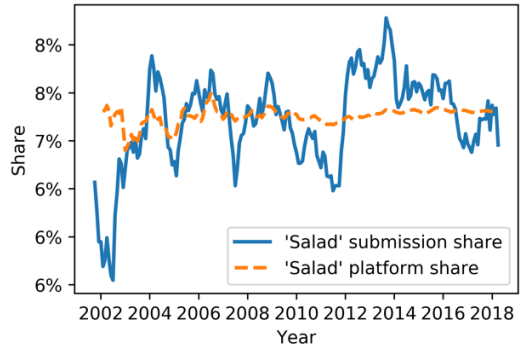
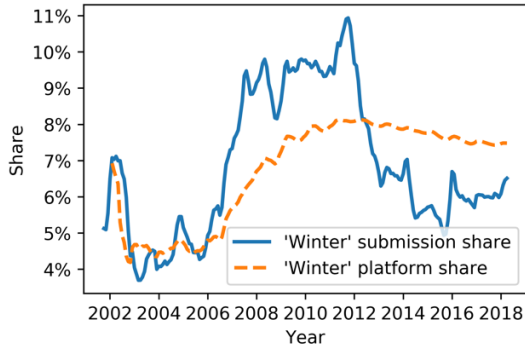
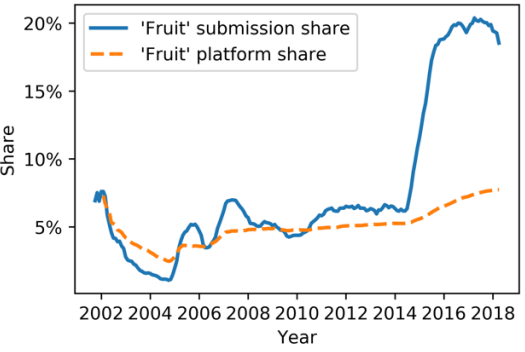
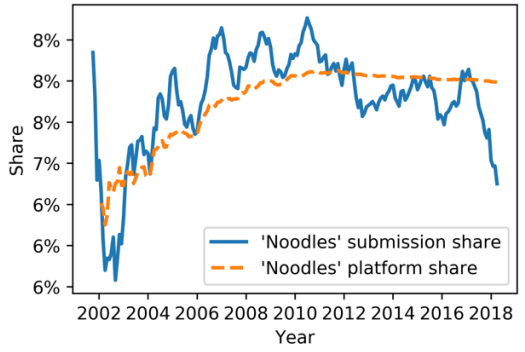
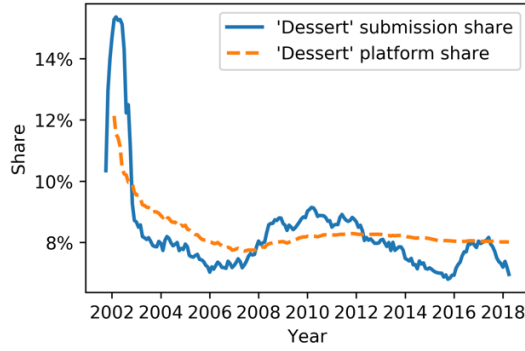
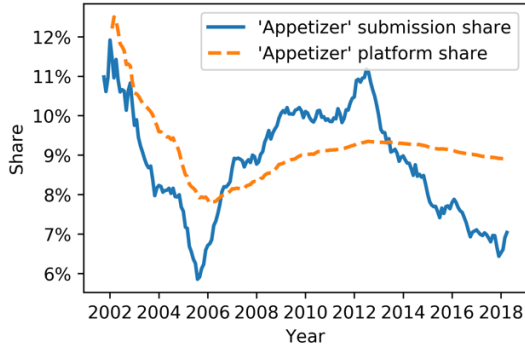
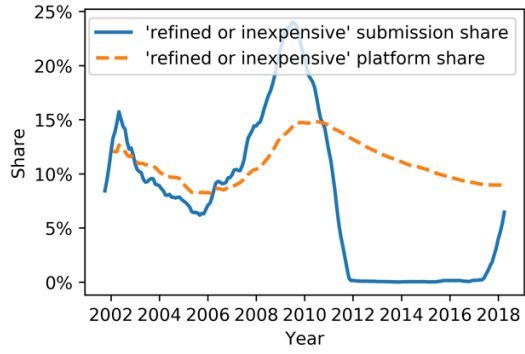
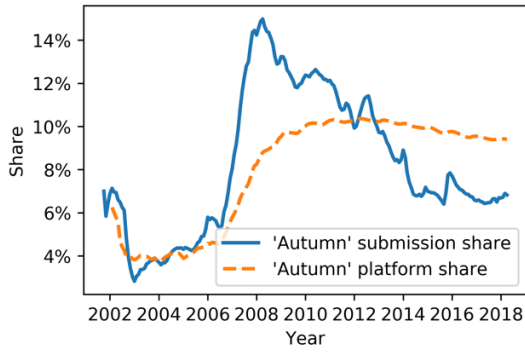
Submission and platform shares against time



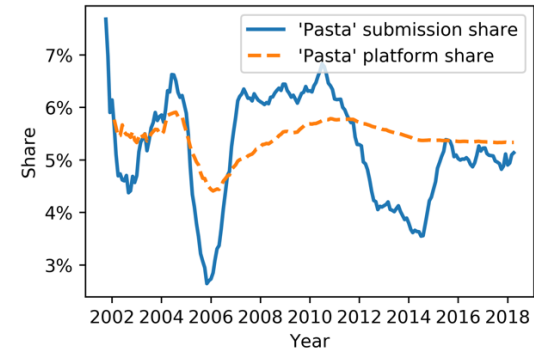
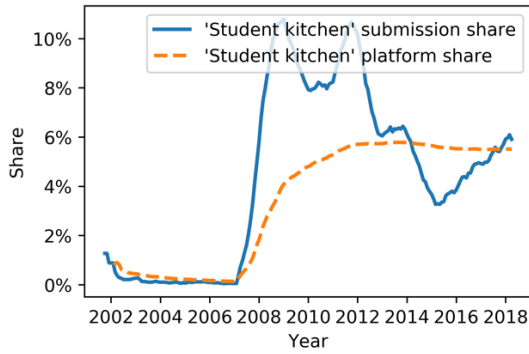
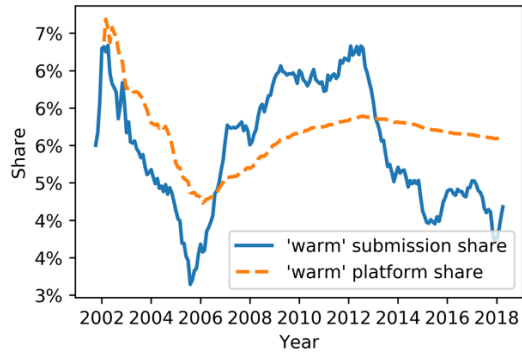
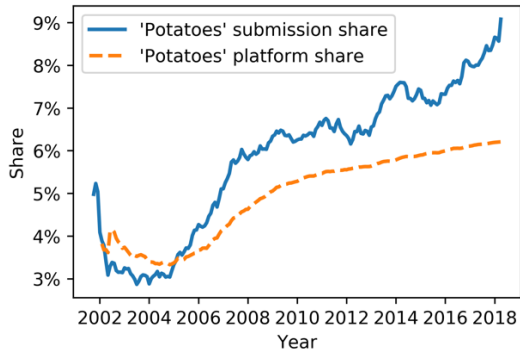
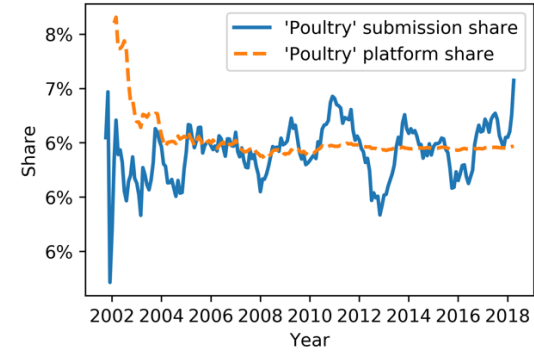
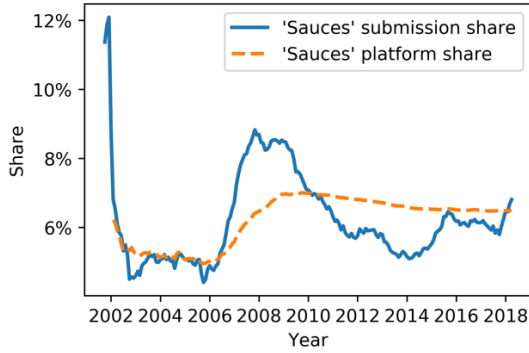
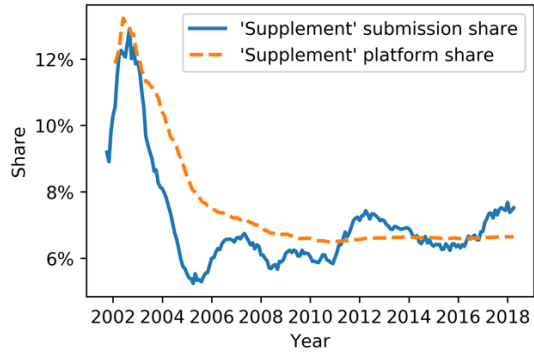
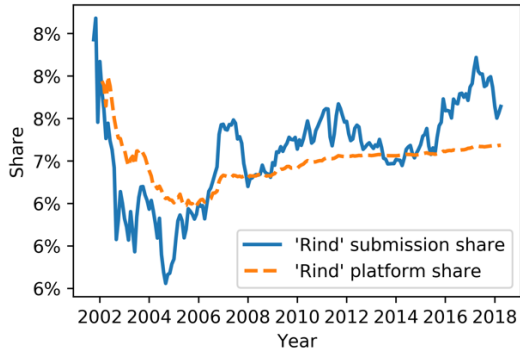
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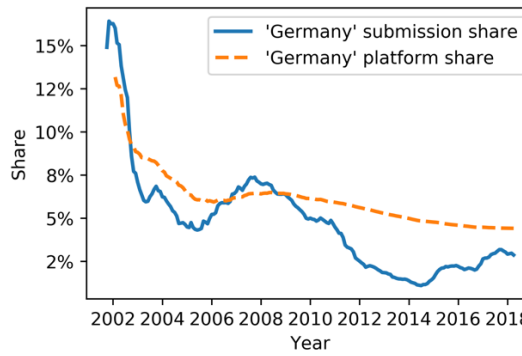
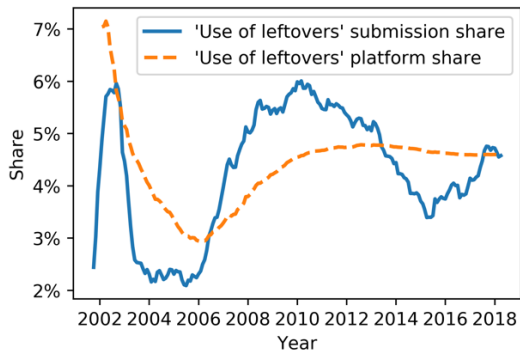
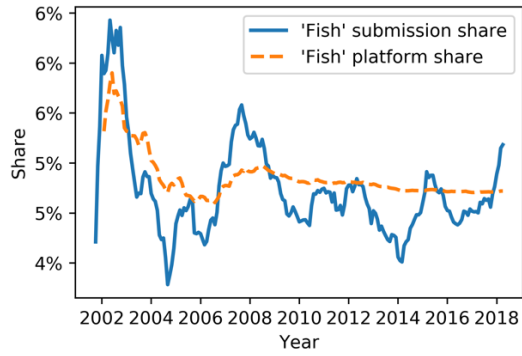
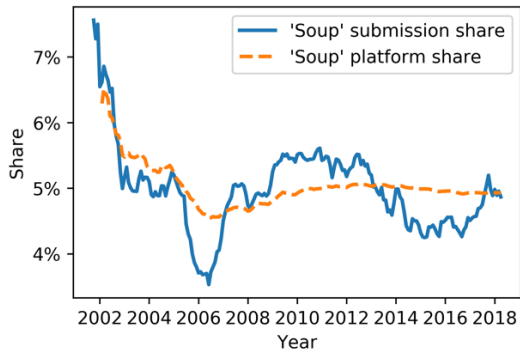
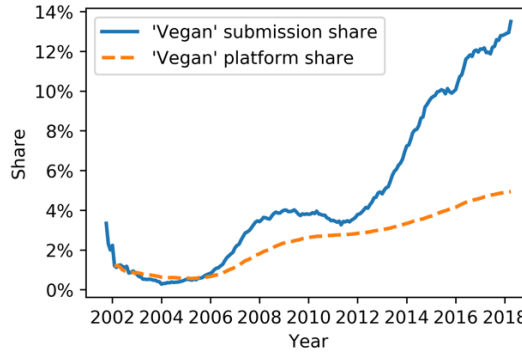
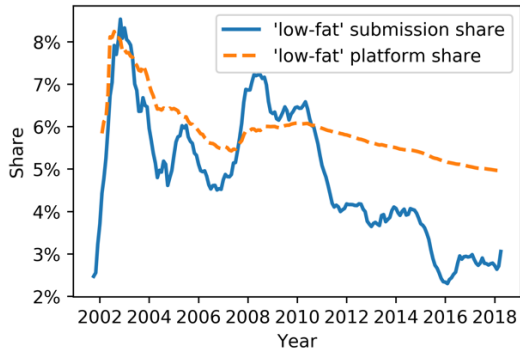
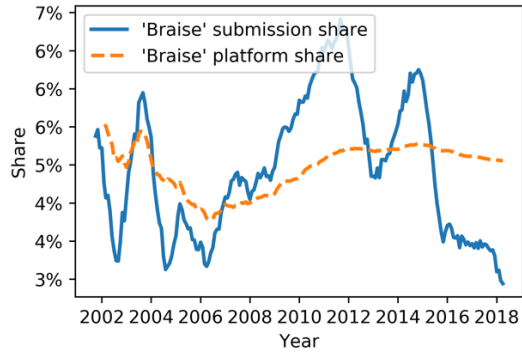
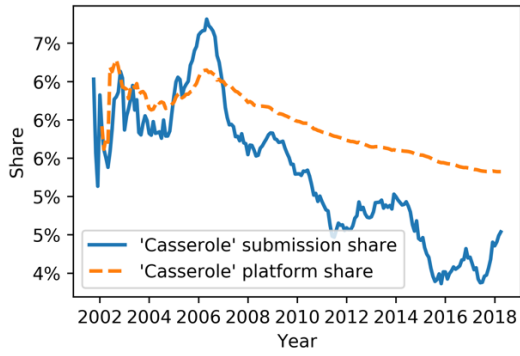
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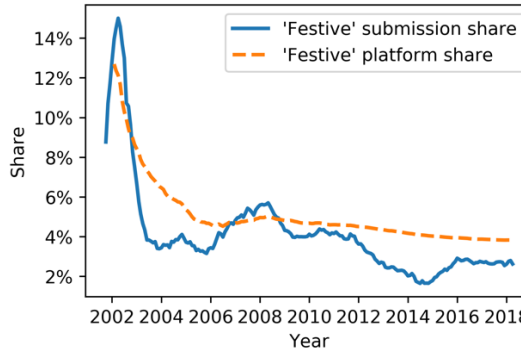
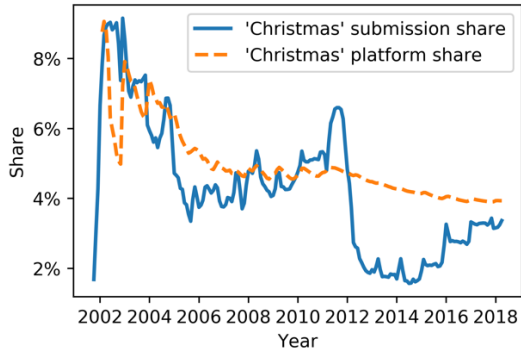
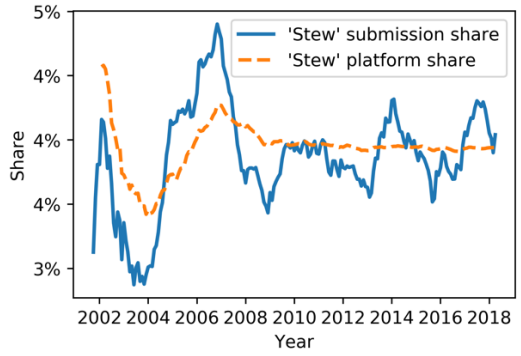
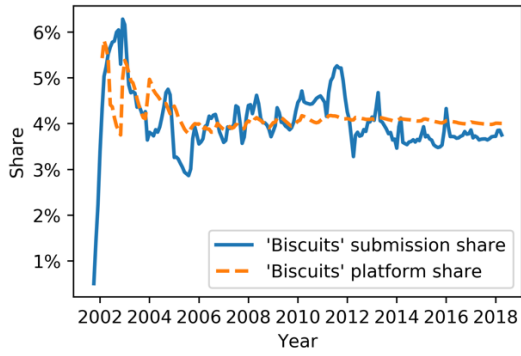
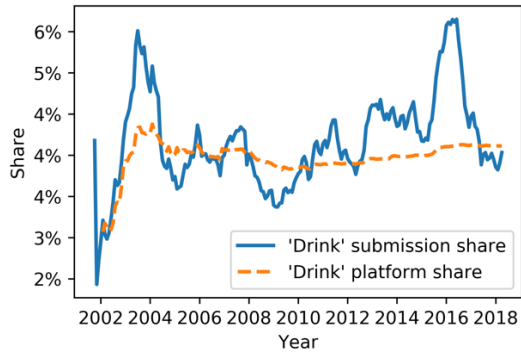
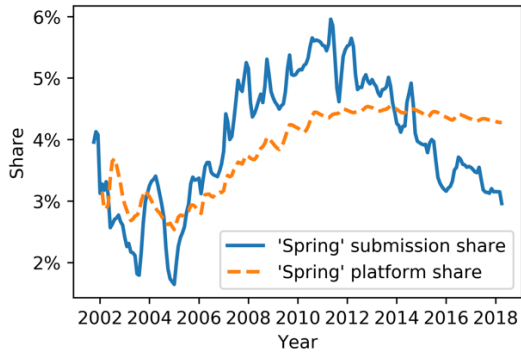
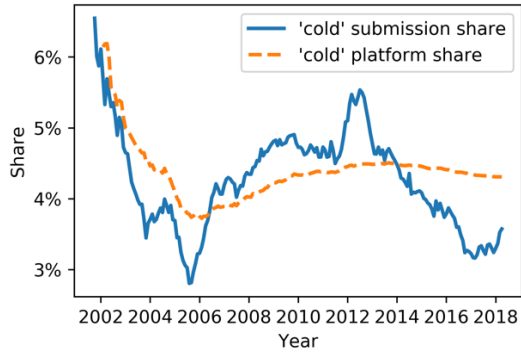
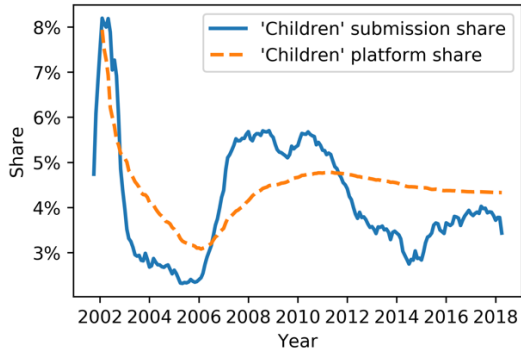
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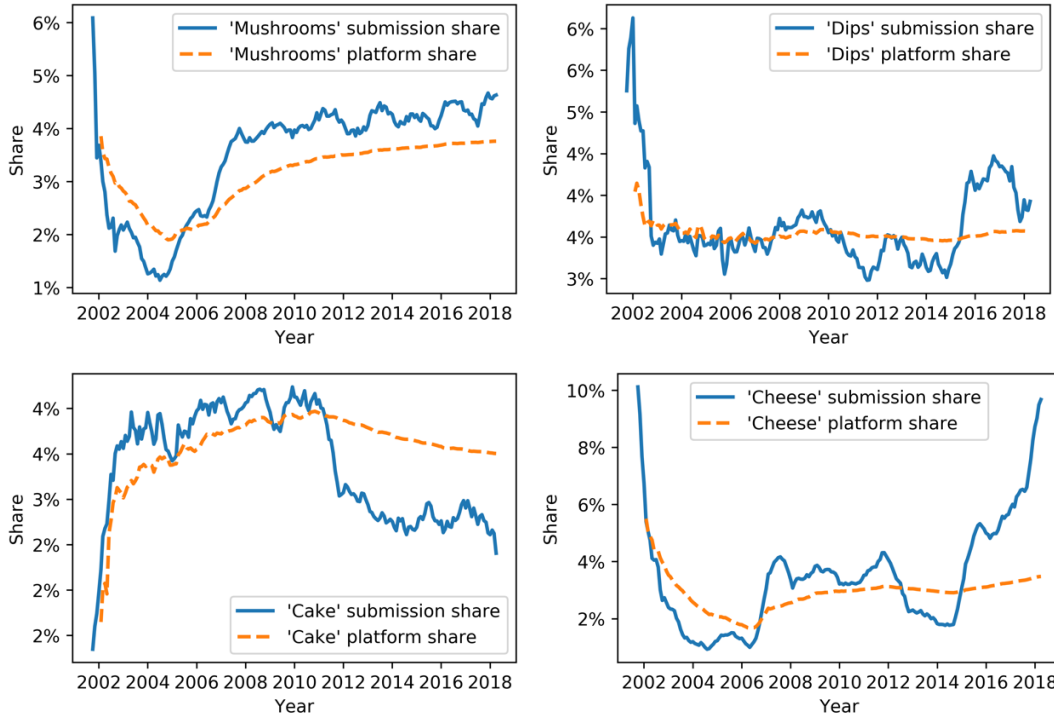
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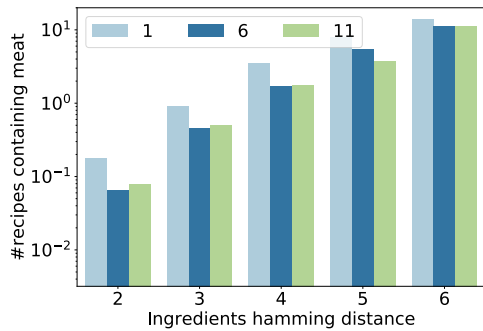


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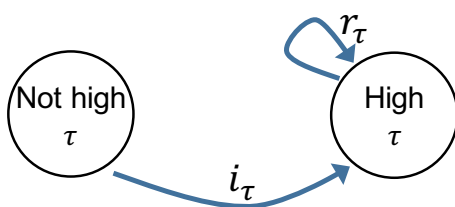
Supplementary Figure 1: Monthly platform and submission shares for the top-50 tags.

Note: Tags are translated into English and the original German title is given in the table below. The subplots are ordered by final prevalence on the site. We can see that while various types of curves exist: approximately constant (“Baking”, “Cooking”, “Poultry”), tags that have fallen after some period (“Fast”, “Europe”, “Festive”) only few, such as “Vegetables”, “Vegan”, “Fruit” and “Vegetarian” seem to have risen sharply in recent years.



Supplementary Figure 2: Closeness to meat-containing recipes in ingredients space.

Note: Here we show the results for (1, 6 and 11 recipes after crossing the 50% line). The closeness to meat containing recipes decreases with the distance to the transition.



Supplementary Figure 3: Schematic of the infection rate and retention rate.

Note: “High” and “not high” refer to the magnitude of the share of recipes rated with tag τ compared to total recipes rated.

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Supplementary Tables

Supplementary Table 1: Summary statistics of the dataset

Num. rec	243,333	Mean num. rec per author	3.7
Num. ratings	2.49M	Mean num. ratings per rec	10.4
Num. users	441,255	Mean num. ratings per user	5.6
Num. authors	65,327	Mean num. ing \pm std.	9.5 \pm 3.7
Num. tags	168	Mean num. tags per rec \pm std.	5.8 \pm 2.8

Supplementary Table 2: Full regression results on tag retention

Controls only:

retention_c ~ num_recipes + avg_vote + share_top10perc + avg_prep_time

	coeff	pvals	conf_lower	conf_higher
num_recipes	-0.0	0.00418	-0.0	-0.0
avg_vote	0.6539	0.0	0.47122	0.83658
share_top10perc	1.56527	0.0	1.26505	1.86549
avg_prep_time	-0.00275	0.0005	-0.00406	-0.00143

R-squared: 0.412
Adj. R-squared: 0.411

Tags only:

retention_c ~ tag -1

	coeff	pvals	conf_lower	conf_higher
tag[Roast]	0.339356	0.0	0.31075	0.367961
tag[Poultry]	0.31647	0.0	0.287864	0.345075
tag[Main Course]	0.618038	0.0	0.589432	0.646643
tag[Cake]	0.573884	0.0	0.545278	0.60249
tag[Beef]	0.213155	0.0	0.184549	0.241761
tag[Pork]	0.379115	0.0	0.350509	0.40772
tag[Vegan]	0.702812	0.0	0.674207	0.731418
tag[Vegetarian]	0.683388	0.0	0.654783	0.711994
tag[low-fat]	0.418875	0.0	0.390269	0.447481

R-squared: 0.773
Adj. R-squared: 0.766

Tags and linear time trend

retention_c ~ tag:time +tag +time -1

	coeff	pvals	conf_lower	conf_higher
tag[Roast]	0.437335	0.0	0.394271	0.480398
tag[Poultry]	0.409813	0.0	0.366749	0.452876
tag[Main Course]	0.75748	0.0	0.714416	0.800543
tag[Cake]	0.65257	0.0	0.609507	0.695634
tag[Beef]	0.202595	0.0	0.159532	0.245659
tag[Pork]	0.422106	0.0	0.379043	0.465169

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tag[Vegan]	0.626889	0.0	0.583826	0.669953
tag[Vegetarian]	0.675149	0.0	0.632086	0.718212
tag[low-fat]	0.546922	0.0	0.503859	0.589985
tag[Roast]:time	-0.195958	0.0	-0.270019	-0.121897
tag[Poultry]:time	-0.186686	1e-06	-0.260747	-0.112625
tag[Main Course]:time	-0.278884	0.0	-0.352945	-0.204824
tag[Cake]:time	-0.157373	3.2e-05	-0.231433	-0.083312
tag[Beef]:time	0.021119	0.576031	-0.052941	0.09518
tag[Pork]:time	-0.085983	0.022904	-0.160043	-0.011922
tag[Vegan]:time	0.151845	6e-05	0.077785	0.225906
tag[Vegetarian]:time	0.016478	0.662606	-0.057582	0.090539
tag[low-fat]:time	-0.256094	0.0	-0.330155	-0.182033

R-squared: 0.870

Adj. R-squared: 0.862

All: retention_c ~ num_recipes + avg_vote + share_top10perc + avg_prep_time + tag:time + tag + time -1

	coeff	pvals	conf_lower	conf_higher
tag[Roast]	1.606927	0.490634	-2.964434	6.178288
tag[Poultry]	1.77128	0.445333	-2.779543	6.322103
tag[Beef]	0.494386	0.842187	-4.375149	5.363921
tag[Pork]	1.577776	0.512715	-3.148519	6.304071
tag[Vegan]	1.450023	0.535233	-3.135843	6.035889
tag[Vegetarian]	1.553747	0.506362	-3.031234	6.138728
tag[low-fat]	2.335095	0.322546	-2.293294	6.963483
num_recipes	1.560285	0.510619	-3.090456	6.211027
avg_vote	1.996767	0.396316	-2.619197	6.61273
share_top10perc	-0.0	0.575019	-0.0	0.0
avg_prep_time	-0.69616	0.298782	-2.009855	0.617534
tag[T.Roast]:time	5.145043	0.01283	1.094051	9.196034
tag[T.Poultry]:time	0.025479	0.034914	0.001807	0.049152
tag[T.Beef]:time	-0.05835	0.37741	-0.187971	0.071272
tag[T.Pork]:time	-0.069886	0.233071	-0.18479	0.045018
tag[T.Vegan]:time	-0.118159	0.457755	-0.43019	0.193871
tag[T.Vegetarian]:time	-0.058604	0.349018	-0.181308	0.064099
tag[T.low-fat]:time	0.134846	0.014492	0.026777	0.242916
tag[Roast]	0.036637	0.545048	-0.082074	0.155348
tag[Poultry]	0.2381	0.001068	0.095617	0.380582
tag[Beef]	0.056479	0.605865	-0.158167	0.271126
tag[Pork]	-0.121727	0.031974	-0.232956	-0.010499

R-squared: 0.870

Adj. R-squared: 0.863

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Supplementary Table 3: Full regression results on tag infection

Controls only:

Infec_c ~ num_recipes + avg_vote + share_top10perc + avg_prep_time

	coeff	pvals	conf_lower	conf_higher
num_recipes	0.0	0.271027	-0.0	0.0
avg_vote	-0.018641	0.0	-0.025405	-0.011877
share_top10perc	0.141902	0.0	0.130786	0.153019
avg_prep_time	0.000151	0.0	0.000102	0.0002

R-squared: 0.864
Adj. R-squared: 0.863

Tags only:

Infec_c ~ tag -1

	coeff	pvals	conf_lower	conf_higher
tag[Roast]	0.001613	0.0	0.001127	0.0021
tag[Poultry]	0.000321	0.196276	-0.000166	0.000807
tag[Main Course]	0.058167	0.0	0.05768	0.058653
tag[Cake]	0.014537	0.0	0.01405	0.015024
tag[Beef]	0.001098	1e-05	0.000611	0.001584
tag[Pork]	0.00349	0.0	0.003003	0.003977
tag[Vegan]	0.002178	0.0	0.001691	0.002664
tag[Vegetarian]	0.01644	0.0	0.015953	0.016926
tag[low-fat]	0.001416	0.0	0.00093	0.001903

R-squared: 0.989
Adj. R-squared: 0.989

Tags and linear time trend:

infec_c ~ tag:time +tag +time -1

	coeff	pvals	conf_lower	conf_higher
tag[Roast]	0.001775	0.0	0.001332	0.002218
tag[Poultry]	0.000209	0.355562	-0.000234	0.000651
tag[Main Course]	0.052757	0.0	0.052314	0.0532
tag[Cake]	0.01439	0.0	0.013947	0.014833
tag[Beef]	0.001132	1e-06	0.000689	0.001575
tag[Pork]	0.002889	0.0	0.002447	0.003332
tag[Vegan]	-0.000249	0.271038	-0.000691	0.000194
tag[Vegetarian]	0.007237	0.0	0.006794	0.00768
tag[low-fat]	0.002016	0.0	0.001573	0.002458
time:tag[T.Roast]	-0.000257	0.639214	-0.001335	0.00082
time:tag[T.Poultry]	0.00029	0.597683	-0.000787	0.001367
time:tag[T.Main Course]	0.010884	0.0	0.009807	0.011962
time:tag[T.Cake]	0.00036	0.512512	-0.000717	0.001437
time:tag[T.Beef]	-2e-06	0.996873	-0.001079	0.001075

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time:tag[T.Pork]	0.001267	0.021169	0.00019	0.002344
time:tag[T.Vegan]	0.004919	0.0	0.003842	0.005996
time:tag[T.Vegetarian]	0.018471	0.0	0.017394	0.019548
time:tag[T.low-fat]	-0.001133	0.039317	-0.00221	-5.6e-05

R-squared: 0.998

Adj. R-squared: 0.998

All: infection_c ~ num_recipes + avg_vote +share_top10perc + avg_prep_time + tag:time +tag +time
-1

	coeff	pvals	conf_lower	conf_higher
tag[Roast]	-0.019035	0.421233	-0.065444	0.027373
tag[Poultry]	-0.014657	0.53386	-0.060858	0.031543
tag[Main Course]	-0.008454	0.737349	-0.05789	0.040982
tag[Cake]	-0.015355	0.530311	-0.063337	0.032627
tag[Beef]	-0.016884	0.47699	-0.06344	0.029672
tag[Pork]	-0.018965	0.424327	-0.065512	0.027582
tag[Vegan]	-0.009102	0.704054	-0.056089	0.037886
tag[Vegetarian]	-0.023872	0.321502	-0.071087	0.023343
tag[low-fat]	-0.013702	0.566405	-0.060563	0.03316
num_recipes	-0.0	0.101007	-0.0	0.0
avg_vote	-0.000984	0.884984	-0.01432	0.012353
share_top10perc	0.145416	0.0	0.10429	0.186542
avg_prep_time	0.000327	0.007679	8.7e-05	0.000567
tag[T.Roast]:time	1.9e-05	0.976919	-0.001297	0.001335
tag[T.Poultry]:time	0.0005	0.400409	-0.000666	0.001667
tag[T.Main Course]:time	0.012453	0.0	0.009286	0.015621
tag[T.Cake]:time	0.001153	0.069631	-9.3e-05	0.002399
tag[T.Beef]:time	0.000471	0.399919	-0.000626	0.001568
tag[T.Pork]:time	0.002086	0.000703	0.000881	0.003291
tag[T.Vegan]:time	0.003881	0.0	0.002435	0.005328
tag[T.Vegetarian]:time	0.016733	0.0	0.014554	0.018912
tag[T.low-fat]:time	-0.00067	0.244844	-0.001799	0.000459

R-squared: 0.998

Adj. R-squared: 0.998

Note: num_recipes = number of recipes; avg_vote = average (mean) voted rating received (between 1-5); share_top10perc = the share of recipes of that tag that are in the top 90th percentile of all recipes by number of ratings; avg_prep_time = average (mean) preparation time for recipes of this tag.

Time was normalized to lie between (0,1), so the coefficient of 23.8% (retention of vegan), equates to a yearly increase in the retention rate of around 3 percentage points explained by outside variables.

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Supplementary Table 4: Extreme user transitions

Transition (original German)	Transition (English translation)	30% <->70% transition			10% <->90% transition		
		up	down	ratio	up	down	ratio
Hauptspeise	Main Course	729	738	0.988	40	41	0.976
Gemüse	Vegetables	649	457	1.42	31	19	1.632
Backen	Baking	738	697	1.059	52	56	0.929
einfach	Simple	417	479	0.871	8	18	0.444
Schnell	Fast	376	452	0.832	6	17	0.353
Vegetarisch	Vegetarian	424	228	1.860	45	14	3.214
gekocht	Cooked	145	128	1.133	5	5	1.0
Kuchen	Cake	206	290	0.71	14	32	0.438
Europa	Europe	82	123	0.667	2	7	0.286
Braten	Roast	33	38	0.868	1	2	0.5
Sommer	Summer	20	42	0.476	1	1	1.0
Party	Party	58	82	0.707	4	8	0.5
Schwein	Pig	73	106	0.689	2	4	0.5
Snack	Snack	26	43	0.605	2	7	0.286
Herbst	Autumn	28	36	0.778	1	2	0.5
raffiniert oder preiswert	Refined or Inexpensive	21	31	0.677	0	3	0.0
Vorspeise	Appetizer	27	34	0.794	2	3	0.667
Dessert	Dessert	26	26	1.0	4	4	1.0
Nudeln	Noodles	28	53	0.528	0	2	0.0
Frucht	Fruit	3	13	0.231	0	1	0.0
Winter	Winter	13	18	0.722	0	1	0.0
Salat	Salad	26	31	0.839	3	7	0.429
Rind	Rind	26	30	0.867	0	1	0.0
Beilage	Supplement	16	12	1.333	2	1	2.0
Saucen	Sauces	13	19	0.684	1	2	0.5
Geflügel	Poultry	13	16	0.812	0	2	0.0
Kartoffeln	Potatoes	9	13	-	0	0	-
warm	Warm	7	8	-	0	0	-
Studentenküche	Student Kitchen	6	9	-	0	0	-
Pasta	Pasta	10	21	0.476	0	1	0.0
Auflauf	Casserole	13	26	0.5	0	5	0.0
Schmoren	Braise	9	6	-	1	0	-
fettarm	Low-Fat	21	46	0.457	4	4	1.0
Vegan	Vegan	93	22	4.227	23	4	5.750
Suppe	Soup	10	10	1.0	3	2	1.500
Fisch	Fish	3	5	-	0	0	-
Resteverwertung	Use of leftovers	0	1	-	0	0	-
Deutschland	Germany	4	8	0.5	0	2	0.0
Kinder	Children	6	13	0.462	1	1	1.0
kalt	Cold	4	9	0.444	0	1	0.0
Frühling	Spring	4	6	-	1	0	-
Getränk	Drink	11	16	0.688	4	3	1.333
Kekse	Biscuits	72	110	0.655	13	17	0.765
Eintopf	Stew	8	9	-	0	0	-
Weihnachten	Christmas	49	80	0.612	6	8	0.75
Festlich	Festive	2	7	-	0	0	-
Pilze	Mushrooms	3	0	-	0	0	-
Dips	Dips	8	7	1.143	1	2	0.5
Torte	Cake	12	15	0.8	1	2	0.5
Käse	Cheese	2	4	-	0	0	-

Note: This table shows the number of users that have transitioned “up”, that is towards rating more recipes of this tag and “down”, that is rating less recipes of this tag. For example, the recipes rated of a user in the 10%<->90% “up” column of tag “vegan” were less than 10% at the start of observation but higher than 90% at the end. The ratio is given by dividing the “up” numbers by the “down” numbers. Vegan and vegetarian rows are highlighted.

A.2 Publication 2

Appetite 153 (2020) 104730

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Appetite

journal homepage: www.elsevier.com/locate/appet

The meaning of meat: (Un)sustainable eating practices at home and out of home



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ARTICLE INFO

Keywords:

Food consumption
Meat
Sustainable diet
Social meaning of food
Practice theory
Behavior change

ABSTRACT

Many sociological accounts of life in the 21st century include reflections on the dissolution of distinctions between the public and private sphere, aided by social media and information technology. In this paper, we argue that everyday practices around the consumption of food continue to display strong home/out-of-home divisions, especially regarding the consumption of meat and its deeply rooted social meanings. Using data from a German online survey on food preparation and consumption practices, we report and critically examine empirical evidence of significant differences between public and private food consumption. In addition to divergent meanings, we pay particular attention to environmental impacts related to the resource implications of eating in or out. For many, eating out in a restaurant means to treat oneself to something special. Cultural links between eating meat and the celebration of special occasions, the role of meat as a signifier of hospitality, and meat consumption as an expression of high social status leads to considerable resource implications for the practice of eating out and hosting guests. This, in turn, throws up interesting questions regarding the (in)effectiveness of sustainable food campaigns, many of which have hitherto ignored the distinction between public and private consumption. We conclude by arguing for strategies that connect the consumption of plant-based dishes to already established social practices such as hosting guests, barbecuing or celebrating special occasions.

1. Introduction

The food we eat has a significant impact on the environment, largely contributing to greenhouse gas (GHG) emissions, deforestation through land-use change, and water use through irrigation (Chemnitz & Becheva, 2014; Clark & Tilman, 2017; Hoekstra & Mekonnen, 2012; Nelson, Hamm, Hu, Abrams, & Griffin, 2016). The environmental impact of the food system is furthermore an intensifying problem: population growth and a shift in dietary habits towards western diets – high in calories and animal products – increase the use of resources (Ranganathan et al., 2016, p. 90). Due to these developments, global crop demand is estimated to increase by 100% from 2005 to 2050 (Tilman, Balzer, Hill, & Befort, 2011). Sustainable food systems research has hitherto focused on ‘sustainable intensification’ as a potential solution, in which production yields are increased without cultivating more land, increasing environmental impact, or compromising animal welfare (Baulcombe et al., 2009; Garnett et al., 2013). However, a sole focus on production will not suffice to reach climate targets. Changes in consumption play an indispensable role for sustainable food security and must be addressed, given the scale of the challenge at hand (Bajželj et al., 2014).

Eating has been the target of policy initiatives in Germany, the EU, and beyond, many of which adopt an explicitly health-oriented outlook. In contrast, much less attention has been paid to environmental sustainability questions, apart from occasional campaigns for a greater uptake of organic food. Research has shown that meat content and GHG emissions correlate positively, with vegetarian and vegan diets promising the most substantial reductions in GHG emissions (Hallström, Carlsson-Kanyama, & Börjesson, 2015). The high resource demand of beef is particularly striking, as its production requires between 6 and 28 times more land, water, GHG emissions, and nitrogen fertilizer than poultry or pork (Eshel, Shepon, Makov, & Milo, 2014). A recent study by Eshel, Stainier, Shepon, and Swaminathan (2019) further shows that nutritional requirements can be met while at the same time reducing environmental impacts (saving 35–50% of diet-related cropland, nitrogen fertilizer, and GHG emissions) by replacing meat with plant alternatives (soy, green pepper, squash, buckwheat, and asparagus, specifically). The most prominent recent attempt to define a ‘sustainable’ or ‘planetary health’ diet (a ‘win-win’ for human health and the environment) was undertaken by the EAT-Lancet commission, which proposed a universal diet low in animal source foods and high in diverse plant-based foods (Willett et al., 2019).

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Received 3 February 2020; Received in revised form 7 April 2020; Accepted 2 May 2020

Available online 15 May 2020

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Aside from environmental considerations, issues of social justice, such as the treatment of workers employed in the agricultural sector and conditions of (un)fair trade, need to be a central element of decisions regarding what is a sustainable diet. However, this has not yet received adequate attention in food sustainability debates (Nemecek, Jungbluth, i Canals, & Schenck, 2016). Even the most affordable version of the EAT-Lancet diet, for example, is out of reach for approximately 1.58 billion of the world's poor (Hirvonen, Bai, Headey, & Masters, 2020). This draws attention to the very uneven distribution of issues such as malnutrition, hidden hunger, and obesity across the globe. Similarly, work that considers regional variations in meat consumption in the context of the anticipated rise in total meat consumption due to the active promotion and growing popularity of meat-heavy 'Western' diets (Popkin, 1993) in Asia and other parts of the world remains scarce (but see Lange (2016) for an important contribution to this debate).

Variations in eating practices¹ across social settings represent a key area of inquiry in this context. While recent empirical work has shed light on social, temporal, and situational influences on the quantity of meat consumed (Horgan, Scalco, Craig, Whybrow, & Macdiarmid, 2019), the extent to which eating at home differs qualitatively from eating out remains an under-researched topic. This is all the more surprising given the social and environmental sustainability implications of possible divergences between domestic eating habits and eating practices outside the home. In this paper, we argue that analyzing these two sites of eating practices separately can provide novel insights into the linkages between the social meanings and material impacts of dietary habits. At the same time, it allows for a new appreciation of the inherently social nature of food choices that extends far beyond what individuals (think they) want. This study thus responds to Shove's (2010) call to 'move beyond the ABC'² by focusing on different constellations of elements that shape and reflect the practice of eating both at home and outside the home.

2. State of the art

Much research on sustainable diets takes an individualistic approach to behavior that overemphasizes the individual's capacity to bring about societal change, including in the realm of food consumption. For example, Wiggins, Potter, and Wildsmith (2001) observe that '[p]sychological research into eating practices has focused mainly on attitudes and behavior towards food, and disorders of eating. Using experimental and questionnaire-based designs, these studies place an emphasis on individual consumption and cognitive appraisal, overlooking the interactive context in which food is eaten' (p. 5). Similarly, Warde (2016 p. 3) finds 'it [...] frustrating that progress in the sociology of consumption was slow to filter into research on food.' The resulting individualistic bias in much food research has also influenced policy thinking and practice in this area, with many healthy nutrition campaigns targeting individuals and their food choices. However, these efforts have not been effective in bringing about large-scale behavior change, initiating proposals for alternative approaches to research and policy that treat eating as a socially embedded, relational consumption practice (Hargreaves, 2011; Shove, 2010; Shove, Pantzar, & Watson, 2012; Southerton, McMeekin, & Evans, 2011, p. 47; Warde, 2005, 2016). Instead of focusing on the individual, practice theory frames daily activities in terms of practices consisting of three core elements: meanings, competences, and material aspects (Shove et al., 2012). A

practice, however, cannot exist without its performance by agents, 'practitioners' (Shove et al., 2012) or 'carriers of the practice' (Reckwitz, 2002), who bring the practice to life. 'A thriving practice not only requires reaffirmation by existing participants but also a flow of new recruits' (Warde, 2016, p. 150). However, because these participants inhabit very different socio-cultural worlds, their performance of the practice of eating varies vastly. According to Warde (2016, p. 150ff.), practice-focused inquiries into food consumption must take into account social occasions (events), food selection (menus) as well as styles of bodily incorporation as elementary units of eating. By focusing on the meaning of meat consumption and its links to social occasions, this study makes an explicit effort to respond to this call.

While habit and routine are central to the practice of eating, it is nevertheless possible to observe shifts away from established patterns of food consumption. In this context, linking or unlinking the elements of a practice can lead to the disappearance of established practices or the formation of new ones (Shove & Pantzar, 2005). For example, recent practice-theoretical research by Godin and Sahakian (2018) on the topic of 'sustainable diets' in Switzerland examined the role of prescriptions, that is, guidelines issued by different social actors (e.g., family and peers, nutritionists, health insurances) on what and how one should eat (i.e., meanings). Their conceptual and empirical work reveals the influence of three key factors on the success or failure of efforts to shift eating practices towards more sustainable ones: 1) time as a condition for enacting prescriptions, 2) mobility and related aspects of access to food provisioning systems, and 3) social relations inside and outside the home. They argue that '[b]efore being enacted, prescriptions pass through the filter of everyday life,' (p. 129) including structural constraints linked to pre-vailling systems of provision (i.e., materials) that are beyond the influence of individuals and households. Moreover, these authors see real merit in identifying suitable public 'demonstration sites' such as workplace and school canteens that can serve as spaces of experimentation (i.e., expanding skills) in relation to healthier, more sustainable diets. This suggests that to challenge existing eating practices that are deemed to be unhealthy and/or unsustainable (e.g., excessive meat consumption) requires a change in all three elements of the practice.

To date, a wide range of topics has been covered in practice-theoretical food research. These include the social construction of prescriptions and their impact on eating practices (Godin & Sahakian, 2018; Plessz, Dubuisson-Quellier, Gojard, & Barrey, 2016), perceptions of environmental responsibilities of food consumers and their (re)production through the media (Halkier, 2009, 2010), detailed inquiries into transitions in food systems and practices (Spaargaren, Oosterveer, & Loeber, 2012; Spurling, McMeekin, Shove, Southerton, & Welch, 2013, p. 56), and socio-economic (van Kesteren & Evans, 2020) as well as cultural aspects of eating and food consumption (Sahakian, Saloma, & Erkman, 2016; Sahakian, Godin, & Courtin, 2020; Warde, 1997, 2016). The latter category includes groundbreaking sociological work on the subject of eating out by Warde and Martens (2000).³ However, what has been largely missing from the literature are systematic comparisons between public and private eating practices. Instead, it is often assumed that a person's food choices at home are more or less identical to those outside the home. Others have argued for a shift towards food consumption outside the home to enhance sustainability. For example, Spurling et al. (2013, p. 56) contend that increased eating outside of home may provide sustainability gains through reduced domestic energy use for cooking and refrigeration. While limiting the scope to

¹ The term 'eating practices' will be used in this paper to describe both food preparation and consumption at home as well as food choice and consumption out of home.

² 'ABC' in this context refers to attitude, behavior, and choice – the dominant paradigm of social change theory – indicating the extent to which focus is put on an individual's values and attitudes to drive social change (Shove, 2010).

³ Eating out has also been the subject of studies in other fields such as health and nutrition studies, medicine, or psychology (Lorenz & Langen, 2018). However, they have been excluded from our review due to their focus on individuals' attitudes and actions (contrasting this study's emphasis on eating practices).

energy consumption for cooking and eating appears to be too narrow,⁴ a focus on the resource implications of eating out compared to eating in seems promising.

We are further particularly interested in the ‘meanings’ element of eating practices and how this relates to issues of sustainability. Many (social) psychological studies of food choices emphasize the role of attitudes and values (Allen & Baines, 2002). Allen and Baines (2002), for example, manipulated the meaning of meat in a randomized controlled trial to reveal the centrality of values in food choices. They state that ‘an endorsed value evokes a more favorable attitude and greater intention to purchase, whereas a value that the individual rejects results in a less favorable attitude and weaker intention to purchase’ (Allen & Baines, 2002, p. 119). In this paper, we argue that individuals’ food choices vary across different food settings – home versus restaurant – which raises serious questions about the stability of values and their influence on such dietary decisions. Moreover, previous work on eating practices points towards the significance of different meanings of food across diverse food-related settings (e.g., the dining room at home, a restaurant, a canteen; see also Goggins & Rau, 2016). Building on these insights, this study thoroughly examines public and private eating practices, with a particular focus on meanings and the material element of meat versus plant-based food items as a proxy for sustainability. It further identifies similarities and differences in these practices that infer barriers to a wider adoption of plant-based diets.

3. Methods

Much empirical work based on a practice-theoretical framework has been qualitative, with unstructured or semi-structured interviews and observations representing primary methods of inquiry. Bueger’s (2014) argument that practice-oriented or praxiographic research follows an interpretative and qualitative tradition reflects this methodological convention. In a blog post, Shove (2017) adopts a ‘technical view’ (Bryman, 1988) of multimethod research, arguing that a practice perspective does not automatically require the adoption of a particular method. Instead, the research question(s) posed should guide the researcher’s methodological choices (see Bryman (1988) for a detailed discussion of this position). A small number of quantitative inquiries into everyday practices have revealed the challenges of operationalizing (elements of) practices, to analyze them statistically (e.g., Bartiaux & Reátegui Salmón, 2014; Spotswood, Chatterton, Tapp, & Williams, 2015). Recent empirical works on energy and food consumption, for example, have taken a quantitative approach (Hess, Samuel, & Burger, 2018; Yates & Warde, 2015). In this study, we follow these examples and answer our research questions using quantitative data. We further elaborate on the implications of this methodological choice in the discussion section.

3.1. Survey design and measurement

The empirical data for this study was collected using an online survey. The survey was part of a larger study of eating practices that contained additional questions not used in this analysis. The construction of the survey was informed by reviewing relevant scientific and policy literature (e.g. BMU & UBA, 2017; Godin & Sahakian, 2018; Piazza et al., 2015) as well as conducting a world café and semi-structured interviews. For the world café, 26 participants (university students, 22–33 years old, 14 women and 12 men) were split into 6 rotating groups representing different settings (home, restaurant, work, university/school, sports, and on-the-go) and asked questions about

materials, meaning, and competences of an ideal (future) sustainable food system. For the in-depth narrative interviews, a convenience sample of eight individuals was asked about their food practices, proceeding from open questions about food routines to more in-depth questions regarding meanings of eating practices at home and out of the home. Five of the eight participants were also asked to record their eating practices in a food diary for approximately 10 days that was used during the interviews to better recall the role of meat in the interviewees diet. The interviews were transcribed and analyzed combining inductive and deductive qualitative content analysis (Kuckartz, 2014). The main categories of analysis were based on practice theory (Shove & Pantzar, 2005; Warde, 2005): materials (food items, infrastructure of provisioning), meanings (emotions, attitudes, and motivations regarding food and the environment), and competences. ‘Competences’ was further split into implicit (unconscious procedures, norms) and explicit knowledge (institutionalized, theoretical, explicit skills). The emerging themes were then translated into questionnaire items.

We created a web-based survey using Unipark, an online survey software hosted in Germany. The quantitative survey⁵ contained 25 closed-ended questions that were relevant for this analysis. The main constructs were (1) materiality of eating practices (type of food, frequency, location, weekday, type of meal, alone/together), (2) meanings of eating practices (at home/restaurant), (3) reasons for eating meat (at home/restaurant), and (4) demographic data. For opinion questions, responses were recorded using a 5-point likert scale. The answer options of close-ended questions were rotated randomly, to prevent primacy-recency effects in the responses (Krosnick, 1999). Dietary groups were based on respondents self-classifying as one of five groups: (1) vegans, (2) non-vegan vegetarians, (3) pescetarians, (4) flexitarians, and (5) omnivores (see Supplementary Material (SM), Table SM1 for details). Subsequent questions concerning meat consumption were posed only to flexitarian and omnivorous respondents, with the exception of cooking meat or fish for others (oneself vs. household members vs. guests), which was also answered by non-meat eaters. The question regarding cooking for household members was only posed to respondents who did not live alone.

To uncover meanings, participants were asked about the values (price, taste, convenience, health, regionality/seasonality, environmental friendliness) and emotions (pleasure, a chore, an expression of their lifestyle, social interaction, a possibility to experience nature, a physical necessity) that they most associate with eating at home and at a restaurant. The intensity and direction of meanings were additionally measured using a semantic differential (Eck, 1982; Osgood, 1952). Semantic differentials were successfully used in recent sustainability studies (Etale, Jobin, & Siegrist, 2018), and work on emotions regarding meat (Berndsen & Pligt, 2004; Graça, Calheiros, & Oliveira, 2015). The scale was developed through the study of the aforementioned literature to cover the most relevant factors linking food choice and sustainability (Garnett & Finch, 2016). The scale was then pretested with native speakers for linguistic contrast (Verhagen, van den Hooff, & Meents, 2015). 14 final pairs of antonyms were presented on a 7-point scale: positive-negative, satisfied-dissatisfied, delicious-unappetizing, joyful-functional, pleasure-duty, environmentally positive-negative, organic-conventional, regional-imported, healthy-unhealthy, meat-less-meat-heavy, transparent-intransparent, special occasion-everyday, together-alone, cheap-expensive. Respondents were asked to mark the position they spontaneously associate with eating at home or at a restaurant (antonyms of each adjective represented the opposing sides of the scale, e.g. ‘together – alone’). We placed positive and negatively connotated words alternately on the left or right side of the scale and randomized items to prevent response bias. An exploratory factor analysis with principal component analysis and varimax rotation was used to test for unidimensionality of the semantic differential for each sphere (home/

⁴ Environmental impact assessments have shown agricultural production to be more impactful than later stages in the supply chain, such as storage and transport (Nemeček et al., 2016). Therefore, in this study, we focus on food choices associated with the practices of eating in and out, as central for sustainability issues.

⁵ The questionnaire is available from the corresponding author upon request.

restaurant) separately. After excluding several item pairs that were cross-loading on several factors or had a loading of less than 0.4, a two-factor solution, based on eigenvalues of 1 was achieved, with each item loading more than 0.4 onto the factor. These two factors explained 59.9% of the total variance. The two final factors for both scales were labeled 'enjoyment' (items: positive-negative, joyful-functional, pleasure-duty, satisfied-dissatisfied, delicious-unappetizing) and 'sustainability' (items: environmentally positive-negative, organic-conventional, regional-imported, healthy-unhealthy). The 'enjoyment' scale had a high level of internal consistency (Cronbach's alpha of 0.84 for at a restaurant and 0.83 at home) and the 'sustainability' scale acceptable levels (Cronbach's alpha of 0.76 and 0.69). Interestingly, the item 'meat-heavy vs. meat-less' only loaded onto the 'sustainability' factor for the set of responses in the home context. Therefore, it was analyzed as a separate variable, along with the items 'transparent-intransparent', 'special occasion-everyday', 'together-alone', and 'cheap-expensive'.

A draft of the survey was discussed for content validity with sustainability and survey experts. It was further pre-tested, using the 'think aloud' technique (Campanelli, 1997), with 5 participants of diverse ages (20–76 years) to ensure comprehensibility for different audiences. After incorporating their feedback, the online survey was rolled out.

3.2. Data collection

Data were collected via a self-administered online survey between January and April 2019. The study protocol followed the International Sociological Association's code of ethics and participants gave informed consent before taking part in the survey study. The survey was conducted in German and distributed online through diverse channels such as social media (Facebook, Twitter), newsletters, personal emails, posting to notice boards, and forums. Channels used included those that cover food generally (e.g., online fora of popular recipe sites such as chefkoch.de), as well as those focusing on sustainability issues in particular (e.g., newsletter of a climate protection network with national reach). No monetary incentives were offered for participation. In total, 420 responses were collected.

The sample demographics point towards an overrepresentation of certain demographic groups (see Table 1). Highly educated German city-dwellers in their 20s and 30s who report normal health and weight and already follow more sustainable diets than average dominate the sample. This overrepresentation of people with more sustainable diets made it possible to draw comparisons between groups with different dietary practices. The results of this study are therefore likely more characteristic of this highly educated sub-group. We further elaborate on the potential impact of participant characteristics on the results in the discussion and limitations section.

3.3. Data analysis

Data analysis followed the three-part definition of a practice (materials, meanings, competences) used by Shove et al. (2012) but focused on materials and meanings of eating out and eating at home. Practitioners of different diets (e.g., vegan, omnivorous) were compared regarding materials (frequency of cooking/eating out; type of meal cooked at home/eaten out; eating meat) and meanings (ascribed meaning to eating at home/eating out; reasons for eating meat) at home versus out of home. Items were reverse-coded where necessary, to reflect the same positive or negative opinion. Univariate and bivariate statistical analyses were carried out using IBM SPSS Statistics 26 (IBM Corp, 2019). Differences between dietary groups were analyzed using a Kruskal-Wallis H test, Welch *t*-test, Mann-Whitney *U* test, and Chi-square test. Post-hoc Dunn-Bonferroni correction was used for pairwise comparisons (Dunn, 1964). To test for significant differences in matched samples, a Wilcoxon signed-rank test, McNemar-Bowker test of symmetry, paired sample *t*-test, and Friedman test were used. Whenever outliers were detected, analyses with and without the outliers were run.

Table 1
Sample compared to population estimates.

	Germany (%)	Sample (%)	(N)
Sex			
Women	50.7	57.0	239
Men	49.3	41.3	173
No response	–	1.7	7
Age group			
< 20	18.4	0.5	2
20–29	12.0	39.6	166
30–39	12.5	26.7	112
40–49	13.2	7.9	33
50–59	16.1	13.1	55
> 60	27.8	12.2	51
Employment			
Working	48.9	59.9	251
In Education	23.6	30.3	127
Unemployed	3.7	1.2	5
Retired	21.7	6.2	26
Other (esp. homemaker)	1.9	2.4	10
Education			
A-levels or less	25.7	23.2	97
Apprenticeship	56.6	4.3	18
University degree	16.5	63.2	265
Doctoral degree	1.2	9.3	39
City population size			
< 5000	14.1	11.0	46
5000–99,999	53.8	20.3	85
100,000–499,999	15.2	15.8	66
> 500,000	16.9	53.0	222
Diet			
Vegan	0.3	10.3	43
Vegetarian	3.4	17.2	72
Pescetarian	1.5	6.4	27
Flexitarian	11.6	21.5	90
Omnivorous	83.2	44.6	187
Weight (BMI)			
Underweight	2.0	4.8	20
Normal	45.3	71.1	298
Overweight	36.4	21.2	89
Obese	16.3	2.6	11
No response	–	0.2	1
Health status			
Very good	18.0	27.7	116
Good	47.2	58.7	246
Average	26.5	12.2	51
Bad	6.9	1.2	5
Very bad	1.4	0.2	1

Note. Body Mass Index (BMI) is defined as body mass divided by the square of body height (Sources: Cordts, Spiller, Nitzko, Grethe, & Duman, 2013; global, 2014; Statistisches Bundesamt, 2016, 2017, 2019).

As the outliers did not lead to different conclusions, they were kept in the analysis. Data are presented as mean \pm standard deviation, unless otherwise stated. Statistical significance was set at $p < .05$ for all analyses.

4. Results

4.1. Material aspects of eating practices

Cooking is (still) a core part of people's daily routine: 45% of respondents cook at home daily and 49% multiple times per week. Eating out at a restaurant does not occur as frequently, however, the majority of respondents (71%) go out to a restaurant multiple times per month. The median cooking frequency of respondents (2 = "multiple times/week") was statistically significantly higher than the frequency of going to a restaurant (4 = "multiple times/month"), $z = -15.42$, $p < .001$ (Wilcoxon signed-rank test). There were no significant differences between dietary groups for the frequency of cooking or eating out.

The division between weekend and weekdays plays a role regarding where people usually go to eat (see Table SM2 for details). During the

week, the majority of respondents (72%) has breakfast at home. Lunch is mainly divided between home (27%), the cafeteria (29%), and bringing something from home (23%), while few respondents also buy take-away food (10%) or eat at a restaurant (10%) during the week. Dinner takes place mostly at home during the week (90%). The weekend brings changes to these practices: for dinner, respondents eat out more often (from 4% during the week to 21% on the weekend) instead of having dinner at home (from 90% to 77%). There is furthermore an increase in having lunch at home (27%–74%) instead of eating at a cafeteria or bringing something from home. During the weekend, breakfast is eaten at home more often (72%–93%) instead of bringing something from home, getting something to go, or skipping breakfast altogether. The practice of eating out at a restaurant is, therefore, more likely part of weekend practices than weekday practices, especially for dinner.

The frequency of meat consumption by type of meal was analyzed using data from the subsample of meat-eaters (omnivores and flexitarians). The results show that lunch and dinner are similar in terms of their focus on meat, more so than breakfast: The majority of respondents (53%) eat meat for lunch and dinner at least 2–3 times per week. For breakfast, only 25% eat meat at least 2–3 times per week, 42% eat meat for breakfast once a week or less and 33% never eat meat for breakfast. We also asked meat-eaters, where they eat meat more often: at home, at a restaurant, or in both places equally. Only 15% of respondents stated that they eat meat more often at home. 42% stated that they consume meat equally frequently in both places, while 43% eat meat more often while dining out. Respondents therefore favor meat consumption at restaurants slightly over an equal distribution between home and restaurant, and strongly over eating meat more frequently at home.

There was a statistically significant, moderate association between the type of diet and place of meat consumption, $\chi^2(2) = 14.12, p < .001$, Cramer's $V = 0.23$ (Cohen, 1988): A higher percentage of flexitarians than omnivores indicated more frequent meat consumption at a restaurant, while fewer flexitarians than omnivores indicated an equal distribution between home and restaurant (see Table 2). This result indicates a stronger stance on the site of meat consumption for flexitarians, with the majority eating more meat at a restaurant.

4.2. Meanings of eating practices

Taste is a central value for eating practices at home and at a restaurant. At home, over half of respondents valued either health (36%) or taste (31%) most highly (see Fig. SM1 for details). In a restaurant setting, taste was valued most highly by almost three-quarters of respondents (74%), while health lost in importance (9%), ranking only slightly above regional/seasonal (8%). The differences in values between eating at home and at a restaurant were statistically significant ($p < .001$, McNemar-Bowker test of symmetry).

Respondents further see food as pleasurable in both settings: at home 42% of respondents associated food most with 'a pleasure' and at

Table 2
Crosstabulation of site of meat consumption and type of diet.

Type of diet	Site of meat consumption		
	Home	Restaurant	Equal
Flexitarian	13.8% 12 (-0.5)	58.6% 51 (3.6)	27.6% 24 (-3.3)
Omnivorous	15.9% 29 (0.5)	35.2% 64 (-3.6)	48.9% 89 (3.3)

Note. Adjusted residuals are presented in parentheses below observed percentages and absolute numbers.

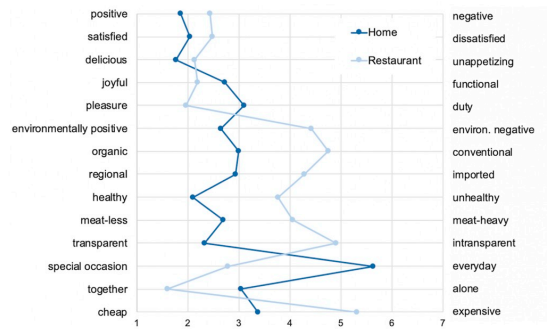


Fig. 1. Meanings profile of eating practices at home and at a restaurant. Note. Means for each profile are presented in the chart. Participants were asked: "What do you associate with cooking and eating at home/eating at a restaurant?", with antonyms presented on the left (i.e., at 1) and right side (7) of the chart.

a restaurant 39% (see Fig. SM2 for details). In the restaurant setting, 'social interaction' was the most chosen option (49%). At home, this only played a minor role, with 10% of respondents associating food most with social interaction. At home, food was much more associated with 'an expression of my lifestyle' (24%) than at a restaurant (8%). The differences between home and restaurant were statistically significant ($p < .001$, McNemar-Bowker test of symmetry).

The semantic differential further illustrates the intensity and direction of meanings (see Fig. 1). There is a significant overall mean difference ($t(373) = 12.61, p < .001, d = 0.65$) between the profiles of home (2.81 ± 0.63) and restaurant (3.37 ± 0.60). The mean 'enjoyment' index was not significantly different for home (2.3 ± 0.97) and restaurant (2.25 ± 0.84). However, the 'sustainability' index, where home (2.67 ± 0.92) was rated significantly more sustainable than a restaurant visit ($4.3 \pm 0.94, t(391) = 25.40, p < .001, d = 1.29$, accounts for a majority of the distinction between the two profiles. The restaurant setting (2.79 ± 1.31) led to a statistically significant, stronger association with 'special occasion' than home ($5.64 \pm 1.43, t(394) = -28.25, p < .001, d = 1.42$ and yielded the largest mean difference (2.83) between the settings of all antonym pairs. For the item 'transparent-intransparent' home was rated as more transparent (2.33 ± 1.25) than restaurant ($4.91 \pm 1.34, t(391) = 26.21, p < .001, d = 1.32$. For 'together-alone', home (3.04 ± 1.86) was rated as statistically significantly more alone than restaurant ($1.60 \pm 0.92, t(397) = -14.79, p < .001, d = -0.74$. The restaurant (4.06 ± 1.87) was rated as significantly more 'meat-heavy' than the home setting ($2.70 \pm 1.66, t(397) = 14.65, p < .001, d = 0.73$ and also as more expensive (5.32 ± 1.02) than at home ($3.38 \pm 1.43, t(396) = 20.96, p < .001, d = 1.05$. The item 'meat-less vs. meat-heavy' was analyzed in more detail: Flexitarians associated 'meat-less' with cooking and eating at home more (2.44 ± 1.08) than omnivores (3.97 ± 1.40), a statistically significant difference, $t(221.712) = -9.93, p < .001$ (Welch t -test). At a restaurant, both groups moved towards 'meat-heavy', but omnivores more strongly (4.98 ± 1.25) than flexitarians ($4.07 \pm 1.37, t(156.27) = -5.26, p < .001$).

Meat/fish consumption increased in the company of others: across all respondents, 20% cook meat/fish frequently when cooking for oneself, 27% when cooking for the household, and 40% when cooking for guests. Observed differences were statistically significantly different for all pairs of social settings, $\chi^2(2) = 104.01, p < .001$.

Analyzing these differences further by dietary group revealed that the trend towards more meat in the company of others is especially prevalent for flexitarians and omnivores (see Fig. 2). For flexitarians the difference is most pronounced between oneself/household versus guests: when cooking for oneself or their household, 4% and 6% of

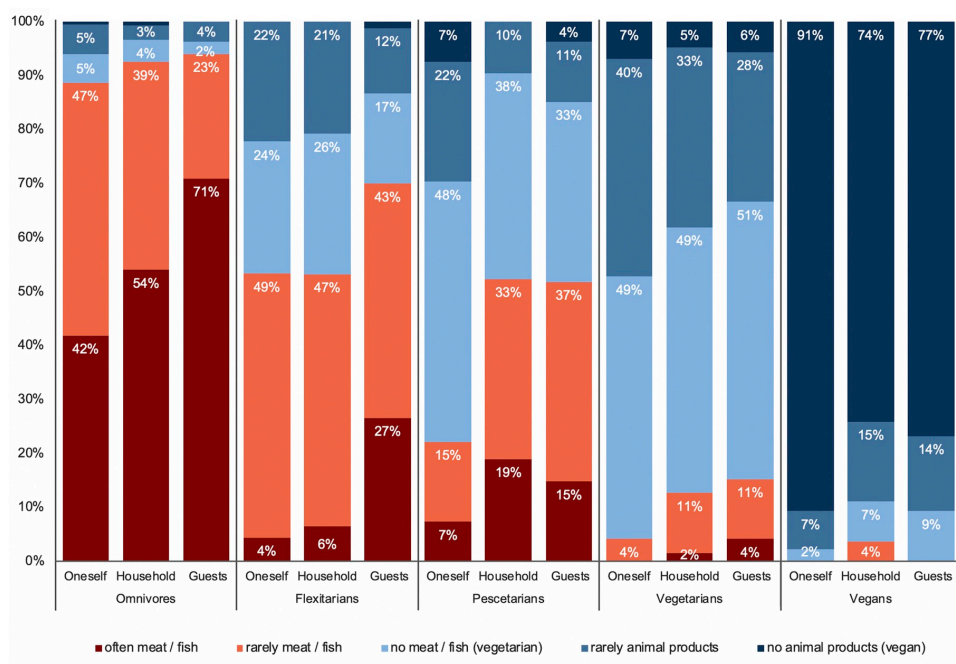


Fig. 2. Differences in meat/fish consumption by social context and dietary group.
 Note. Participants were asked: "When I cook for myself/household members/guests, I cook ..."

flexitarians often cook meat or fish, while, when cooking for guests, 27% opt for meat or fish. For omnivores, the increase in meat/fish consumption is also apparent, but more linear across categories: 42% often cook meat or fish for themselves, 54% for their household, and 71% for guests. Median meat/fish cooking frequencies were statistically significantly different between dietary groups when cooking for oneself, $\chi^2(4) = 243.50, p < .001$, for household members, $\chi^2(4) = 180.56, p < .001$, and guests $\chi^2(4) = 238.24, p < .001$ (Kruskal-Wallis H test). Differences for all group combinations when cooking for oneself or guests ($p = .002$) were significant, except between pescetarians and vegetarians or flexitarians. When cooking for household members, all group differences were significant ($p = .04$), except between pescetarians and flexitarians.

4.3. Linking materials and meanings

The main reason for eating meat at a restaurant is 'treating oneself' (77% (completely) agree), followed by 'meat is prepared better than at home' (55%), 'preparing meat myself is too much effort' (48%), and 'restaurants offer few good vegetarian alternatives' (42%) (see Fig. 3). Agreement with the statement 'the restaurant offers few good vegetarian alternatives' was statistically significantly higher for flexitarians (mean rank = 65.06) than for omnivores (mean rank = 51.59), $z = -2.22, p = .03$ (Mann-Whitney U test; see Fig. SM3 for details). Agreement with the statement 'I have access to higher quality meat at a restaurant' was statistically significantly lower for flexitarians (mean rank = 47.47) than for omnivores (mean rank = 65.34), $z = -2.95, p = .003$. Other statements did not yield significant differences in agreement for the two dietary groups.

Being in control of the origin of meat is the main driver (64% (completely) agree) for eating more meat at home (see Fig. 4). Agreement with the statements 'I can prepare meat better than at a restaurant' and 'I cannot prepare vegetarian dishes well' was statistically

significantly lower for flexitarians (mean rank = 15.46; 15.17) than for omnivores (mean rank = 23.49; 23.41), $z = -2.01, p = .045$; $z = -2.13, p = .03$ (see Fig. SM4 for details). Agreement levels did not yield significantly different results for the remaining statements.

5. Discussion

This paper has revealed surprising divisions between public and private forms of eating, many of which remain severely under-researched (cf. Goggins & Rau, 2016 for some reflection on this). Our findings suggest that few people eat sustainably all the time. Instead, we can detect pronounced divergences between eating in the home and eating out in restaurants. This distinction would not have been possible to identify, if we had not linked meanings to materials and the site of consumption in our empirical approach but had instead focused on an individuals' values and attitudes. By asking about the meaning of eating practices at home and at a restaurant and associated material elements, we were able to identify eating practices that were more meat heavy as well as reasons given for engaging in them. When asked where meat is eaten more frequently, at a restaurant, at home, or split equally between both, our study finds that 43% of respondents eat meat more frequently when at a restaurant. These findings are in line with those of Horgan et al. (2019), who found an increased likelihood and amount of meat eaten at a restaurant compared to the home or work context in the UK. In our survey, even many of those who have already adopted reasonably sustainable diets when eating at home switched to more unsustainable choices when eating out: 59% of flexitarian respondents ate more meat at a restaurant. Similarly, Edwards, Meiselman, Edwards, and Lesher (2003) demonstrate that the site of consumption shapes its perception: They showed that the same dish is evaluated differently in terms of its acceptability, depending on the setting it is served in (a military dining room, a residential home, and a 4-star restaurant). Our findings are in line with these results and extend them

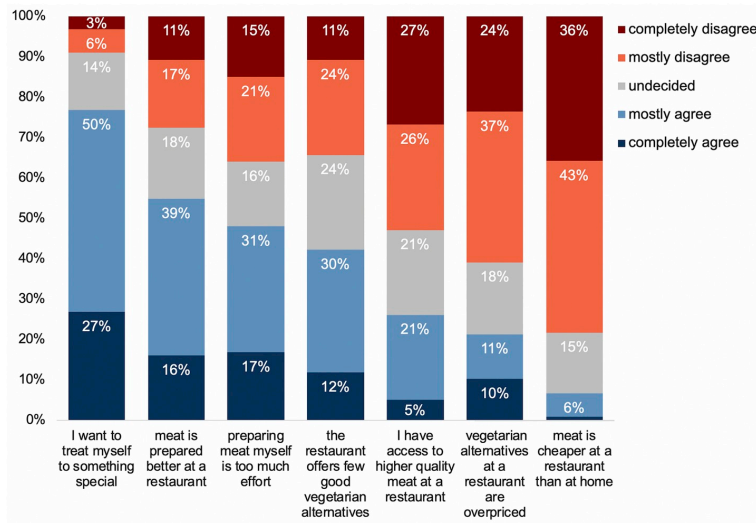


Fig. 3. Reasons for more frequent meat consumption at restaurants than at home. Note. Participants were asked: “I eat meat more often at a restaurant than at home, because...”

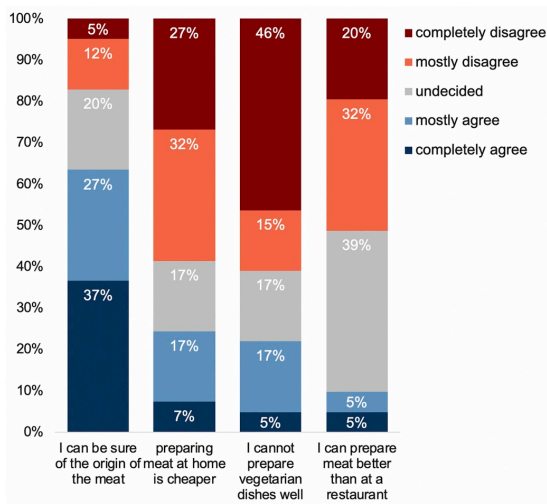


Fig. 4. Reasons for more frequent meat consumption at home than at restaurants. Note. Participants were asked: “I eat meat more often at home than at a restaurant, because...”

to the (un)favorability of plant-based dishes in different consumption settings.

Exploring the reasons behind the differences in material food choices, we find that ‘treating oneself’ plays the most substantial role in choosing meat at a restaurant. While eating is generally seen as pleasurable, the practice of eating out at a restaurant, especially, is associated with taste, social interaction, a special occasion, and eating together. In contrast, social interaction is deprioritized in the home context, where health plays an almost equally important role next to taste. The home context is also more strongly associated with ‘an expression of my lifestyle’ indicating that respondents see their home (especially when eating alone) as a realm where self-identity can be

lived out – free of others’ expectations connected to a social event such as eating out. It is, however, important to note potential interactions between sample characteristics and meanings ascribed to cooking: while previous studies have found cooking to be perceived mainly as a chore (Daniels, Glorieux, Minnen, & van Tienoven, 2012), many survey respondents’ high education levels and more privileged socio-economic status may mean that many of them view cooking more as a creative pursuit rather than a necessity.

Research on dining out has found the practice to be generally associated with pleasure, placing a high value on its social function (Warde & Martens, 2000). Our findings are further in line with a recent qualitative focus group study of young adults, which found that restaurant visits are seen as a special occasion, prioritizing taste and treating oneself over health (Allman-Farinelli, Rahman, Nour, Wellard-Cole, & Watson, 2019). Concerning meat as a food item, previous research highlights its association with good taste, social status, and special occasions (Kenyon & Barker, 1998; Macdiarmid, Douglas, & Campbell, 2016), legitimizing its consumption by viewing meat as ‘natural,’ ‘normal,’ ‘necessary,’ and ‘nice’ (Piazza et al., 2015). Graça et al. (2015) further quantified ‘meat attachment’ using a four-dimensional construct: hedonism (meat as a source of pleasure), affinity, entitlement, and dependence. They found a negative association between meat attachment and the willingness to follow a plant-based diet, providing further evidence of the role of affective elements in meat consumption. We believe that the alignment of meanings associated with meat consumption and eating out at a restaurant (special, treat, high social status) solidifies the (unsustainable) material components of the practice of eating out, ultimately leading to more meat consumption at restaurants.

Social interaction has been found to have a significant effect on different aspects of eating, such as the amount of food consumed and the length of the meal (Edwards, 2013; Herman, 2015; Ruddock, Brunstrom, Vartanian, & Higgs, 2019). Interestingly, the ‘socialness’ of eating also had a significant effect on whether or not meat was prioritized beyond the restaurant setting in our study: within the home, we found significantly more meat is served when cooking for household members or, especially, guests, than when cooking for oneself. This practice of cooking for others requires different materials to satisfy the meanings associated with it. This insight is in line with research by

Daniels et al. (2012) which found the meaning of cooking to change depending on social context: survey respondents gained more pleasure from cooking in the presence of others. Also, Horgan et al. (2019) found a greater quantity and higher probability of eating meat, when eating with others. This effect was stronger for family and friends, compared to colleagues, regardless of the situational context (home, restaurant, work). The higher occurrence of meat as part of eating with others should not lead to the conclusion that commensality is to be avoided. Social eating has been found to facilitate social bonding (Dunbar, 2017) and can also facilitate healthier eating (Fulkerson, Larson, Horning, & Neumark-Sztainer, 2014; Higgs & Thomas, 2016). The key lies in connecting the meanings associated with commensal eating to those of plant-focused diets.

At present, there is little acceptance of plant-based meals as special treats. Offering only plant-based dishes might be seen as inhospitable, ungenerous, or penitential, contradicting ideas of ‘the good life.’ As a result, efforts to lower meat consumption in countries such as Germany have not yet had any significant impact (cf. Asano and Biermann (2019) for evidence of this changing). The resulting argument cannot be to simply go out less since the authors believe that this trend will continue and even gain momentum (see also Goggins & Rau, 2016). The increasing performance of this practice will solidify associated meanings, such as deeming meat an appropriate dish (for celebratory occasions or when having guests over). Increasing the sustainability of eating practices at home and out of home will require different approaches and the involvement of diverse actors. Decoupling the ‘specialness’ of a restaurant visits with the ascribed meaning of meat as ‘treating oneself’ could reduce meat consumption. But how can plant-based cuisine be made more ‘special’?

Little is known about the extent to which individual elements of practices (i.e., materials, meanings, and competences) display a particular ‘stickiness’ or resistance to change, which in turn ensures the longevity of certain practices that may or may not be sustainable. The practice of eating meat constitutes a compelling case: here, we have an example of the element of meaning displaying a particular level of resistance to change. This fixation is understandable given the very long history of meat consumption as part of celebrations, religiously motivated feasts, or other special occasions. The Christian tradition of fasting by disavowing meat on Friday and eating meat as a central part of Sacristy and Easter celebrations strengthens the image of meat as something special (Leroy & Praet, 2015). Political institutions further reinforce this by measuring ‘material deprivation’ using meat consumption as an indicator. For example, the European Statistical Office’s (Eurostat) measure of economic strain includes ‘a meal with meat, chicken or fish (or vegetarian equivalent) every second day’ as one of nine items in the scale. The items are chosen to represent what is “... considered by most people to be desirable or even necessary to lead an adequate life” showing the centrality bestowed on animal-based protein as part of an ‘adequate life’ (Eurostat, 2020). Here, the phrasing of ‘vegetarian equivalent’ as an unspecified substitute for meat/fish appears to give lower priority to plant-based eating. This fixation on meat presents a substantial obstacle to the promotion of more sustainable, plant-based diets. The answer, however, is not to ban meat but to challenge positive connotations of meat consumption as a sign of ‘the good life’ (Sato, Gittelsohn, Unsain, Roble, & Scagliusi, 2016).

A series of laboratory studies have found that exposure to descriptive social norm messaging (information on the healthy eating patterns of others) corresponded with an increase in vegetable purchases with meals for participants who did not usually consume vegetables (Robinson, Fleming, & Higgs, 2014). In a follow-up study, ‘liking norms’ were tested by providing information about how much people enjoyed a particular behavior. While the authors observed no effects for regular consumers of vegetables, they found a significant increase in broccoli consumption among low habitual consumers (Higgs, Liu, Collins, & Thomas, 2019). Next to messages, the visual presentation of the material elements of a practice transport their social meaning. A

series of recent field experiments in Dutch restaurants showed that attractive displays of vegetable offerings increased overall meal satisfaction, even when meat or fish was partly replaced with vegetables (Reinders et al., 2020). A strategy to increase sustainable eating in the restaurant setting could therefore be to connect plant-based diets with prevailing notions of ‘the good life’: showcasing the sheer variety of edible plants, their colorful appearance, decorative features, and messages about how others enjoy plant-based food might help to break the seemingly inextricable link between eating out and choosing meat.

Drawing on the process of changing meanings discussed by Shove et al. (2012, p. 53 ff.), we argue that responsibility for creating new links between eating vegetables and ‘the good life’ cannot be attributed to one actor alone. For example, the case of the disastrous ‘Veggie Day’ campaign run by the German Green Party in 2010 serves as a cautionary tale of how not to politicize food consumption.⁶ Here, a political party’s attempt to promote more sustainable diets by endorsing the establishment of meat-free days in canteens resulted in the formation of very vocal resistance. Apart from the party-political rivalry that came into play, the Veggie Day example aptly demonstrates how food is an inherently political topic, yet many people do not view it that way. Instead, food choices are often seen as a private matter linked to personal identity formation: ‘you are what you eat.’ A multitude of actors interested in promoting plant-based diets thus needs to act collectively to reshape food as a topic of public interest ‘beyond the private kitchen.’

The role of celebrity chefs and ‘gourmets’ as public advocates for sustainable diets (whether meat-free or not) deserves specific mention in this context (Schösler & de Boer, 2018). For example, successful campaigns by UK-based celebrity chefs Hugh Fearnley-Whittingstall⁷ and Jamie Oliver,⁸ Irish-based Michelin star chef and food advocate JP McMahon,⁹ and German-Austrian celebrity chef Sarah Wiener¹⁰, a member of the European Parliament since 2019, demonstrate how more sustainable food can become a public matter. Given the insights presented in this paper regarding the central role of meat consumption during restaurant visits, chefs are a professional group that is uniquely positioned to de- and re-classify the meaning of meat.

Complementing the work of (celebrity) chefs, social media influencers and authors of (non) fiction are increasingly shaping eating practices. The American novelist Jonathan Safran Foer, for example, published two widely read works of non-fiction taking a stance to promote conscientious (plant-based) food choice with *Eating Animals* (2009) and *We Are the Weather: Saving the Planet Begins at Breakfast* (2019). The younger generation, especially, is also using social media for food inspiration and information (Doub, Small, Levin, LeVangie, & Brick, 2016). Instagram alone had 377 million posts tagged #food in March 2020. In a survey on social media use in Germany, 43% of respondents further indicated following food/drink ‘influencers’, making them the most popular type of bloggers (Statista, 2018). Moreover, a 2019 study found that 38% of Instagram users in Germany have bought a product recommended by an influencer, demonstrating one of the many material consequences of online activities (Statista, 2019).

While the price point of vegetarian offerings at a restaurant was not a significant issue for the respondents of our survey, limited vegetarian offers did lead to increased meat consumption. A recent study by Garnett, Balmford, Sandbrook, Pilling, and Marteau (2019) found that increasing the proportion of vegetarian dishes on offer at a university cafeteria led to an increase in vegetarian meal sales, with the largest

⁶ This is not to deny the complexity of the Green Party’s Veggie Day campaign failure, including the roles of political opponents in the Christian Democratic Union (CDU) and the Liberal party (FDP) and also of the German tabloid newspaper BILD in whipping up controversy in this particular case.

⁷ <https://www.rivercottage.net/hugh-fearnley-whittingstall> (accessed 22 July 2019).

⁸ <https://www.jamieoliver.com/> (accessed 22 July 2019).

⁹ <http://www.cookitraw.org/cooks/jp-mcmahon/> (accessed 22 July 2019).

¹⁰ <http://sarahwienergruppe.de/> (accessed 22 July 2019).

effect for diners who consumed a low ratio of vegetarian dishes previously. Our results are in line with this, although in our study, flexitarians felt more strongly than omnivores that little vegetarian offerings in restaurants led them to choose a dish that contains meat. Similar to [Mu, Spaargaren, and Oude Lansink \(2019\)](#), we see the responsibility of providing menu suggestions that are more in line with sustainability targets (i.e., less meat, more plant-based options) with restaurant owners. However, merely offering more plant-based choices may not lead to the desired changes, as meat-dishes would still be viewed as 'more worthy' of a restaurant visit, when in direct competition with plant-based ones. [Mu et al. \(2019\)](#) further discuss the exciting avenue of using digitalization, visualization, or artificial intelligence technologies in mobile applications to increase the sustainability of dining out practices. While they mention the meaning aspects of dining out (networking, relaxation, enjoyment), they do not draw a connection to the opportunities of mobile technology in this regard, focusing instead on how apps can be used to 'explain sustainability' to the customer and provide more information about the CO₂-footprint of the meal, for example.

Our findings show that a lack of cooking skills may result in more meat consumption by two distinct mechanisms: lacking vegetarian cooking skills may lead to the consumption of meat dishes at home, while lacking meat preparation skills may lead to more meat consumption at a restaurant. While not being able to prepare vegetarian dishes well played only a minor role overall, comparing answers between omnivores and flexitarians revealed significantly higher agreement levels for omnivores (8% vs. 29% (completely) agree): Their lack of vegetarian cooking skills led them to cook meat at home more often than flexitarians. Therefore, increasing (plant-focused) cooking skills could aid those practitioners who are not yet focused on decreasing their meat consumption at home. This observation is backed by the practice theoretical work of [Devaney and Davies \(2017\)](#), who, in their HomeLabs study (in-home experiments for more sustainable eating) found that existing cooking skills increased the willingness to try new sustainable cooking practices. This said, education cannot replace addressing systematic inequalities, such as access to healthy ingredients and a domestic environment conducive to cooking ([van Kesteren & Evans, 2020](#)).

6. Limitations

Despite the importance of these findings, our approach is limited by its mostly quantitative nature. While qualitative interviews preceded our survey, practice theoretical studies usually prescribe ethnographic methods, such as field-observations, to observe what is happening in practice ([Hargreaves, 2011](#)). Nonetheless, we would like to highlight the application of semantic differentials as a tool in practice-oriented survey research to elicit the meaning component of a practice. The spontaneous and associative nature of this type of rating scale helps elicit what [Shove, Watson, Hand, and Ingram \(2007, p. 12\)](#) call 'tacit and unconscious forms of knowledge and experience.'

The practice of eating at a restaurant may also require further distinction in future research. Differentiating between fast-food, casual, and fine dining, as well as the purpose of eating out (work vs. leisure) and take-out/food delivery, could provide more in-depth insights into the specific distinctions between this multifaceted practice. A third setting, fluidly situated between the private and the public sphere, – namely, informal (public) gatherings of neighbors or acquaintances for a street party, picnic, birthday, funeral or the like – poses a further interesting avenue of investigation.

While a full analysis of differences between men and women was beyond the scope for this paper, the role of gender in (un)sustainable eating practices needs to be acknowledged. For example, men are found to be more attached to meat and less likely to view a vegetarian diet in positive terms ([Graça et al., 2015; Ruby, 2012](#)). For our sample, we also found significant gender differences for type of diet, with more women

following meat-less or reduced meat diets. We would like to further investigate these differences in a follow-up analysis.

It should be noted that the self-classification of dietary behavior presents a further limitation: Recent research has found that even those who self-identified as 'low-meat consumers' ate more than recommended amounts of meat as set by the Swiss government ([Hagmann, Siegrist, & Hartmann, 2019](#)). A study by [Rosenfeld and Tomiyama \(2019\)](#) confirmed this, with over half of vegan/vegetarians having eaten meat since starting this form of diet. These findings indicate a possible underestimation of meat consumption, when based on self-classification. To reduce this risk, we used a two-step approach: we asked participants to self-classify their diet and compared those answers to a second question about the frequency of meat consumption in the past month for breakfast, lunch, and dinner. Where discrepancies were found, we reclassified participants (N = 53) based on the second question, as we expected less social confirmation bias in asking about actual behavior rather than dietary self-classification. Interestingly, flexitarians were most affected (13 flexitarians were actually omnivorous, 7 were pescetarians, and 32 omnivores were flexitarians), indicating potential confusion surrounding the term. One participant was relabeled from flexitarian to vegetarian. The research by [Rosenfeld and Tomiyama \(2019\)](#) also found the most common setting in which breaches by vegetarians/vegans happened were family events and/or special occasions, where vegans/vegetarians ate meat to ease social situations, supporting the overall findings of this study.

7. Conclusion

This study shows that recognizing the effect of the site of food consumption on the configuration of meanings and materials of eating practices is essential for effective sustainability strategies. Eating at home and out-of-home have different social meanings. The meanings element of the practice of eating implies different expectations of 'appropriate' food for different sites of consumption. The material element (here eating meat) follows these meanings. Our results show eating meat is more dominant in the out-of-home context, than at home. The meaning of plant-based diets does not align well with expectations, especially around commensal eating. Reasons for (un)sustainable eating practices can therefore not be changed solely by altering price, expanding offering, or increasing knowledge. Changes to the meaning component of eating out will require the involvement of diverse actors, such as restaurant managers, role models in the food space – celebrity chefs and social media influencers – and finally, political actors opening up business opportunities and leading by example through provisioning in public institutions. Future practice theoretical research on eating practices should explore these opportunities in more detail, using a mixed-methods approach involving observational data.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

The authors declare no competing interests.

Acknowledgments

We would like to thank T. Hermes and T. Schreiber for their attentive reading and valuable comments on an earlier draft of this manuscript. We are also grateful to everyone who agreed to participate in our qualitative interviews and online survey, making this research possible.

Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.appet.2020.104730>.

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Supplementary Material:

The meaning of meat: (Un)sustainable eating practices at home and out of home

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APPENDIX

Table SM1. Definition of dietary groups

omnivorous	No dietary restrictions regarding animal products
flexitarian	Meat or fish no more than once per week
pescetarian	no meat, but fish (undefined how often)
vegetarian	no meat and no fish
vegan	no animal products

Table SM2. Comparison of meal location by weekend and weekday

	Breakfast				Lunch				Dinner						
	weekday	weekend	Δ		weekday	weekend	Δ		weekday	weekend	Δ				
At home	297	72.4%	388	92.8%	20.4%	109	26.5%	300	73.9%	47.4%	375	90.1%	318	77.2%	-13.0%
At a restaurant	1	0.2%	5	1.2%	1.0%	40	9.7%	28	6.9%	-2.8%	15	3.6%	87	21.1%	17.5%
At a cafeteria	7	1.7%	2	0.5%	-1.2%	120	29.1%	2	0.5%	-28.6%	1	0.2%	0	0.0%	-0.2%
Brought from home	35	8.5%	0	0.0%	-8.5%	95	23.1%	6	1.5%	-21.6%	6	1.4%	1	0.2%	-1.2%
To go (from the bakery, supermarket)	25	6.1%	3	0.7%	-5.4%	42	10.2%	11	2.7%	-7.5%	12	2.9%	2	0.5%	-2.4%
I usually do not eat this meal	45	11.0%	20	4.8%	-6.2%	6	1.5%	59	14.5%	13.1%	7	1.7%	4	1.0%	-0.7%
Total	410	100%	418	100%		412	100%	406	100%		416	100%	412	100%	

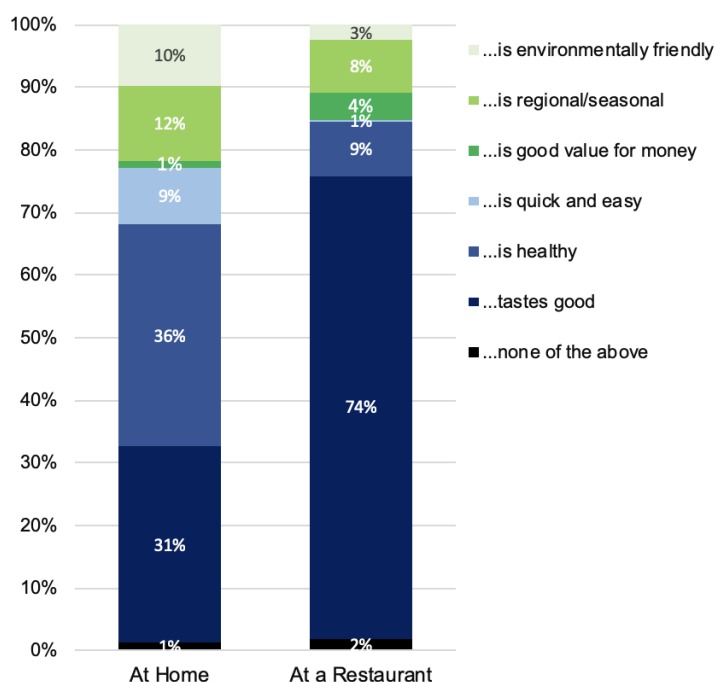


Fig. SM1. Values related to food consumption at home and at a restaurant.

Note. Responses to the question "What is most important to you when eating at home/at a restaurant? That your food...". Response numbers at home N=417, at a restaurant N=399.

APPENDIX

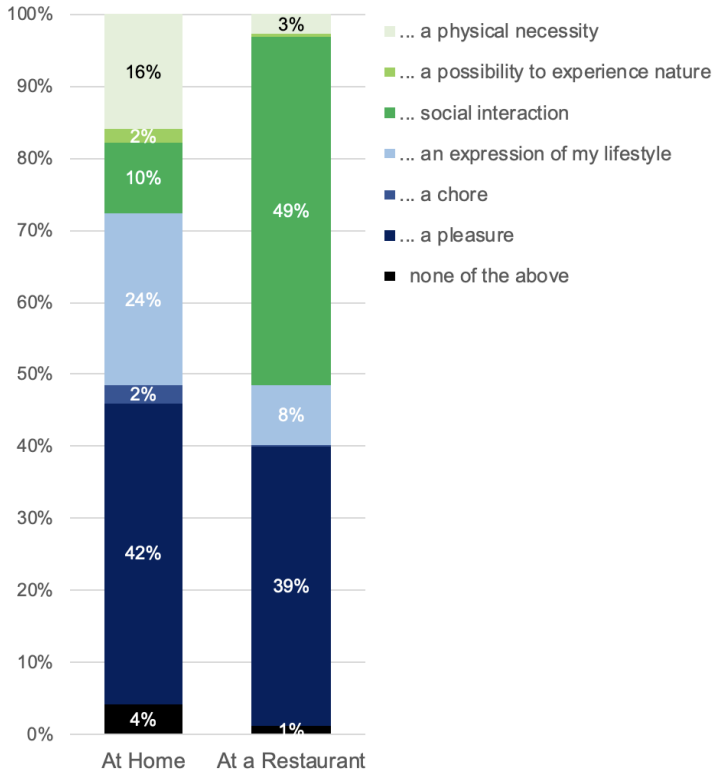


Fig. SM2. Emotions related to food consumption at home and at a restaurant.
Note. Responses to the question “Food for me is.....”. Response numbers at home N=419, at a restaurant N=400.

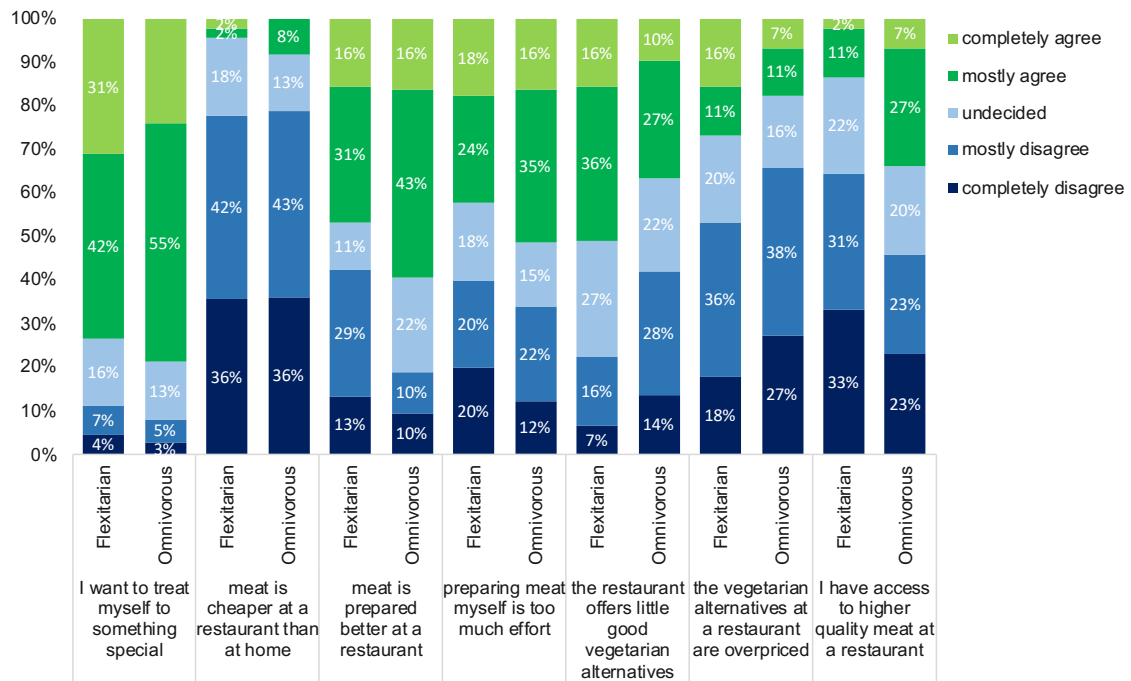


Fig. SM3. Reasons for more frequent meat consumption at a restaurant by dietary type.
Note. Responses to the question “I eat meat more often at a restaurant than at home, because...”

APPENDIX

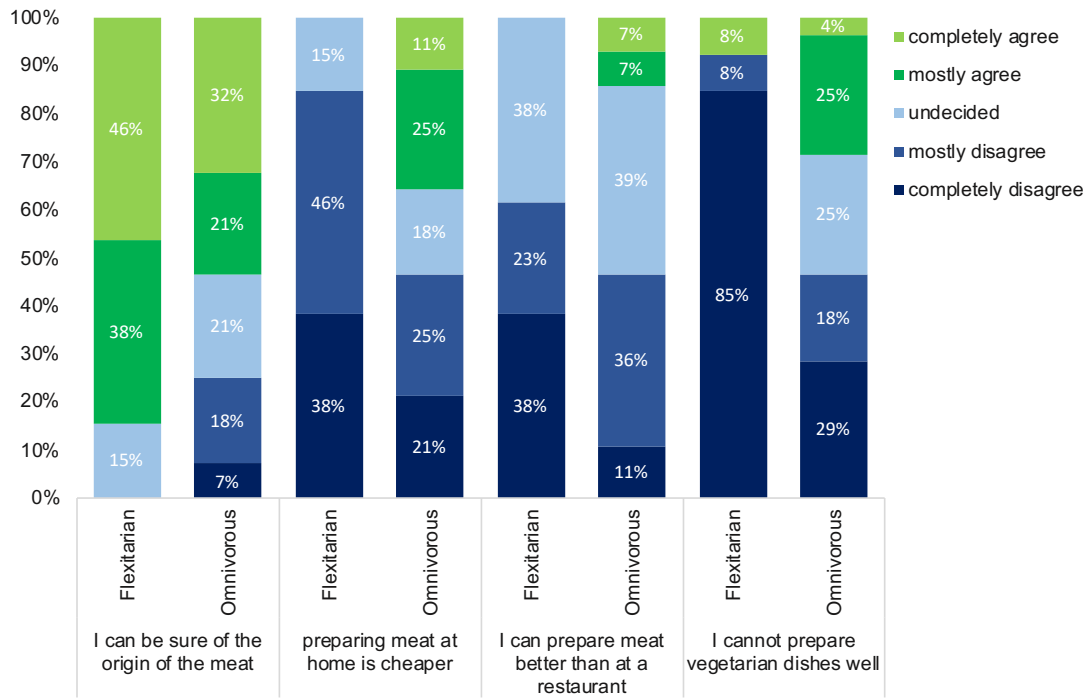


Fig. SM4. Reasons for more frequent meat consumption at home by dietary type.
Note. Responses to the question “I eat meat more often at home than at a restaurant, because...”

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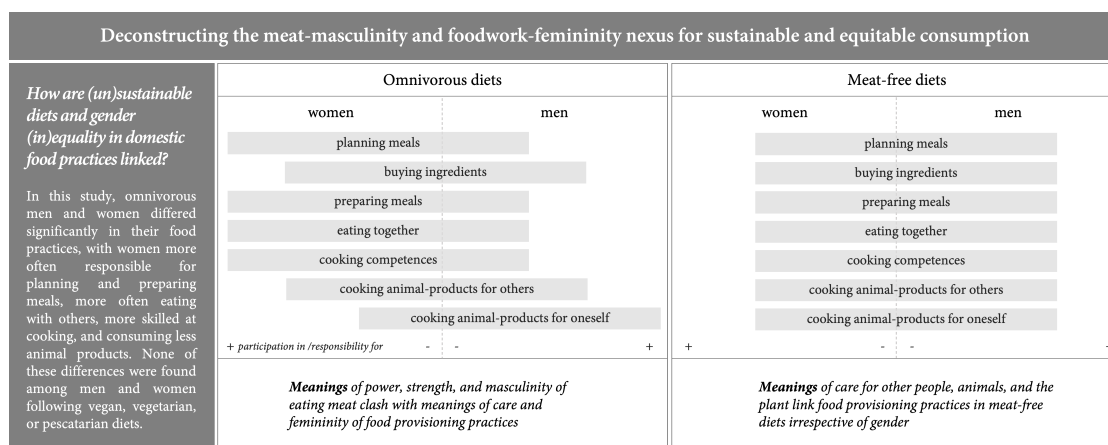
Gender differences in household food practices: The role of sustainable diets

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Graphical Abstract



Highlights

- This study directly compares household food practices of men and women following omnivorous and meat-free diets
- Gender differences in food practices were found for omnivores and flexitarians, but not for meat-free dieters
- Men following meat-free diets were equally as involved in food provisioning as women
- Practicing meat-free diets is still more prevalent among women
- Shifting gender identities may enable plant-focused dieting and gender equality in foodwork

Keywords

Sustainable diet, gender, foodwork, practice theory

Abstract

Research on sustainable consumption has yet to fully acknowledge the intersectionality of multiple strands of sustainable development, such as planetary health, human health, and gender equality. This study makes an explicit effort to consider the interlinkages of gender (in)equality and (un)sustainable food practices in the home. Previous research warns of the risk of layering yet another burden – that of a sustainable household – on women. Drawing on empirical evidence from a German online survey on food consumption, this study reveals that foodwork, when embedded in sustainable dietary practices, is shared equally by men and women. Omnivorous men and women differ significantly in their food practices, with women more often responsible for food provisioning (especially planning and cooking meals), more often eating with others, more skilled at cooking, and consuming fewer animal products. None of these food-related gender differences were found among men and women following vegan, vegetarian, or pescatarian diets. Flexitarians still exhibit gender differences in the responsibility for food provisioning, marking a threshold in the gendered nature of food practices. The implications of everyday sustainable cooking and eating practices in their relation to (un)changing gender identities and larger socio-economic inequalities are discussed. This research concludes by arguing for the importance of including gendered meanings in policy and marketing initiatives aimed at increasing sustainable food consumption at the household level.

1. Introduction

“Being a *real man* used to be easy, or so the contemporary fantasy goes; as long as one had a family and brought home the bacon one was fine.” (Ostberg, 2019, p. 212)

Addressing intersecting issues of inequality and environmental sustainability is imperative for a future within ecologically safe and socially just planetary boundaries (Dearing et al., 2014). The food system exerts a multitude of pressures on the environment through land-use change, pollution through nitrogen and phosphorous use, freshwater depletion, and greenhouse gas (GHG) emissions (e.g. Springmann et al., 2018; Vermeulen et al., 2012). The pressure of the food system on the environment will only intensify in the future due to population growth and an ongoing *nutrition transition* increasing the per capita calorie consumption and the demand for animal products (Popkin, 2006; Sans and Combris, 2015; Tilman and Clark, 2014). Research has shown that a technocentric focus on food production without changing consumption at large will be insufficient to reach climate targets (Bajželj et al., 2014). Shifts in household consumption can contribute substantially to staying within climate targets, especially for high-income contexts (Ivanova et al., 2020).

Livestock is a key leverage point of the food system's environmental impact. The sector is responsible for around 15% of all human-induced GHG emissions, 44% of anthropogenic methane emissions, and 53% of anthropogenic nitrous oxide emissions (Gerber et al., 2013). While there is no agreement on any one definition of what constitutes a 'sustainable' diet, scientific findings are pointing towards diets with reduced animal protein, and especially meat, as beneficial for human health and the environment (e.g. Hallström et al., 2015; Westhoek et al., 2014; Willett et al., 2019). The impact of ruminant meat cannot be stressed enough: a meta-analysis of Clark and Tilman (2017) found them to be 3-10 times more impactful than other animal products and 20-100 times more than plant-based foods for all indicators investigated (GHG emissions, land use, energy use, acidification potential, and eutrophication potential).

In Germany, the average meat consumption (1.2 kg/week) is twice as high as recommended by the German Nutrition Society (BMEL, 2017; DGE, 2018). However, even when adhered to, many national dietary guidelines are highly inconsistent with climate targets (Ritchie et al., 2018). In Germany, following recommended diets would be consistent with a 1.5°C climate target, only if household food waste was near zero and all other sectors achieved near total decarbonization by 2050. While overall the number of people following low-meat and no-meat diets is slowly increasing in Germany, men are lagging behind. In 2019, 71% of vegetarians in Germany were women and only 29% were men (Statista, 2019).

Studies across numerous (Western) countries on gender and meat support the association between men and meat: men eat larger portions of meat and do so more frequently, they are less likely to be a vegetarian, and less inclined to become one (Rosenfeld, 2018). Meat is a highly gendered food linked to masculinity that carries significant symbolic meaning of strength and power (e.g. Büning-Fesel and Rückert-John, 2016; Love and Sulikowski, 2018; Rozin et al., 2012). Consuming meat, especially red meat, may affirm a masculine gender identity (Rosenfeld, 2018). This link is problematic from a planetary and human health perspective given that red meat has the highest environmental impact of all food groups and is associated with increased disease risk (Clark et al., 2019).

In this study, gender is viewed through the lens of contemporary feminist thought, as a product of political, historical, and social macro-level processes. In this view, gender is not predetermined but socially constructed. It is "constantly created and re-created out of human interaction" (Lorber, 1994, p. 13) by people 'doing gender' (West and Zimmerman, 1987). By

eating meat, men ‘do gender’ and adhere to the social expectations of hegemonic¹ masculinity. Masculine identity is neither homogeneous nor static. However, the study of popular culture can shed light on a society’s understanding of ‘ideal’ manhood. For example, the German food and lifestyle magazine *BEEF!* (beef.de) explicitly sets male cooking apart from female cooking in their slogan “Men Cook Differently” and lists meat, high-tech grills, and expensive knives as status symbols of their target group.

The link between meat and masculinity appears to be so strong that it can undermine sustainability campaigns. A recent example is the failed introduction of a ‘meat-free Monday’ in the Norwegian Armed Forces (Kildal and Syse, 2017). Considerable resistance stemmed from the association of meat with ‘protein, masculinity and comfort’ (p. 69), which is reflected in soldiers’ self-identity and military culture. The German Green Party further failed to introduce a ‘Veggie Day’ in public canteens as part of their campaign for the 2013 German federal elections. While adverse reactions of rival parties and (tabloid) media fueled the controversy, consumer surveys also showed a large gender gap: 54% of men were against the proposition, while only 34% of women rejected the veggie day (Heid, 2013). As Rothgerber (2013) summarizes: “it seems reasonable to assume that following a vegetarian diet or deliberately reducing meat intake violates the spirit of Western hegemonic masculinity, with its socially prescribed norms of stoicism, practicality, seeking dominance, and being powerful, strong, tough, robust, and invulnerable” (p. 9).

The meat-masculinity nexus is also instrumentalized by women to distance themselves from ‘feminine foods’, associated with personal characteristics they deem undesirable. In a *New York Times* article titled “Be Yourself, Girls, Order the Rib-Eye” (Salkin, 2007), women described signaling to be “down to earth and unneurotic [...] not obsessed with my weight even though I’m thin, and I don’t have any food issues” by eating steak and burgers in a dating context. Meat’s association with desirable qualities may thereby hinder sustainable dietary trajectories for both men and women.

Household consumption is a central source of environmental pressure, contributing to over 60% of global GHG emissions, as well as 50-80% of total land, material, and water use (Ivanova et al., 2016). Wealthier countries generally generate higher footprints per capita. Across studies, the most critical consumption categories consistently are mobility, shelter, and food (e.g.

¹ Hegemonic masculinity refers to the dominant form of masculinity - at the local, regional, or global level and at a specific time - against which all other forms of (non-hegemonic) masculinities and femininities are evaluated (Connell and Messerschmidt, 2005). While not all men endorse this standard, they are measured against it. It is thereby not ‘normal,’ as in statistically common behavior, but a normative ideal.

Hertwich and Peters, 2009; Ivanova et al., 2016; Tukker et al., 2010). In the Global North, households, and household food consumption, are therefore key sites to reduce environmental impact through changes in consumption. However, gender inequality at the household level has to be part of the scope of analysis (Kennedy and Kmec, 2018; MacGregor, 2010). As Organo et al. (2013) stress, “the key role of women in the home provides both an opportunity to institute sustainable practices and the potential to overlay yet another burden on domestic labour” (p. 561).

Historically, domestic chores – especially quotidian cooking – have been put on the shoulders of women (DeVault, 1991; Kerr and Charles, 1986) and are associated with feminine characteristics such as ‘caring’ (Daniels et al., 2012). While the discourse about who *should be* responsible for domestic labor may be changing (Beagan et al., 2008), women still *are* more often responsible in many socio-cultural groups, despite the dramatic increase in women's labor market participation (Bianchi et al., 2012; Hook, 2010; Szabo, 2011). In Germany, 72% of women cook or do housework (outside of paid work) every day, while only 29% of men do (EIGE, 2019). This difference holds true even for single households (68% vs. 46%), couples without children (79% vs. 31%), and intensifies for couples with children (93% vs. 25%). Even when men are involved in overall domestic labor, women remain primarily responsible for food provisioning (planning meals, buying ingredients, preparing meals, and clean-up) (Som Castellano, 2015). As Allen and Sachs (2007) state: “Although women rarely work as chefs and head cooks in restaurants, they almost always hold the position of head cook in their homes” (p. 9). This arrangement reinforces gender inequality and has significant economic disadvantages for women (Lorber, 1994).

Several scholars qualify the household as a relatively new, but essential frame for studying the socio-environmental implications of everyday life (e.g. Liu, 2020; Reed and Christie, 2009). Few studies, however, investigate the intersection of sustainability, gender, and domestic labor. This gap is all the more surprising, given the policy implications of interlinked issues of sustainability. As Reed and Christie (2009) lament: “[T]here is no question that feminist ontology, methodology, and possibly even epistemology have infused much work in critical environmental geography. But the absence of gender as an analytical category in exposing inequality and marginalization is striking.” (p. 247). This study makes an explicit effort to respond to this call by investigating differences between men and women in sustainable diets and food practices² at the household level. In using routinized food practices as the unit of

² The term ‘food practices’ will be used throughout this paper to describe both food provisioning/foodwork (planning meals, buying ingredients, preparing meals) as well as food consumption.

analysis, this research moves beyond gender differences in attitudes and intentions. Combining the gendered performance of food practices with sustainability issues aims to provide novel insights into these issues' interlinkages.

2. Sustainable diets and gender equality at the household level

Much research on (un)sustainable food consumption follows an approach which emphasizes individuals' values, attitudes, and rational choice (Rozin, 2020). Food policy has adopted this perspective, often focusing on individuals' choices, with limited effectiveness in bringing about large-scale social change (John et al., 2016; Watson et al., 2020). Similarly, reducing gender inequality – also concerning time spent on cooking and housework – has moved at a 'snail's pace' in the EU (EIGE, 2020, p. 3). As a response, alternative approaches suggest viewing eating and foodwork as a socially and materially embedded practice (e.g. Hargreaves, 2011; Shove, 2010; Shove et al., 2012; Warde, 2016, 2005). From a practice-theoretical perspective, "more or less sustainable patterns of consumption, are not seen as the result of individuals' attitudes, values and beliefs constrained by various contextual 'barriers', but as embedded within and occurring as part of social practices" (Hargreaves, 2011, p. 82). Instead of evaluating an *individual's* environmental footprint, the focus lies on the footprint of *practices* (Spaargaren, 2011).

This work adopts Shove's (2012) definition of a practice as consisting of three main elements: meanings, competences, and materials. 'Competences' refer to the know-how necessary to engage in a practice, 'materials' are the things, technologies, and physical infrastructure a practice is embedded in, and 'meanings' relate to the emotions, ideas, and motivations associated with a practice. In this way, the practice paradigm synthesizes agency and structure, the interpretative and systemic schools of thought (Spaargaren, 2011). A practice is upheld through 'performance' by practitioners (Reckwitz, 2002). Thereby, "practices emerge, persist, shift and disappear when *connections* between elements of these three types [materials, competences, meanings] are made, sustained or broken" (Shove et al., 2012, p. 9). By focusing on the combinations of food practices men and women engage in, this study makes an explicit effort to respond to the call of Warde (2005) "to ask what types of practice are prevalent, and what range of the available practices do different individuals engage in, as well as what are the typical combinations of practices" (p. 149).

While the topic of environmental sustainability has recently received more attention in practice-theoretical food research (e.g. Biermann and Rau, 2020; Brons and Oosterveer, 2017; Godin and Sahakian, 2018; Halkier, 2009; House, 2018; O'Neill et al., 2019; Plessz et al., 2016;

Schösler and de Boer, 2018; Spurling et al., 2013; Twine, 2018), the topic of gender and gender equality has been much less of a focus. Recent exceptions of studies using a practice-theoretical lens to study food with an explicit focus on gender include a study of Danish women as cooking practitioners (Halkier, 2007), research on domestic food practices of fathers in the UK (Meah, 2017) and men in Belgium (Daniels and Glorieux, 2017), and a study on healthy cooking practices and the links to socio-economic inequalities for mothers in the UK (van Kesteren and Evans, 2020). A thorough search of the relevant literature yielded no empirical works using a practice-theoretical lens to study the intersection of food, planetary-health diets, and gender, explicitly.

Exceptions in related fields, without an explicit practice-theoretical perspective, include studies on Alternative Food Networks (Som Castellano, 2015) and households practicing sustainability (Organo et al., 2013). Som Castellano (2015) studied gender inequality in food provisioning among men and women engaging in Alternative Food Networks in Ohio. Although respondents engaged in food practices promoting organic, fair-trade, and local consumption, the women in the study remained predominantly responsible for all aspects of food provisioning (planning, buying, cooking, cleaning). In their research on sustainable (nuclear) households, Organo et al. (2013) find that women were more often responsible for the everyday implementation of sustainable practices than men. The gap in time spent on sustainability practices between men and women was mostly accounted for by the differences in time spent on cooking. Many studies on gender differences in pro-environmental behavior at the household level miss the importance of food choice in terms of its impact. These studies fail to base 'sustainable' domestic food practices on the findings of environmental impact assessments. The focus is often on how food is produced (e.g. organic) or how food waste is treated (e.g. composting), but rarely on the type of food eaten. In the study by Organo et al. (2013), the sustainability of food was conceptualized as 'cooking from scratch,' food items free from preservatives, time spent on cooking, composting, growing vegetables, and keeping chickens. Similarly, Barr et al. (2011) list organic produce and composting as environmentally-friendly food practices, while Barr and Gilg (2006) add fair-trade and local production. Changes in diet were not considered, thereby missing a key leverage point of sustainable food practices at the household level. The next section will examine findings from the separate strands of research on the links between meat and masculinity as well as foodwork and femininity that this study aims to connect.

2.1. Delinking the meat-masculinity nexus

Empirical studies have found evidence of plant-focused diets delinking the meat-masculinity nexus. However, there is a discussion in the scientific community as to whether the performance of gender non-conforming diets leads to a destabilization of the gender binary or if practitioners ultimately defeminize no-meat diets to reinstate hegemonic masculinity within sustainable diets. In this way men following sustainable diets may be 'redoing' rather than 'undoing' gender (Brenton and Elliott, 2014) by rejecting feminine aspects of sustainable diets such as concerns for animal welfare, instead grounding their choices on rationality and expert opinions (Mycek, 2018). Drawing a parallel to men and women in gender non-conforming occupations, Lorber (1994) states that “gender typing is often maintained symbolically, as when policewomen view their work as social work and men nurses emphasize the technical and physical strength aspects of what they do” (p. 195). A study by Sumpter (2015) gives an example of vegetarian men engaging in hybrid masculinity³ by defeminizing meat replacement products on the grill, using them as a symbol of masculinity. Similarly, in her qualitative work on vegan and vegetarian men, Mycek (2018) argues that her interviewees’ food practices do not challenge gender norms. Instead, they masculinize their diets by linking them to rationality and distancing them from emotions. “Masculinizing a perceived feminine practice rather than accepting a feminized identity is a way for these men to subvert challenges to the gender binary and perform a slightly less conventional masculine practice rather than undo it” (p. 18). Similar conclusions were recently drawn for vegan men by Greenebaum and Dexter (2018). They find that while vegan men contest hegemonic masculinity, they do not fundamentally challenge gender inequalities by focusing on the connection of veganism to strength, power, athleticism, and self-control. The interviewed men further described how the involvement of men added legitimacy to the vegan movement. DeLessio-Parson (2017) adds similar findings for vegetarian and vegan men in Argentina, who employ rationality to frame meat-eating as a sign of weakness. Therefore, while these studies show the potential of meat-free diets to destabilize the meat-masculinity nexus and contest masculine gender norms, they seem to not be “undoing” gender or gender hierarchies. Instead, non-meat-eating men seem to be making room for meat-free diets within masculine ideals by arguing for their diets using masculine logics of rationality. This study goes beyond the meat-masculinity nexus in asking if engaging in (un)sustainable dietary practices links to practices of domestic foodwork. Is men’s dominant position in the gender division of labor still apparent for practitioners of sustainable diets? Who, in the end, takes on the task of cooking up sustainable fare?

³ Hybrid masculinity is understood as a distancing from hegemonic masculinity by incorporating elements of subordinated masculinities or femininities (Bridges and Pascoe, 2014). While various gendered practices become possible, gendered inequality can remain.

2.2. Delinking the foodwork-femininity nexus

Research has shown that when men participate in cooking, it is more often understood as a self-oriented leisure activity, rather than a domestic chore or duty (DeVault, 1991; Roos et al., 2001). However, recent empirical studies are finding the two distinct areas of pleasure and duty to merge for men involved in domestic food practices. Szabo (2014) investigated gender dichotomies in cooking practices using qualitative data of 30 Canadian men with significant domestic cooking responsibility. Even those men who took on the primary responsibility for domestic food provisioning framed their cooking in masculine terms of leisure, performance, or culinary art. However, about half of the interviewees additionally drew on narratives of love, care, and creating home. The use of these ‘culinary femininities’ was observed most for men with the most substantial responsibilities for food provisioning. As Szabo concludes: “Participants did not automatically take on feminine positionings in the kitchen as soon as they became frequent household cooks [...] their new cooking roles created new interactions with others and new self-concepts, which, in turn, influenced their approaches to cooking.” (p. 29) Similar results were found for Swedish (Neuman et al., 2017a, 2017b), Belgian (Daniels and Glorieux, 2017) and English men (Meah, 2017) who engaged in ‘more emotionally intimate forms of fathering’ (p. 16) through foodwork. These findings lead to the conclusion that a change in social role does not predetermine the lived experience, but rather shapes it, the more central the practice becomes. Men’s cooking can be care-oriented, especially if their degree of responsibility for cooking is high.

The results of this literature review point to a potential conflict in meanings. If men engaged in sustainable diets mainly link them to logic and rationality, while men routinely engaged in food provisioning practices frame them as caring, can these practices be linked? The next section details the empirical approach used to study links between everyday practices of (un)sustainable diets and broader structures of gender inequality in domestic foodwork.

3. Methods

Practice approaches to studying consumption typically follow a qualitative research tradition, employing in-depth interviews, participant observations, or historical case studies (e.g. Halkier et al., 2011). More recently, the potential of quantitative data and mixed-methodology in tracing the diversity of practices across populations or over time is highlighted (Browne et al., 2014). Research on social practices has started to employ mixed-methods (e.g. Bartiaux and Salmón, 2014; Browne et al., 2014; Paddock et al., 2016; Spotswood et al., 2015) or answered practice-theoretical questions purely quantitatively (e.g. Biermann and Rau, 2020; Hess et al.,

2018; Yates and Warde, 2017, 2014). The empirical data used in this study also diverges from the traditional qualitative approach of practice theory, by using data from a quantitative online survey. Operationalizing practices in a quantitative survey poses certain limitations, which are elaborated on in the discussion section.

3.1. Measurements

The data used for this study stems from a larger survey study on food practices in Germany. The construction of the survey was informed by qualitative work (semi-structured interviews and focus groups), as well as reviewing relevant literature. Details on the construction of the survey can be found in Biermann and Rau (2020). The survey contained ten closed-ended questions evaluated as part of this study (see Supplementary Materials Table S1). The main constructs were food provisioning practices of planning meals, shopping for ingredients, preparing meals, cooking skills, and commensality (eating meals together). The use of animal products (especially meat and dairy) served as a proxy for sustainability. Cooking was further differentiated by social situation (cooking for oneself, the household, or guests). Filters were used in the survey to direct respondents only to those questions relevant to them (e.g. questions about the household were only posed to respondents not living alone). Additionally, respondents self-classified their diet as either vegan, vegetarian, pescatarians, flexitarians, or omnivorous. Gender was recorded in four categories: male, female, other, and 'I do not want to categorize myself.'

3.2. Data collection

Data were collected between January and April 2019 by distributing the survey online. The study followed the International Sociological Association's code of ethics: Participants gave informed consent before taking part in the study and were debriefed upon concluding the survey. In total, 420 responses were collected. Certain demographics are overrepresented in the self-selected sample: sustainable diets, high education, living in cities, aged between 20-30, good health, and healthy weight. While this leads to certain limitations elaborated on in the discussion section, the overrepresentation of respondents following sustainable diets allowed for dietary subsets large enough for statistical analyses. A detailed comparison of the sample with the German population can be found in Biermann and Rau (2020).

3.3. Data analysis

Practitioners who assigned themselves to different genders were compared regarding their dietary and food practices. Respondents ($n = 7$) who selected either 'other' or 'I do not want to categorize myself' for the gender variable, were excluded from further analyses. Gender differences were analyzed using Mann-Whitney U tests. Somers' d was used to determine the association between gender and diet. A Friedman test was run to determine if the answers for men or women (within gender) were significantly different for buying, planning, or preparing meals as well as the use of animal products when cooking for themselves, the household or guests. Where the Friedman test was significant, a series of six post hoc tests for multiple comparisons, ranging from conservative to liberal, was run (Pereira et al., 2015). Statistical analyses were carried out with IBM SPSS Statistics 26 (IBM Corp, 2019). Additionally, pairwise comparisons following the results of the Friedman test were performed using the packages 'PMCMRplus' (Pohlert, 2020) and 'NSM3' (Schneider et al., 2020) in the R statistical programming environment (R Development Core Team, 2020). The results of the Wilcoxon Signed-Rank test with Dunn-Bonferroni correction (Dunn, 1964) are reported in the text, except where difference scores were not symmetrically distributed. In this case, the results of the Sign test are reported. Statistical significance was set at $p < .05$.

4. Results

4.1. Linking gender and domestic food practices

Analyzing food practices for all men and women in the sample revealed significant differences, with men significantly less often responsible for practices related to food provisioning (see Table 1). Over 50% of women indicated that they are solely responsible for planning meals, buying ingredients, and preparing meals, while only approximately 40% of men indicated the same (see Fig. 1). There were no significant differences between the practices within gender. The frequency of eating with other household members was not significantly different for men and women: 86% of men and women eat together at least multiple times per week. Women classified themselves as significantly more skilled at cooking than men: 65% of men indicated their cooking skills as at least good, while 82% of women indicated the same.

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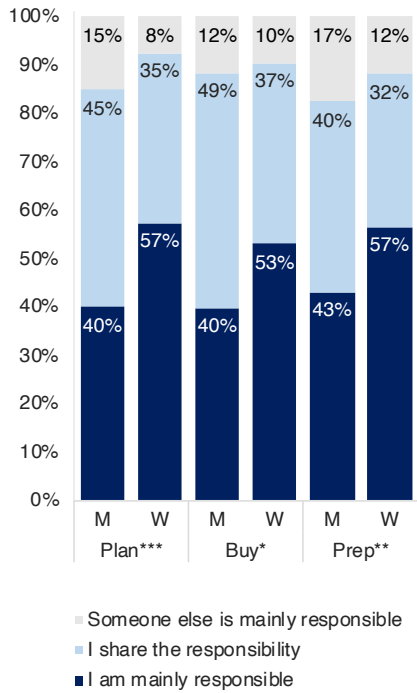


Fig. 1. Responsibility for food provisioning practices by gender.

Note. Participants were asked: “How much responsibility do you have in your household for planning meals/buying ingredients/preparing meals...”. Statistical significance for gender differences is indicated by asterisks: * $p < 0.05$, ** $p < 0.01$, *** $p < .001$.

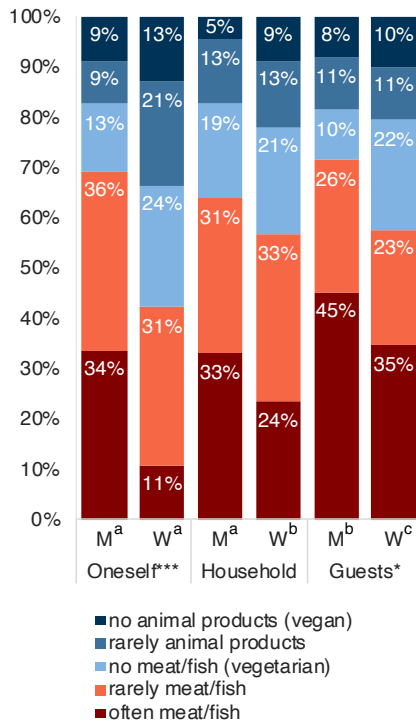


Fig. 2. Use of animal products in different social settings by gender.

Note. Participants were asked: “When I cook for myself/household members/guests, I cook...”. Statistical significance for gender differences is indicated by asterisks: * $p < 0.05$, ** $p < 0.01$, *** $p < .001$. Different superscript letters indicate significant differences within gender found in pairwise comparisons (e.g. observed differences for women between cooking for oneself, the household, and guests were significantly different).

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The materiality of cooking practices was further analyzed in different social settings: using animal-based ingredients (especially meat/fish) when cooking for oneself versus the household or guests. Men cooked significantly more meat/fish for themselves and guests than women (see Table 1). 34% of men indicated making use of meat/fish often when cooking for themselves, while only 11% of women indicated the same. Similarly, 45% of men often cook meat/fish for guests, while 35% of women do so (see Fig. 2). Meat/fish use when cooking for the household indicated similar trends between men and women. However, these were only marginally significant ($p = .057$). Within gender, the use of animal products increased for women when cooking for others (household, $Mdn = 4$, $p < .001$ or guests, $Mdn = 4$, $p < .001$) versus cooking for themselves ($Mdn = 3$). When cooking for guests ($Mean\ rank = 2.28$, $p < .001$) women's use of animal-based ingredients also increased significantly, compared to cooking for the household ($Mean\ rank = 2.06$), $\chi^2(2) = 94.54$, $p < .001$. Pairwise comparisons for men revealed an increase in animal product use when cooking for guests ($Mean\ rank = 2.17$) versus cooking for themselves ($Mean\ rank = 1.93$, $p < .001$) or the household ($Mean\ rank = 1.90$, $p < .001$), $\chi^2(2) = 21.81$, $p < .001$ (see Table S3 for details).

Table 1

Differences in domestic food practices between men and women.

Variable	Men			Women			<i>U</i>	<i>p</i>
	N	Median	Mean rank	N	Median	Mean rank		
Cooking skills	173	4	184.33	239	4	222.55	24509.50	0.001**
<i>Responsibility for ...</i>								
buying ingredients	173	2	191.10	239	3	217.65	23337.50	0.01*
planning meals	173	2	182.58	237	3	222.23	24465.00	< .001***
preparing meals	172	2	187.98	237	3	217.35	23310.00	0.006**
<i>Animal products when...</i>								
cooking for oneself	172	4	245.72	239	3	177.43	13722.50	< .001***
cooking for household	133	4	176.70	196	4	157.06	11477.50	0.057
cooking for guests	172	4	221.89	239	4	194.56	17820.50	0.02*
Commensality	133	2	172.78	196	2	159.72	11999.50	0.18

Note. Statistical significance for gender differences (Mann-Whitney U test) is indicated by asterisks:

* $p < 0.05$, ** $p < 0.01$, *** $p < .001$.

There was a moderate, statistically significant negative correlation, showing men more prone to follow less sustainable diets ($d = -.26$, $p < .001$). Adjusted residuals indicated that this association is best explained by gender differences in omnivorous, pescatarian, and vegetarian

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diets (see Table 2). More men were omnivores than women (60% vs. 35%), but fewer men were vegetarians (10% vs. 21%) or pescatarians (2% vs. 10%). Gender differences for vegan (9% vs. 11%) and flexitarian diets (19% vs. 23%) did not yield adjusted residuals larger than two standard errors. The next section zooms in on results for men and women, distinguishing by type of diet.

Table 2

Crosstabulation of diet and gender.

Type of diet	Gender	
	Men	Women
Vegan	8.7%	11.3%
	15	27
	(-.9)	(.9)
Vegetarian	10.4%	21.3%
	18	51
	(-2.9)	(2.9)
Pescatarian	2.3%	9.6%
	4	23
	(-3.0)	(3.0)
Flexitarian	19.1%	23.0%
	33	55
	-1.0	1.0
Omnivorous	59.5%	34.7%
	103	83
	(5.0)	(-5.0)

Note. Observed percentages are presented above frequencies. Adjusted residuals are presented in parentheses.

4.2. Sustainable diets delink gender and domestic food practices

Omnivores. For omnivores, differences in food practices between men and women are similar to those found for all respondents. While omnivorous men were also less often (solely) responsible for planning and preparing meals, no significant differences were found for buying ingredients (see Table 3 and Fig. 3). Within gender, pairwise comparisons revealed omnivorous women as significantly more often solely responsible for planning meals (*Mean rank* = 2.09, *p*

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= .04) than buying ingredients (*Mean rank* = 1.89), $\chi^2(2) = 6.89$, $p = .03$ (see Table S2 for details). Other pairs did not reveal significant differences for women. No significant differences were found for omnivorous men between the practices of planning, buying, and preparing meals. Unlike for all diets, commensality was significantly more common for omnivorous women than men. While 58% of women indicated eating together with their household daily, only 34% of men indicated the same. Omnivorous women again classified themselves as significantly more skilled at cooking than men. The use of animal-based ingredients in cooking practices revealed significant gender differences only when cooking for oneself. Omnivorous men indicated ‘often preparing meat/fish for themselves’ significantly more (53%) than omnivorous women (29%). Analyzing within gender differences, the use of animal products again increased for omnivorous women when cooking for others (household, *Mdn* = 5, $p = .02$ or guests, *Mdn* = 5, $p < .001$) versus cooking for themselves (*Mdn* = 4), $\chi^2(2) = 39.42$, $p < .001$ (see Fig. 4). Cooking for the household versus guests did not yield significant differences for omnivorous women. Pairwise comparisons for omnivorous men revealed an increase in animal product use when cooking for guests (*Mean rank* = 2.20) versus cooking for themselves (*Mean rank* = 1.92, $p = .02$) or the household (*Mean rank* = 1.88, $p = .04$), $\chi^2(2) = 14.99$, $p < .001$. Cooking for the household versus oneself did not yield significant differences for omnivorous men (see Table S3 for details).

Table 3

Differences in domestic food practices between omnivorous men and women.

Variable	Men			Women			<i>U</i>	<i>p</i>
	N	Median	Mean rank	N	Median	Mean rank		
Cooking skills	103	4	86.47	83	4	102.23	4999.00	0.03*
<i>Responsibility for ...</i>								
buying ingredients	103	2	87.91	83	3	100.44	4850.50	0.08
planning meals	103	2	83.72	82	3	104.66	5179.00	0.003**
preparing meals	103	2	86.00	82	3	101.80	4944.50	0.03*
<i>Animal products when...</i>								
cooking for oneself	102	5	105.46	83	4	77.69	2962.00	< .001***
cooking for household	73	5	74.57	74	5	73.44	2659.50	0.86
cooking for guests	102	5	91.73	83	5	94.56	4362.50	0.65
Commensality	73	2	83.18	74	1	64.94	2030.50	0.004**

Note. Statistical significance for gender differences (Mann-Whitney U test) is indicated by asterisks:

* $p < 0.05$, ** $p < 0.01$, *** $p < .001$.

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Flexitarians. Looking at differences between flexitarian men and women, gender differences in the responsibility for provisioning are still apparent: Flexitarian men were less often solely responsible for planning meals, buying ingredients, and preparing meals (see Table 4 and Fig. 3). Within gender, pairwise comparisons revealed flexitarian men as significantly less often solely responsible for planning meals (*Mean rank* = 1.86, $p = .009$) than buying ingredients (*Mean rank* = 2.25), $\chi^2(2) = 12.06$, $p = .002$; see Table S2 for details). Other pairs did not reveal significant differences. No significant differences were found for flexitarian women between the practices of planning, buying, and preparing meals. Gender differences in commensality were not significant for flexitarians. Cooking skills and the use of animal-based ingredients when cooking were no longer significantly different between flexitarian men and women. Analyzing within gender differences, the use of animal products was significantly higher for flexitarian women when cooking for guests (*Mean rank* = 2.39) versus themselves (*Mean rank* = 1.67, $p < .001$) or their household (*Mean rank* = 1.94, $p = .02$), $\chi^2(2) = 23.24$, $p < .001$ (see Fig. 4 and Table S3). No significant differences between social settings were found for flexitarian men.

Table 4

Differences in domestic food practices between flexitarian men and women.

Variable	Men			Women			<i>U</i>	<i>p</i>
	N	Median	Mean rank	N	Median	Mean rank		
Cooking skills	33	4	39.52	55	4	47.49	1072.00	0.13
<i>Responsibility for ...</i>								
buying ingredients	33	2	37.47	55	3	48.72	1139.50	0.03*
planning meals	33	2	34.35	55	3	50.59	1242.50	0.002**
preparing meals	32	2	34.66	55	3	49.44	1179.00	0.004**
<i>Animal products when...</i>								
cooking for oneself	33	4	47.62	55	4	42.63	804.50	0.34
cooking for household	31	3	35.90	44	4	39.48	747.00	0.45
cooking for guests	33	4	39.82	55	4	47.31	1062.00	0.16
Commensality	31	2	37.48	44	2	38.36	698.00	0.85

Note. Statistical significance for gender differences (Mann-Whitney U test) is indicated by asterisks: * $p < 0.05$, ** $p < 0.01$, *** $p < .001$.

Vegans, vegetarians, and pescatarians. Vegans, vegetarians, and pescatarians were analyzed separately, but all three subgroups showed no significant gender differences. Therefore, the combined ‘meat-free’ group is presented here (see Table 5). Analyzing within gender

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differences, the use of animal products increased for women who follow meat-free diets when cooking for others (household, $Mdn = 3$, $p < .001$ or guests, $Mdn = 3$, $p < .001$) versus cooking for themselves ($Mdn = 2$), $\chi^2(2) = 36.52$, $p < .001$ (see Fig. 4 and Table S3). Cooking for the household versus guests did not yield significant differences for women following meat-free diets. No significant differences between social settings were found for men following meat-free diets.

Table 5

Differences in domestic food practices between men and women following meat-free diets.

Variable	Men			Women			U	p
	N	Median	Mean rank	N	Median	Mean rank		
Cooking skills	37	4	65.23	101	4	71.06	2026.50	0.41
<i>Responsibility for ...</i>								
buying ingredients	37	2	67.89	101	2	70.09	1928.00	0.75
planning meals	37	3	67.88	100	3	69.42	1891.50	0.82
preparing meals	37	3	70.15	100	3	68.58	1807.50	0.82
<i>Animal products when...</i>								
cooking for oneself	37	2	65.07	101	2	71.12	2032.50	0.41
cooking for household	29	2	48.67	78	3	55.98	1285.50	0.26
cooking for guests	37	2	61.72	101	3	72.35	2156.50	0.15
Commensality	29	2	52.05	78	2	54.72	1187.50	0.67

Note. Statistical significance for gender differences (Mann-Whitney U test) was accepted at $p < .05$.

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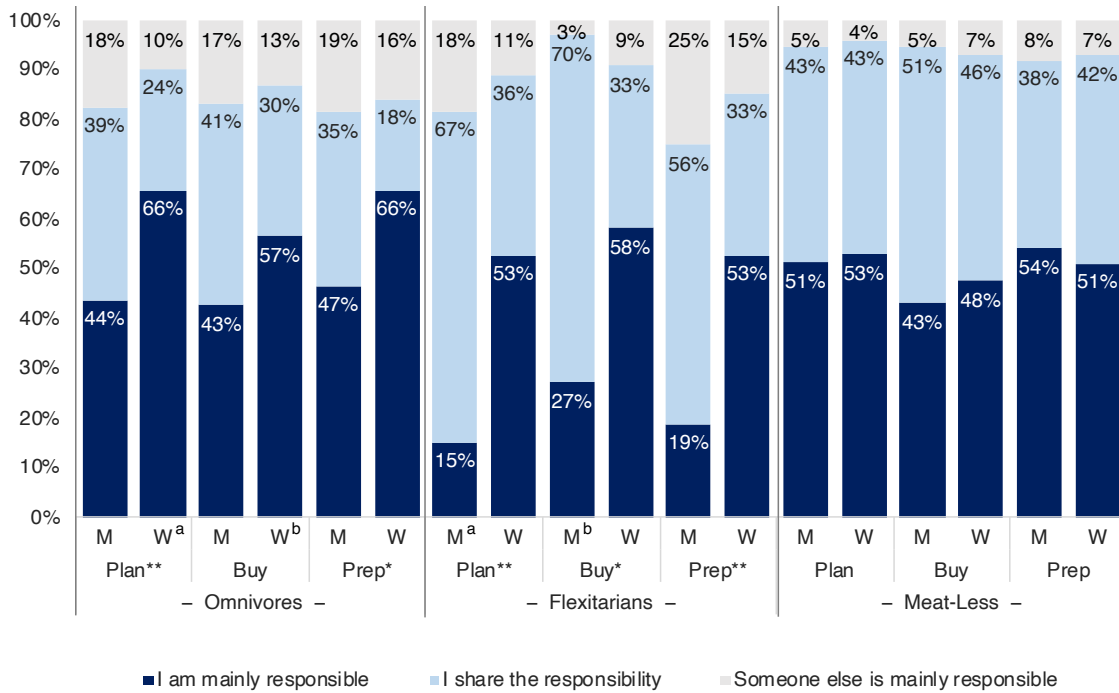


Fig. 3. Responsibility for food provisioning practices by gender and diet.

Note. Participants were asked: “How much responsibility do you have in your household for planning meals/buying ingredients/preparing meals...”. Statistical significance for gender differences is indicated by asterisks: * $p < 0.05$, ** $p < 0.01$, *** $p < .001$. Different superscript letters indicate significant differences within gender found in pairwise comparisons (e.g. observed differences for omnivorous women between planning and buying were significant).

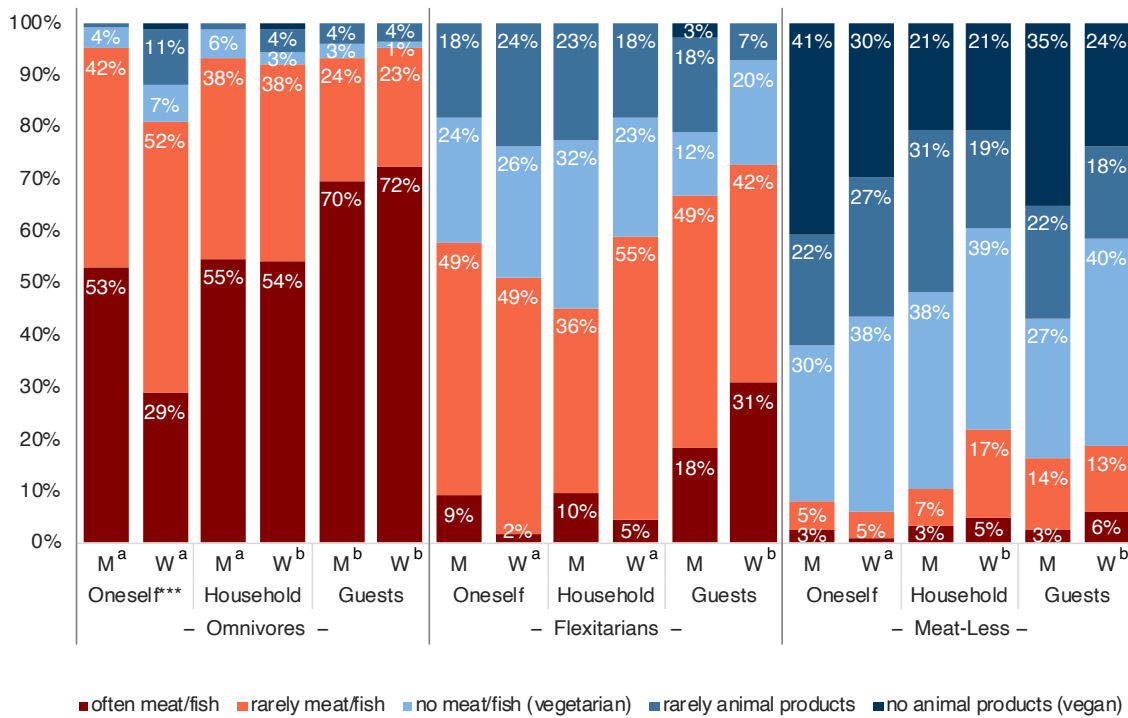


Fig. 4. Use of animal products in different social settings by gender and diet.

Note. Participants were asked: “When I cook for myself/household members/guests, I cook...”. Statistical significance for gender differences (Mann-Whitney U test) is indicated by asterisks: * $p < 0.05$, ** $p < 0.01$, *** $p < .001$. Different superscript letters indicate significant differences within gender found in pairwise comparisons (e.g. observed differences for omnivorous women between cooking for oneself and the household or guests were significant but between cooking for the household and guests not).

5. Discussion

This study is among the first to empirically examine the intersecting sustainability issues of environmental impact and gender inequality in domestic food practices. It builds on and connects previously separate strands of research on the relation of gender and diet as well as gender and domestic foodwork. Thereby, this approach explicitly acknowledges the intersectionality of multiple aspects of sustainability, such as planetary health, human health, and gender equality. The results reveal significant differences in the sustainability of and engagement in domestic food practices between men and women. Overall, men are less often responsible for food provisioning practices, indicate lower cooking skills, follow diets heavier in animal products, and cook more meat, especially for themselves. Zooming in on these gender differences and differentiating by type of diet paints a clearer picture: no differences in men's and women's performance of food practices were found when meat and other animal products are excluded from the diet.

The results show men to overall be less likely to follow plant-focused diets than women. Omnivorous men further prepare more animal products for themselves than omnivorous women. Moreover, omnivorous and flexitarian men participate less in household food provisioning (especially planning and cooking) than women. These findings confirm numerous previous studies on the link between masculinity and meat (e.g. Rosenfeld, 2018) as well as femininity and domestic foodwork (e.g. Kerr and Charles, 1986; Szabo, 2011). However, the results also reveal that those men who engage in sustainable, meat-free diets also partake equally in all duties of food provisioning. Following a gender non-conforming sustainable diet thus seems to be linked to gender non-conforming food provisioning practices for the men in this study. While no studies have compared domestic foodwork for men following omnivorous and non-meat diets directly, insights can be drawn from studies with neighboring research questions. The findings for men and women engaged in Alternative Food Networks (Som Castellano, 2015) and households engaging in sustainability practices (Organo et al., 2013) show that women were still more often responsible for the everyday implementation of sustainability at the household level, than men. This inequality holds especially true for food provisioning. The results of this study do not confirm these earlier findings, but rather speak for more gender equality in household food provisioning within plant-focused dietary practices. These divergent findings may stem from differences in how sustainability is conceptualized. Most studies fail to include diets as a critical leverage point of sustainable domestic food practices, focusing instead on the mode of production and food waste disposal.

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Previous studies have shown women's cooking to be largely 'other-oriented': the gendered expectation of women is to care for others' health and emotional well-being through their foodwork (Beagan et al., 2008; Cairns et al., 2013, 2010). In this study, women made more frequent use of animal products when cooking for guests than when cooking for themselves, irrespective of their own diet. The use of animal products increased significantly when cooking for guests, even for women following no-meat diets. Men following flexitarian and meat-free diets, on the other hand, did not differentiate significantly between themselves and guests in their use of animal products. Women (except flexitarians) also distinguished between themselves and the household, whereas men – no matter the diet – did not. This differentiation between themselves and others can negatively impact the sustainability of women's cooking for others, irrespective of their own dietary practice. The link between femininity and care, as well as care and meat, may thereby provide a particularly vexing nexus of meanings. These findings are in line with those of DeLessio-Parson (2017), who found vegetarian women in Argentina to be more willing to continue to fill their position as cooks (of meat) for others. In contrast, vegetarian men in her study often refused to even participate in meals where meat was served in order to avoid 'complicity' in killing animals. Linking plant-focused dishes to meanings of care and 'special occasions' (Biermann and Rau, 2020), such as cooking for the household or hosting guests, may therefore be particularly relevant for sustainability goals, when women participate in these practices.

Recent experimental research has shown that experiencing a threat to their masculinity leads men to express more meat attachment. In the context of vegetarianism, social interaction may further strengthen gender norm conforming behavior for impression management (Rosenfeld, 2020). Since men following a non-meat diet transgress the expectation of masculine eating, how do they manage their seemingly clashing gender and dietary identities? In the findings of this study, men do not overcompensate when in the company of others: neither flexitarian men nor men following meat-free diets cook more (or less) animal products for their household or others than women. In this way, the flexitarian, pescatarian, vegetarian, and vegan men in this study seem to be contributing to undoing the meat-masculinity nexus, confirming previous research (e.g. DeLessio-Parson, 2017; Greenebaum and Dexter, 2018; Mycek, 2018). However, in contrast to previous findings, the men in this study go beyond hybrid masculinities and 'a slightly less conventional masculine practice' (Mycek, 2018, p. 18) by also participating in gender non-conforming food provisioning practices. Men following meat-free diets did not exhibit the expected 'overcompensation' to reestablish their masculinity by abstaining from 'feminine' domestic food provisioning practices. Rather, they are responsible for them just as much as women are. Vegan, vegetarian, and pescatarian men in this study are thereby undoing the link between meat and masculinity, as well as domestic foodwork and femininity. Does the

gender identity of the non-meat-eating men in this study encompass plant-based diets and gender equality in food provisioning?

While this study has shown a link between sustainable diets and domestic food practices in contributing to ‘undoing’ gender, a causal direction is difficult to establish. As Szabo (2014) asks herself in her study of domestic cooking and masculinity: “Did my participants who had significant responsibilities for feeding others develop more ‘feminine’ approaches to cooking because of their involvement in this cooking? Or were they nurturing, caring men to begin with and self-select into these household roles?” (p. 27). Similarly, the direction of the interaction between diet and (lack of) gender differences in domestic food provisioning cannot be derived from this cross-sectional study. However, previous findings shed light on possible explanations. Studies on shifting gender identities reveal interesting links to dietary intentions and behavior. De Backer et al. (2020) studied the link between ‘new’ forms of masculinity and intended or actual meat consumption and attitudes towards vegetarians. While the ‘New Masculinity Inventory’ (Kaplan et al., 2017) used in the study does not explicitly include household chores, it does include items related to childcare and balancing career and family duties. De Backer et al. (2020) found the more men identified with non-traditional masculinity, the weaker their meat attachment, the more positive their attitude to vegetarians, and the stronger their willingness to reduce meat consumption. The results on current meat intake were less definitive, with non-traditional masculine identity and higher education related to less meat consumption for breakfast and snacks, but not lunch or dinner. Similarly, Schösler et al. (2015) find second-generation Turkish-Dutch to exhibit a stronger meat-masculinity link, while also being more bound to traditional gender roles, than Dutch natives. In their study of Swedish men, Neuman et al. (2017a) argue that boundaries between feminine and masculine domestic cooking are blurring and that domestic cooking held social functions of “caring, proving one’s worth as a modern man, giving, showing off, treating oneself, and building communion” (p. 828) for modern, gender-equal Swedish men. Can this ‘new’ masculinity, associated with care, domestic responsibility, and egalitarianism serve both, to open men up to plant-based diets and the responsibilities of food provisioning?

Different practices may share common elements, serving as a ‘connective tissue’ (Shove et al., 2012, p. 11) that stabilizes social arrangements. Using practices of car driving as an example, Shove et al. (2012) argue that “notions of masculinity provide a point of connection between practices of repairing [machinery] and driving.” (p. 36) From a practice-theoretical perspective, plant-based diets, foodwork, and new ways of ‘doing gender’ may share meanings of ‘care.’ Regarding plant-focused diets, ‘care’ translates to caring for animals, the planet, and future generations. For foodwork, ‘care,’ in turn, includes caring for the well-being of the household

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by planning, buying, and preparing planetary-health meals. Previous research proposes that vegetarian, and especially vegan diets, go well beyond the consumption of goods and are seen as a social identity (e.g. Costa et al., 2019; Rosenfeld, 2019). Vegetarianism has been linked to liberal political views, advocating for environmental protection, social justice, and equality more than an omnivorous diet (Nezlek and Forestell, 2020). Flexitarianism, on the other hand, appears to be less central to social identity (Rosenfeld et al., 2020). While omnivorous and flexitarian dietary practices may therefore only form looser *bundles*⁴ of practices for men, divided by more traditional meanings of femininity and masculinity, stricter, meat-free dietary practices potentially form a *complex* of interlinked food provisioning practices by a shared meaning of ‘caring’ for animals, the environment, and others, through food (see Fig. 5).

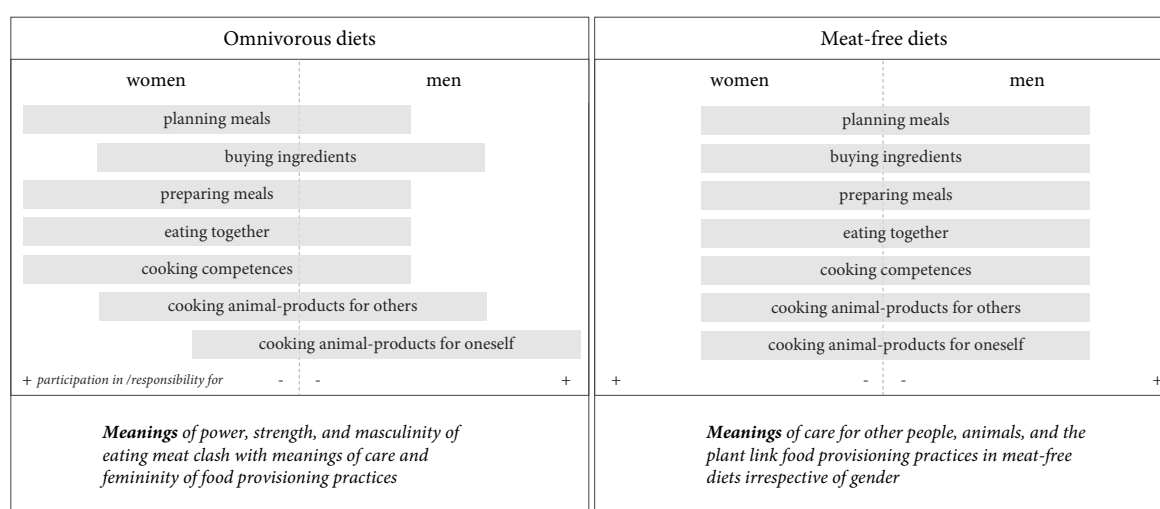


Fig. 5 Gendered meanings of intersecting food practices.

Empirical work has found vegan blogs run by women to reflect these “themes of caring for family members, daily food work, and healthy living,” (p. 141) however vegan eating was framed as a hobby rather than daily food work on vegan blogs run by men (Hart, 2018). While the author of the article argues that this gendered discourse reinforces traditional gender norms, again unlinking care and veganism for men, it is worthwhile to zoom out and acknowledge that most food blogs (Boepple and Thompson, 2014), and especially vegan blogs are run by women (Hart, 2018). This confrontation with themes of ‘caring,’ when engaging in and learning about sustainable food practices, may contribute to a link between meanings of consuming a more plant-focused diet and household food provisioning. In this study, no gender differences in cooking skills were found for practitioners of reduced meat and non-meat diets, further strengthening this hypothesis.

⁴ *Bundles* of practices are understood as ‘loose-knit patterns based on co-location and coexistence,’ while *complexes* are ‘stickier and more integrated arrangements including co-dependent forms of sequence and synchronization’ (Shove et al., 2012, p. 11).

The issue of redefining gender stereotypes and gendered meanings of practices is not one any individual, the market, or policy can solve alone. Rothgerber (2013) lists a series of suggestions to unlink the meat-masculinity nexus to reduce men's meat intake: (1) raising awareness of gender socialization, (2) enlisting women as change agents, (3) influencing the perception of norms, and (4) framing appeals in a masculine way. These suggestions can be extended to include not only the link of gender identity and dietary choice but also foodwork. Influencing the perception of norms by explicitly showing role models previously admired for fitting traditional masculine ideals who engage in meat-free diets can be a powerful tool to reshape gender identity. Popular culture is full of celebrities abstaining from meat: from the bodybuilder, actor, activist, and politician Arnold Schwarzenegger, to the hardcore punk band singer, Ironman triathlete, and author of *Meat Is for Pussies* John Joseph, boxing champion Mike Tyson, and rapper RZA of the Wu-Tang Clan. Aside from using traditionally masculine personas to reframe meat-free diets in the short term, long term strategies might rather aim to deconstruct gender stereotypes. Inspiration on how to do so can be taken from the Swedish approach to promote shared, gender-equal child- and domestic care. In government campaigns between 2002-2006, “[p]arents were approached as though it is natural and self-evident they will share the parental leave equally [...] men’s and women’s rights, capacities and responsibilities were communicated in terms of *similarity*, rather than *difference*.” (Klinth, 2008, p. 32ff.) Similarly, meat-free diets and foodwork could be communicated as self-evident, desirable practices for any person, not men or women specifically.

Aside from marketing and policy initiatives targeting gender identities, the broader structural context inhibiting equality in domestic labor cannot be ignored. The insightful study of time use in 36 countries by Hook (2010) reveals that housework is most equally distributed in national contexts with short average workweeks, high (full-time) employment for women, parental leaves of moderate length with leave specified for men, and extended offers of child care. While Germany ticks some of these boxes, it scores below EU-average on the gender inequality index (EIGE, 2020), lacking in essential elements such as easily accessible childcare. Only when these macro-scale gender inequalities are addressed can food practices truly be environmentally and socially just at the household level.

6. Limitations

Despite the importance of these findings, the results are limited by the quantitative empirical approach. Further qualitative inquiries into the lived experiences of men and women practicing sustainable diets at the household level are important to understand the transitions and interlinkages of practices of gender, food, and domesticity. Recent findings also show the

importance of taking into account more nuanced gender identities (De Backer et al., 2020) and differentiating between country of residence and cultural heritage (Schösler et al., 2015), when studying gendered food practices. Measuring gender identity on a scale rather than as a dichotomous variable may shed more light on current developments of shifting gender identities. Further, the intersectionality of oppressions aside from gender should be considered in sustainable consumption research. As most survey respondents were from well-educated, middle-class backgrounds, the sample did not lend itself to further analyses of intersections of inequality such as race and class (Alkon and Agyeman, 2011; Hamilton et al., 2019).

Researchers have further questioned the validity of ‘spill-over effects,’ noting that sustainable behaviors in one site or social setting may not transfer to others (Barr et al., 2011). While this strand of consumption research is rooted in individualistic, behavioral traditions, from a practice perspective, it is interesting to look for sustainability patterns of intersecting practices. For food, a divergence between sustainability practices at home and out of home has been noted (Biermann and Rau, 2020). Therefore, the findings of this study for the domestic sphere are not generalizable to a ‘sustainable lifestyle’ outside of the home context. Future research should investigate gendered patterns of sustainable food consumption beyond the household.

7. Conclusion

Foodwork is, by its nature, an issue closely connected to sustainability. Whether households explicitly take on sustainability practices or not, their everyday food practices largely contribute to consumers’ impact on the environment. This study showed that low-meat and no-meat diets exhibit fewer gender differences in their performance when compared to omnivorous diets with more frequent consumption of animal products. However, the performance of sustainable diets is gender non-conforming for men, with more women as practitioners of these diets. Therefore, to advance sustainable and gender-equitable food provisioning, it may not be sufficient to make plant-focused diets more attractive. Additionally, social norms of masculinity need to be taken into account, making non-traditional versions of masculinity more attractive and, ultimately, deconstructing traditional gender stereotypes and their connections with food. A practice-theoretical lens is helpful in this endeavor, as it sheds light on the link between meanings of plant-focused diets, femininity, and food provisioning in the household.

8. Acknowledgments

The author would like to thank Henrike Rau for her general guidance and insightful discussions, as well as Pauline Heusterberg, Felix Krauth, and Florian Fincke for their valuable comments on an earlier draft of this manuscript. The author is grateful to everyone who agreed to participate in the qualitative interviews and online survey, making this research possible.

9. Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

10. Competing interests

The author declares no competing interests.

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12. Supplementary Material

Table S1

Questions used in the analysis.

1. Gender	1 = man 2 = woman 3 = other 4 = I do not want to categorize myself
2. Do you follow a specific diet?	1 = vegan (no animal products) 2 = vegetarian (no meat and no fish) 3 = pescatarian (no meat, but fish) 4 = flexitarian (meat or fish no more than once per week) 5 = omnivorous (no restrictions regarding animal products)
3-5. How much responsibility do you have in your household for...	1 = someone else is mainly responsible
a. buying ingredients	2 = I share the responsibility
b. planning meals	3 = I am mainly responsible
c. preparing meals	
6. Can you cook?	1 = not at all 2 = a little 3 = average 4 = well 5 = very well
7. Think about the past month: How often did your household eat together?	1 = daily 2 = multiple times / week 3 = once / week 4 = multiple times / month 5 = less often 6 = never
8-10. Please complete the following sentence: <i>When I cook for...</i>	1 = no animal products (vegan) 2 = rarely animal products
a. <i>my household, I cook...</i>	3 = no meat/fish (vegetarian)
b. <i>guests, I cook...</i>	4 = rarely meat/fish
c. <i>myself, I cook...</i>	5 = often meat/fish

Table S2

Within-subject differences in responsibility for food provisioning practices for omnivorous women and flexitarian men.

	Test statistic	Women, omnivores	Men, flexitarian
	Friedman	$\chi^2(2) = 6.89, p = .03$	$\chi^2(2) = 12.06, p = .002$
Buy vs. Plan	Exact	0.59	0.36
	Nemenyi	0.40	0.26
	Conover	0.03*	0.005**
	WNMT	0.03*	0.003**
	Wilcoxon signed-rank	0.04*	0.009*** ^a
	Sign	0.06	0.01*
Buy vs. Prepare	Exact	1.00	0.45
	Nemenyi	0.69	0.32
	Conover	0.28	0.01*
	WNMT	0.27	0.008**
	Wilcoxon signed-rank	0.72 ^a	0.06 ^a
	Sign	0.63	0.12

Note. Statistical significance is indicated by asterisks: * $p < 0.05$, ** $p < 0.01$, *** $p < .001$. Values reported in the main text are marked in bold. Pairwise comparisons for “Prepare vs. Plan” did not yield statistical significance with any post hoc testing procedure and is therefore not presented here. Pairwise comparisons were performed with a Bonferroni correction for multiple comparisons for the Exact (Eisinga et al., 2017), Conover (Conover and Iman, 1979), Wilcoxon-signed rank (Sheskin, 2004), and Sign test (Sheskin, 2004). For the Nemenyi test (Demšar, 2006), p-values are computed from the studentized range distribution. The Wilcoxon, Nemenyi, McDonald-Thompson test (WNMT) uses the Monte Carlo (with 10000 Iterations) method (Hollander et al., 2013).

^aDifference scores were not symmetrically distributed, therefore the results of the Sign test were used instead of the Wilcoxon-signed rank test.

APPENDIX

Table S3

Within gender differences in use of animal products for different social occasions.

Test statistic	Women, all diets	Women, omnivores	Women, flexitarian	Women, non-meat	Men, all diets	Men, omnivores
	$\chi^2(2) = 94.54$	$\chi^2(2) = 39.42$	$\chi^2(2) = 23.24$	$\chi^2(2) = 36.52$	$\chi^2(2) = 21.81$	$\chi^2(2) = 14.99$
Friedman	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$
Self vs. Guests						
Exact	< .001***	< .001***	0.002**	0.006**	0.14	0.27
Nemenyi	< .001***	< .001***	0.002**	0.006**	0.11	0.21
Conover	< .001***	< .001***	< .001***	< .001***	< .001***	0.005**
WNMT	< .001***	< .001***	< .001***	< .001***	< .001***	0.004**
Wilcoxon signed-rank	< .001*** ^a	< .001*** ^a	< .001*** ^a	< .001*** ^a	0.02* ^a	0.21 ^a
Sign	< .001***	< .001***	< .001***	< .001***	< .001***	0.02*
Self vs. HH						
Exact	< .001***	0.02*	0.66	0.02*	1.00	1.00
Nemenyi	< .001***	0.02*	0.41	0.02*	0.97	0.98
Conover	< .001***	< .001***	0.21	< .001***	1.00	1.00
WNMT	< .001***	< .001***	0.17	< .001***	0.90	0.95
Wilcoxon signed-rank	< .001*** ^a	< .001*** ^a	0.04* ^a	< .001*** ^a	1.00	1.00
Sign	< .001***	< .001***	0.07	< .001***	1.00	1.00
Guests vs. HH						
Exact	0.09	0.39	0.11	1.00	0.08	0.17
Nemenyi	0.08	0.28	0.09	0.92	0.07	0.14
Conover	0.002**	0.08	0.01*	1.00	< .001***	0.001**
WNMT	0.002**	0.07	0.009**	0.78	< .001***	0.002**
Wilcoxon signed-rank	< .001*** ^a	0.07	0.009*** ^a	1.00	0.006*** ^a	0.003*** ^a
Sign	< .001***	0.45	0.02*	1.00	< .001***	0.04*

Note. Statistical significance is indicated by asterisks: * $p < 0.05$, ** $p < 0.01$, *** $p < .001$. Values reported in the main text are marked in bold. Pairwise comparisons for “Prepare vs. Plan” did not yield statistical significance with any post hoc testing procedure and is therefore not presented here. Pairwise comparisons were performed with a Bonferroni correction for multiple comparisons for the Exact (Eisinga et al., 2017), Conover (Conover and Iman, 1979), Wilcoxon-signed rank (Sheskin, 2004), and Sign test (Sheskin, 2004). For the Nemenyi test (Demšar, 2006), p-values are computed from the studentized range distribution. The Wilcoxon, Nemenyi, McDonald-Thompson test (WNMT) uses the Monte Carlo (with 10000 Iterations) method (Hollander et al., 2013).

^aDifference scores were not symmetrically distributed, therefore the results of the Sign test were used instead of the Wilcoxon-signed rank test.

